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Protecting People and the Environment

NUREG-1437
Supplement 49
Volume 1

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 49

Regarding Limerick Generating Station, Units 1 and 2

Chapters 1 to 12

Final Report

Office of Nuclear Reactor Regulation

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ABSTRACT

This final supplemental environmental impact statement has been prepared in response to an application submitted by Exelon Generation Company, LLC (Exelon) to renew the operating license for Limerick Generating Station, Units 1 and 2 (LGS) for an additional 20 years.

This final supplemental environmental impact statement includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include natural gas combined-cycle (NGCC), supercritical pulverized coal, new nuclear, wind power, purchased power, and not renewing the license (the no action alternative).

The U.S. Nuclear Regulatory Commission's preliminary recommendation is that the adverse environmental impacts of license renewal for LGS are not great enough to deny the option of license renewal for energy planning decisionmakers. This recommendation is based on the following:

- the analysis and findings in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*;
- the environmental report submitted by Exelon;
- consultation with Federal, state, and local agencies;
- the NRC's environmental review;
- consideration of public comments received during the scoping process;
- consideration of public comments received on the draft supplemental environmental impact statement; and
- consideration of the information presented in the Natural Resources Defense Council's severe accident mitigation alternatives-related waiver petition.

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BACKGROUND

By letter dated June 22, 2011, Exelon Generation Company, LLC (Exelon), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue renewed operating licenses for Limerick Generating Station, Units 1 and 2 (LGS) for an additional 20-year period.

Pursuant to Title 10 of the *Code of Federal Regulations* 51.20(b)(2) (10 CFR 51.20(b)(2)), the renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that, in connection with the renewal of an operating license, the NRC shall prepare an EIS, which is a supplement to the Commission's NUREG-1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*.

The GEIS was originally published in 1996, and amended in 1999. Subsequently, on June 20, 2013, the NRC published a final rule (78 FR 37282) revising 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." The final rule updates the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A 2013 revised GEIS, which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of National Environmental Policy Act (NEPA) issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The 2013 rule revised the previous rule to consolidate similar Category 1 and 2 issues; change some Category 2 issues into Category 1 issues; consolidate some of those issues with existing Category 1 issues; and, add new Category 1 and 2 issues.

The 2013 rule became effective July 22, 2013, after publication in the Federal Register. Compliance by license renewal applicants is not required until June 20, 2014 (i.e., license renewal applications submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze, in its license renewal Supplemental Environmental Impact Statement (SEIS), the potential significant impacts described by the revised rule's new Category 2 issues, and, to the extent there is any new and significant information, the potential significant impacts described by the revised rule's new Category 1 issues.

Upon acceptance of Exelon's application, the NRC staff began the environmental review process described in 10 CFR Part 51 by publishing a Notice of Intent to prepare a supplemental EIS (SEIS) and conduct scoping. In preparation of this SEIS for LGS, the NRC staff performed the following:

- conducted public scoping meetings on September 22, 2011, in Pottstown, Pennsylvania;
- conducted a site audit at LGS on November 7–10, 2011;
- reviewed Exelon's environmental report (ER) and compared it to the GEIS;
- consulted with Federal, state, and local agencies;
- conducted a review of the issues following the guidance set forth in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*; and

- considered public comments received during the scoping process and the comment period on the draft SEIS as well as information presented in the Natural Resources Defense Council's SAMA-related waiver petition.

PROPOSED FEDERAL ACTION

Exelon initiated the proposed Federal action—issuing renewed power reactor operating licenses—by submitting an application for license renewal of LGS, for which the existing licenses (NPF-39 and NPF-85) will expires on October 26, 2024, and June 22, 2029, respectively. The NRC's Federal action is the decision whether or not to renew the licenses for an additional 20 years. In accordance with 10 CFR 2.109, if a licensee of a nuclear power plant files an application to renew on operating license at least 5 years before expiration date of that license, the existing license will not be deemed to have expired until the safety and environmental reviews are completed and the NRC has made a final decision to either deny the application or issue a renewed license for the additional 20 years.

PURPOSE AND NEED FOR THE PROPOSED FEDERAL ACTION

The purpose and need for the proposed action (issuance of a renewed license) is to provide an option that allows for power generation capability beyond the term of the current nuclear power plant operating license to meet future system generating needs. Such needs may be determined by other energy-planning decisionmakers, such as state, utility, and, where authorized, Federal agencies (other than NRC). This definition of purpose and need reflects the NRC's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application, the NRC does not have a role in the energy-planning decisions as to whether a particular nuclear power plant should continue to operate.

If the renewed licenses are issued, the appropriate energy-planning decisionmakers, along with Exelon, will ultimately decide if the plant will continue to operate based on factors such as the need for power. If the operating licenses are not renewed, then the facility must be shut down on or before the expiration dates of the current operating licenses.

ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

The SEIS evaluates the potential environmental impacts of the proposed action. The environmental impacts from the proposed action are designated as SMALL, MODERATE, or LARGE. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

- The environmental impacts associated with the issue are 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 characteristics.
- A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts, except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.
- Mitigation of adverse impacts associated with the issue is considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

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, important attributes of the resource.

LARGE: Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For Category 1 issues, no additional site-specific analysis is required in this SEIS unless new and significant information is identified. Chapter 4 of this report presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criteria for Category 1 issues; therefore, an additional site-specific review for these nongeneric issues is required, and the results are documented in the SEIS.

The environmental review of the LGS license renewal application was performed using the criteria from the 1996 and 1999 GEIS. Neither Exelon nor NRC identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. This conclusion is supported by the NRC's review of the applicant's ER and other documentation relevant to the applicant's activities, the public scoping process and substantive comments raised, and the findings from the environmental site audit conducted by the NRC staff.

The NRC staff also reviewed information relating to the new issues identified in the 2013 GEIS, specifically, geology and soils; radionuclides released to the groundwater; effects on terrestrial resources (noncooling system intake); exposure of terrestrial organisms to radionuclides; exposure of aquatic organisms to radionuclides; human health impacts from chemicals; physical occupational hazards; environmental justice; and cumulative impacts. These issues are documented in Chapter 4 of this SEIS

Finally, the NRC staff did not identify any new issues applicable to LGS that have a significant environmental impact. The NRC staff, therefore, relies upon the conclusions of the 1996 and 2013 GEIS for all Category 1 issues applicable to LGS.

Table ES-1 summarizes the Category 2 issues relevant to LGS as well as the NRC staff's findings related to those issues. If the NRC staff determined that there were no Category 2 issues applicable for a particular resource area, the findings of the GEIS, as documented in Appendix B to Subpart A of 10 CFR Part 51, are incorporated for that resource area. Hereafter in this SEIS, general references to the GEIS, without stipulation, are inclusive of the 1996 and 1999 GEIS. Information and findings specific to the June 2013 final rule and GEIS are clearly identified.

Table ES–1. Summary of NRC Conclusions Relating to Site-Specific Impacts of License Renewal

Resource Area	Relevant Category 2 Issues	Impacts
Land Use	Not applicable	SMALL
Air Quality	Not applicable	SMALL
Surface Water Resources	Water use conflicts	SMALL
Groundwater Resources	Groundwater use conflicts Radionuclides released to groundwater[(a)]	SMALL SMALL
Aquatic Resources	Not applicable	SMALL
Terrestrial Resources	Effects on terrestrial resources (noncooling system impacts)[(a)]	SMALL
Protected Species	Threatened or endangered species	No effect[(b)]
Human Health	Electromagnetic fields—acute effects (electric shock) Microbiological organisms (public health)	SMALL
Socioeconomics	Housing impacts Public services (public utilities) Offsite land use Public services (transportation) Historic and archaeological resources	SMALL
Cumulative Impacts[(a)]	Aquatic resources Terrestrial resources All other resource areas	SMALL to MODERATE MODERATE SMALL

(a) These issues are new Category 2 issues identified in the 2013 GEIS and Rule (78 FR 37282). U.S. Nuclear Regulatory Commission. **"**Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses.**"** June 2013.

(b) For Federally protected species, the 2013 GEIS and rule state that, in complying with the Endangered Species Act (ESA), the NRC will report the effects of continued operations and refurbishment in terms of its ESA findings, which vary by species for LGS. While the analyses of environmental impacts under NEPA and NRC's Regulations in the SEIS include assignment of NRC impact levels of SMALL, MODERATE, and LARGE for each issue, the assessment of endangered species under ESA must include determination of "no effect," may effect, but not likely to adversely effect," or "may affect, and is likely to adversely affect."

With respect to environmental justice, the NRC staff has determined that there would be no disproportionately high and adverse impacts to these populations from the continued operation of LGS during the license renewal period. Additionally, the NRC staff has determined that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

The NRC staff previously considered Severe Accident Mitigation Alternatives (SAMAs) for LGS in NUREG-0974, Supplement 1, the "Final Environmental Statement Related to the Operation of

Limerick Generating Station, Units 1 and 2." The NRC staff's analysis was based on the licensee's analysis in the updated probabilistic risk assessment. Because the NRC staff has previously considered SAMAs for LGS, NRC regulations do not require the NRC staff to reconsider SAMAs for this license renewal proceeding. Nonetheless, the NRC must consider whether there is new and significant information related to this issue, as it must for all environmental issues the NRC addresses through a generic determination in its regulations. By Order dated October 31, 2013, the Commission directed the NRC staff to review the significance of any new information presented in the Natural Resources Defense Council's (NRDC's) SAMA-related waiver petition in its environmental review of Exelon's license renewal application, and to discuss this review in the final supplemental EIS. The NRC staff has not identified any new and significant SAMA-related information.

ALTERNATIVES

The NRC staff considered the environmental impacts associated with alternatives to license renewal. These alternatives include other methods of power generation and not renewing the LGS operating license (the no-action alternative). The feasible and commercially viable replacement power alternatives considered were:

- natural-gas-fired combined-cycle (NGCC),
- supercritical pulverized coal (SCPC),
- new nuclear,
- wind power, and
- purchased power.

The NRC staff initially considered a number of additional alternatives for analysis as alternatives to the license renewal of LGS; these were later dismissed because of technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the existing LGS license expires rendering these alternatives not feasible and commercially viable. The no action alternative and the effects it would have were also considered by the NRC staff.

Where possible, the NRC staff evaluated potential environmental impacts for these alternatives located both at the LGS site and at some other unspecified alternate location. Alternatives considered, but dismissed, were:

- solar power;
- combination alternative of wind, solar, and NGCC;
- combination alternative of wind and compressed-air energy storage (CAES);
- wood waste;
- conventional hydroelectric power;
- ocean wave and current energy;
- geothermal power;
- municipal solid waste (MSW);
- biofuels;
- oil-fired power;

- delayed retirement;
- fuel cells;
- coal-fired integrated gasification combined-cycle (IGCC); and
- demand-side management (DSM).

The NRC staff evaluated each alternative using the same impact areas that were used in evaluating impacts from license renewal.

RECOMMENDATION

The NRC's recommendation is that the adverse environmental impacts of license renewal for LGS are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- the analyses and findings in the GEIS;
- the ER submitted by Exelon;
- the NRC staff's consultation with Federal, state, and local agencies;
- the NRC staff's independent environmental review;
- the NRC staff's consideration of public comments received during the scoping process;
- the NRC staff's consideration of public comments received on the draft SEIS; and
- the NRC staff's consideration of the information presented in the NRDC's SAMA-related waiver petition.

ABBREVIATIONS AND ACRONYMS

°C	degree(s) Celsius
°F	degree(s) Fahrenheit
AADT	average annual daily traffic
ac	acre(s)
AC	alternating current
ACHP	Advisory Council on Historic Preservation
ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
AEPS	alternative energy portfolio standard
ALARA	as low as is reasonably achievable
ANSI	American National Standards Institute
APE	area of potential effect
AQCR	air quality control region
ATWS	anticipated transient without scram
BHP	Bureau of Historic Preservation
BMP	best management practice
BOL	Bureau of Laboratories
BTU	British thermal unit(s)
BTU/kWh	British thermal unit(s) per kilowatt-hour
BTU/lb	British thermal unit(s) per pound
BWR	boiling water reactor
BWROG	BWR Owners' Group
CAA	Clean Air Act, as amended through 1990
CAES	compressed air energy storage
CCS	carbon capture and storage
CDF	core damage frequency
C_{eq}/kWh	carbon equivalent per kilowatt-hour
CEQ	Council on Environmental Quality
CEUS	central and eastern United States
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
cm	centimeter(s)

cm/s	centimeter(s) per second
CO	carbon monoxide
CO_2	carbon dioxide
CPI	Containment Performance Improvement
CRGIS	Cultural Resources Geographic Information System
CS	candidate species
CSAPR	Cross-State Air Pollution Rule
CSP	concentrated solar power
CT	combustion turbine
CWA	Clean Water Act of 1972
dB	decibels
dBA	decibels adjusted
DBA	design-basis accident
DC	direct current
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DRBC	Delaware River Basin Commission
DSEIS	draft supplemental environmental impact statement
DSM	demand-side management
DVRPC	Delaware Valley Regional Planning Commission
DWS	drinking water standard
E.O.	Executive Order
EFH	essential fish habitat
EI	exposure index
EIA	Energy Information Administration (of DOE)
EIS	environmental impact statement
ELF EMF	extremely low-frequency electromagnetic field
EMS	environmental management system
EP	emergency preparedness
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act of 1986
EPG	Emergency Procedure Guidelines
EPRI	Electric Power Research Institute
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ER	Environmental Report

ESA	Endangered Species Act of 1973, as amended
ESEP	Expedited Seismic Evaluation Process
Exelon	Exelon Generation Company, LLC
FE	Federally endangered
FENOC	First Energy Nuclear Operating Company
FES	final environmental statement
fps	feet per second
FR	*Federal Register*
FSAR	final safety analysis report
ft	foot (feet)
FT	Federally threatened
ft^3	cubic foot (feet)
FW	feedwater
FWCA	Fish and Wildlife Coordination Act
FWS	U.S. Fish and Wildlife Service
g	gram(s)
gal	gallon(s)
GDC	general design criterion/criteria
GE	General Electric
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG–1437
GHG	greenhouse gas
GIC	Green-is-Clean
GMRS	ground motion response spectrum/spectra
gpd	gallons per day
gpm	gallons per minute
GW	groundwater
ha	hectare(s)
Hg	mercury
HLSA	high-level storage area
Hz	hertz
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IGCC	integrated gasification combined-cycle
IHS	IPEEE HCLPF spectrum/spectra

IN	information notice
in.	inch(es)
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination of External Events
ISFSI	Independent Spent Fuel Storage Installation
ISO	International Organization for Standardization
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(s)
kW	kilowatt(s)
kWh	kilowatt-hour(s)
L/min	liter(s) per minute
lb	pound(s)
LEFM	Leading Edge Flow Meter
LGS	Limerick Generating Station, Units 1 and 2
Limerick	Limerick Generating Station, Units 1 and 2
LLMW	low-level mixed waste
LLRW	low-level radioactive waste
m	meter(s)
m/s	meter(s) per second
m^2	square meter(s)
m^3	cubic meter(s)
m^3/s	cubic meters per second
mA	milliampere(s)
MACCS2	MELCOR Accident Consequence Code System 2
MAIS	macroinvertebrate aggregated index for streams
MassDEP	Massachusetts Department of Environmental Protection
MATS	Mercury and Air Toxics Standards
MBTA	Migratory Bird Treaty Act of 1918
MCPC	Montgomery County Planning Commission
MDPH	Massachusetts Department of Public Health
MF	migratory fishes
mg/L	milligrams per liter
mgd	million gallons per day

mGy	million gallons per year
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mm	millimeter(s)
MMI	Modified Mercalli Intensity
MMPA	Marine Mammal Protection Act of 1972
mph	mile(s) per hour
mrad	milliradiation absorbed dose
mrem	milliroentgen equivalent man
MSA	Magnuson–Stevens Fishery Conservation and Management Act, as amended through 2006
MSL	mean sea level
mSv	millisievert
MSW	municipal solid waste
MT	metric ton(s)
MUR	measurement uncertainty recapture
MW	megawatt(s)
MWd	megawatt-day(s)
MWd/MTU	megawatt-day(s) per metric ton of uranium
MWe	megawatt(s) electrical
MWt	megawatt(s) thermal
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NASS	National Agricultural Statistics Service
NCI	National Cancer Institute
NCRP	National Council on Radiation Protection and Measurements
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NERC	North American Electric Reliability Corporation
NESC	National Electrical Safety Code
NETL	National Energy Technology Laboratory
NGCC	natural-gas-fired combined-cycle
NHPA	National Historic Preservation Act of 1966, as amended

NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service (of NOAA)
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide(s)
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRCS	National Resources Conservation Service
NRHP	National Register of Historic Places
NRR	Office of Nuclear Reactor Regulation
NTTF	Near-Term Task Force
NUREG	NRC technical report designation (Nuclear Regulatory Commission)
NWS	National Weather Service
O_3	ozone
OCA	Owner-Controlled Area
ODCM	Offsite Dose Calculation Manual
OPA	Office of Public Affairs
PADEP	Pennsylvania Department of Environmental Protection
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PBAPS	Peach Bottom Atomic Power Station
PCBs	polychlorinated biphenyl
pCi/L	picocuries per liter
PDCNR	Pennsylvania Department of Conservation and Natural Resources
PDEP	Pennsylvania Department of Environmental Protection
PE	Pennsylvania endangered
PECO	PECO Energy Company, the energy delivery subsidiary of Exelon Corporation serving retail customers in southeastern Pennsylvania (also used as an acronym for Philadelphia Electric Company, a predecessor of PECO Energy Company and Exelon Generation)
PFBC	Pennsylvania Fish and Boat Commission
PGA	peak ground acceleration
PGC	Pennsylvania Game Commission
PJM	PJM Interconnection, LLC
PM	particulate matter

PM_{10}	particulate matter >2.5 microns and ≤10 microns in diameter
$PM_{2.5}$	particulate matter ≤2.5 microns in diameter
PNDI	Pennsylvania Natural Diversity Inventory
PNHP	Pennsylvania Natural Heritage Program
PNNL	Pacific Northwest National Laboratory
POST	Parliamentary Office of Science and Technology
PPC	Preparedness, Prevention, and Contingency
PR	Pennsylvania rare
PSD	Prevention of Significant Deterioration
psia	pounds per square inch absolute
PT	Pennsylvania threatened
PV	photovoltaic
PWR	pressurized water reactor
RAI	request for additional information
RCA	radiological control area
RCRA	Resource Conservation and Recovery Act of 1976, as amended
REMP	radiological environmental monitoring program
REOP	Radiological Environmental Operation
RERS	reactor enclosure recirculation system
RGPP	Radiological Groundwater Protection Program
RKm	river kilometer
RM	river mile
RMC	RMC-Environmental Services
ROI	region of influence
ROP	Reactor Oversight Process
ROW(s)	right(s)-of-way
RPS	renewable portfolio standard
RSP	radwaste storage pad
RWCU	reactor water cleanup
SAMA	Severe Accident Mitigation Alternative
SAMDA	Severe Accident Mitigation Design Alternative
SAMGs	Severe Accident Mitigation Guidelines
SAR	safety analysis report
SCPC	supercritical pulverized coal
SCR	selective catalytic reduction

SE	state endangered
SEIS	supplemental environmental impact statement
SER	safety evaluation report
SGTS	standby gas treatment system
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMA	Seismic Margin Assessment
SNF	spent nuclear fuel
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SPCC	Spill Prevention Control and Countermeasure
SPID	Screening, Prioritization and Implementation Details
SPRA	Seismic Probabilistic Risk Assessment
SR	state rare
SSC	species of special concern
SSCs	structures, systems, and components
SSE	safe-shutdown earthquake
ST	state threatened
State	Commonwealth of Pennsylvania (or other state if specified)
STG	steam turbine generator
Stroud	Stroud Water Research Center
Sv	sievert
SW	surface water
SWPPP	Stormwater Pollution Prevention Plan
TDS	total dissolved solids
TLD	thermoluminescent dosimeters
TMDL	total maximum daily upload
TMI	Three Mile Island
tpy	ton(s) per year
TSP	total suspended particles
TWh	terawatt-hour(s)
U	uranium
U.S.	United States
U.S.C.	United States Code
UCB	upper confidence bound

UFSAR	updated final safety analysis report
USACE	U.S. Army Corps of Engineers
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USGCRP	United States Global Change Research Program [or GCRP]
USGS	U.S. Geological Survey
VOC	volatile organic compound
WEC	wave energy conversion
WHC	Wildlife Habitat Council
WWF	warm water fishes

1.0 PURPOSE AND NEED FOR ACTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10 of the *Code of Federal Regulations* Part 51 (10 CFR Part 51)—which carry out the National Environmental Policy Act (NEPA)—renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement (EIS).

The Atomic Energy Act of 1954 (AEA) originally specified that licenses for commercial power reactors be granted for up to 40 years. The 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

The decision to seek a license renewal rests entirely with nuclear power facility owners and, typically, is based on the facility's economic viability and the investment necessary to continue to meet NRC safety and environmental requirements. The NRC makes the decision to grant or deny license renewal based on whether the applicant has demonstrated that the environmental and safety requirements in the agency's regulations can be met during the period of extended operation.

1.1 Proposed Federal Action

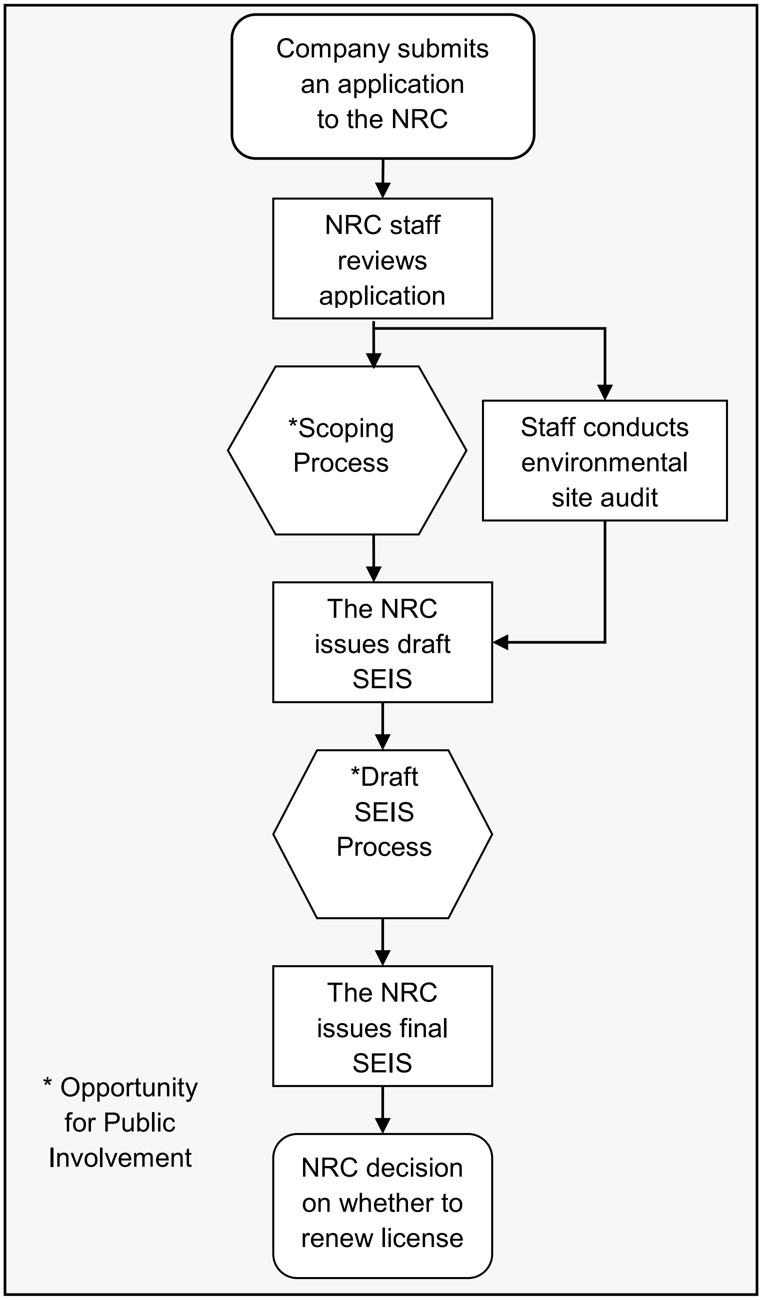
Exelon Generation Company, LLC (Exelon), initiated the proposed Federal action by submitting an application for license renewal of Limerick Generating Station, Units 1 and 2 (LGS), for which the existing licenses (NPF-39 and NPF-85) expires on October 26, 2024, and June 22, 2029, respectively. The NRC's Federal action is to decide whether to renew the licenses for an additional 20 years beyond these dates. In accordance with 10 CFR 2.109, if a licensee of a nuclear power plant files an application to renew an operating license at least 5 years before the expiration date of that license, the existing license will not be deemed to have expired until the safety and environmental reviews are completed and the NRC has made a final decision to either deny the application or issue a renewed license for the additional 20 years beyond the initial license date.

1.2 Purpose and Need for the Proposed Federal Action

The purpose and need for the proposed action (issuance of a renewed 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 other energy-planning decision-makers, such as state, utility, and, where authorized, Federal agencies (other than NRC). This definition of purpose and need reflects the Commission's recognition that, unless there are findings in the safety review required by the Atomic Energy Act or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application, the NRC does not have a role in the energy-planning decisions as to whether a particular nuclear power plant should continue to operate.

If the renewed licenses are issued, the appropriate energy-planning decision-makers and Exelon will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the state's jurisdiction or the purview of the owners. .

Figure 1–1. Environmental Review Process



1.3 Major Environmental Review Milestones

Exelon submitted an Environmental Report (ER) (Exelon 2011b) as part of its license renewal application (Exelon 2011a) on June 22, 2011. After reviewing the application and ER for sufficiency, the staff published a *Federal Register* Notice of Acceptability and Opportunity for Hearing (76 FR 52992) on August 24, 2011. Then, on August 26, 2011, the NRC published another notice in the *Federal Register* (76 FR 53498) on the intent to conduct scoping, thereby beginning the 60-day scoping period.

Two public scoping meetings were held on September 22, 2011, in Pottstown, Pennsylvania (NRC 2011). The comments received during the scoping process are presented in "Environmental Impact Statement, Scoping Process, Summary Report," published in February 2013 (NRC 2013a). The scoping process summary report presents NRC responses to comments that the NRC staff considered to be out-of-scope of the environmental license renewal review. The comments considered to be within the scope of the environmental license renewal review, and the NRC responses, are presented in Appendix A of this supplemental environmental impact statement (SEIS).

To independently verify information provided in the ER, NRC staff conducted a site audit at LGS in November 2011. During the site audit, NRC staff met with plant personnel, reviewed specific documentation, toured the facility, and met with interested Federal, state, and local agencies. A summary of that site audit and the attendees is contained in "Summary of Site Audit Related to the Environmental Review of the License Renewal Application for Limerick Generating Station, Units 1 and 2," published May 21, 2012 (NRC 2012).

Upon completion of the scoping period and site audit, NRC staff compiled its findings in a draft SEIS (Figure 1–1). This document was made available for public comment for 50 days. During that time, NRC staff hosted public meetings and collected public comments. Based on the information gathered, the NRC staff amended the draft SEIS findings, as necessary, to publish this final SEIS.

The NRC has established a license renewal process that can be completed in a reasonable period of time with clear requirements to ensure safe plant operation for up to an additional 20 years of plant life. The safety review, which documents its finding in a safety evaluation report, is conducted simultaneously with the environmental review. The findings in both the SEIS and the safety evaluation report are factors in the Commission's decision to either grant or deny the issuance of a renewed license.

1.4 Generic Environmental Impact Statement

The NRC performed a generic assessment of the environmental impacts associated with license renewal to improve the efficiency of the license renewal process. The *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants*, NUREG-1437 (GEIS), documented the results of the NRC staff's systematic approach to evaluate the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years. NRC staff analyzed in detail and resolved those environmental issues that could be resolved generically in the GEIS. The GEIS was originally issued in 1996, and Addendum 1 to the GEIS issued in 1999.

The GEIS established 92 separate issues for NRC staff to independently verify. Of these issues, NRC staff determined that 69 are generic to all plants (Category 1) while 21 issues do not lend themselves to generic consideration (Category 2). Two other issues remained uncategorized; environmental justice and chronic effects of electromagnetic fields, and must be evaluated on a site-specific basis. A list of all 92 issues can be found in Appendix B.

On June 20, 2013, the NRC published a final rule (78 FR 37282), which revised the agency's environmental protection regulation, 10 CFR Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions." Specifically, the final rule updated the potential environmental impacts associated with the renewal of an operating license for a nuclear power reactor for an additional 20 years. A revised GEIS (NRC 2013b), which updates the 1996 GEIS, provides the technical basis for the final rule. The revised GEIS specifically supports the revised list of NEPA issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of the revised 10 CFR Part 51. The revised GEIS and final rule reflect lessons learned and knowledge gained during previous license renewal environmental reviews. In addition, public comments received on the draft revised GEIS and rule and during previous license renewal environmental reviews were reexamined to validate existing environmental issues and identify new ones.

The final rule identifies 78 environmental impact issues, of which, 17 will require plant-specific analysis. The final rule consolidates similar Category 1 and 2 issues, changes some Category 2 issues into Category 1 issues, and consolidates some of those issues with existing Category 1 issues. The final rule also adds new Category 1 and 2 issues. The new Category 1 issues include geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. Radionuclides released to groundwater and cumulative impacts were added as new Category 2 issues. Minority and low-income populations (i.e., environmental justice) was recharacterized as a Category 2 issue. “Refurbishment impacts” was expanded in scope and renamed “effects on terrestrial resources” (non-cooling system impacts) and remains a Category 2 issue.

The final rule became effective July 22, 2013 after publication in the *Federal Register*. Compliance by license renewal applicants is not required until June 20, 2014, from the date of publication (i.e., license renewal environmental reports submitted later than 1 year after publication must be compliant with the new rule). Nevertheless, under NEPA, the NRC must now consider and analyze, in its license renewal SEISs, the potential significant impacts described by the final rule’s new Category 2 issues and, to the extent there is any new and significant information, the potential significant impacts described by the final rule’s new Category 1 issues.

For each potential environmental issue, the GEIS:

(1) describes the activity that affects the environment,

(2) identifies the population or resource that is affected,

(3) assesses the nature and magnitude of the impact on the affected population or resource,

(4) characterizes the significance of the effect for both beneficial and adverse effects,

(5) determines if the results of the analysis apply to all plants, and

(6) considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

The NRC’s standard of significance for impacts was established using the Council on Environmental Quality (CEQ) terminology for “significant.” The NRC established three levels of significance for potential impacts: SMALL, MODERATE, and LARGE, as defined below.

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, important attributes of the resource.

Significance indicates the importance of likely environmental impacts and is determined by considering two variables: **context** and **intensity**.

Context is the geographic, biophysical, and social context in which the effects will occur.

Intensity refers to the severity of the impact, in whatever context it occurs.

LARGE: Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted (Figure 1–2). Issues are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet the following criteria:

(1) 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 characteristics.

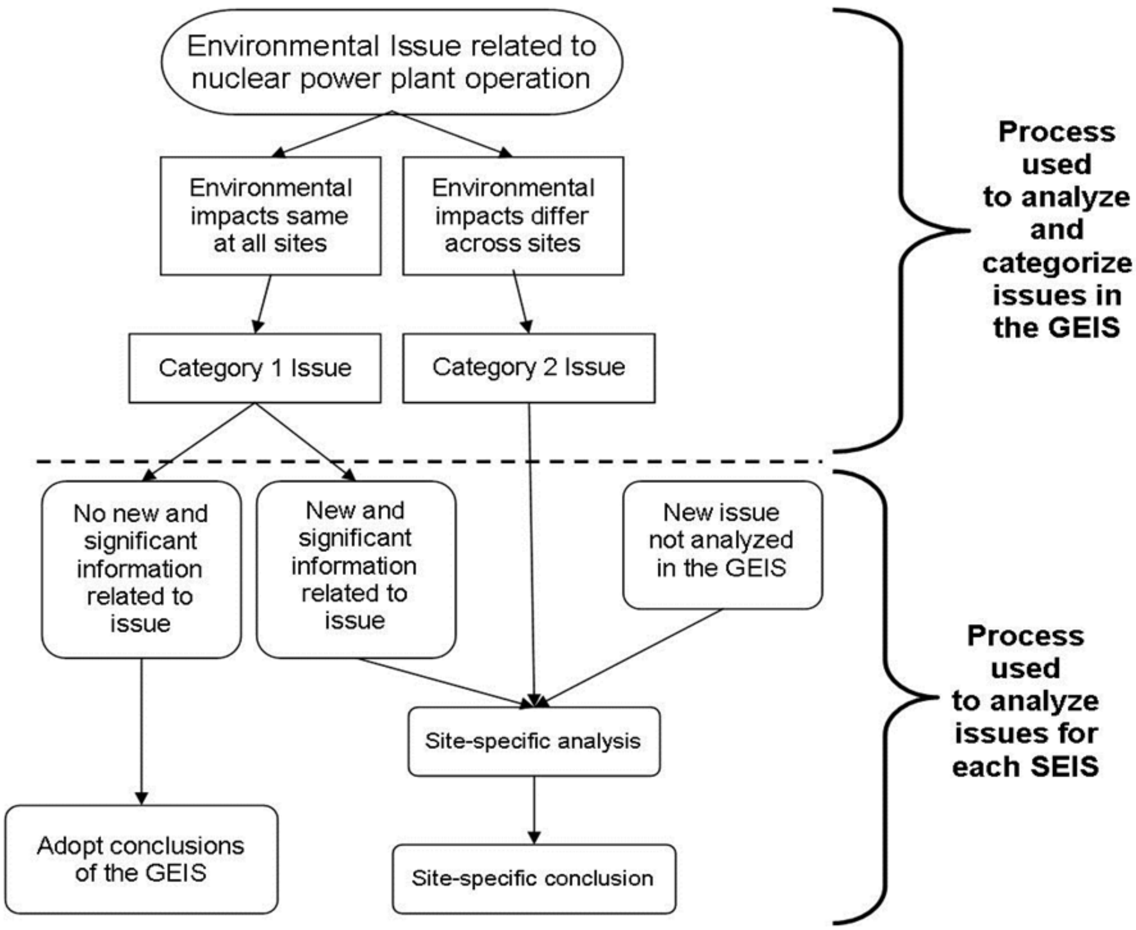
(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective off-site radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) 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 not to be sufficiently beneficial to warrant implementation.

For generic issues (Category 1), no additional site-specific analysis is required in this SEIS unless new and significant information is identified. The process for identifying new and significant information is presented in Chapter 4. Site-specific issues (Category 2) are those that do not meet one or more of the criteria of Category 1 issues, and therefore, additional site-specific review for these issues is required. The results of that site-specific review are documented in the SEIS.

Figure 1–2. Environmental Issues Evaluated during License Renewal

The NRC staff initially evaluated 92 issues in the GEIS. Based on the findings of the GEIS, a site-specific analysis is required for 23 of those 92 issues.



1.5 Supplemental Environmental Impact Statement

The SEIS presents an analysis that considers the environmental effects of the continued operation of LGS, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 8 contains analysis and comparison of the potential environmental impacts from alternatives while Chapter 9 presents the staff's recommendation to the Commission on whether or not the environmental impacts of license renewal are so great that preserving the option of license renewal would be unreasonable. The recommendation includes consideration of comments received during the public scoping period.

In the preparation of this SEIS for LGS, the staff:

- reviewed the information provided in Exelon's ER,
- consulted with other Federal, state, and local agencies,
- consulted with Tribal governments,
- conducted an independent review of the issues during a site audit, and

- considered the public comments received during the scoping process and the comment period on the draft SEIS.

New and significant information either:

(1) identifies a significant environmental issue not covered in the GEIS, or

(2) was not considered in the analysis in the GEIS and leads to an impact finding that is

New information can be identified from a number of sources, including the applicant, the NRC, other agencies, or public comments. If a new issue is revealed, then it is first analyzed to determine if it is within the scope of the license renewal evaluation. If it is within scope and not addressed in the GEIS, then the NRC determines its significance and documents its analysis in the SEIS.

Exelon submitted its Environmental Report (ER) under NRC's 1996 rule governing license renewal environmental reviews (61 FR 28467, June 5, 1996, as amended), as codified in NRC's environmental protection regulation, 10 CFR Part 51. The 1996 GEIS (NRC 1996) and Addendum 1 to the GEIS (NRC 1999) provided the technical basis for the list of NEPA issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of 10 CFR Part 51. For LGS, the NRC staff initiated its environmental review in accordance with the 1996 rule and GEIS (NRC 1996, 1999) and documented its findings in Chapter 4 of this SEIS.

As described in Section 1.4, the NRC published a final rule (78 FR 37282, June 20, 2013) revising 10 CFR Part 51 including the list of NEPA issues and findings in Table B–1. Under NEPA, the NRC must now consider and analyze in this SEIS the potential significant impacts described by the final rule's new Category 2 issues, and to the extent there is any new and significant information, the potential significant impacts described by the final rule's new Category 1 issues. The new Category 1 issues include geology and soils, exposure of terrestrial organisms to radionuclides, exposure of aquatic organisms to radionuclides, human health impact from chemicals, and physical occupational hazards. Radionuclides released to groundwater, effects on terrestrial resources (non-cooling system impacts), minority and low-income populations (i.e., environmental justice), and cumulative impacts were added as new Category 2 issues. These new issues are also analyzed in Chapter 4 of this SEIS. Hereafter in this SEIS, general references to the "GEIS" without stipulation are inclusive of the 1996 and 1999 GEIS (NRC 1996, 1999). Information and findings specific to the June 2013 final rule (78 FR 37282) and/or the June 2013 GEIS (NRC 2013) are appropriately referenced as such.

1.6 Cooperating Agencies

During the scoping process, no Federal, state, or local agencies were identified as cooperating agencies in the preparation of this SEIS.

1.7 Consultations

The *Endangered Species Act of 1973*, as amended; the *Magnuson–Stevens Fisheries Management Act of 1996*, as amended; and the *National Historic Preservation Act of 1966* require that Federal agencies consult with applicable state and Federal agencies and groups prior to taking action that may affect endangered species, fisheries, or historic and archaeological resources, respectively. Below are the agencies and groups with whom the NRC consulted; Appendix D to this report includes copies of consultation documents.

- Advisory Council on Historic Preservation;
- National Marine Fisheries Service;
- U.S. Environmental Protection Agency, Region 3;
- U.S. Fish and Wildlife Service, State College, Pennsylvania;
- Absentee Shawnee Tribe of Oklahoma;
- Cayuga Nation;
- Delaware Nation;
- Delaware Tribe;
- Eastern Shawnee Tribe of Oklahoma;
- Oneida Indian Nation;
- Oneida Nation of Wisconsin;
- Onondaga Nation;
- Seneca Nation of Indians;
- Seneca-Cayuga Tribe of Oklahoma;
- St. Regis Mohawk Tribe;
- Shawnee Tribe;
- Stockbridge-Munsee Band of the Mohican Nation of Wisconsin;
- Tonawanda Seneca Nation; and
- Tuscarora Nation.

1.8 Correspondence

During the course of the environmental review, the NRC staff contacted the Federal, state, regional, local, and tribal government agencies listed in Section 1.7, as well as the following:

- Pennsylvania Fish & Boat Commission;
- Pennsylvania Game Commission;
- Pennsylvania Historical and Museum Commission; and
- Pennsylvania Department of Conservation and Natural Resources.

Appendix E contains a chronological list of all the documents sent and received during the environmental review.

A list of persons who received a copy of this SEIS is provided in Chapter 11.

1.9 Status of Compliance

Exelon is responsible for complying with all NRC regulations and other applicable Federal, state, and local requirements. A description of some of the major Federal statutes can be found in Appendix H of the GEIS. Appendix C to this SEIS includes a list of the permits and licenses issued by Federal, state, and local authorities for activities at LGS.

1.10 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulator Functions."

76 FR 52992. U.S. Nuclear Regulatory Commission, Washington, DC, "Notice of Acceptance for Docketing of the Application and Notice of Opportunity for Hearing Regarding Renewal of Facility Operating License Nos. NPF-39 and NPF-85 for an Additional 20-Year Period, Exelon Generation Company, LLC, Limerick Generating Station." *Federal Register* 76(164):52992-52994, August 24, 2011.

76 FR 53498. U.S. Nuclear Regulatory Commission, Washington, DC, "Exelon Generation Company, LLC; Notice of Intent To Prepare an Environmental Impact Statement and Conduct Scoping Process for Limerick Generating Station, Units 1 and 2." *Federal Register* 76(166):53498–53500, August 26, 2011. 78 FR 37282. U.S. Nuclear Regulatory Commission, Washington, DC, "Revisions to Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." *Federal Register* 78(119):37282-37324, June 20, 2013.

Atomic Energy Act of 1954, as amended. 42 U.S.C. §2011 et seq.

Endangered Species Act of 1973, as amended. 16 U.S.C. §1531 et seq.

[Exelon] Exelon Generation Company, LLC, 2011a*. Limerick Generating Station, Units 1 and 2—License Renewal Application*. June 2011. Agencywide Documents Access and Management System (ADAMS) No. ML11179A101.

[Exelon] Exelon Generation Company, LLC, 2011b*. License Renewal Application, Limerick Generating Station, Units 1 and 2, Appendix E, Applicant's Environmental Report, Operating License Renewal Stage.* ADAMS No. ML11179A104.

Magnuson–Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996. 16 U.S.C. §1855, et seq.

National Environmental Policy Act of 1969, as amended. 42 U.S.C. §4321 et seq.

National Historic Preservation Act of 1966. 16 U.S.C. §470 et seq.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG–1437, Volumes 1 and 2. Washington, DC. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report, "*Section 6.3–Transportation, Table 9.1, Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants," Final Report, NUREG–1437, Volume 1, Addendum 1. Washington DC. August 1999. ADAMS No. ML040690720.

[NRC] U.S. Nuclear Regulatory Commission. 2011. "Summary of Public Scoping Meetings Conducted on September 22, 2011, Related to the Review of the Limerick Generating Station, Units 1 and 2, License Renewal Application." September 2011. ADAMS No. ML11272A237.

[NRC] U.S. Nuclear Regulatory Commission. 2012. "Summary of Site Audit Related to the Environmental Review of the License Renewal Application for Limerick Generating Station, Units 1 and 2." May 21, 2012. ADAMS No. ML12124A127.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. "Environmental Impact Statement, Scoping Process, Summary Report," March 2013. ADAMS No. ML12131A499.

[NRC] U.S. Nuclear Regulatory Commission. 2013b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: Office of Nuclear Reactor Regulation. NUREG-1437, Revision 1, Volumes 1, 2, and 3. June 2013. ADAMS Nos. ML13106A241, ML13106A242, and ML13106A244.

2.0 AFFECTED ENVIRONMENT

Limerick Generating Station, Units 1 and 2 (LGS) is located in Limerick Township of Montgomery County, Pennsylvania, 1.7 miles (2.7 kilometers [km]) southeast of the Borough of Pottstown. The City of Reading is about 19 miles (30.6 km) northwest of the site and the Borough of Phoenixville is about 9.3 miles (15 km) southeast of the site. Other nearby population centers are the Municipality of Norristown, about 11 miles (17.7 km) southeast of the site, and the City of Philadelphia, the city limits of which are about 21 miles (33.8 km) southeast from the site. Figure 2–1 and Figure 2–2 present the 6-mile (10-km) and 50-mile (80-km) vicinity maps, respectively.

For the purposes of the evaluation in this supplemental environmental impact statement (SEIS), the "affected environment" is the environment that currently exists at and around LGS. Because existing conditions are at least partially the result of past construction and operation at the plant, the impacts of these past and ongoing actions and how they have shaped the environment are presented here. Section 2.1 of this SEIS describes the facility and its operation, and Section 2.2 discusses the surrounding environment.

2.1 Facility Description

LGS is a two-unit nuclear-powered steam electric generating facility that began commercial operation in February 1986 (Unit 1) and January 1990 (Unit 2). The nuclear reactor for each unit is a General Electric (GE) boiling water reactor (BWR) producing a reactor core rated thermal power of 3,515 megawatts (MWt). The nominal net electrical capacity is 1,170 megawatts electric (MWe). Figure 2–3 provides a general site layout of LGS. Both LGS reactors have Mark II primary containment structures.

2.1.1 Reactor and Containment Systems

The nuclear reactor system for each Limerick unit includes a single-cycle, forced circulation, GE BWR. The reactor core heats water that is dried by steam separators and dryers located in the upper portion of the reactor vessel. The steam is then directed through four main steam lines to the main turbine where it turns the turbine generator to produce electricity.

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. LGS operates on a 24-month refueling cycle.

The reactor and related systems are enclosed in primary and secondary containments. The Mark II 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's 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 secondary containment system is a reinforced concrete building and is designed to minimize the release of airborne radioactive materials under accident conditions.

2.1.2 Radioactive Waste Management

The radioactive waste systems collect, treat, and dispose of radioactive and potentially radioactive wastes that are byproducts of LGS operations. The byproducts are activation products associated with nuclear fission and impurities (i.e., metallic corrosion products) in the reactor coolant.. Release of liquid and gaseous effluents is controlled to meet the limits specified in Title 10, *Code of Federal Regulations* (CFR) Part 20 and 10 CFR Part 50, Appendix I, through the Radioactive Effluent Controls Program defined in the LGS technical specifications (Exelon 2011a). Operation procedures for the radioactive waste system ensure that radioactive wastes are safely processed and discharged from the LGS. The systems are designed and operated to ensure that the quantities of radioactive materials released from LGS are as low as is reasonably achievable (ALARA) and within the dose standards set forth in 10 CFR Part 20, “Standards for protection against radiation,” and Appendix I to 10 CFR Part 50, “Domestic licensing of production and utilization facilities.” The LGS Offsite Dose Calculation Manual (ODCM) contains the methods and parameters used to calculate offsite doses resulting from radioactive effluents. These methods are used to ensure that radioactive material discharges from the LGS meet regulatory dose standards.

Radioactive wastes resulting from LGS operations are classified as liquid, gaseous, and solid. The design and operation objectives of the radioactive waste management systems are to limit the release of radioactive effluents from LGS during normal operation and anticipated operation.

Reactor fuel that has exhausted a certain percentage of its fissile uranium content is referred to as spent fuel. Spent fuel assemblies that are removed from the reactor core are replaced with fresh fuel assemblies during routine refueling outages. Spent nuclear fuel from the reactor is stored on site in a spent fuel pool and an independent spent fuel storage installation (ISFSI) located west of the turbine enclosures. Under 10 CFR Part 50, LGS has a general license to store spent fuel from both units in pre-approved dry storage casks in accordance with the requirements in 10 CFR Part 72, Subpart K (Exelon 2011b).

2.1.2.1 Radioactive Liquid Waste

The liquid waste-management system collects, segregates, stores, and disposes of radioactive liquid waste. The system is designed to reduce radioactive materials in liquid effluents to levels that are ALARA and reduce the volume of waste through recycling. Liquid wastes that accumulate in radwaste drain tanks or in sumps at locations throughout each LGS unit are transferred to collection tanks in the common radwaste enclosure based on the classification of waste: equipment drain, floor drain, chemical drain, or laundry drain waste. The liquid wastes are processed for packaging and offsite shipment, returned to the condensate system, or mixed with cooling-tower blowdown and released from the plant.

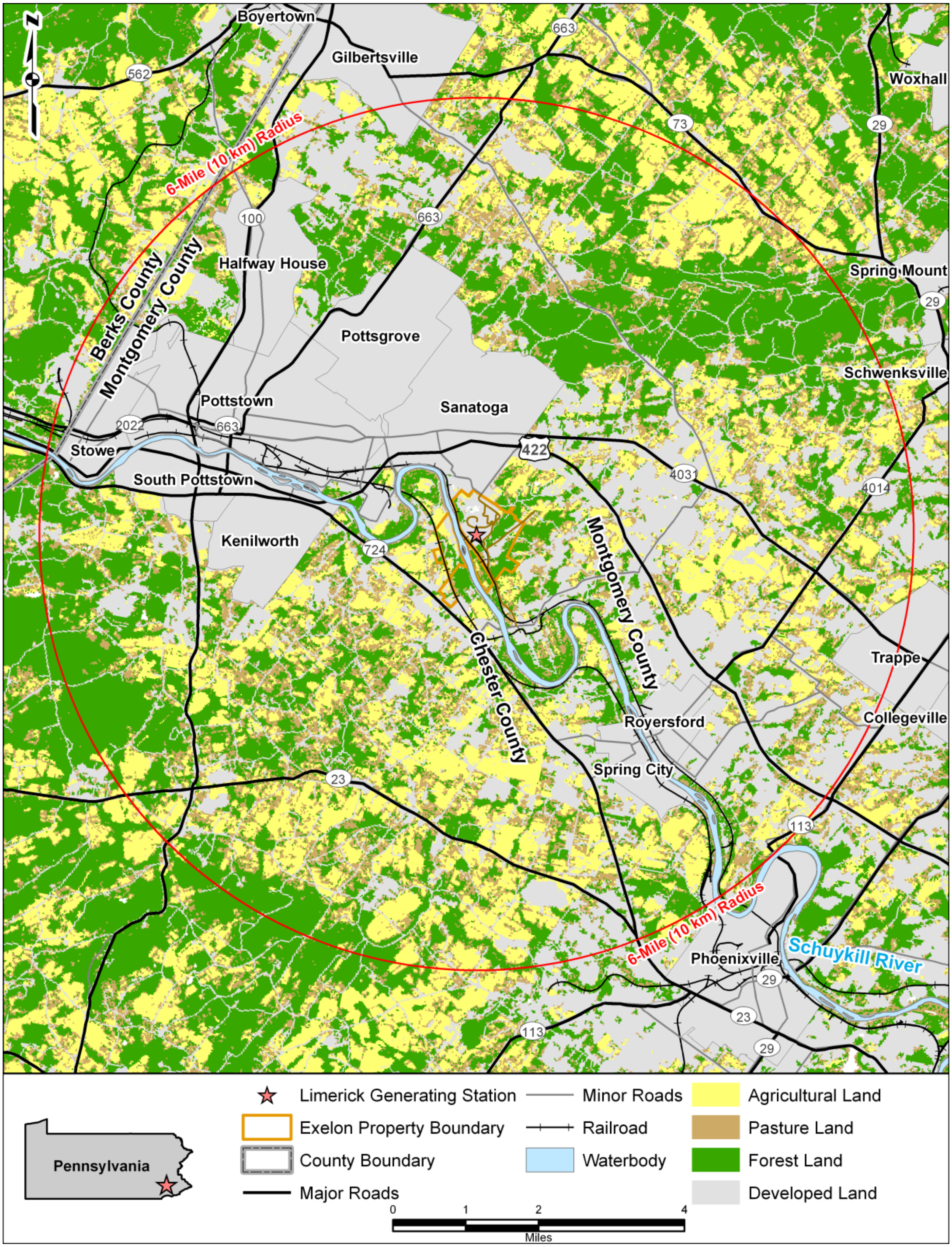
Wastes from the equipment drains and floor drains are processed through separate precoat filters and mixed resin bed demineralizers. The processed waste is collected in one of two sample tanks. Usually, the water from these tanks is sent to the condensate tank for reuse, but if necessary, it will be treated or discharged into the Schuylkill River with radionuclide concentrations below 10 CFR Part 20 limits.

Laboratory wastes, decontamination solutions, and other wastes that may be corrosive are collected and, if necessary, chemically neutralized before being sent to the floor drain system for processing.

Waste from decontamination laundry facilities is processed through the laundry filter and then collected in a sample tank.

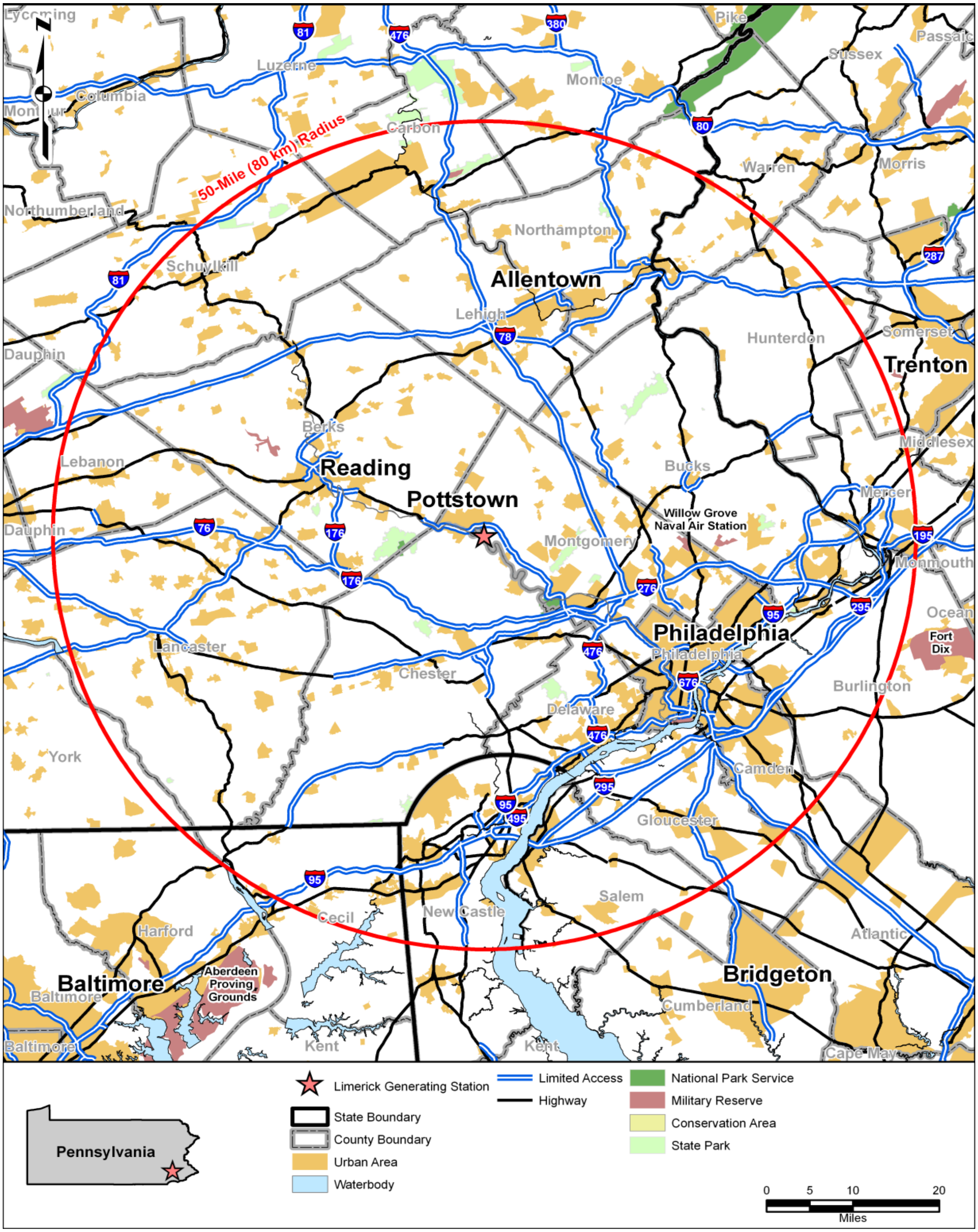
The contamination in the liquid wastes is concentrated in filters and ion exchange resins and then sent to solid waste management for processing. The waste is stored and eventually shipped to a licensed waste disposal facility. The processed liquids are either recycled or discharged from the plant in the cooling-tower blowdown into the Schuylkill River with radionuclide concentrations below 10 CFR Part 20 limits.

Figure 2–1. Location of LGS, 6-mile (10-km) Vicinity



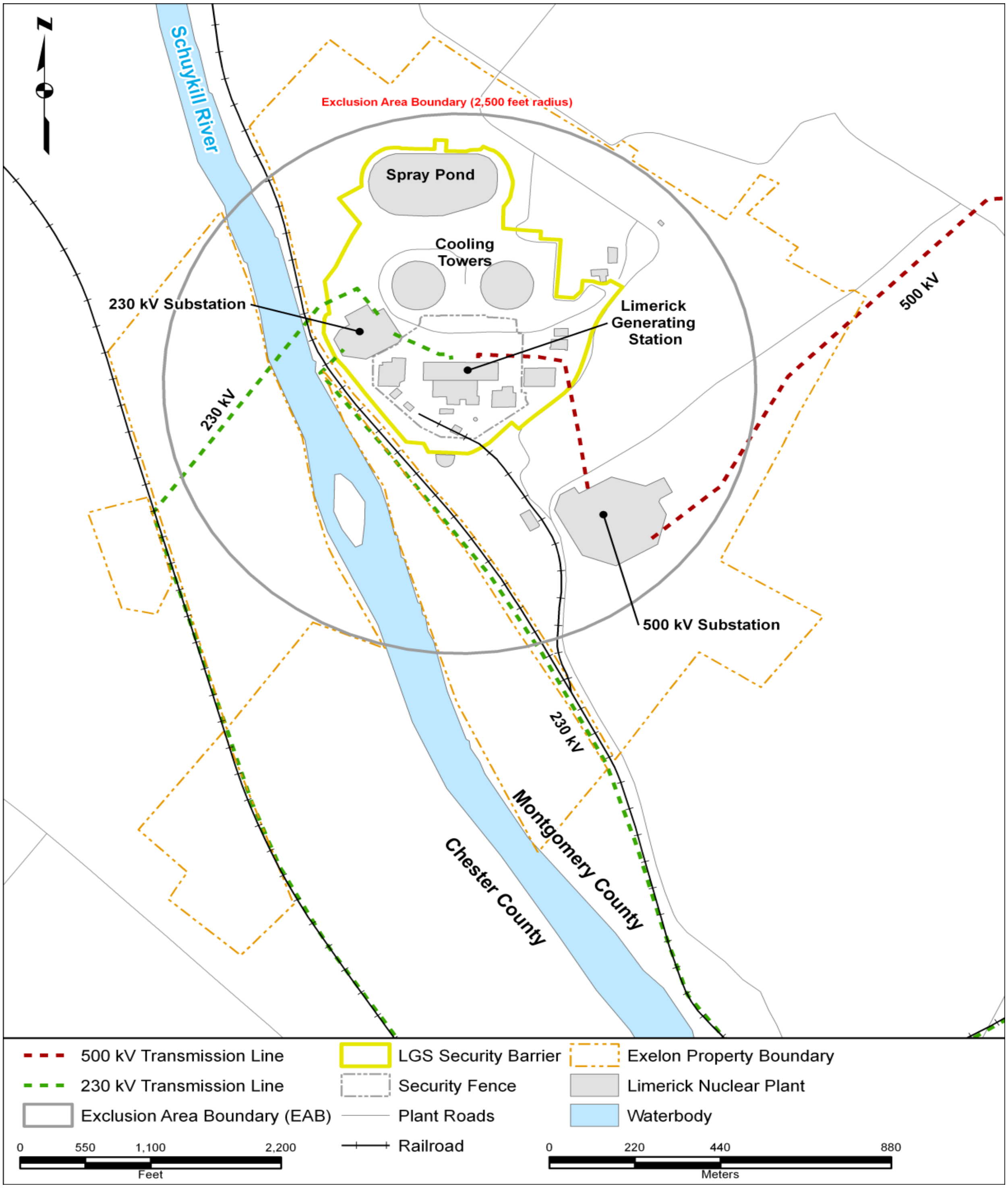
Source: Exelon 2011b

Figure 2–2. Location of LGS, 50-mile (80-km) Region



Source: Exelon 2011b

Figure 2–3. LGS Site Boundary and Facility Layout



Source: Exelon 2011b

2.1.2.2 Radioactive Gaseous Waste

Gaseous waste management systems process and control the release of gaseous radioactive effluents to the atmosphere. Sources of radioactive gases from LGS include condenser offgases, sources from the reactor enclosure, containment systems, and the "hot" maintenance shop.

The condenser offgases are the largest source of radioactive gaseous waste. The offgas system collects the noncondensable radioactive gases that are removed by the air ejectors from the main condensers. The release of the offgas is delayed to allow for radioactive decay. The stream is released to the turbine enclosure vent stack and diluted with air and monitored upon release through the north stack.

Other sources of radioactive gases are from the reactor enclosures, the turbine enclosures, and radwaste enclosure. Discharge of these gases is planned, monitored, and controlled. All are discharged through the north stack, except those from the reactor enclosures, which are discharged through the south stack.

The standby gas treatment system (SGTS) and the reactor enclosure recirculation system (RERS) are used to reduce radioactivity levels in gases from the reactor enclosures before they are discharged into the environment.

2.1.2.3 Radioactive Solid Waste

The solid waste management system collects, processes, and packages solid radioactive wastes for temporary onsite storage, as well as shipment and permanent offsite disposal. To ensure compliance with applicable regulations in 10 CFR Parts 20, 61, and 71, characterization, classification, processing, waste storage, handling, and transportation are controlled by the LGS Process Control Program.

Dry wastes (mostly Class A low-level radioactive wastes [LLRWs]) are collected throughout the plant. Compressible and non-compressible wastes are packaged and temporarily stored until they are sent offsite for processing or final disposal.

Wet wastes, generally Class A LLRWs, are collected, dewatered, packaged, and stored before offsite shipment. However, wet wastes from the reactor water cleanup (RWCU) system usually exceed the criteria for both Class A LLRW and low specific activity material. Therefore, if they cannot be reused, they are packaged in containers and stored in the high level storage area (HLSA), which is located in the Radwaste Enclosure. Exelon Generation Company, LLC (Exelon) transports Class A LLRWs to EnergySolutions, LLC, in Clive, Utah, for disposal.

LGS has a "Green-is-Clean" (GIC) waste program that collects noncontaminated waste from the radiological control area (RCA) from the different controls streams. This waste is packaged separately and shipped to Duratek, in Tennessee, for processing and disposal. Any waste sent to Duratek that is found to be contaminated is repackaged and sent to the offsite LLRW facility in Clive, Utah. Exelon's corporate policy is to minimize the generation of radioactive wastes by following corporate waste minimization procedures.

There is an onsite radwaste storage pad (RSP) for temporary storage of radioactive waste containers. The RSP is located west of the spray pond and has a fenced-in holding area and another area surrounded by a concrete shell. Contaminated reusable equipment is stored here as well as Class A wastes. Higher activity Class B/C wastes are not stored in this area.

Since closure of the Barnwell Facility to LGS in 2008, there has been no licensed facility that accepts Class B/C LLRW shipments. Exelon has been temporarily storing the Class B/C wastes in the HLSA. In May 2011, the NRC approved transport and temporary storage of LGS Class B/C wastes at Exelon's Peach Bottom Atomic Power Station (PBAPS). Class B/C LLRW stored at LGS or packaged in the future may be sent to PBAPS to be stored at the LLRW storage facility at that site. The storage capacity for LGS Class B/C wastes at PBAPS is expected to be sufficient through the extended operating license for both LGS units. However, in February 2013, Exelon signed a contract with Waste Control Specialists, LLC (WCS) for the treatment and disposal of LGS's LLRW at WCS's licensed facility in Texas. Therefore, storage of LGS Class B/C wastes at PBAPS should be unnecessary during LGS's license renewal term.

2.1.2.4 Low-Level Mixed Wastes

Low-level mixed wastes (LLMWs) are wastes that contain both low-level radioactive waste and Resource Conservation and Recovery Act (RCRA) hazardous waste (40 CFR 266.210). LLMW is handled in accordance with Exelon guidance and procedures. There is currently no LLMW stored at LGS. It is rare that LGS generates LLMW; however, if LLMW were generated during the license renewal term, Exelon would store it on site, in compliance with the RCRA storage and treatment regulations administered in the State by the Pennsylvania Department of Environmental Protection (PADEP) (25 Pa. Code 260a). Transportation and disposal of LLMW would also follow RCRA requirements.

2.1.3 Nonradiological Waste Management

The LGS site generates nonradioactive wastes as part of routine plant maintenance, cleaning activities, and plant operations. RCRA governs the disposal of solid and hazardous waste. RCRA waste regulations are contained in 40 CFR Parts 239–299. In addition, 40 CFR Parts 239–259 contain regulations for solid (nonhazardous) waste, and 40 CFR Parts 260–279 contain regulations for hazardous waste. RCRA Subtitle C establishes a system for controlling hazardous waste from "cradle to grave," and RCRA Subtitle D encourages States to develop comprehensive plans to manage nonhazardous solid waste and mandates minimum technological standards for municipal solid waste landfills. RCRA hazardous waste regulations are administered in the State by the Pennsylvania Department of Environmental Protection (PADEP) (25 Pa. Code 260a). PADEP classifies nonhazardous solid waste as either municipal waste (25 Pa. Code 271) or residual waste (25 Pa. Code 287).

2.1.3.1 Nonradioactive Waste Streams

LGS generates solid nonradioactive waste, defined by RCRA, as part of routine plant maintenance, cleaning activities, and plant operations. Exelon manages these wastes, including waste minimization, using corporate procedures that meet applicable regulations (Exelon 2011b). RCRA hazardous waste regulations are administered in the state by the PADEP (25 Pa. Code Article 260a).

EPA classifies certain nonradioactive wastes as hazardous based on characteristics including ignitability, corrosivity, reactivity, or toxicity (hazardous wastes are listed in 40 CFR Part 261). State-level regulators may add wastes to the EPA's list of hazardous wastes. RCRA supplies standards for the treatment, storage, and disposal of hazardous waste for hazardous waste generators (regulations are available in 40 CFR Part 262).

EPA recognizes the following main types of hazardous waste generators based on the quantity of the hazardous waste produced (EPA 2012d):

- large quantity generators that generate 2,200 lb (1,000 kg) per month or more of hazardous waste, more than 2.2 lb (1 kg) per month of acutely hazardous waste, or more than 220 lb (100 kg) per month of acute spill residue or soil;
- small quantity generators that generate more than 220 lb (100 kg) but less than 2,200 lb (1,000 kg) of hazardous waste per month; and

- conditionally exempt small quantity generators that generate 220 lb (100 kg) or less per month of hazardous waste, 2.2 lb (1 kg) or less per month of acutely hazardous waste, or less than 220 lb (100 kg) per month of acute spill residue or soil.

LGS, based on past and current generation of hazardous waste, is classified as a small quantity generator of hazardous waste according to 40 CFR 262 and given in Pa. Code 262a, with hazardous wastes between 220 lb (100 kg) and 2,200 lb (1,000 kg) per month. The quantities of hazardous waste and nonhazardous wastes are annually reported to PADEP (Exelon 2011b).

The EPA classifies several hazardous wastes as universal wastes; these include batteries, pesticides, mercury-containing items, and fluorescent lamps (25 Pa. Code 266b). Exelon has and expects to continue to generate universal waste such as discarded batteries, pesticides, thermostats, and mercury-containing devices. Other wastes that are not classified as hazardous waste but require regulation in Pennsylvania are (1) residual wastes such as discarded solid, liquid, semisolids from industrial operations, waste treatment system sludges, and laboratory chemicals; (2) infectious waste; (3) regulated asbestos-containing material; and (4) municipal waste. LGS is considered a Small Quantity Handler of universal wastes (less than 11,000 lb [5,000 kg] accumulated at any time) (Exelon 2011b).

National Pollutant Discharge Elimination System (NPDES) permits that provide limits and conditions for wastewater discharge are held by Exelon for industrial wastewater discharges and storm water discharges from the LGS site into the Schuylkill River (No. PA0051926) and discharges from the Bradshaw Reservoir to the East Branch Perkiomen Creek (No. PA0052221) (Exelon 2011b). Radioactive liquid waste is addressed in Section 2.1.2.1 of this SEIS. Section 2.2.4.2 gives more information about the LGS NPDES permit and permitted discharges.

The Emergency Planning and Community Right-to-Know Act (EPCRA) (42 USC 11001, et seq.) requires applicable facilities to supply information about hazardous and toxic chemicals to local emergency planning authorities and the EPA. On November 3, 2008 (73 FR 65452), the EPA finalized several changes to the Emergency Planning Notification (Section 302), Emergency Release Notification (Section 304), and Hazardous Chemical Reporting (Sections 311 and 312) regulations, which it had proposed on June 8, 1998 (63 FR 31268).

Exelon does not expect its generation rates of nonradiological waste to increase significantly during the extended period of operation (Exelon 2011b).

2.1.3.2 Pollution Prevention and Waste Minimization

In compliance with PADEP requirements, Exelon has implemented a Preparedness, Prevention and Contingency (PPC) Plan as well as a Spill Prevention Control and Countermeasure (SPCC) Plan compliant with 40 CFR Part 112, “Oil Pollution Prevention.”

In support of nonradiological waste-minimization efforts, EPA’s Office of Prevention and Toxics has established a clearinghouse that supplies information about waste management and technical and operational approaches to pollution prevention (EPA 2012a). The EPA clearinghouse can be used as a source for additional opportunities for waste minimization and pollution prevention at LGS, as appropriate. EPA also encourages the use of environmental management systems (EMSs) for organizations to assess and manage the environmental impacts associated with their activities, products, and services in an efficient and cost-effective manner. EPA defines an EMS as “a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency.” EMSs help organizations fully integrate a wide range of environmental initiatives, establish environmental goals, and create a continuous monitoring process to help meet those goals. The EPA Office of

Solid Waste especially advocates the use of EMSs at RCRA-regulated facilities to improve environmental performance, compliance, and pollution prevention (EPA 2012b). Exelon has implemented an EMS.

2.1.4 Plant Operation and Maintenance

Various types of maintenance activities are conducted at LGS, including inspection, testing, and surveillance to maintain the current licensing basis of the facility and to ensure compliance with environmental and safety requirements. Various programs currently exist at LGS to maintain, inspect, test, and monitor performance of facility equipment. These maintenance activities include inspection requirements for reactor vessel materials, boiler and pressure vessel inservice inspection and testing, a maintenance structures monitoring program, and maintenance of water chemistry.

Additional programs include those carried out to meet technical specification surveillance requirements, those implemented in response to NRC generic communications, and various periodic maintenance, testing, and inspection procedures. Certain program activities are performed during operation of the plant, while others are carried out during scheduled refueling outages. Nuclear power plants must periodically discontinue production of electricity for refueling, periodic inservice inspection, and scheduled maintenance. Each LGS unit refuels on a 24-month interval.

2.1.5 Power Transmission System

Four 230-kilovolt (kV) lines were constructed specifically to connect LGS Unit 1 to the regional power grid, and one 500-kV line was constructed to connect LGS Unit 2 to the regional electric grid. PECO Energy Company (PECO), an energy delivery subsidiary of Exelon Corporation, owns and operates these lines. The LGS site also includes two switchyards—one for each reactor unit. The Unit 1 switchyard is a 230-kV substation, and the Unit 2 switchyard is a 500-kV substation. Lines beyond these switchyards have been integrated into the regional electric grid and would stay in service regardless of LGS license renewal. PECO Energy Company (PECO), an energy delivery subsidiary of Exelon Corporation, owns and operates these lines. Because the lines are owned and operated by PECO and not the applicant, Exelon, they are outside of NRC's regulatory purview. Section 2.2.8 provides additional details regarding the scope of the transmission lines that should be considered. Unless otherwise noted, the discussion of the power transmission system is adapted from the Environmental Report (ER) (Exelon 2011b) or information gathered at NRC's November 2011 environmental site audit (NRC 2012a).

2.1.5.1 Description of the Lines

<u>220-60 and 220-61 Lines</u>

These lines extend southeast from the plant to the Cromby Substation in East Pikeland Township, Chester County (see Figure 2–4). The two lines run parallel to the Schuylkill River within two separate pre-existing railroad corridors on opposite sides of the river for about 12.9 km (8 miles). The 220-60 line traverses the Montgomery County side of the river, and the 220-61 line traverses the Chester County side of the river. The 220-60 line crosses the river into Chester County before terminating at the Cromby Substation in East Pikeland Township, Chester County. The 220-60 corridor is 18.3 m (60 ft) wide for the first 10.1 km (6.3 miles), at which point the line leaves the railroad corridor and joins with an existing 76.2-m (250-ft)-wide PECO corridor for 1.8 km (1.1 miles). The 220-60 line travels through the 220-61 corridor once it crosses the river. The 220-61 corridor is 18.3 m (60 ft) wide for the entire length of the corridor. The 220-61 line is within the Schuylkill River National and State Heritage Area and parallels a planned portion of the Schuylkill River Trail.

220-62 Line

This line spans a total of 25.7 km (16 miles) from the Cromby Substation (the termination point of the 220-60 and 220-61 lines) to north and then east to the North Wales Substation in Upper Gwynedd Township, Montgomery County (see Figure 2–5). When constructed, the line was routed through an existing PECO transmission line corridor. The corridor varies from 45.7 m (150 ft) to 137.2 m (450 ft) wide and traverses the Evansburg State Park in Skippack Township.

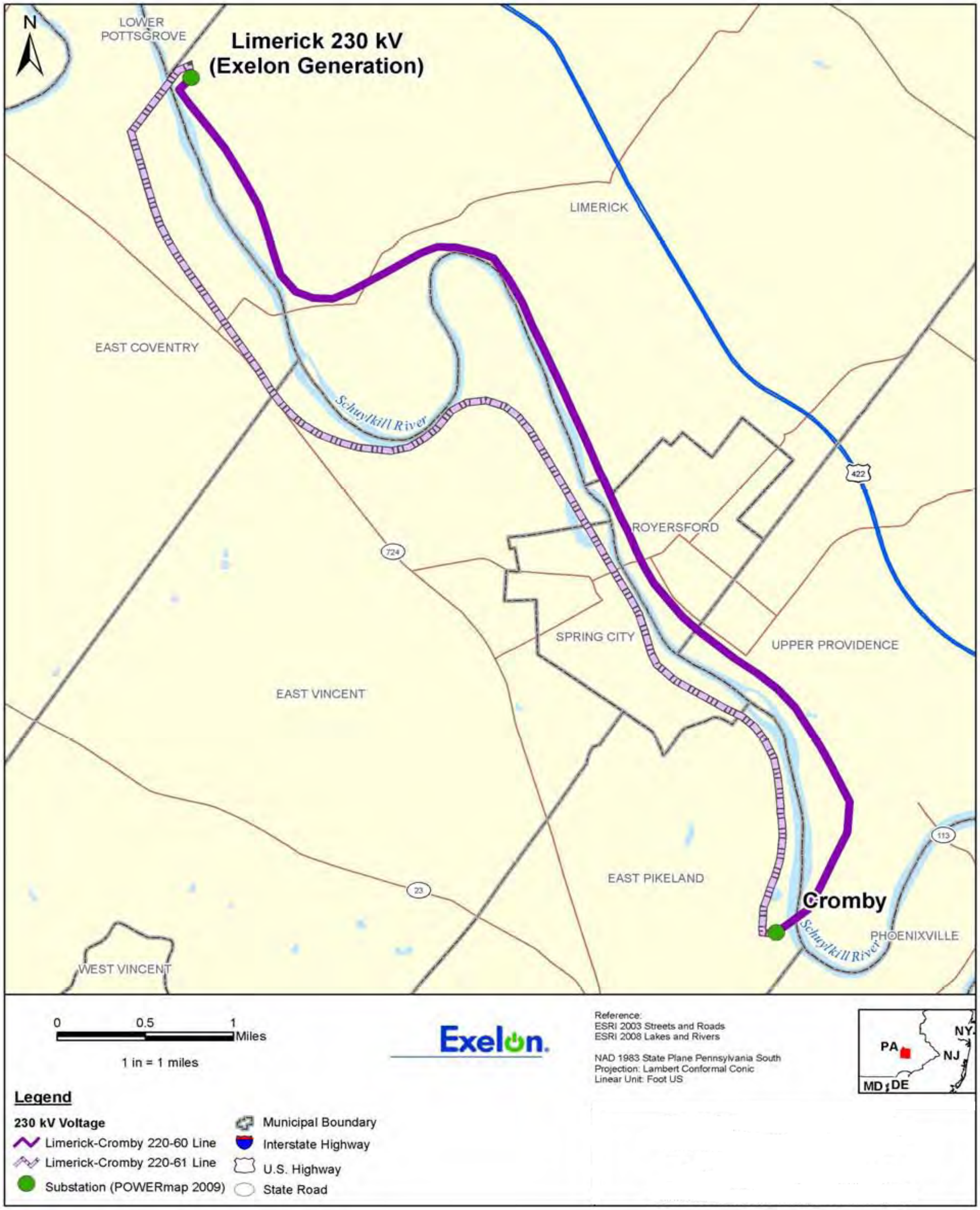
220-63 and 220-64 Lines

The 220-63 and 220-64 lines span a total of 16.1 km (10 miles) and 5.6 km (3.5 miles), respectively, from the Cromby Substation southeast and then south to their respective termination points at Barbadoes Substation in West Norristown Township and Plymouth Meeting Substation in Plymouth Township, Montgomery County (see Figure 2–6). The lines cross the Schuylkill River in five locations and parallel an open portion of the Schuylkill River Trail between Phoenixville Borough and Philadelphia. The lines also traverse the Valley Forge National Park. When constructed, the lines were routed through a combination of existing PECO transmission line corridors and railroad corridors. The corridor width varies from 45.7 m (150 ft) to 137.2 m (450 ft).

5031 Line

This line spans a total of 27.4 km (17 miles) from the Limerick 500-kV substation east to the Whitpain Substation in Whitpain Township, Montgomery County (see Figure 2–7). The line crosses the Schuylkill River in Limerick Township and Evansburg State Park in Skippack Township. When constructed, the line was routed along an existing transmission line corridor associated with a 500-kV line originating from Peach Bottom Atomic Power Station in Delta, Pennsylvania. The line also merges with the 220-62 line corridor for about 4.8 km (3 miles). The corridor width varies from 91.4 m (300 ft) to 137.2 m (450 ft).

Figure 2–4. Limerick to Cromby 230-kV Transmission Line Route

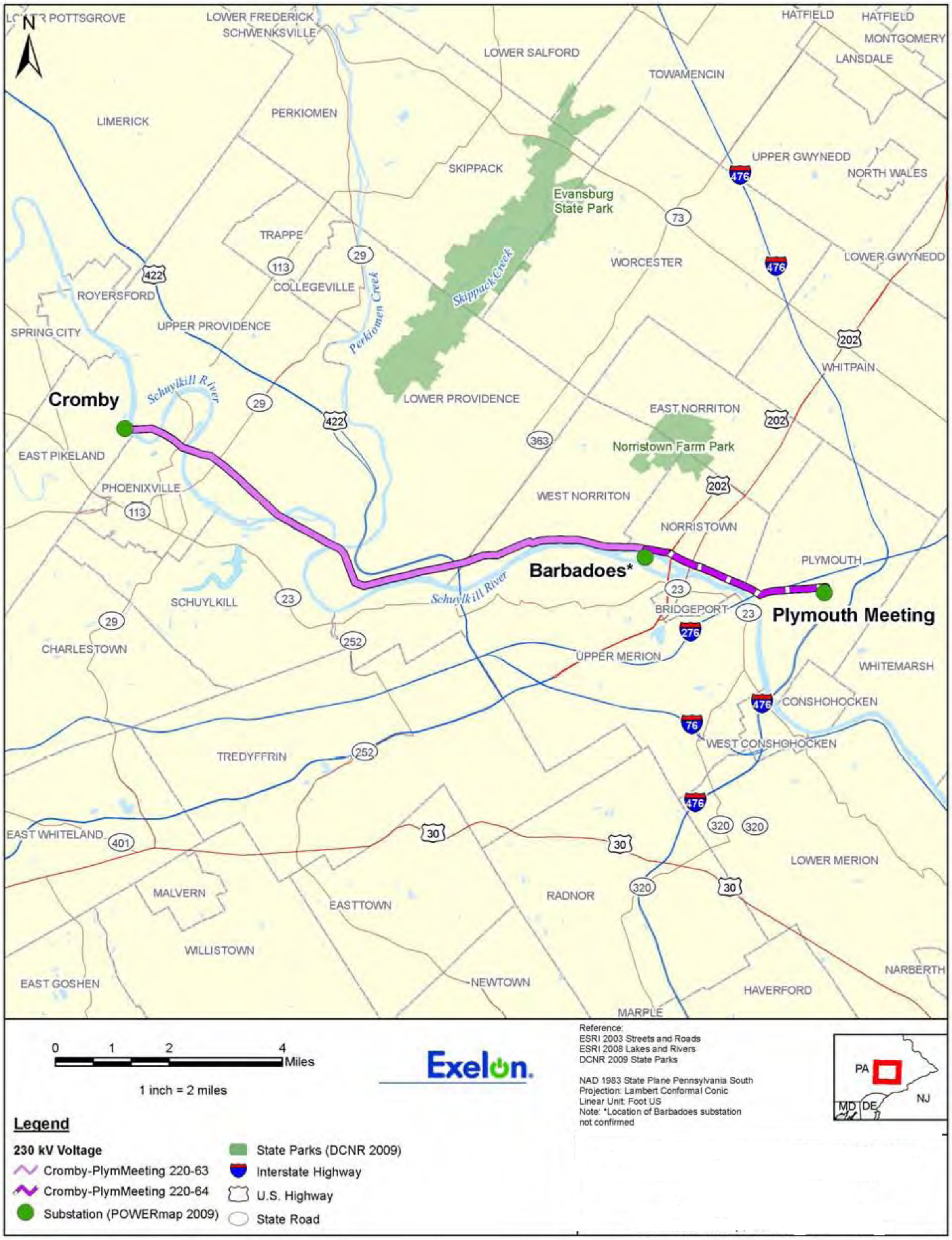


Source: Exelon 2011b

Figure 2–5. Cromby to North Wales 230-kV Transmission Line Route

Source: Exelon 2011b

Figure 2–6. Cromby to Plymouth Meeting 230-kV Transmission Line Route



Source: Exelon 2011b

Figure 2–7. Limerick to Whitpain 500-kV Transmission Line Route

Source: Exelon 2011b

2.1.5.2 Transmission Line Corridor Vegetation Maintenance

> Transmission line corridors (or right-of-ways) are strips of land used to construct, operate, maintain, and repair transmission line facilities. The transmission line is usually centered in the corridor. The width of a corridor depends on the voltage of the line and the height of the structures. Transmission line corridors typically must be clear of tall-growing trees and structures that could interfere with a power line.

The majority of the transmission line corridors associated with LGS lines traverse suburban areas and agricultural lands. PECO follows an integrated vegetation management program that combines manual, mechanical, biological, and chemical control techniques to maintain proper clearance from transmission lines and structures. PECO maintains vegetation on a 5-year cycle, and the degree and type of clearance varies by line voltage and the type, growth rate, and branching characteristics of trees and vegetation. PECO contracts with Asplundh Tree Expert Company to perform the majority of maintenance work, and the Davey Resources Group, part of the Davey Tree Expert Company, oversees quality assurance.

Workers follow the current American National Standards Institute (ANSI) guideline document, *A300 Standards for Tree Care Operations*, which contains requirements and recommendations for tree care practices, including pruning, lightning protection, and integrated vegetation management. These standards describe a wire-border zone management approach in which the wire zone (the section of the corridor directly under the wires and extending outward about 10 ft [3 m]) is managed to promote low-growing plant communities dominated by grasses, herbs, and small shrubs (Miller 2007). The border zone (the remainder of the corridor on either side of the lines) is managed to promote small shrubs and lower growing trees (Miller 2007).

PECO has also followed the North American Electric Reliability Corporation (NERC) FAC-003, *Vegetation Management*, since 2003. This guidance document recommends that all transmission line owners have a specific vegetation maintenance plan that addresses vegetation inspections, clearances, qualifications of workers, and environmental impact mitigation.

2.1.5.3 PECO's Environmental Stewardship and Partnerships with State and Local Agencies

As part of its environmental stewardship effort, PECO maintains a program to protect birds and comply with applicable Federal and state bird regulations. This promotes native vegetation, maintains an environmental management certification, and partners with Federal and state agencies for specific mitigation or restoration projects.

PECO's avian management program provides guidance to workers on how to deal with bird nests or dead birds when encountered during field operations. It also provides guidance on compliance with applicable Federal and state bird regulations, including the Migratory Bird Treaty Act, the Endangered Species Act, and the Bald and Golden Eagle Protection Act.

As part of its maintenance procedures, PECO favors native warm season grass mixtures and native flower mixtures that include species such as little blue stem (*Schizachyrium scoparium*), big blue stem (*Andropogon gerardi*), Indian grass (*Sorghastrum nutans*), goldenrod (*Solidago* spp.), milkweed (*Asclepias* spp.), and aster (*Aster* spp.).

PECO maintains an International Organization for Standardization (ISO) 14001 certification, which provides a framework for environmental management systems to help companies manage the environmental impact of their activities and demonstrate sound environmental management (ISO 2009).

When the National Park Service (NPS) acquired an additional 65 acres (ac) (26 hectares[ha]) parcel of land for the Valley Forge National Park that coincided with the 220-63 and 220-64 corridor, PECO partnered with NPS to restore the acquired land to a native warm season grass community. PECO provided both contractors and equipment for this effort (Exelon 2011b).

2.1.6 Cooling and Auxiliary Water Systems

LGS uses a cooling tower-based heat dissipation system that normally withdraws from and discharges cooling water to the Schuylkill River. In summary, the majority of the makeup water withdrawn is to provide cooling water for the LGS steam turbine condensers. As water evaporates in the cooling towers to dissipate heat to the atmosphere, cooling water is lost and must be replaced. Additionally, to control the chemistry of the circulating water in the cooling system, a portion of the cooling water is continuously discharged (i.e., blowdown). A much smaller portion of the makeup water is used to remove heat from auxiliary equipment during normal operation. A clay-lined spray pond located north of the cooling towers provides emergency cooling but has an insignificant interface with the environment. Four groundwater wells are also located on the LGS site to support LGS operations. Unless otherwise cited for clarity, the NRC drew information about LGS's cooling and auxiliary water systems from Exelon's ER (Exelon 2011b) and responses to NRC's request for additional information (Exelon 2012b). NRC staff also toured these systems and facilities during the environmental site audit (NRC 2012).

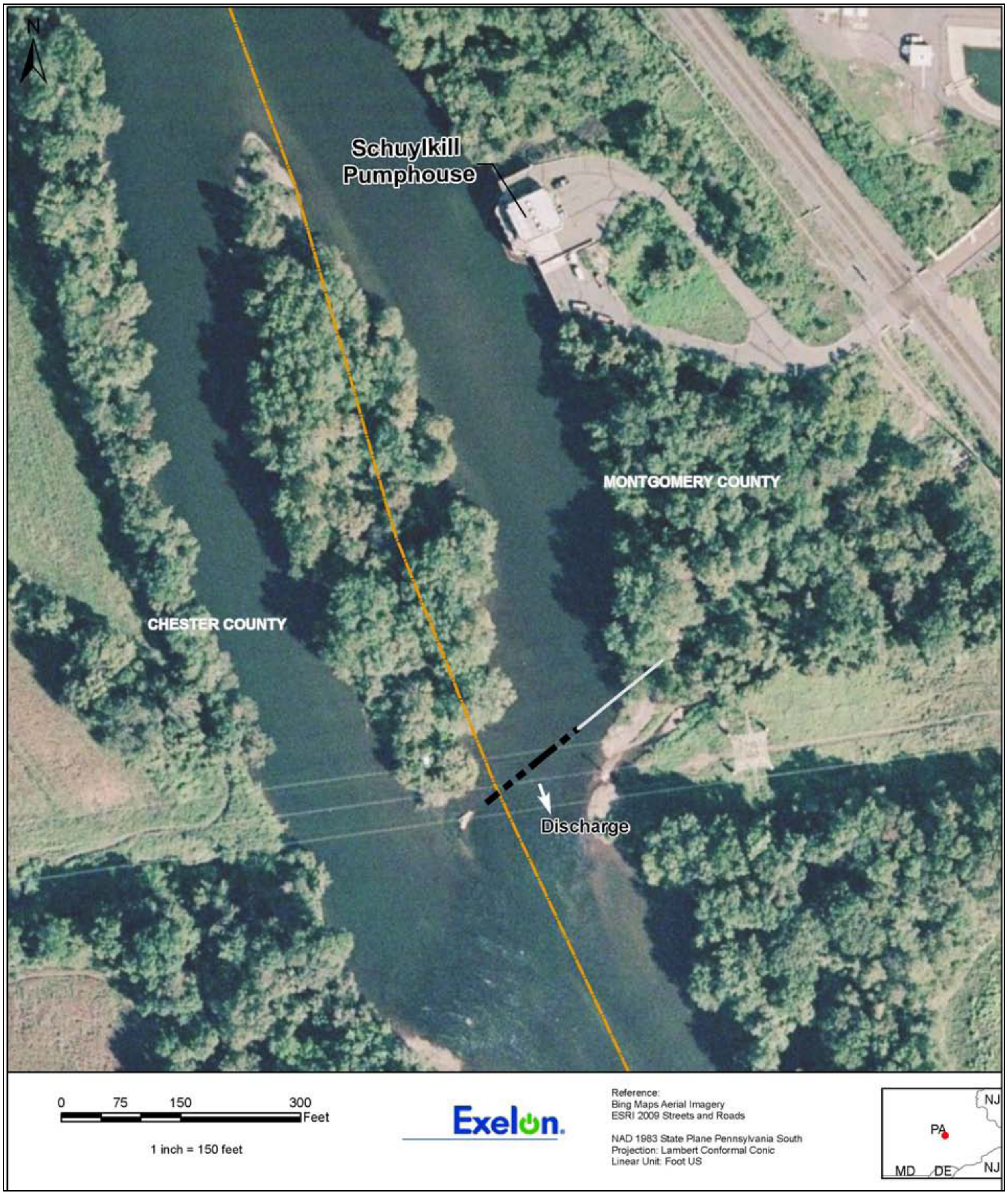
Individual LGS systems that interact with the environment are summarized below and focus on facilities owned and operated by Exelon.

Makeup Water Supply System. The LGS makeup water supply system is comprised of the individual water sources, facilities, systems, and components used for supplying makeup water to LGS plant systems. These include the cooling water system, including the circulating water systems for each LGS unit, and other plant systems. In total, LGS operates its makeup water supply system and uses its makeup sources in accordance with Delaware River Basin Commission (DRBC) approvals (Docket No. D-1969-210 CP-13, as revised) (DRBC 2013a, 2013b). A discussion of these makeup sources and associated facilities and their attributes follows.

2.1.6.1 Schuylkill River Source

The Schuylkill River is the primary source of makeup water for LGS (see Figure 2–8). Water is withdrawn from the river via the Schuylkill Pumphouse located on the eastern bank of the river on the LGS site. River water enters the pumphouse through eight trash rack (bar screen) panels with sufficient bar spacing to allow aquatic life to pass. A floating trash dock with skirt located in front of the trash rack functions to divert river debris and some aquatic life before reaching the trash racks. Intake water then passes through four travelling screens before the intake bays (Exelon 2012b). The screens have 0.25-in. (0.64-cm) mesh openings designed to limit water approaching the screens to a velocity of 0.61 fps (0.19 m/s) (Exelon 2012b, Exelon 2013a; DRBC 2013a). A backwash system operates automatically to clean the traveling screens of debris to maintain adequate pump wet-well levels. Screen backwash water is returned to the river via a Pennsylvania NPDES permitted outfall (no. 011). Leaves and debris removed from the traveling screens are collected in a dumpster and transported off site for disposal (Exelon 2012b). The facility has three pumps for cooling water makeup and two pumps for blowdown (nonconsumptive) water makeup use. The three cooling water pumps each have a rated capacity of 11,300 gpm (25.2 cfs or 0.71 m^3/s), and the two blowdown makeup pumps are each rated at 4,000 gpm (8.9 cfs or 0.25 m^3/s). These pumps are usable in any combination to meet the total plant makeup demand (for consumptive and nonconsumptive use) of up to 56.2 million gallons per day (mgd) (212,700 m^3/d). From the pumphouse, a 36-in. (91-cm) pipeline conveys water to the cooling tower basins. Two smaller lines supply water to (1) a raw water clarifier in the process water treatment system and (2) the spray pond.

Figure 2–8. Location of Schuylkill Pumphouse and LGS Discharge Structure



Source: Exelon 2011b

Seasonal low flows in the Schuylkill River and specific conditions and limitations imposed by the DRBC require that alternative makeup water sources be used by LGS either directly or to augment flow in the Schuylkill River. In point, source augmentation averaging 35 mgd (132,500 m^3/d) or 24,300 gpm (54.1 cfs or 1.5 m^3/s) is required about 6 months per year (Exelon 2012d). Pursuant to DRBC rules and regulations, dockets are used to place limits and conditions on individual projects, such as LGS, that use water within the Delaware River Basin. DRBC Docket No. D-1969-210 CP-13 was finalized in May 2013 (see also Section 2.1.7.1) as part of the consolidation of 12 previous dockets and multiple DRBC resolutions approved with respect to LGS operations since 1973 (DRBC 2013c). It prescribes the low-flow conditions that trigger the requirement for LGS to use alternative water sources for consumptive use, while also providing for terms and conditions with respect to non-contact cooling water and cooling tower blowdown discharges from LGS (DRBC 2013a, 2013b). Depending on conditions, a combination of the DRBC-approved alternative water sources (as depicted in Figure 2–9) are used to supply consumptive use makeup water to LGS, although LGS may withdraw water from the Schuylkill River for nonconsumptive use without restriction. Perkiomen Creek is the first supplemental water source to be considered when withdrawals from the Schuylkill River are restricted because of low flow.

2.1.6.2 Perkiomen Creek Source

LGS must also withdraw water from Perkiomen Creek when the flow in the Schuylkill begins to drop below 560 cfs (15.9 m^3/s) for two-unit operation (as measured at the U.S. Geological Survey [USGS] maintained Pottstown, Pennsylvania, gage station), if instream flow conditions in Perkiomen Creek allow. Water is withdrawn via Exelon's Perkiomen Pumphouse (auxiliary intake pumphouse), which is located just inland from the west bank of Perkiomen Creek. Water is withdrawn from the creek through a set of 15 submerged, stationary "wedge-wire" screen intakes on the middle of the streambed. Each screen is sized at 24-in. (61-cm) by 72-in. (183-cm), with a slot size of 0.08 in. (0.2 cm). The screens provide an average through-slot velocity of 0.4 fps (0.12 m/s). An air burst backwash system automatically functions to remove accumulated debris (Exelon 2012b). Three intake pumps, including a spare, rated at 14,600 gpm (33 cfs or 0.92 m^3/s) are sized to supply the consumptive cooling demands for both LGS units. A small auxiliary pump operates as needed to maintain the facility's water storage tank when the intake system is not active. Water is conveyed by an underground pipeline approximately 8 miles (13 km) to the storage tank located at the LGS site.

2.1.6.3 Delaware River Augmentation Source

The natural flow in Perkiomen Creek is not always adequate for LGS's consumptive makeup water needs. This situation arises when the natural flow of Perkiomen Creek falls below 210 cfs (5.9 m^3/s) for two-unit operation, as measured at the USGS-maintained Graterford, Pennsylvania, gage station. Therefore, Exelon has established a system to transfer water for flow augmentation purposes from the Delaware River to East Branch Perkiomen Creek and, ultimately, Perkiomen Creek. This diversion of water originates at the Point Pleasant Pumping Station on the Delaware River, located about 30 miles (48 km) northeast of the LGS site (see Figure 2–9). The pumping station is owned by a municipal water purveyor and not Exelon. The Point Pleasant Pumping Station withdraws from a deep water, mid-channel intake in the Delaware River. The intake structure consists of two rows of fixed cylindrical wedge-wire screens, with each row comprised of 12 screens. Each screen measures 40-in. (102-cm) in diameter and 80-in. (203-cm) of total screened length. Screens have a slot size of 0.08 in. (0.2 cm). At the maximum pumping rate of 95 mgd (360,000 m^3/d), the average intake velocity is 0.35 fps (0.11 m/s). Maintenance of the intake screens includes high-pressure spray washing and scrubbing by divers four times a year, with return of organic debris to the Delaware River (Exelon 2012b).

Figure 2–9. LGS Makeup Water Supply System and Alternative Water Sources within the Delaware River Basin

Source: Modified from Exelon 2011b

Once withdrawn at Point Pleasant, water is conveyed through a series of pumping stations, to the Bradshaw Reservoir, and then via transmission mains to East Branch Perkiomen Creek. At the outset, water is transferred as necessary to the Bradshaw Reservoir to maintain adequate reservoir operational volume and reserve storage. Located on a 43-ac (17-ha) site and approximately 27 miles (44 km) northwest of LGS, both the reservoir and associated Bradshaw Pumphouse are owned and operated by Exelon. According to Exelon personnel, the reservoir is maintained at an operating level of 17 to 21 ft (5.2 to 6.4 m), and the reservoir can be pumped down as far as 8 ft (2.4 m) before suction is lost. From the Bradshaw Reservoir, water is pumped about 6 miles (10 km) by pipeline routed along a natural gas pipeline right-of-way to East Branch Perkiomen Creek. Located about midway along the pipeline routing, Exelon also owns and operates the Bedminster Water Processing (Treatment) Facility that is used to seasonally disinfect the water before it is discharged into the East Branch Perkiomen Creek in accordance with NPDES Permit PA0052221.

In the event drought conditions on the Delaware River threaten the ability to transfer water to East Branch Perkiomen Creek, Exelon also has an agreement in place as one of the seven utility owners of the Merrill Creek Reservoir in northwestern New Jersey to release water to the Delaware for flow augmentation purposes. This could be exercised in the event of a DRBC-declared drought emergency. A separate DRBC docket governs operation of the reservoir.

2.1.6.4 Wadesville Mine Pool and Still Creek Reservoir Augmentation Sources

LGS also uses two additional upstream water sources, the Wadesville Mine Pool and Still Creek Reservoir, to directly augment Schuylkill River flow (see Figure 2–9). As a demonstration project, DRBC approved the use of these sources in 2002 to compensate for the withdrawal of cooling water from the Schuylkill River and to evaluate the feasibility of continuing withdrawals from the river even under low flow conditions. Flow augmentation with these sources began in 2003 and has included DRBC oversight. The Wadesville Mine Pool is located approximately 70 miles (112 km) northwest of LGS in Pennsylvania's anthracite coal region. The mine pool is comprised of an extensive complex of flooded underground mine workings some 700 ft (210 m) deep, storing an estimated 3.6 billion gal (13.6 billion m^3) of water. The mine pool is unique, as compared to other coal workings that contribute to acid mine drainage, in that the water percolating through the workings has a neutral pH (NAI and URS 2011). Additionally, releases from the Still Creek Reservoir, located northeast of the Wadesville Mine Pool, are included in the list of approved supplemental water sources under the consolidated docket governing LGS's operations (DRBC 2013a, 2013b). DRBC previously approved this reservoir for emergency releases under a contract between Exelon and its owner and operator to augment low flows in the Schuylkill River when the Delaware River diversion system is unavailable (see Section 2.1.7.1).

<u>Circulating Water System</u>

The LGS circulating water system is a closed-cycle cooling system that removes heat from the condenser and transfers it to the atmosphere through evaporation using hyperbolic natural-draft cooling towers. The plant's twin cooling towers rise more than 500 ft (152 m) above the ground. The circulating water system uses water from the LGS makeup water system to replenish the water lost from evaporation, drift, and blowdown. For each LGS unit, the circulating water system consists of one cooling tower, three main condensers, four 25-percent-capacity circulating water pumps, and associated piping, valves, controls, and instrumentation.

<u>Blowdown Discharge System</u>

Operation of LGS's closed-cycle cooling system results in evaporative water losses of approximately 75 percent from the plant's twin cooling towers. To control the chemistry of the water in the cooling system due to the buildup of total dissolved solids, a portion of the water must be continuously discharged. Each cooling tower basin has a blowdown line that combines into a single 36-in. (91.4-cm) line that discharges through a submerged multi-port diffuser pipe into the Schuylkill River at a point about 700 ft (210 m) downstream from the Schuylkill Pumphouse (see Figure 2–8). The diffuser is encased in a concrete channel stabilization structure on the east side of the river. The discharge structure consists of a 28-in. (71-cm) pipe with a total of 283 nozzles installed on 6-in. (15-cm) centers; nozzles have a 1.25-in. (3.2-cm) diameter opening. As shown in Figure 2–8, the diffuser does not use the entire channel width.

Plant Service Water System

The plant service water system functions continuously to supply water for service-water cooling (e.g., removal of heat rejected from auxiliary equipment), emergency service water, residual heat removal service water, and the clarified water system. Generally, these are small and normally nonconsumptive uses of water.

Each LGS unit has a nonsafety-related single-loop cooling system for normal operations that uses three 50-percent capacity pumps operating, with one pump on standby status. These loops take water from each unit's cooling tower basin. These pumps circulate cooling water from the cooling tower basins through various heat exchangers and then back to the cooling towers. This service water system may at times also support decay heat removal during a refueling outage.

An emergency service water system exists to supply cooling water to emergency equipment in the event of the loss of normal cooling. The system consists of two independent cooling loops and associated pumps. The pumps circulate water through the LGS spray pond located north of the LGS cooling towers for cooling through spray nozzles or winter bypass lines. Another safety-related system, the residual heat removal system, is also routed through the spray pond. The two loops of this system supply cooling water to each of the two heat exchangers that serve each LGS unit.

Clarified river water for component lubrication and as makeup to the demineralized water system is supplied by the clarified water system. This system uses water from the cooling water intake system.

Groundwater Supply System

Potable water and a backup supply of fire emergency water for LGS are provided by two separate wells. Two additional wells supply nonpotable water intermittently to the Limerick Training Center and the Limerick Energy Information Center, respectively.

2.1.7 Facility Water Use and Quality

As discussed above, LGS Units 1 and 2 use a closed-cycle cooling system that primarily relies upon the Schuylkill River for its makeup water supply and, secondarily, Perkiomen Creek (see Section 2.1.6). Water losses from the plant's cooling towers because of evaporation and drift average about 75 percent. As this water must be continually replaced, such a high consumptive use can conflict with the needs of other downstream users and with aquatic life, especially on smaller rivers (Exelon 2011b).

However, Exelon has developed an extensive surface water diversion system to supplement LGS's consumptive cooling water needs and to manage (augment) low river flows, as also described in Section 2.1.6. The Schuylkill River is also the makeup water source for replacing water discharged as blowdown from the cooling towers, which is necessary to control the quality of the recirculating cooling water. This use is considered to be nonconsumptive in nature. Nevertheless, all surface water withdrawals by LGS are regulated by the DRBC. Cooling tower blowdown, in addition to other plant wastewaters, is ultimately discharged back to the Schuylkill River via a submerged discharge structure. This is LGS's main outfall (no. 001), which is regulated under its Pennsylvania NPDES permit (No. PA0051926), in addition to DRBC docket provisions (Exelon 2011b).

Exelon also operates two primary groundwater supply wells in the main plant area to meet the potable needs of plant personnel and to provide a backup supply of fire emergency water, respectively. Two additional wells, one at the Limerick Training Center and another at Limerick Energy Information Center, supply water for sanitary needs in restrooms (Exelon 2011b).

Exelon is annually required to report water use data for LGS to the PADEP in accordance with the Pennsylvania Water Resources Planning Act pursuant to 25 Pa. Code 110 (Exelon 2011b). NRC staff reviewed the last 5 years of Exelon's Act 220 Water Withdrawal and Use Reports submitted to the PADEP.

A description of surface water resources at LGS and vicinity is provided in Section 2.2.4, and a description of the groundwater resources is presented in Section 2.2.5. The following sections further describe the water use from these resources.

2.1.7.1 Surface Water Use

Makeup water demands for LGS Units 1 and 2 nominally total 56.2 mgd or 39,000 gpm (87 cfs or 2.5 m^3/s). For full operations, this includes 42 MGD or 29,200 gpm (65 cfs or 1.8 m^3/s) for consumptive cooling water use and 14.2 mgd or 9,860 gpm (22 cfs or 0.6 m^3/s) for nonconsumptive use (Exelon 2011b). As previously discussed, LGS water usage is governed by the DRBC docket approval that restricts surface water withdrawals from the Schuylkill River for consumptive use to protect water quality and quantity. These restrictions are triggered, requiring Exelon to switch to alternative water sources, when either the flow of the river falls below 560 cfs (15.9 m^3/s) for two-unit operation, or 530 cfs (15 m^3/s) for one-unit operation. This is adjusted based on upstream releases from DRBC-approved projects (DRBC 2004, 2013a; Exelon 2011b).

In addition, PADEP requires that water users submit water use information annually, in support of its State Water Plan. Accordingly, Exelon 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 15-year planning horizon.

Since initiating the water supply diversion project in 2003, Exelon has sought to demonstrate that makeup water demands could be obtained from the Schuylkill River over a much wider range of conditions without deleterious effects. This included a major modification to the demonstration project that was approved in 2005 which, for the first time, allowed for withdrawals from the Schuylkill River for consumptive use when ambient water temperature was at or above 59 °F (15 °C). Previously, DRBC prohibited withdrawals for consumptive use makeup at or above that temperature and required LGS to rely upon the Perkiomen Pumphouse (Exelon 2011b). In summary, the objectives of the demonstration project included: (1) gaining an understanding of increased reliance on the Schuylkill River, (2) evaluating the effects of permanently lifting the 59 °F (15 °C) temperature restriction, (3) evaluating the effects of using the Wadesville Mine Pool and Still Creek Reservoir as low flow augmentation sources, (4) evaluating the effects of reducing water diversions from the Delaware River, and (5) evaluating the effects on public water supplies (Exelon 2012d). Based on the results of the demonstration project, Exelon submitted an application to the DRBC in September 2007 to make the provisions of the demonstration project permanent to support LGS operations and to consolidate all of DRBC's docket approvals for surface water withdrawal, discharge, and groundwater usage into a single comprehensive docket (Exelon 2011b, DRBC 2011a).

In May 2011, the DRBC passed a resolution approving Exelon's request to increase LGS's peak daily surface water withdrawals from 56.2 mgd or 39,000 gpm (87 cfs or 2.5 m^3/s) to 58.2 mgd or 40,420 gpm (90 cfs or 2.6 m^3/s). This request was made to increase consumptive use withdrawals by 2 mgd or 1,390 gpm (3.1 cfs or 0.09 m^3/s) to provide operational flexibility to counter conditions of high air temperature combined with low relative humidity that had caused LGS to approach its maximum daily withdrawal limit in 2010 (DRBC 2011b). In December 2011, the DRBC extended the terms of Docket No. D-69-210 CP Final (Revision 12) for LGS, including the demonstration project for another year to enable it to complete work on Exelon's consolidated revision and to hold a public hearing (DRBC 2011c).

Exelon officials met with DRBC officials on the status of the consolidated docket in February 2012 (Exelon 2012a). In June 2012, DRBC issued a draft consolidated docket (Revision 13) for review and comment and held a hearing on August 28, 2012. The August 2012 public hearing was held jointly with the PADEP to take comments both on DRBC's draft consolidated docket and on PADEP's proposed NPDES permit revision for LGS. Subsequently, the DRBC voted once again to extend docket Revision 12 until December 31, 2013, or until the DRBC approved a revised docket. This allowed for additional time to complete a thorough comment and response document in consideration of comments received during the public hearing and associated 120-day comment period (DRBC 2012b).

On May 8, 2013, the DRBC voted unanimously to approve the consolidated docket which provides terms and conditions for (1) continued surface water withdrawals from several sources to support LGS consumptive and non-consumptive water uses, (2) permits the discharge of non-contact cooling water and cooling tower blowdown to the Schuylkill River, and (3) approves the use of the supplemental water sources including Wadesville Mine Pool when LGS is restricted from withdrawing water from the Schuylkill River or the Perkiomen Creek. As evaluated during the demonstration project, the approved docket specifically rescinds the 59 °F (15 °C) temperature restriction on withdrawals from the Schuylkill River for consumptive cooling water needs. Finally, the docket also approves Exelon's water supply operation and maintenance plan which, in part, provides for the collection of data and analysis to determine Exelon's compliance with the terms of the docket (DRBC 2013a, 2013b, 2013c).

As of March 2014, the PADEP has not finalized revisions to LGS's NPDES permit (No. PA0051926) and so the terms and conditions of the current NPDES permit remain in effect until the revised permit is issued, as further described in Section 2.2.4.2.

2.1.7.2 Groundwater Use

Groundwater is withdrawn at LGS through two onsite wells to support LGS operations, with two additional wells supporting secondary uses (see Section 2.1.7).

Well 1 (the "Alley" Well) supplies potable water to LGS personnel. Well 3 (the "Batch Plant" Well) supplies water to a backup fire emergency water storage tank. Both wells were constructed as open boreholes in the Brunswick Formation with completion depths of 310 ft (94 m) and 585 ft (178 m) and pump capacities of 50 gpm (189 L/min) and 65 gpm (246 L/min), respectively. Both wells had their pumps replaced in 2004. Well 1 is located just east of the Unit 2 buildings and southeast of the Unit 2 cooling tower, while Well 3 is located about 500 ft (150 m) east of the Unit 2 cooling tower (CRA 2006; Exelon 2011b). As a potable supply well for the plant, Well 1 is operated by Exelon under a public water supply permit from the PADEP. Before distribution, the water is treated by disinfection, for corrosion control for lead and copper, and by filtration to reduce arsenic levels (Exelon 2011b).

Two additional active groundwater wells (i.e., the Training Center and Energy Information Center wells) are located on the LGS plant site but outside the main plant complex. These wells are seldom operated and only to provide sanitary water for restrooms at the referenced facilities (Exelon 2011b). The Training Center well is 560 ft (170 m) in depth and the Information Center well is 123 ft (37.5 m) in depth, based on Pennsylvania well records (Exelon 2011b; PADCNR 2012).

LGS's wells are located in the Southeastern Pennsylvania Ground Water Protected Area designated by the DRBC. Specifically, LGS is located in the Schuylkill–Sprogels Run Subbasin designated by the DRBC and for which basin-wide groundwater withdrawal limits have been set due to stress on the bedrock aquifer system (DRBC 1999, Exelon 2011b). Groundwater users in subbasins designated by the DRBC as stressed and withdrawing 10,000 gallons per day (gpd) (38,000 L/day) or more during any 30-day period are required to obtain a protected area permit from the DRBC or have docket approval for such withdrawals (18 CFR 430; DRBC 1999). The consolidated docket issued to Exelon (see Section 2.1.7.1) establishes daily and maximum monthly groundwater withdrawal limits for each of LGS's four supply wells. The docket also restricts total site groundwater production to a maximum of 6.1 million gallons per month (equivalent to 203,300 gpd or 141 gpm [534 L/min]). However, groundwater withdrawal restrictions do not apply during fire and other emergencies at LGS (DRBC 2013a, 2013b).

Based on data from 2001 through 2010, LGS's total groundwater production from its primary production wells has ranged from 14.3 to 21.1 gpm (54.1 to 79.9 L/min) or 20,600 to 30,300 gpd, and averaged 17.9 gpm (67.8 L/min) or 25,800 gpd (Exelon 2011b, 2012b). While not subject to reporting under PADEP regulations, the two LGS secondary wells produce less than 4 gpm (13.9 L/min) combined (Exelon 2011b).

2.2 Surrounding Environment

The LGS plant site comprises a total of 645 ac (261.0 ha), including 491 ac (198.7 ha) in Montgomery County and 154 ac (62.3 ha) in Chester County. The LGS site is located 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.

The LGS plant site is located about 1.7 miles (2.7 km) southeast of the Borough of Pottstown, the nearest population center. Other nearby population centers are the City of Reading located 19 miles (30.6 km) northwest of the site, the Borough of Phoenixville located about 9.3 mi(15 km) southeast of the site, the Municipality of Norristown about 11 miles (17.7 km) southeast of the site, and the city limits of Philadelphia, which are about 21 miles (33.8 km) southeast of the site.

2.2.1 Land Use

The site is surrounded by gently rolling countryside and farmland, with several valleys containing tributary drainages of the Schuylkill River. The vicinity of the site has experienced suburban growth as local farmland has been converted to several new residential subdivisions since the LGS units came online in 1986 and 1990. Figure 2–1 illustrates the principal land uses in the vicinity of the LGS, out to 6 miles (10 km).

Exelon owns both the primary LGS site and several offsite support facilities, including the Perkiomen Pumphouse, the Perkiomen Pumphouse-to-LGS pipeline, Bradshaw Reservoir and Pumphouse, and the Bedminster Water Processing (Treatment) Facility. Additional offsite facilities and components of the LGS makeup water system having contractual agreements with Exelon, but which are neither owned nor controlled by Exelon, include:

- Wadesville Mine Pool, Pumphouse, and discharge channel;
- Still Creek Reservoir;

- Point Pleasant Pumping Station and combined water transmission main to the Bradshaw Reservoir; and
- Pottstown Gage Station, the Graterford Gage Station, and the Bucks Road Gage Station.

Exelon jointly owns and operates the Merrill Creek Reservoir near Phillipsburg, New Jersey, with six other utilities. The reservoir stores water for release when required to mitigate consumptive use at designated electric generating facilities, including LGS, in the event of low-flow conditions in the Delaware River.

The major transportation routes located within 6 miles (10 km) of the site include U.S. Highway 422 (US-422), an east-west highway passing about 1.5 miles (2.4 km) north of the site; Pennsylvania Route 100 (PA-100), a north-south highway passing about 4 miles (6.4 km) west of the site in Chester County; and PA-724, a southeast-northwest highway passing about 1 mile (1.6 km) southwest of the site. The single plant entrance/exit can only be accessed by Evergreen Road, either directly from the Sanatoga exit of US-422 or indirectly from the Limerick Linfield exit of US-422 by several local roads. Figure 2–2 illustrates prominent features of the LGS region, out to 50 miles (80 km).

All activities on the LGS site are under the control of Exelon. The immediate area surrounding LGS is enclosed by a security barrier shown in Figure 2–3. Access to LGS is through a security gate by a three-lane road, Evergreen Road, north of the plant. A Conrail rail line (formerly Reading Company) traverses the LGS site along the eastern side of the Schuylkill River. The rail line includes two tracks and a rail spur serving LGS. Another Conrail rail line (formerly Penn Central Railroad) runs along the western side of the Schuylkill River, traversing the Chester County portion of the LGS site.

Notable manmade features within a 6-mile (10-km) radius of LGS (see Figure 2–1) include the Pottstown–Limerick regional airport roughly 1.5 miles (2.5 km) northeast, the Philadelphia Premium Outlets shopping mall roughly 1 mile (1.6 km) northeast, and the Occidental Chemical Corporation/Firestone Tire EPA superfund site roughly 1.5 miles (2.4 km) west of the LGS site.

Nearby communities include Pottstown, approximately 1.7 miles (2.7 km) northwest; Royersford, 3.8 miles (6.1 km) southeast; Phoenixville, 9.3 miles (15 km) southeast; and Philadelphia, 21 miles (33.8 km) southeast of the LGS site.

2.2.2 Air Quality and Meteorology

The LGS site is located within the Schuylkill River valley of the Piedmont Plateau in southeastern Pennsylvania. LGS maintains two meteorological towers that are in close proximity to the site. The primary tower (Tower 1) is located approximately at site grade and is 76.2 m (250 ft) above mean sea level (MSL) (Exelon 2011b). The secondary tower (Tower 2) is located closer to the Schuylkill River and is at an elevation of 36.9 m (121 ft) above mean sea level. The meteorological towers are instrumented at three levels and take measurements of wind direction, wind speed, and temperature. Additional measurements, including wind direction fluctuations, relative humidity, pressure, and precipitation, are made at Tower 1.

The region surrounding the LGS site is characterized by a humid, continental climate that is moderated by the presence of the Appalachian Mountains to the west and the Atlantic Ocean to the east (NCDC 2012a). Periods of extreme heat or cold are generally short-lived. The summer months of June through September are warm and humid, and at times the area is engulfed in maritime air from the western Atlantic (NCDC 2012b). The winter months of December through February are characterized by frequent periods of warming and cooling from mid-latitude, low-pressure systems and associated fronts passing through the area; minimum temperatures during this time are usually below freezing, but temperatures below zero are rarely observed (NCDC 2012c).

The staff obtained climatological information with 30-year averages (1981−2010) for the Allentown and Philadelphia, Pennsylvania, first-order National Weather Service (NWS) stations. Both stations are approximately 30 miles from the LGS site and can be used to characterize the region's climate because of their nearby location, comparable elevation, and long period of record. Regionally, the prevailing wind direction is from the southwest during most of the year, except during the winter months, when it is generally from the west-northwest (NCDC 2012b, 2012c). During stable atmospheric conditions, low-level winds at the LGS site may be channeled in the same general direction as the Schuylkill River Valley, which is oriented in the north-northwest to south-southeast direction (Exelon 2012c). Mean annual wind speeds average around 8 to 9 mph (3.5 to 4.0 m/s); winds are faster than average in the spring and slower than average in late summer (NCDC 2012b, 2012c). Peak wind gusts were 69 mph (30.8 m/s) in Allentown (NCDC 2012c) and 75 mph (33.5 m/s) in Philadelphia (NCDC 2012b).

In Allentown, monthly mean temperatures range from a low of 27.9 °F (−2.3 °C) in January to a high of 74.1 °F (23.4 °C) in July (NCDC 2012b). In Philadelphia, monthly mean temperatures are slightly warmer and range from 32.3 °F (0.2 °C) in January to 77.6 °F (25.3 °C) in July (NCDC 2012b). Recent monthly mean temperature observations taken at the LGS site are consistent with these ranges (Exelon 2012b).

Normal annual liquid precipitation is 42.05 in. (1,068 mm) in Philadelphia (NCDC 2012b) and 45.17 in. (1,147 mm) in Allentown (NCDC 2012c). The precipitation during the wettest year from the most recent 30-year period of record was 71.72 in. (1,822 mm) in 2011 (NCDC 2012c); during the driest year from the same period it was 30.41 in. (772 mm) in 1992 (NCDC 2012b). The summer months of June, July, and August are the wettest, averaging 4.0 in. (102 mm) of precipitation each month at both locations (NCDC 2012b, 2012c). February is the driest month, averaging 2.75 in. (70 mm) of precipitation (NCDC 2012b, 2012c). Precipitation trends measured at LGS (Exelon 2012c) are consistent with trends observed at Allentown and Philadelphia. Average annual snowfall for the area is 19.3 in. (49.0 cm) in Philadelphia (NCDC 2012b) and 32.3 in. (80.0 cm) in Allentown (NCDC 2012c). The higher snowfall amounts at Allentown are likely to be more representative of the LGS site because the Philadelphia NWS station is warmer due to its more southeastern location, as well as additional heating from the urban environment.

Thunderstorms are normally observed on 27 days throughout the year (NCDC 2012b, 2012c). Severe weather in the form of hail, tornadoes, or hurricanes is not commonly observed in the region. In the past 5 years, there have been 29 large hail (more than 0.75 in. [1.9 cm] in diameter) events reported in both Montgomery and Chester Counties, but many of the hail reports are associated with the same storm (NCDC 2012d). Tornadoes do not occur frequently in the region. In the past 5 years, no tornadoes were reported in Montgomery County and one tornado (classified on the Enhanced Fujita scale as an EF0, with a 65–85 mph (29.1–38.0 m/s) 3-second wind gust) occurred in Chester County (NCDC 2012d). Using tornado data for the period from January 1, 1950, through August 31, 2003, the annual best-estimate tornado strike probability for a 1-degree box that includes the LGS site is 1.59×10^{-4} (Ramsdell and Rishel 2007). Tropical cyclones are rarely of hurricane strength by the time they are in the vicinity of the LGS site. The National Oceanic and Atmospheric Administration (NOAA) maintains a database of tropical cyclone tracks and intensities that covers the period from 1842 through 2010. During this time, only two Category 1 hurricanes, with maximum sustained winds of 74−95 mph (33.0–42.5 m/s), have passed within 80 km (50 miles) of the LGS site (NOAA 2012).

2.2.2.1 Air Quality

Under the Clean Air Act of 1963 (CAA), EPA has set primary and secondary National Ambient Air Quality Standards (NAAQSs, 40 CFR Part 50) for six common criteria pollutants to public health and the environment. The NAAQS criteria pollutants include carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter (PM). PM is further categorized by size—PM_{10} (diameter of 10 micrometers or less) and $PM_{2.5}$ (diameter of 2.5 micrometers or less).

EPA designates areas of "attainment" and "nonattainment" with respect to the NAAQSs. Areas for which insufficient data are available to determine designation status are denoted as "unclassifiable." Areas that were once in nonattainment, but are now in attainment, are called "maintenance" areas; these areas are under a 10-year monitoring plan to maintain the attainment designation status.

Air quality designations are generally made at the county level. For the purpose of planning and maintaining ambient air quality with respect to the NAAQSs, EPA has developed Air Quality Control Regions (AQCRs). AQCRs are intrastate or interstate areas that share a common airshed (40 CFR Part 81). The LGS site is located in Montgomery and Chester Counties, Pennsylvania; these counties are part of the Metropolitan Philadelphia Interstate AQCR (40 CFR 81.15). Additional counties in this AQCR include Bucks, Delaware, and Philadelphia Counties. With regard to the NAAQSs, Montgomery and Chester Counties are designated as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10} and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

States have primary responsibility for ensuring attainment and maintenance of the NAAQSs. Under Section 110 of the CAA (42 USC 7410) and related provisions, states are to submit, for EPA approval, State Implementation Plans (SIPs) that provide for the timely attainment and maintenance of the NAAQSs. On March 26, 2012, EPA approved and promulgated the PADEP's SIP for ozone in the Philadelphia area, including Montgomery and Chester Counties (77 FR 17341). Similarly, on March 29, 2012, EPA approved and promulgated the PADEP's revisions to the SIP for $PM_{2.5}$ (77 FR 18987).

As required under 25 Pa. Code Chapter 127, Exelon maintains a Title V operating permit (TVOP-46-00038) for sources of air pollution at the LGS site (Exelon 2011b). Permitted sources include two cooling towers, a spray pond, several standby diesel generators and boilers, a solvent-based degreasing unit, and air emissions from various sources of waste oil (Exelon 2011b). As a condition of the Title V operating permit, Exelon is required to submit an annual compliance certification to the PADEP, which includes fuel usage and estimated air pollutant emissions (Exelon 2012b). Table 2–1 lists the total diesel fuel usage and associated air emissions for the most recent 5 years (Exelon 2012b). There are no plans for refurbishment of structures or components at LGS for license renewal. Therefore, there are no expected new air emissions associated with license renewal (Exelon 2011b).

40 CFR Part 81 Subpart D lists mandatory Class I Federal Areas where visibility is an important value. There are no mandatory Class I Federal areas within 50 miles (80 km) of the LGS site. The closest mandatory Class I Federal area is the Brigantine Wilderness in New Jersey, which is approximately 78 miles (127 km) southeast of the LGS site (40 CFR 81.420). Because of the significant distance from the site and prevailing wind direction, no adverse impacts on Class I areas are anticipated from LGS operation.

Table 2–1. Annual Fuel Use and Air Emission Estimates for Significant Sources at LGS

Year	Fuel Usage (gal)[a]	NO_x (T)[b]	CO (T)[b]	SO_x (T)[b]	$PM_{2.5}$ (T)[b]	PM_{10} (T)[b]	VOC (T)[b]	Pb (T)[b]
2007	1,128,502	29.3	22.7	6.1	0.44	42.3	0.80	0.0000
2008	927,297	31.2	19.8	4.8	0.47	42.2	0.90	0.0010
2009	858,760	28.4	18.5	3.8	0.41	42.7	1.97	0.0005
2010	1,003,210	35.3	21.8	4.0	0.72	161.1[c]	2.13	0.0006
2011	1,145,960	32.8	24.2	7.8	0.80	166.3[c]	2.10	0.0010

[a] To convert gallons to liters, multiply by 3.8.
[b] To convert T to MT, multiply by 0.91.
[c] Beginning in 2010, the emission calculation for PM_{10} was changed for reporting purposes; no actual change in operations occurred and therefore no change in actual PM_{10} emissions (LGS RAI Reply E1-1).
NO_x = nitrogen oxides; CO = carbon monoxide; SO_x = sulfur oxides; $PM_{2.5}$ = particulate matter with a diameter of 2.5 micrometers or less; PM_{10} = particulate matter with an aerodynamic diameter between 2.5 and 10 micrometers; VOC = volatile organic compounds; Pb = lead.

Source: Exelon 2012b

2.2.3 Geologic Environment

This section describes the current geologic environment of the LGS site and vicinity including landforms, geology, soils, and seismic setting.

2.2.3.1 Physiography

LGS is located within the Gettysburg-Newark Lowland Section of the Piedmont physiographic province. This region is generally comprised of rolling lowlands, shallow valleys, and isolated hills and mainly underlain by red shale, siltstone, and sandstone, with some conglomerate and diabase (DCNR 2000).

The main plant complex, including the LGS nuclear island, is situated on a broad, semicircular ridge on the eastern bank of the Schuylkill River. Site topography slopes steeply to the west and south toward the Schuylkill River and Possum Hollow Creek, respectively. Elevations range from less than 110 ft (34 m) above MSL at the Schuylkill River to approximately 280 ft (85 m) MSL at the highest elevation near the cooling towers. Blasting and other construction activities have modified the natural land surface across the plant site (Exelon 2011b).

2.2.3.2 Geology

Thick bedrock consisting of reddish-brown siltstone and interbedded sandstone and shale of the Brunswick Formation underlies the majority of the LGS site and vicinity. Rocks of the Sanatoga Member of the Lockatong Formation interfinger with the Brunswick in the northern part of the LGS site area and occur in the area of the spray pond, but do not occur beneath the cooling towers or the main plant structures. The Sanatoga is a bluish-gray, calcareous argillite with beds of black shale. This rock is relatively harder than the siltstone and other rocks of the Brunswick. In total, the uppermost bedrock sequence beneath the site is more than 5,000 ft (1,520 m) thick (Exelon 2008b).

The sediments that now comprise the Brunswick and other formations making up the near surface bedrock were deposited by streams feeding into one of a series of down-warped or down-faulted basins that formed during the late Triassic (i.e., between about 200 and 228 million years ago). LGS overlies the northern (Newark) portion of one such basin, the Newark–Gettysburg Basin. The sediments that now constitute the rocks of the Brunswick

Formation originally were deposited by an ancient river system in the form of a large alluvial fan while the Lockatong was deposited in a shallow lake environment (Exelon 2008b).

Subsequent to the deposition and consolidation of the basin sediments, the region was uplifted, tilted, and deformed. In addition, the sedimentary materials have been broken by numerous small faults and fractures and locally include interbeds of and intrusions by volcanic rocks. Numerous intrusions of the basin's sedimentary rocks by volcanic diabase have been mapped throughout southeast Pennsylvania. One such prominent feature is a diabase dike (named the Downingtown Dike) that extends from about 11 miles (18 km) southwest of Downingtown, Pennsylvania, through Sanatoga Station, just north of the site, and continues about 3 miles (5 km) to the northeast. The sedimentary rock immediately bordering this feature has been thermally altered to a tough gray hornfels. Age dating of the numerous dikes in the region indicates that they were emplaced between about 140 and 198 million years ago (Exelon 2008b).

Across the LGS site and region, bedrock is overlain by up to 40 ft (12 m) of residual soil, developed in place by the weathering and decomposition of the bedrock. This material (regolith) grades into weathered rock (saprolite), then into fresh, unweathered rock; no clearly defined boundary exists between soil and rock. Holocene (recent) alluvium consisting of silt, sand, and gravel occurs along the Schuylkill River and tributaries such as Possum Hollow Run (Exelon 2008b).

Numerous small faults and fractures occur in the Triassic strata underlying LGS. These features formed as a result of regional uplift that occurred following the consolidation of sediments in the Newark basin (Exelon 2008b). Most notable on a regional basis, the northwest border of the Newark basin in northern New Jersey and southeastern New York State is marked by a system of normal faults known as the Ramapo fault system. This fault system has been extensively studied by various investigators, including the USGS, in part because historical epicenters of small earthquakes have been loosely associated with this fault system (Crone and Wheeler 2000). Information compiled by Exelon (2008b) indicated that there is no clear association between the Ramapo fault and earthquake epicenters in the region, and no evidence for fault reactivation or fault offset at the surface. USGS's review of data for evidence of Quaternary fault activity (i.e., within the last 1.6 million years) encompassing the eastern United States supports these conclusions, finding that geologic evidence is insufficient to demonstrate either the existence of a tectonic fault or Quaternary slip or deformation associated with the feature (Crone and Wheeler 2000, Wheeler 2006). Further, the Ramapo is not included in the USGS's latest Quaternary Fault and Fold Database (USGS 2012a).

Three small faults, the Sanatoga, the Brooke Evans, and the Linfield, occur within 2 miles (3.2 km) of the LGS site. The nearest approach of any fault, the Sanatoga fault, to the reactor area is 1,300 ft (400 m) to the west. The fault plane is intruded by Triassic diabase, which is part of the Downingtown Dike. The Brooke Evans fault passes within 2,800 ft (850 m) to the south of the plant area, and the trace of the Linfield fault lies about 2 miles (3.2 km) southeast of the LGS site. All three of these faults are associated with the Jurassic–Triassic events that occurred some 140 to 200 million years ago. Field studies of diabase intrusions of these faults indicate that they have been inactive for at least 140 million years (Exelon 2008b). Thus, none of these faults are active or considered "capable" of producing earthquakes per 10 CFR Part 100, Appendix A.

During foundation excavation for the plant, several features, including shear-fractures with some small offsets (displacement), were encountered. While not unusual for the region and not posing a hazard to plant structures, these areas were treated as necessary to ensure subsurface stability. Treatment included excavating any soft or otherwise weathered material down to competent bedrock and/or by replacing excavated material with concrete, as further described in the updated final safety analysis report (UFSAR) (Exelon 2008b).

There are no outstanding mineral rights within the LGS exclusion area (Exelon 2008b). There is one quarry (Pottstown Trap Rock Sanatoga Quarry) located about 0.8 miles (1.2 km) from the center of the main plant complex and adjacent to LGS's northern property boundary. Operations at the quarry consist of blasting, crushing, grading, and stockpiling rock (Exelon 2008b). The Sanatoga Quarry produces red aggregate stone for use in construction and landscaping applications. The site also has an asphalt production operation (H&K Group 2012).

2.2.3.3 Soils

Soils at the site, where present, consist predominantly of residual clayey silts (Exelon 2008b). Soil unit mapping by the Natural Resources Conservation Service (NRCS) identifies the majority of the LGS site complex as Urban land-Udorthents, shale and sandstone complex, 8 to 25 percent slopes. Consistent with the developed nature of the LGS site, this soil mapping unit is used to identify buildings and other impervious surfaces on hills and other uplands on graded land surfaces underlain by shale and sandstone. Natural soils bordering the main plant complex to the north and northeast include Penn silt loam, Readington silt loam, and Reaville silt loam, 0 to 8 percent slopes. These are generally moderately to well-drained soils on hills and hillslopes that developed from residuum weathered from sandstone and shale parent material. Depth to bedrock ranges from 20 to 40 in. (50 to 100 cm), which imparts a slight limitation for building site development. These soils are all prime farmland soils or farmland of statewide importance, where otherwise not committed to developed uses (7 CFR 657.5). This includes a continuous area totaling about 25 ac (10 ha) of Penn silt loam, 3 to 8 percent slopes just to the northeast of the spray pond. To the south and southeast along the north side of Possum Hollow Run, the soils are mapped as Klinesville channery silt loam, 35 to 60 percent slopes. These soils are relatively shallow and somewhat excessively drained. Soils along both banks of the Schuylkill River in the vicinity of LGS are mapped as Gibraltar silt loam. These soils are relatively deep, well-drained soils occupying valley flats, hills, and levees. Their parent material is coal overwash (i.e., materials derived from upstream coal mining) over alluvium derived from shale and siltstone. These soils are very limited for building site development because of the threat of ponding and flooding (NRCS 2012).

Foundations for all seismic Category I (safety-related) structures at LGS are founded on hard, competent bedrock or were excavated to unweathered bedrock. In addition, no other localized geologic hazards, old landslides, rock slips, or landslide scars have been identified near plant structures (Exelon 2008b).

2.2.3.4 Seismic Setting

Eastern Pennsylvania lies within a region that has experienced a moderate level of earthquake activity. However, zones of major earthquakes are located more than 200 miles (340 km) from the site and have not had an appreciable effect at LGS (Exelon 2008b). Probabilistic analysis that considers both the occurrence and intensity of earthquakes within and outside Pennsylvania indicates a relatively low seismic risk overall (PADCNR 2003).

Pennsylvania is affected by small earthquakes that occur on local faults (PADCNR 2003). Within a radius of 62 miles (100 km) of LGS, a total of 56 earthquakes have been recorded since 1973. The largest was a magnitude 4.6 event in January 1994, centered 24 miles (39 km) west of the site near Reading, Pennsylvania. The closest event was a magnitude 2.7 event in November 2003 with an epicenter 15 miles (24 km) west-northwest of LGS (USGS 2012b). These earthquakes are generally in association with the Lancaster Seismic Zone, an area of increased seismic activity, which encompasses recorded seismic events in Lancaster, York, Lebanon, and Berks Counties. This is the most active seismic zone in Pennsylvania. Southeastern Pennsylvania is not known to have experienced an earthquake with a magnitude greater than 4.7 (DCNR 2003).

The largest earthquake recorded to date within the Commonwealth's borders was a magnitude 5.2 event on September 25, 1998, in northwestern Pennsylvania, some 280 miles (450 km) northwest of LGS. It caused only minor structural damage near the epicenter (e.g., bricks shaken from chimneys) and was classified by the USGS as producing Modified Mercalli Intensity (MMI) VI shaking. It was felt throughout northern Ohio and most of Pennsylvania and into bordering states (Dewey and Hopper 2009; USGS 2012c, 2012d). By comparison, a magnitude 6 earthquake occurring in southeastern New York or northern New Jersey could affect the easternmost counties of Pennsylvania. Historically, such events (i.e., in 1737 and 1884) have produced MMI IV shaking in eastern Pennsylvania (DCNR 2003). Such a level of shaking would likely result in little to no damage to structures.

As documented in the LGS UFSAR, evaluation of tectonic structures and the historical seismic record for the region indicated that a plant design for MMI VII shaking was adequately conservative for the site. MMI VII shaking was determined to correspond with a peak ground acceleration (PGA) of 0.13 g (i.e., force of acceleration relative to that of Earth's gravity, "g"). For additional conservatism, 0.15 g was adopted for the LGS safe-shutdown earthquake (SSE) (Exelon 2008b).

For the purposes of comparing the plant SSE with a more contemporary measure of predicted earthquake ground motion for the site, the NRC staff also reviewed current PGA data from the USGS National Seismic Hazard Mapping Project. The PGA value cited is based on a 2 percent probability of exceedance in 50 years. This corresponds to an annual frequency (chance) of occurrence of about 1 in 2,500 or 4×10^{-4} per year. For LGS, the calculated PGA is approximately 0.11 g (USGS 2008).

2.2.4 Surface Water Resources

2.2.4.1 Site Description and Surface Water Hydrology

The LGS main plant site is situated on a terraced hill that adjoins and overlooks the eastern bank of the Schuylkill River, and is located approximately 4 river miles (6.6 km) downriver from Pottstown, Pennsylvania. The plant site also lies 49 miles (79 km) upstream from the Schuylkill's confluence with the Delaware River (Exelon 2011b). The Schuylkill River is within the boundaries of the Delaware River Basin.

In addition to being bordered by the Schuylkill River, the LGS property is also cut by two northeast to southwest trending tributaries to the Schuylkill River, Possum Hollow Run, and Brooke Evans Creek. Possum Hollow Run runs along the southeastern boundary of the main plant complex and receives stormwater runoff from plant facilities (see Section 2.2.4.2). The only other notable surface water features on the LGS site are the spray pond and a small holding pond. Part of the emergency cooling system (see Section 2.1.6), the spray pond is a clay-lined, man-made impoundment covering 9.9 ac (4 ha). The holding pond is a concrete-lined structure located south of the power block and beyond the main plant protected area. It covers less than 0.5 ac (0.2 ha) and receives industrial wastewater from various plant systems; it is an internal NPDES monitoring point (outfall 201) to the plant's main outfall 001 (Exelon 2010d, 2011b). These features are not further assessed from the perspective of surface water hydrology.

As described in Sections 2.1.6 and 2.1.7, all the water needs for the plant are provided by a combination of multiple subbasins' flows in addition to flow from the mainstem Delaware River. While the Schuylkill River is the primary source of water for the plant, makeup water for consumptive (evaporative cooling) use must be supplemented with water taken from Perkiomen Creek during low flow periods on the Schuylkill River. Perkiomen Creek and its tributary (East Branch Perkiomen Creek) provide a channel to convey water pumped from the Delaware River to LGS. The nonconsumptive water withdrawals and other plant effluents are discharged to the Schuylkill River downstream of the LGS Schuylkill River intakes.

Schuylkill River

The Schuylkill River flows for approximately 130 miles (209 km) to its confluence with the Delaware River at Delaware River Mile (RM) 92.5. Its watershed encompasses approximately 1,916 m^2 (4,962 km^2) and is one of the two largest tributaries to the Delaware River. Exelon's Schuylkill Pumphouse is located at Schuylkill RM 48 (Exelon 2011b). The mean annual discharge measured at the USGS gage at Pottstown, Pennsylvania, for water years 1928 through 2010 is 1,935 cfs (54.8 m^3/s). The 90 percent exceedance flow is 482 cfs (13.6 m^3/s) (USGS 2010a, 2012e). For water year 2011, the mean discharge was 3,145 cfs (89.1 m^3/s). The 90 percent exceedance flow is an indicator value that a drought warning is appropriate. It signifies that the current 30-day average flow has been exceeded 90 percent of the time, as compared to the average flow for the period of record (DEP 2012). For the Schuylkill River, August is the low-flow month and March is the high-flow month over the period of record.

East Branch Perkiomen Creek

The East Branch Perkiomen Creek flows for a distance of 24 miles (39 km) and enters Perkiomen Creek at a point about 11 stream miles (18 km) from the confluence of Perkiomen Creek with the Schuylkill River. Its flow is highly variable and, before the establishment of the diversion of water from Exelon's Bradshaw Reservoir, the creek was reportedly intermittent in nature during the summer and fall (Exelon 2011b). Based on water year data from 1990 through 2011, the mean annual discharge and 90 percent exceedance flow measured at the USGS gage at Dublin, Pennsylvania, are 35.8 cfs (1.0 m^3/s) and 13 cfs (0.37 m^3/s), respectively (USGS 2011a).

Perkiomen Creek

Perkiomen Creek drains an area of some 363 mi^2 (940 km^2) and joins with the Schuylkill River at a point approximately 16 stream miles (26 km) downstream from LGS. For the period of 1915 through 1956 and before flow regulation due to Green Lane Reservoir beginning in late 1956, the reported mean annual discharge and 90 percent exceedance flow at the USGS gage at Graterford, Pennsylvania, are 389 cfs (11 m^3/s) and 42 cfs (1.2 m^3/s), respectively. As previously described (see Section 2.1.6), water has been diverted to the creek since August 1989 from the Delaware River at Point Pleasant to Bradshaw Reservoir and then pumped from the reservoir to East Branch Perkiomen Creek. For the period 1957 through 2011, the measured mean annual discharge and 90 percent exceedance flow values are 435 cfs (12.3 m^3/s) and 65 cfs (1.8 m^3/s), respectively (USGS 2011b).

Delaware River

The Delaware River flows 330 miles (531 km) from its origin in southern New York to the Delaware Bay, and it is the longest un-dammed river in the United States east of the Mississippi (DRBC 2012a). The tidal portion of the Delaware River extends upriver from the estuary at Delaware Bay to Trenton, New Jersey. Upriver salinity intrusion varies according to increases or decreases in upriver inflows. The boundary of salinity intrusion, also known as the salt line, fluctuates with flow changes. The salt line is the point where the average sodium chloride concentration in the river exceeds 250 mg/L. The Point Pleasant Pumping Station used to transfer Delaware River water is located at Delaware RM 157, which is above the salt line (Exelon 2011b). Based on data for 1913 through 2010, the mean annual discharge and 90 percent exceedance flow measured at the USGS gage at Trenton, New Jersey, are 11,900 cfs (337 m^3/s) and 3,080 cfs (87.2 m^3/s), respectively. This gage site is at Delaware RM 134.5, about 20 river miles (32.2 km) downstream from the Point Pleasant Pumping Station (USGS 2010b).

2.2.4.2 Surface Water Quality and Effluents

Among the powers and duties assigned to the DRBC are classifying all waters in the basin as to use, setting basin-wide water quality standards, establishing pollutant treatment and control regulations, and reviewing projects or other undertakings with the potential to affect basin water resources for conformance with the DRBC Comprehensive Plan (DRBC 2001). DRBC has also promulgated water quality standards for the basin under 18 CFR Part 410. The DRBC acts in cooperation with the States and other parties that are signatories to the DRBC Compact (DRBC 1961) and who retain their authority to set more stringent standards necessary to protect the water resources of the basin. Article 3.8 of the DRBC Compact (DRBC 1961) requires that the DRBC approve a project whenever it finds and determines that the project would not substantially impair or conflict with the Comprehensive Plan. DRBC's Comprehensive Plan already accounts for existing LGS operations (DRBC 2001).

The Commonwealth of Pennsylvania has established surface water quality standards for individual rivers, streams, and unnamed tributaries, including wetlands, along with associated numeric water quality criteria to protect the desired and designated uses of the water bodies. Relative to the LGS site, PADEP has specifically designated the main stem of the Schuylkill River traversing Montgomery County to its mouth with the Delaware River for use in the maintenance and propagation of warm water fishes (WWF) and the passage, maintenance, and propagation of migratory fishes (MF). The main stem of Perkiomen Creek is also designated as WWF and MF. East Branch Perkiomen Creek is designed for use in the maintenance of stocked trout from February 15 to July 31 of each year, in addition to WWF and MF during the rest of the year. It should be noted that all surface waters in Pennsylvania are protected for water supply (public, industrial, and wildlife use) and for recreational uses (25 Pa. Code 93). Ambient water quality data Exelon compiled (Exelon 2011b) to support its 2010 NPDES permit renewal application and as part of the DRBC monitored demonstration study (Exelon 2012d) were reviewed by NRC staff during the course of the LGS license renewal environmental review. Comparison of the available data with the water quality criteria established by the PADEP under 25 Pa. Code 93.7 and 93.9 for the designated uses of the Schuylkill River and tributaries indicate that existing water quality is supportive of designated uses. Section 2.2.6 of this SEIS discusses key trends in ambient water quality and its influence on aquatic biota.

Section 303(d) of the Federal Clean Water Act (CWA) requires the Commonwealth of Pennsylvania and other states to identify all waters for which effluent limitations and pollution control activities are not sufficient to attain water quality standards in such waters. The 303(d) list includes those water quality limited segments that require the development of total maximum daily loads (TMDLs) to assure future compliance with water quality standards. While the Schuylkill River is listed as supporting its designated aquatic life uses, Pennsylvania's draft 2012 Clean Water Act Section 303(d) list of impaired waters continues to list the main stem of the Schuylkill River in the plant vicinity as impaired because of polychlorinated biphenyl (PCB) contamination from unidentified upstream sources (PADEP 2011, Exelon 2011b).

Industrial wastewater, cooling water, and stormwater discharges from LGS are governed by a Pennsylvania DEP-issued NPDES permit (No. PA0051926) and regulated under PADEP's regulations at 25 Pa. Code 92a. Exelon's current permit sets effluent quality limits and monitoring requirements for the plant's discharges covering some 24 outfall locations. These include 17 outfalls discharging stormwater either to the Schuylkill River or Possum Hollow Run, with one outfall discharging stormwater runoff north to the headwaters of Sanatoga Creek. Six outfalls discharge industrial wastewater (mainly noncontact cooling water) or comingled noncontact cooling water with stormwater. Most notably, cooling tower blowdown, closed-cycle cooling water, spray pond water, stormwater via the plant's holding pond, and other plant wastewaters (e.g., liquid radwaste treatment system and laundry drain wastes) are discharged through the plant's primary outfall (no. 001) to the Schuylkill River (Exelon 2010d, 2011b). In particular, the treated liquid radwaste is batch discharged to the cooling tower blowdown line where it is diluted by the normal blowdown flow. This ensures that radionuclides discharged through outfall 001 comply with 10 CFR 20 limits (Exelon 2011b).

The cooling tower blowdown line is also equipped with an overflow vent, which is monitored as a separate NPDES outfall (no. 023) (Exelon 2010d, 2011b). The vent, which NRC staff observed during the November 2011 environmental site audit (NRC 2012), is located south of the power block and just downslope from the plant's holding pond.

LGS's current NPDES permit for plant operations was issued by PADEP with an effective date of April 1, 2006; the permit expired on March 31, 2011 (Exelon 2011b, 2012b). However, Exelon submitted a permit renewal application to PADEP on September 28, 2010, which the PADEP accepted as administratively complete on December 15, 2010 (Exelon 2010d, 2012a; PADEP 2010). As a result, LGS's NPDES permit for LGS operations remains in effect (i.e., administratively continued) because Exelon submitted an application for renewal at least 180 days before the expiration of the current permit in accordance with 25 Pa. Code 92a.7.

Exelon has a separate PADEP-issued NPDES permit (No. PA0052221) for the discharge of diversion water from the Bradshaw Reservoir to East Branch Perkiomen Creek. The permit was issued with an effective date of July 1, 2009, and expires June 30, 2014.

Continued NPDES permit coverage is an indication that Exelon's discharges from LGS and other facilities meet applicable water quality standards, while satisfying state Water Quality Certification requirements under Section 401 of the Federal Clean Water Act. This is because, in Pennsylvania, the 401 Water Quality Certification process is integrated with other PADEP-issued permits and approvals, including those under the NPDES permit program.

The NRC staff's review of the last 3 years of NPDES Discharge Monitoring Reports (DMRs) submitted by Exelon to the PADEP revealed no unusual conditions or exceedances of effluent limitations. The staff determined that Exelon has not received any Notices of Violation, nonconformance notifications, or related infractions associated with the site's NPDES permits or related to other water quality matters within the past 5 years (Exelon 2012a, 2013a). Otherwise, the only potential water quality-related regulatory infraction stems from a Notice of Violation issued to Exelon and dated March 6, 2012, relating to a December 2011 PADEP inspection of LGS's storage tanks. The inspection found external wear on the outer shells of the Unit 1 and 2 sulfuric acid aboveground storage tanks (DEP Tank Nos. 001A and 002A). Exelon subsequently completed required corrective actions, had the tanks re-inspected, and submitted a letter to PADEP on March 27, 2012, documenting the corrective actions. At present, there are no open actions with respect to this issue (Exelon 2013a).

2.2.5 Groundwater Resources

2.2.5.1 Site Description and Hydrogeology

Groundwater beneath LGS and vicinity occurs in the thick bedrock of the Brunswick and Lockatong Formations, as described in Section 2.2.3.

The USGS has grouped the water-bearing portions (i.e., aquifers) of these formations into the Aquifers in the Early Mesozoic Basins system (Trapp and Horn 1997). The Brunswick bedrock aquifer is the most widespread source of groundwater in the plant region and across the Triassic lowlands of the Newark Basin (Exelon 2008a). In general, aquifer zones occur in association with secondary fractures, joints, and bedding planes in the rock where groundwater is stored and may move along (Exelon 2008a, 2011b; Trapp and Horn 1997). In strata where approximately vertical sets of joints are tightly spaced and have some degree of interconnection, aquifer permeability is increased and groundwater flow and yield to wells are greatly enhanced. However, these localized zones of enhanced aquifer permeability vary vertically and laterally through the rock, especially as the basin strata dips to the north and northwest at 10 to 20 degrees on a regional basis and strikes approximately east to west (Exelon 2008a). Consequently, individual bedrock aquifer zones also dip downward and may run in the downdip direction for only a few hundred feet but can be continuous in extent for thousands of feet along (parallel to) the bedrock strike (Trapp and Horn 1997). As such, groundwater yield to individual wells can vary greatly over relatively short distances (Exelon 2008a, Trapp and Horn 1997). Because of decreasing fracture density with depth, groundwater movement primarily occurs in the upper 600 ft (180 m) of the Brunswick system (Exelon 2008b). In fact, within the Newark Basin in Pennsylvania, yields are highest from wells with completion depths ranging from 200 to 500 ft (60 to 150 m). Groundwater yields from large-diameter wells within the basin typically range from about 12 gpm (45 L/min) in shale and argillite up to 80 gpm (300 L/min) in massive sandstones (Trapp and Horn 1997).

Recharge to the bedrock aquifer occurs from precipitation that falls over the higher elevations of the region’s groundwater basins, and which is able to infiltrate through the overlying soils and regolith (Exelon 2008a, 2011b). While overlying surficial materials (i.e., soils, regolith, and stream alluvium), where present in the region, are not typically thick enough to be a sustained source of groundwater to wells by themselves, thick deposits do help to increase the availability of water to wells withdrawing from the underlying bedrock (Trapp and Horn 1997). Nevertheless, the majority of the precipitation and runoff occurring in recharge areas moves laterally downgradient through the regolith and discharges to streams or low-lying areas rather than recharging groundwater (Trapp and Horn 1997). The regolith across the LGS site is relatively thin at no more than 12 ft (3.7 m) in thickness, and well measurements indicate that the materials are not water-bearing (Exelon 2011b).

Beneath LGS, groundwater occurs under water table (unconfined) conditions but can occur under confined (artesian) conditions at depth. From static water levels recorded in the plant’s primary production wells, the depth to the water table surface beneath the plant ranges from 20 to 30 ft (6 to 9 m) below ground surface. The water table approximates the surface topography, with groundwater generally flowing to the south and southwest beneath the site and discharging to Possum Hollow Run and the Schuylkill River. The groundwater flow rate through the Brunswick bedrock is estimated to be on the order of 0.07 ft (0.02 m) per day or about 26 ft (7.9 m) per year, based on the results of the site’s 2006 hydrogeologic investigation, as further described in Section 2.2.5.2. Locally on the plant site, a groundwater high point and groundwater flow divide (striking northeast to southwest) is evident just northeast of the cooling towers adjacent to the spray pond (Exelon 2008a, 2011b). Water table mapping does not indicate any groundwater mounding beneath the spray pond, an observation that would be expected if significant seepage were occurring from the pond.

LGS's four groundwater production wells are completed in the Brunswick aquifer system. These wells range in depth from 198 ft (60 m) to 585 ft (178 m), as further described in Section 2.1.7. They are located within a groundwater protected area (Schuylkill–Sprogels Run Subbasin) designated by the DRBC, and site groundwater withdrawals are otherwise subject to Pennsylvania reporting requirements as also described in Section 2.1.7. As for other groundwater users in the vicinity of LGS, a search of Pennsylvania water well records revealed 54 wells within a 1-mile (1.6-km) radius from the center of the LGS site. This number includes eight wells attributed to the LGS property, although only four remain in service. Other than the LGS wells, only 3 of the 54 wells reportedly are used for other than domestic (i.e., residential) purposes. Most of the recorded residential wells range in depth from 120 to 200 ft (37 to 61 m). For the other nondomestic wells, they include one public water supply well at a mobile home park located northeast of the plant; the well depth is not recorded. One other nondomestic (commercial/industrial) supply well is located at the Pottstown Trap Rock–Sanatoga Quarry located just to the north of the LGS property boundary. This well is recorded as 100 ft (30 m) deep. The remaining well supplies a local bed and breakfast business located southeast of LGS; the well is recorded as 96 ft (29 m) in depth (DCNR 2012; Exelon 2011b).

2.2.5.2 Groundwater Quality

Regional groundwater is characteristically of the calcium bicarbonate type and is generally suitable for a wide range of purposes (Exelon 2008a, Trapp and Horn 1997). However, the natural quality of groundwater from the region's bedrock aquifers is typically hard with total dissolved solids (TDS) concentrations averaging 230 mg/L and hardness (measured as calcium carbonate) of 160 mg/L (Trapp and Horn 1997). Groundwater from the Brunswick aquifer system can naturally have a TDS in excess of 500 mg/L, which exceeds the EPA secondary drinking water standard (DWS) primarily established for aesthetic (taste) purposes (40 CFR Part 143). Data collected from the plant's production wells to establish background water quality indicated moderately hard water ranging from 134 to 618 mg/L with TDS concentrations from 199 to 1,052 mg/L (Exelon 2008a). As noted in Section 2.1.7, groundwater used at LGS is treated, as necessary, including that withdrawn to meet the potable needs of LGS site personnel.

Exelon initiated a program at LGS in 2006 to characterize the hydrogeologic environment of the plant site and to specifically assess the potential impacts on groundwater quality of any inadvertent releases of tritium or other LGS-related radionuclides. The assessment conducted at LGS was part of a fleet-wide effort by Exelon to assess conditions at all of its nuclear plants and which was undertaken consistent with its participation in the Nuclear Energy Institute's Groundwater Protection Initiative (NEI 2007). These efforts provided the framework for the plant's ongoing Radiological Groundwater Protection Program (RGPP) (CRA 2006; Exelon 2011b). The RGPP incorporates knowledge gained from the LGS pre-operational Radiological Environmental Monitoring Program (REMP) assessment conducted between 1982 and 1984 (CRA 2006).

The 2006 hydrogeologic investigation and its associated report (CRA 2006) considered historical releases from LGS facilities to include the structures, systems, and components (SSCs) and areas that may have the potential to contribute to releases. Consequently, a groundwater monitoring well network was designed, sited, and installed as part of the study to include wells located at appropriate upgradient and downgradient locations (i.e., relative to groundwater flow) so as to assess the potential for radionuclides to migrate off site. The monitoring network established as part of the investigation initially included use of seven (i.e., nos. P3, P11, P12, P14, P16, P17, and SP22) of the 22 wells that were installed on site before and during LGS construction plus eight new wells (wells MW-LR-1 through MW-LR-8). The wells have total depths in the Brunswick Formation ranging from 34 to 115 ft (10 to 35 m) below ground surface. Aside from groundwater, surface water samples also were collected and analyzed for tritium and other radionuclides (CRA 2006; Exelon 2011b).

From the initial 2006 sampling, no strontium-90 or gamma-emitting radionuclides were detected in groundwater or surface water above analytical detection limits. Tritium was detected in 5 of 16 wells sampled (i.e., in well nos. MW-LR-4, MW-LR-5, MW-LR-8, MW-LR-9, and P12). Observed tritium concentrations ranged from 222±118 pCi/L to 4,360±494 pCi/L, all below the EPA primary DWS of 20,000 pCi/L (40 CFR Part 141). From three of the five wells with detectable tritium (MW-LR-4, MW-LR-5, MW-LR-8), levels ranged from 222±121 pCi/L to 305±121 pCi/L, which are within the range of measurement uncertainty of background levels (established as 200 pCi/L) documented for the site and vicinity. The highest tritium level measured, at 4,360±494 pCi/L, was from monitoring well P12 located almost immediately south and within 100 ft (30.5 m) of the LGS power block perimeter. A subsequent sample yielded a comparable result. At the same time, a sample from the power block foundation sump had tritium at 2,020±154 pCi/L. Nevertheless, it was affirmed during the site investigation that well P12 was completed in a discrete zone normally located above the water table and thus not representative of overall site groundwater flow conditions (CRA 2006). This also had been noted before the start of plant operations, as documented in the UFSAR (Exelon 2008a). As a result, well MW-LR-9 was installed nearby to a depth of 100 ft (30.5 m) below ground surface to take the place of well P12. The new well was sampled in August 2006 and yielded a tritium concentration of 1,500±210 pCi/L (CRA 2006).

Tritium was also detected in one surface water sample collected from the plant's holding pond. The holding pond is located approximately 500 ft (152 m) due south and downgradient from wells P12 and MW-LR-9. Tritium was measured at 523±137 pCi/L. This concrete-lined structure receives nonradioactive wastewater, roof, and plant yard runoff from power block buildings, and collected drainage from the power block sump (CRA 2006). It is also an internal monitoring point (outfall 201) under the site's NPDES permit, as discussed in Section 2.2.4.1 (Exelon 2010d, 2011b).

The 2006 hydrogeologic investigation identified two possible sources of tritium to account for the levels in the referenced monitoring wells: (1) releases that occurred in December 2004 and February 2005 from the Unit 1 Condensate Storage Tank dike because of heating steam valves leaking condensation and (2) the release of tritiated steam condensation to the ground from an auxiliary heating steam pipe in October 2002. The releases could have migrated directly downgradient and through bedrock fractures toward the wells or were collected by the power block drain system and into the sump, which then migrated through the bedrock fractures to groundwater. From observations the staff made during the November 2011 environmental site audit (NRC 2012) and the data reviewed, the conclusions presented in the 2006 hydrogeologic report are reasonable.

Under the ongoing RGPP at LGS, groundwater and surface water samples are collected and analyzed for tritium and other radionuclides at least semiannually. The results are reported as a component of the annual Radiological Environmental Operation (REOP) reports (Exelon 2008a, 2009, 2010c, 2011b, 2012c, 2013b) submitted to the NRC. Exelon continues to adhere to a detection limit of 200 pCi/L for tritium, which is lower than the detection threshold (2,000 pCi/L) recommended by industry guidance (NEI 2007) and the site ODCM. This enables early detection and response to any releases (Exelon 2011b). As documented in the annual REOPs referenced above, a number of releases of tritiated water from plant SSCs have been documented and for which investigative and corrective action was taken, as necessary.

Between 2007 and 2011, the highest tritium level observed was 1,750 pCi/L in well MW-LR-9 in 2009 and was attributed to a release of condensate from the outside of the Unit 1 and 2 condenser bays in February 2009. Tritium in MW-LR-9 had decreased to a maximum of 1,154 pCi/L by April 2011, with the highest level observed in 2012 at 872 pCi/L in August 2012 (Exelon 2012c, 2013b).

On March 19, 2012, LGS's cooling tower discharge line overflowed through its relief vent. This overflow was ongoing as a radwaste tank batch discharge was being performed. The resulting overflow of contaminated water traveled into Possum Hollow Creek and toward the Schuylkill River. Initial sampling of the overflow indicated the presence of tritium. Exelon pumped out the remaining standing water and completed remediation of the area within one day of the event by removing sludge and contaminated soils. Groundwater sampling results from the monitoring well (MW-LR-5) located along the flow path of the spill revealed a maximum tritium concentration of 14,200±1,450 pCi/L (below the EPA primary DWS of 20,000 pCi/L). By October 2012, tritium levels had fallen to 215 pCi/L (Exelon 2013b).

Overall, the RGPP results reveal that there is no migration of tritium in groundwater at LGS at concentrations exceeding the EPA primary DWS of 20,000 pCi/L, and maximum observed tritium levels in all onsite monitoring wells had fallen to below 1,000 pCi/L by the end of 2012.

2.2.6 Aquatic Resources

Potentially affected waterbodies primarily occur within the Piedmont physiographic province portion of the Delaware River Basin, including the Schuylkill River, Perkiomen Creek, East Branch Perkiomen Creek, and the Delaware River near the Point Pleasant Pump Station (Figure 2–9). LGS relies on consumptive and nonconsumptive water primarily from the Schuylkill River, as described in Section 2.1.6. When flow conditions in the Schuylkill River do not meet DRBC criteria for water use as prescribed by LGS's consolidated docket (DRBC 2013a), LGS secondarily relies on water from Perkiomen Creek. Withdrawing water from Perkiomen Creek often requires augmentation of flow by transferring water from the Delaware River. A series of pumping stations delivers Delaware River water from the Point Pleasant Pump Station by pipeline to the Bradshaw Reservoir, which is then delivered by pipeline to the East Branch Perkiomen Creek. Water ultimately flows from the East Branch Perkiomen Creek to the Perkiomen Creek. The rate of flow into the East Branch Perkiomen Creek equals the LGS consumptive water demand plus an additional 3 percent to account for evaporative losses (Exelon 2011b). Because of the complex water diversion system, descriptions of the biological communities for each water body appear as separate resources.

2.2.6.1 Description of the Aquatic Resources Associated With Limerick Generating Station

<u>Schuylkill River</u>

The Schuylkill River flows 209.2 km (130 miles) from headwaters at Tuscarora Springs, Pennsylvania, to the confluence of the Delaware River in Philadelphia, Pennsylvania. LGS is located on the Schuylkill River, 6.4 river km (4 river miles) downriver of Pottstown, Pennsylvania, and 56.3 river km (35 river miles) upriver of Philadelphia, Pennsylvania.

The Schuylkill River historically contained abundant aquatic resources, including large populations of mussels and anadromous fish. Around the turn of the 18th century, coal mining became a predominant industry near the headwaters of the Schuylkill River. Mining waste effluents degraded downstream water quality and reduced optimal habitat for aquatic life (Rhoads and Block 2008). For example, the flow of acidic waters from mines, known as acid mine drainage, lowered pH values and increased dissolution of heavy metals in the river. Aquatic biota often cannot survive in waters with low pH values and increased concentrations of heavy metals (Sadak 2008). Water quality throughout the Schuylkill River basin continues to be influenced by mining activities from the last several decades (Interlandi and Crockett 2003).

The Schuylkill River once supported large numbers of anadromous fishes such as the American shad (*Alosa sapidissima*), alewife (*A. pseudoharengus)*, and river herring (or blueback herring, *A. aestivalis*), which spawn in freshwater and inhabit marine waters as adults. Anadromous fish would migrate from the Atlantic Ocean to the Delaware and Schuylkill Rivers to spawn. However, construction of the Fairmont Dam, built in 1820, and eight subsequent dams built in the 1800s, cut off access to upriver spawning locations for anadromous fish. Starting in the 1970s, fish passage systems, such as vertical fish slots and the removal of dams along the Schuylkill River, have helped to reestablish migration upriver. For example, Pennsylvania Fish and Boat Commission (PFBC) conducted fish ladder passage counts in 2004 and 2005 and observed a total of 91 and 41 American shad migrating upriver, respectively (PFBC 2012b). In addition, the PFBC has been stocking American shad fry in the Schuylkill River for the past 13 years in an effort to restore the legacy fishery (NMFS 2012c; PFBC 2012a). PFBC collected migrating shad between 2003 and 2007 in the Schuylkill River and observed that 95 percent were of hatchery origin. PFBC plans to continue to stock American shad fry annually until monitoring results indicate a self-sustaining fishery with spring runs averaging 300,000 to 850,000 returning adults (PFBC 2012b).

Biological Communities in the Schuylkill River

The aquatic ecology of eastern U.S. streams and rivers is made up of producers and consumers that transfer energy through food web interactions. The base of the food web is primary producers, which convert light energy into organic matter. Common primary producers in the Schuylkill River include diatoms (a common phytoplankton), filamentous green alga such as *Cladophora*, and *Myriophyllum*, a freshwater flowering plant (NRC 1984). Detritus, nonliving organic matter such as leaves, is also an important base of the food web. Primary producers are consumed by zooplankton (small animals that float, drift, or weakly swim in the water column of any body of water), ichthyoplankton (fish eggs and larvae), and herbivorous fish and invertebrates (e.g., aquatic insects, worms, and snails). Predatory invertebrates and fish, such as sunfish (*Lepomis* spp.) and brown bullhead (*Ictalurus nebulosus*), in turn consume zooplankton (including ichthyoplankton) and herbivorous fish and invertebrates.

Before LGS operations, LGS-related aquatic surveys conducted in the Schuylkill River near the LGS site provided baseline information for aquatic plant, benthic invertebrate, and fish assemblages. Surveys included sampling for phytoplankton (microscopic floating photosynthetic organisms), macrophytes (aquatic plants), macroinvertebrates, ichthyoplankton (fish eggs and larvae), and fish, from 1970 through 1984 (PECO 1984; RMC 1984, 1985, 1989). Subsequent sampling after LGS began operations included sampling for macroinvertebrates, ichthyoplankton, and fish from 1985 through 2009 (Exelon 2001, 2002, 2003, 2004, 2005; NAI 2010a; RMC 1986, 1987, 1988, 1989).

Periphyton, Phytoplankton, and Macrophytes. To support the operating license for LGS, PECO (1984) surveyed the seasonal abundances of periphyton (sessile algae and crustaceans that grow attached to hard surfaces) and phytoplankton (microscopic plants) from 1973 through 1974 and macrophytes (plants that can be observed with the naked eye) from 1974 through 1977. PECO (1984) observed peak productivity during summer and fall when light and temperature requirements are optimal for plant growth in shallow, lotic systems. Commonly collected periphyton and phytoplankton included diatoms (*Navicula*, *Diatoma*, and *Gomphonema*) and blue green algae. PECO (1984) observed 10 species of macrophytes. No additional LGS-related studies were conducted to examine plankton and periphyton communities since 1977.

Macroinvertebrates. For macroinvertebrate surveys, RMC-Environmental Services (RMC) placed buried cylinder samplers in sediments upstream and downstream of LGS and collected the colonized samplers after several months of deployment (RMC 1984, 1985, 1986). Oligochaetes, true flies (Diptera), and the snail *Goniobasis virginica* dominated downriver macroinvertebrate communities. In 1984, RMC characterized the macroinvertebrate community as typical of other U.S. temperate rivers (RMC 1984).

From 1985 through 1988, RMC surveyed macroinvertebrates using the same sampling methods as described above for pre-operational surveys. Oligochaetes, snails, beetles (Coleoptera) and flies (Diptera and Trichoptera) dominated the macroinvertebrate surveys both upstream and downstream of the Schuylkill River intake and discharge structures. RMC (1988) did not observe a substantial variation in the macroinvertebrate community when comparing pre-operational samples to post-operational samples at the same sampling sites (RMC 1988). Similarly, RMC (1988) did not observe a significant change in the benthic macroinvertebrates community when comparing the 3 years of data after LGS operations began. During this time period, LGS solely relied upon the Schuylkill River water for makeup water and did not use Perkiomen Creek (RMC 1988).

In 2009, Normandeau Associates, Inc. (NAI) (2010a) surveyed the macroinvertebrate community in the Schuylkill River using kick nets. Although NAI used different sampling methods than RMC in the 1980s, approximately 95 percent of the taxa collected in the 1980s were also collected in 2009. Both studies found midges (Diptera and Trichoptera) and snails to be among most the abundant taxa.

Fish. RMC (1984) used drift and push nets to survey fish eggs and larvae; seines to survey fish fry, juveniles, and small fish; and electrofishing to survey larger fish in the Schuylkill River. Sunfish, goldfish (*Carassius auratus*), and unidentified minnows dominated egg and larval fish samples, which were highest in May, June, and July (PECO 1984). Spot-fin shiner (*Notropis spilopterus*), swallowtail shiner (*Notropis procne*), and redbreast sunfish (*Lepomis auritus*) dominated seine samples. During electrofishing surveys, RMC (1984) captured redbreast sunfish, white sucker (*Catastomus commersonii*), goldfish, brown bullhead, and pumpkinseed (*Lepomis gibbosus*) most often.

RMC (1987) conducted the most recent surveys of ichthyoplankton, in the Schuylkill River near LGS in 1986. The species composition and relative abundances of the most common species were similar to that found in pre-operational surveys. The most common taxa included minnows and sunfish (RMC 1987).

Several juvenile and adult fish studies have occurred since LGS began operations. From 1985 through 1988, RMC surveyed juvenile and adult fish using the same sampling methods as described above for pre-operational surveys (RMC 1986, 1987, 1989). RMC collected shiner species, redbreast sunfish, and goldfish most often during seining and electrofishing surveys from 1985 through 1988 (RMC 1986, 1987, 1988, 1989). RMC (1988) noted no obvious shifts in fish population abundances or species diversity in the area of the LGS discharge.

NAI (2010a) compared the fish community from 1987 to 2009. However, the timing and frequency of sampling efforts varied slightly among studies: NAI (2010a) conducted electrofishing and seining surveys in September and October, whereas RMC sampled monthly from spring through fall. The most commonly collected species in 2009 were spotfin shiner (73.8 percent of the total catch), swallowtail shiner (8.1 percent), banded killifish (*Fundulus heteroclitus*) (3.7 percent), and tessellated darter (*Etheostoma olmstedi)* (3.4 percent) (NAI 2010a). In 1987, spotfin shiner was also the most abundant species, although the relative abundance (53.9 percent of the total catch) was lower compared to 2009 surveys. NAI collected all age groups of fish (fry, juveniles, and adults) for most fish families observed, with the exception of sunfishes, which were primarily fry and juveniles. NAI electroshocking surveys collected primarily adult and juvenile redbreast sunfish (27.7 percent of the total catch). Other commonly collected species included white sucker (17.4 percent), rock bass (*Ambloplites rupestris)* (17.2 percent), common carp (*Cyprinus carpio)* (16.9 percent), and smallmouth bass *(Micropterus dolomieu)* (8.3 percent). In 1987 the most abundant species was rock bass (19.0 percent), followed by goldfish (17.6 percent), redbreast sunfish (15.7 percent), yellow bullhead (*Ameiurus natalis)* (8.8 percent), and pumpkinseed (8.6 percent). Despite the increased sampling frequency during earlier fish surveys, NAI (2010a) concluded that the overall species diversity was similar to the earlier fish surveys by RMC in 1987. However, the relative abundance of certain species changed between 1987 and 2009. For example, common carp replaced goldfish as one of the more abundant species in 2009 (NAI 2010a). In addition, goldfish (an introduced species) was not collected in 2009 and a single brown bullhead was collected in 2009. Both of these species were among the five most commonly collected species during 1987 surveys.

The Schuylkill River supports recreational fishing, although there is little public access to the river near the LGS site. Creel surveys indicate that the most common recreational species include sunfishes and smallmouth bass (NRC 1984; RMC 1984, 1985, 1986).

Schuylkill River Flow Augmentation

In 2003, Exelon started a flow augmentation demonstration project, which pumped water from the Wadesville Mine Pool into the Schuylkill River. NAI and URS (2004 and 2011) conducted monitoring studies to determine the potential effects of the flow augmentation demonstration project on aquatic biota. Monitoring studies during the first year of the project indicated that the flow augmentation had no effect on water quality parameters such as total dissolved solids and pH (NAI and URS 2004). Aquatic biota monitoring included an assessment of macroinvertebrate and fish community composition and abundances before and after initiation of the demonstration project at upstream and downstream locations of the Norwegian Creek confluence with the Schuylkill River (NAI and URS 2004). NAI and URS sampled macroinvertebrates using kick nets and fish using electroshocking. Before the initiation of the demonstration project, predominant fish species included blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), white sucker and green sunfish (*Lepomis cyanellus*), while macroinvertebrate sampling revealed limited species diversity with decapods, oligochaetes, and Trichoptera comprising the majority of samples. Fish abundances and community composition remained similar following commencement of the demonstration project. However, macroinvertebrate diversity and abundance increased below the confluence of Norwegian Creek and the Schuylkill River (NAI and URS 2004). Exelon and the DRBC have extended the initial demonstration project on a year-to-year basis. The most recent assessment compared water quality and aquatic biotic from 2003 to 2011. NAI and URS (2011) reported no significant changes to water quality or aquatic biota species diversity or abundances within the Schuylkill River due to use of the Wadesville Mine Pool water using sampling methods described for the initial study conducted in 2003. As described in Section 2.1.6, Exelon plans to continue to rely more on use of Schuylkill River water for consumptive water use rather than Perkiomen Creek in the future (Exelon 2012b).

<u>Perkiomen Creek</u>

As described in Section 2.1.6, LGS withdraws water from Perkiomen Creek, rather than the Schuylkill River, if the flow conditions in the Schuylkill River do not meet DRBC criteria for water use. Maintenance of minimal flow in Perkiomen Creek to meet the DRBC criteria often requires diversion of Delaware River water via East Branch Perkiomen Creek as discussed in Section 2.1.6.

The Perkiomen Creek enters the middle reach of the Schuylkill River at RM 32.3 which is 25.7 stream km (16 stream miles) downstream of LGS (Exelon 2011b). Perkiomen Creek supports a warm water fishery with migratory fishes (Rhoads and Block 2008). The watershed includes predominantly agricultural and increasingly more residential land uses. Few large industrial facilities operate within the watershed, although some municipal wastewater treatment plants discharge to Perkiomen Creek (PECO 1984, PADEP 2003). The Perkiomen Railroad historically ran along a portion of Perkiomen Creek. The rail bed today is now part of the Perkiomen Trail used for recreation (Rhoads and Block 2007). The Pennsylvania Fish and Boat Commission (PFBC), in partnership with American Rivers, is currently proposing to restore habitat in the creek for diadromous fish, including American eels, alewife, and blueback herring (NMFS 2012c).

Biological Communities in Perkiomen Creek

Pre-operational biotic sampling of Perkiomen Creek began in 1970 and included surveys of macroinvertebrates and fish in the 1970s and early 1980s, ichthyoplankton from 1973 through 1975, and phytoplankton in 1974 (PECO 1984; RMC 1984, 1985, 1989). Post-operational biotic sampling included surveys of macroinvertebrates from 1996 through 2007 (Stroud 2011) and fish from 1985 to 1987 (RMC 1986, 1987, 1988).

Periphyton and Phytoplankton. Surveys from 1973 through 1974 indicated that diatoms dominated periphyton and phytoplankton communities (PECO 1984). The most common diatom was *Navicula*, which is a benthic diatom that occurs throughout the year in Perkiomen Creek. No additional LGS-related studies were conducted to examine plankton and periphyton communities since 1974.

Macroinvertebrates. Pre-operational benthic macroinvertebrate surveys indicated that a diverse and productive macrobenthos occurs within Perkiomen Creek (NRC 1984). Caddisflies, black flies, and Chironomidae (midges) dominated the collected species. PECO (1984) collected the greatest overall biomass during the fall.

Stroud Water Research Center (Stroud) conducted a diversity assessment of macroinvertebrates between 1996 and 2007 using hand-picked collection of rocks and Hess samplers (Stroud 2011). The goal of the study was to use macroinvertebrate diversity as an indicator of water and habitat quality. Stroud evaluated the diversity at different areas of Perkiomen Creek by calculating the macroinvertebrate aggregated index for streams (MAIS) score. The MAIS score incorporates 10 indices, such as the number of sensitive taxa and diversity of certain taxa, to come up with a score of 0 through 20. Sites with an MAIS score of 0 to 6 are considered “Poor,” 6.1 to 13 “Fair,” and 13.1 to 20 “Good.” Stroud (2011) ranked the lower Perkiomen Creek as fair and assigned the site an MAIS value of 9.5 (Stroud 2011). The most abundant taxa included Chironomidae (midges), Elmidae (riffle beetles), and Oligochaeta (aquatic earthworms) (Stroud 2011). Midges also dominated samples collected during pre-operational studies (PECO 1984).

Fish. Pre-operational studies employed seines and electrofishing to survey juvenile and adult fish (PECO 1984). In addition, drift and shoreline traps were used to survey fish larvae (PECO 1984). Fish sampling efforts between 1970 and 1987 indicated that Perkiomen Creek supports fish assemblages typical of same-sized southeastern Pennsylvania lotic systems (PECO 1984; RMC 1984, 1985, 1986, 1987, 1988). Carp and minnows dominated larval fish collections, while dominant adult and juvenile species included minnows and sunfishes (PECO 1984).

After operations began at LGS, RMC sampled Perkiomen Creek as part of the annual nonradiological monitoring program for LGS from 1985 through 1986. Species diversity for adult fish remained similar to pre-operational studies with redbreast sunfish being the predominant species (RMC 1986, 1987, 1988).

LGS-related studies did not include ichthyoplankton surveys after operations began or juvenile or adult surveys following initiation of the Point Pleasant Water Diversion Project in 1988. However, the current fish community in Perkiomen Creek is likely similar to the current fish community in the East Branch Perkiomen Creek, which NAI (2010b, 2010c) sampled for fish from 2001 through 2009, as described below. The two creeks likely have similar fish communities because the creeks are in the same watershed, the East Branch Perkiomen Creeks flows into Perkiomen Creek, similar land uses (and related anthropogenic stresses) surround both creeks, and because both creeks provide similar habitats for fish. Furthermore, LGS-related studies collected a total of 54 fish species in East Branch Perkiomen Creek and Perkiomen Creek between 1970 and 2009 (Exelon 2011b). Of the 54 fish species collected, 47 species (87 percent) were collected in both waterbodies (Exelon 2011b). Based on the historical similarities in fish communities, the hydraulic connection of the two creeks, and similar habitats, NRC staff expects that the current fish communities would be similar in Perkiomen Creek and East Branch Perkiomen Creek.

Recreational fishing in Perkiomen Creek existed historically for sunfishes, pike fishes, and carp (NRC 1984). Currently, the PFBC stocks Perkiomen Creek with brown trout (*Salmo trutta*) and rainbow trout (*Onchorhynchus mykiss*) in Montgomery County (PFBC 2011a).

<u>East Branch Perkiomen Creek</u>

As part of the transfer of water from the Delaware River to the Perkiomen Creek, a series of pumping stations delivers Delaware River water from the Point Pleasant Pump Station to the Bradshaw Reservoir by pipeline and then to East Branch Perkiomen Creek by pipeline (see Section 2.1.6). The water then flows from the East Branch Perkiomen Creek to Perkiomen Creek.

The East Branch Perkiomen Creek joins the Perkiomen Creek approximately 18 stream km (11.2 stream miles) upstream of the Perkiomen Creek and Schuylkill River confluence. The East Branch Perkiomen Creek is a warm water stream with riffles, runs, and shallow pools (Exelon 2011b).

Biological Communities in East Branch Perkiomen Creek

Aquatic sampling in the East Branch Perkiomen Creek before LGS operations included surveys of phytoplankton from 1973 through 1974, macroinvertebrates and fish in the 1970s through 1984, and ichthyoplankton from 1973 through 1975 (PECO 1984; RMC 1984, 1985, 1989). Aquatic sampling after LGS operations began includes surveys of macroinvertebrates and fish from 1985 through 1986 and 2001 through 2009 (RMC 1986, 1987; Exelon 2011b; NAI 2010b, 2010c).

Periphyton and Phytoplankton. Surveys from 1973 through 1974 indicated that diatoms dominated periphyton and phytoplankton communities (PECO 1984). The most common diatoms were *Navicula*, *Melosira*, *Synedra*, *Nitzschia*, and *Cocconeis*. No additional LGS-related studies were conducted to examine plankton and periphyton communities since 1974.

Macroinvertebrates. Aquatic sampling for macroinvertebrates occurred from 1970 through 1987, 1979 through 1986, and 2001 through 2009 (Exelon 2011b; NAI 2010b, 2010c; PECO 1984; RMC 1986, 1987). Sampling methods followed those previously described under the studies described for Perkiomen Creek. Pre-operational sampling indicated that a diverse macroinvertebrate community made up of a variety of aquatic insects, annelids, and mollusks occurred within the East Branch Perkiomen Creek (PECO 1984). Subsequent sampling between 1983 and 1986 showed similar diversity with the earlier studies. In addition, the biotic communities in the East Branch Perkiomen Creek resembled those found in the Perkiomen Creek with regard to macroinvertebrate assemblages (Exelon 2011b). After LGS operations began, RMC (1986 and 1987) reported the most abundant taxa as oligochaetes, stoneflies, caddisflies, snails, and clams from 1985 through 1986.

After the initiation of the Point Pleasant water diversion project, which transported water from the Delaware River to East Branch Perkiomen Creek, NAI (2010b, 2010c) sampled macroinvertebrates between 2001 and 2009 using methods similar to those reported by RMC. This study was part of an analysis to examine post-operational effects of the Point Pleasant water diversion effort (Exelon 2011b). NAI (2010b, 2010c) observed similar levels of macroinvertebrate species diversity as compared to pre-diversion sampling. Midges and oligochaetes dominated samples both before and after the diversion project. However, after the diversion project, less variability existed along the stream gradient and pollution-sensitive species increased in abundance over time (NAI 2010b, 2010c).

Fish. Fish studies from 1970 through 1976 examined fish larvae using drift nets and juvenile and adult fish using seines and electroshocking (PECO 1984). White sucker, yellow bullhead, sunfish, and minnows dominated larval fish samples (PECO 1984). Common species collected in juvenile and adult fish surveys included minnows, sunfish, shiners, banded killifish, suckers, catfish, and pike (PECO 1984). Species abundances varied by sampling site, suggesting possible species zonation along the regions sampled.

From 1985 through 1987, dominant species in the seining and electrofishing studies included shiners, minnows, suckers, and sunfish (RMC 1986, 1987, 1988). NAI (2010b, 2010c) sampled for fish in East Branch Perkiomen Creek from 2001 through 2009. Dominant species included sunfishes and minnows, which is similar to the dominant species captured in previous studies (NAI 2010b, 2010c). NAI (2010b, 2010c) did not observe approximately one quarter of the species identified in the 1970s and 1980s surveys. NAI (2010b, 2010c) may not have observed these species because they are no longer present or because the aquatic biota was sampled more frequently in the 1970s and 1980s, which would make it more likely that the surveys captured more species (Exelon 2011b). As with the macroinvertebrate sampling, NAI (2010b, 2010c) noted that pollution-sensitive fish species increased in abundance and that less variability existed between sampling locations.

Recreational fishing in East Branch Perkiomen Creek existed historically for catfish, sunfishes, and pike fishes (NRC 1984). Currently, the PFBC stocks East Branch Perkiomen Creek with brown trout and rainbow trout in Montgomery County (PFBC 2011a).

<u>Delaware River</u>

The Delaware River flows 531 km (330 miles) from its origin in southern New York to the Delaware Bay. Historically, degradation of the Delaware River began as early as the late 1700s and by 1940, the Delaware River was considered one of the most polluted rivers in the United States. The Delaware River has high vessel traffic ports along with a large concentration of industry and oil-refinery plants (Albert 1988). The toxicity and low dissolved oxygen levels of the estuarine and tidal portions of the Delaware River presented a chemical barrier for fish to complete migration from the tidal to freshwater portions of the Delaware River. Restoration efforts started in the 1960s and continue to this day. The DRBC manages water resources and contaminant levels in the Delaware River (Albert 1988).

The Point Pleasant Pump Station, which withdraws water that is transferred to the East Branch Perkiomen Creek, occurs at RM 157. The Point Pleasant Pump Station is above the salt line, or the boundary where salt intrudes the river from tidal flows (Exelon 2011b). Riffle, run, and pool habitat characterize the Delaware River within 2.5 km (1.5 miles) upstream and downstream of the Point Pleasant Pump Station.

Biological Communities in the Delaware River

Aquatic sampling in the Delaware River before LGS operations included surveys for macrophytes, macroinvertebrates, and fish from 1972 through 1973 and ichthyoplankton from 1979 through 1984 (NRC 1984; PECO 1984; RMC 1984, 1985). Once operations began, RMC (1986) sampled ichthyoplankton in 1985.

Periphyton and Macrophytes. Similar to the other waterbodies discussed above, diatoms dominated periphyton samples collected in the early 1970s (Exelon 2011b). Pre-operational monitoring for macrophytes indicated that water milfoils (*Myriophyllum* sp.) were common in back eddies near the Point Pleasant Pump Station (Exelon 2011b). No additional LGS-related studies have been conducted near the Point Pleasant Pump Station to examine periphyton and macrophyte communities since 1973.

Macroinvertebrates. Aquatic sampling for macroinvertebrates occurred from 1972 through 1973 using dip nets, hand removal, and stationary fine mesh nets. Sampling areas included approximately 2 km (1.2 miles) upstream to 2.4 km (1.5 miles) downstream of Point Pleasant Pump Station. Samples included aquatic insects, snails, clams, mollusks, and worms (Exelon 2011b). Dominant taxa within dip net samples included chironomid midges and amphipods (Exelon 2011b). No additional LGS-related macroinvertebrate studies have been conducted near the Point Pleasant Pump Station since 1973.

DRBC conducted a diversity assessment of macroinvertebrates between 2001 and 2008 throughout the non-tidal portion of the Delaware River (DRBC 2009). DRBC collected invertebrates annually using kick nets at 25 sites along the river, including two sites within 3 RM of the Point Pleasant Pump Station. DRBC calculated a multi-metric Index of Biotic Integrity (IBI) score, which was composed of 6 ecological metrics, including species richness (total number of species), EPT Richness (total number of species within three insect orders: Ephemeroptera, Plecoptera, Trichoptera), Shannon-Wiener Diversity (an index of species diversity based on the relative abundance and total number of species), the Biotic Index (an index based on the relative abundance of species sensitive to environmental stress), Intolerant Percent Richness (the percent of species intolerant to environmental stress relative to the overall number of species), and Scraper Richness (degree of overlap and number of select invertebrate species). The IBI score for the two sites near the Point Pleasant Pump Station was generally similar to or slightly less than the IBI score of upriver sites within the Delaware Watergap National Recreation Area and the Upper Delaware Scenic & Recreational River (DRBC 2009). These results suggest that the area surrounding the Point Pleasant Pump Station is similar to, or slightly more disturbed, than upriver sites within Federally designated areas.

Fish. RMC and PECO surveyed ichthyoplankton in the Delaware River from 1972 through 1973 and 1979 through 1985 using drift and push nets (PECO 1984; RMC 1984, 1985, 1986). RMC sampled ichthyoplankton near the Point Pleasant Pump Station and downriver to RM 138 near Yardley, Pennsylvania (RMC 1984, 1985, 1986). Dominant species within ichthyoplankton samples included herring (Clupeidae), *s*unfish, American shad, and common carp eggs and larvae.

Adult fish studies were conducted from 1972 through 1973 and 1979 through 1980 in the vicinity of the Point Pleasant Pump Station using seines, fyke nets, and trap nets (Exelon 2011b). The most common taxa included sunfishes, shiners, and catfishes (Exelon 2011b). The adult fish studies also observed anadromous species such as the alewife, American shad, and blueback herring (Exelon 2011b). These species used this region of the Delaware River as a nursery area (Exelon 2011b). No additional LGS-related studies have been conducted near the Point Pleasant Pump Station to examine adult fish communities since 1980.

PFBC sampled American shad in the non-tidal portion of the Delaware River at RM 178.9, which is approximately 20 RM upstream of the Point Pleasant Pump Station (PFBC 2011c). PFBC conducted the electrofishing surveys during the spring from 1997 through 2001 and 2010 through 2011. The average annual catch per unit effort (CPUE) ranged from approximately 11 to 50 shad per hour (PFBC 2011c). All females collected in 2011 were gravid, indicating that the females had produced eggs but had not yet spawned or released the eggs into the river.

Recreational and commercial fishing occur in the Delaware River (NYSDEC 2009). Common recreational species caught in the non-tidal portion of the Delaware River include American shad, American eel, channel catfish, rainbow trout, smallmouth bass, striped bass (*Morone saxatilis*), and walleye (PFBC 2012d; Versar 2003). In 2003, river herring and hickory shad comprised a small portion of the catches (Versar 2003). As of October 2012, river herring and hickory shad fisheries are closed in the Delaware River (PFBC 2012d).

<u>Onsite Water Bodies</u>

Two streams, Possum Hollow Run and Brooke Evans Creek, run parallel to each other and flow through the LGS site. LGS discharges industrial wastewater and stormwater to Possum Hollow Run under NPDES compliance (Exelon 2012b). Brooke Evans Creek is a freestone stream and a tributary to the Schuylkill River (PADEP 2006a). The Commonwealth of Pennsylvania designates both streams with water use protection for maintenance and propagation of flora and fauna indigenous to warm water habitat (Pa. Code 93.3).

Exelon has not conducted any sampling or monitoring of aquatic biota in Possum Hollow Run (Exelon 2012b). PADEP (2006a) conducted an evaluation of indigenous aquatic biota as an indicator of long-term water quality conditions in Brooke Evans Creek. PADEP staff collected benthic macroinvertebrate data and assessed habitat using a modified index of biotic integrity protocols under PADEP's antidegradation implementation guidance (PADEP 2006a). PADEP observed relatively high abundances of macroinvertebrates tolerant of water quality degradation, indicating that human activity in the basin has influenced the habitat quality and composition of aquatic biota within Brooke Evans Creek.

2.2.6.2 NOAA Trust Resources

NOAA trust resources include, but are not limited to, commercial and recreational fishery resources, anadromous species (fish that spawn in freshwater and then migrate to salt water), catadromous species (species that spawn in salt water and then migrate to freshwater), and threatened and endangered species. NOAA trust resources in the Schuylkill River and Perkiomen Creek include alewife, blueback herring, American shad, striped bass, hickory shad, bluefish, yellow perch, white perch, bay anchovy, and American eel and their habitat (NMFS 2012a). Alewife, blueback herring, American shad, striped bass, hickory shad, and white perch are anadromous species that spawn in freshwater, such as the Delaware River and its estuary, and then return to the Atlantic Ocean after spawning (PFBC 2012c). American eel is a catadromous species that spawns in the Atlantic Ocean and returns to the Delaware River after spawning (PFBC 2012c). Table 2–2 describes the NOAA trust species that have been observed in LGS-related surveys of the Delaware River, Perkiomen Creek, East Branch Perkiomen Creek, and the Schuylkill River. As noted above, dams throughout the Schuylkill River historically have limited the movement of migrating fish. More recent efforts to remove dams, the addition of fish ladders, and stocking rivers with fry have helped to increase the population of anadromous fish (NMFS 2012a).

Table 2–2. NOAA Trust Resources Observed in LGS-related Aquatic Studies

	Schuylkill River[a]	East Branch Perkiomen Creek[b]	Perkiomen Creek[c]	Delaware River[d]
Alewife	X			X
American eel	X	X	X	X
American shad	X			X
Bay anchovy				
Blueback herring				
Bluefish				
Hickory shad				
Striped bass				
White perch	X			X
Yellow perch	X	X	X	X

(a) LGS-related surveys occurred from 1970–1976, 1979–2004, and 2009.
(b) LGS-related surveys occurred from 1970–1976, 1979–1987, and 2001–2009.
(c) LGS-related surveys occurred from 1970–1977 and 1979–1987.
(d) LGS-related surveys occurred from 1972–1973 and 1982–1985 near the Point Pleasant Pumping Station on the Delaware River.
Note: A blank cell indicates that the species was not observed during LGS-related surveys.

Source: Exelon 2011

2.2.6.3 Invasive or Introduced Aquatic Species

Hydrilla (*Hydrilla verticillata*), an aquatic plant, forms dense mats at the surface of waterbodies and reduces light to aquatic plants residing below. Hydrilla can also impair commercial water use by clogging pipes and reducing flow rates (Sea Grant Pennsylvania 2012). Hydrilla grows in freshwater habitats and tolerates a wide range of environmental conditions. Hydrilla occurs in the Schuylkill River near Philadelphia, Pennsylvania (Exelon 2011b).

The Asiatic clam (*Corbicula fluminea*) can be problematic for nuclear facilities in terms of biofouling in the intake and circulating water systems (NRC 1996). NAI indicated that this invasive organism is present in the Schuylkill River upstream and downstream of LGS (NAI 2010a, 2010d), in Perkiomen Creek near the Perkiomen Pumphouse (NAI 2010d), East Branch Perkiomen Creek (NAI 2010b, 2010c), and the Delaware River near the Point Pleasant Pump Station (RMC 1989).

Zebra mussels (*Dreissena polymorpha*) actively filter feed large amounts of freshwater and remove available plankton food sources making less food available for other aquatic organisms (Sea Grant Pennsylvania 2007). Exelon conducted surveys to determine if any zebra mussels were present near the LGS intakes in the Schuylkill River and in Perkiomen Creek (Exelon 2011b). Exelon did not find evidence of zebra mussels in the Schuylkill River or Perkiomen Creek (Exelon 2011b; NAI 2010d).

2.2.7 Terrestrial Resources

2.2.7.1 LGS Ecoregion

The LGS site lies in the Triassic Lowlands portion of the Northern Piedmont ecoregion (EPA 2010). The Triassic Lowlands contain wide undulating ridges and broad, nearly level, valleys with limited local relief. Appalachian oak forest dominated by white oak (*Quercus alba*) and red oak (*Q. rubra*) is the most prevalent forest community. Hickory (*Carya* spp.) is more abundant in this region of the Piedmont because of the less acidic soils, while red maple (*Acer rubrum*) and black tupelo (*Nyssa sylvatica*) are present but less abundant than in other portions of the Northern Piedmont ecoregion (EPA 2010). Streams, wetlands, and a few ponds occur in the Triassic lowlands. Farms and houses have replaced much of the native vegetation, and suburban development intensifies nearer to Philadelphia (EPA 2010), which lies about 21 miles (34 km) southeast of the LGS site. In the immediate vicinity of the LGS site, land uses include light residential development, agriculture, old fields, and woodlands.

The LGS site is included in the Upper Schuylkill Conservation Landscape. The Montgomery County Planning Commission designated this as one of 13 conservation landscapes in the county that have high natural biodiversity. The Upper Schuylkill Conservation Landscape totals 2,392 ac (968 ha) and extends from just above Royersford Borough to the Berks County line. The conservation landscape includes 1,064 ac (431 ha) of forest, about 275 ac (111 ha) of which qualify as interior forest. Although this area, especially along the Schuylkill River, has been the site of intensive industrial development, riparian habitat remains along the Schuylkill River and some of its tributaries, such as Possum Hollow Run and Brook Evans Run, which enter the Schuylkill River from the LGS site (Rhoads and Block 2008).

The riparian area of the Schuylkill River is included in the river's designation as a Pennsylvania Scenic River (PDCNR 2010). The Pennsylvania Department of Conservation and Natural Resources (PDCNR) manages designated scenic rivers that are free-flowing and capable of supporting water-based recreation and aquatic life.

Pennsylvania State Game Land #234 lies about 2 miles (3.2 km) southeast of the LGS site on the east side of the Schuylkill River in close proximity to the Limerick-to-Cromby 230-kV transmission line corridor (220-60 line) (PGC 2011). Pennsylvania State Game Lands are managed by the Pennsylvania Game Commission (PGC) for hunting, trapping, and fishing.

2.2.7.2 LGS Site

Before construction of the LGS plant, the LGS site consisted primarily of immature, nearly climax oak-hickory forest, and some fruit orchards (AEC 1973). LGS construction disturbed about 270 ac (110 ha; 42 percent of the current LGS site) (AEC 1973). PECO (which constructed and first operated LGS) seeded temporarily disturbed areas with perennial grasses after construction (AEC 1973, NRC 1984). When LGS first began operating in 1984, mixed deciduous forest occurred along the Schuylkill River, Possum Hollow Run, and in an area approximately 50 m (164 ft) west of the LGS Unit 1 cooling tower (NRC 1984). Today, riparian and upland forest, small forested and emergent wetlands, pioneer herbaceous, old fields, agricultural fields, and developed areas occupy the site (Exelon 2011a; WHC 2006). A description of each of these habitats appears below. Several linear corridors run through the LGS site, including utility distribution rights-of-way that are maintained as grass or scrub-shrub habitat (WHC 2006).

Forest habitat on the LGS site includes both lowland riparian and upland communities. Riparian forest occurs along the banks of the Schuylkill River and smaller tributaries such as Brooke Evans Creek and Possum Hollow Run. Tree species in these areas include silver maple (*Acer saccharinum*), American sycamore (*Plantanus occidentalis*), American elm (*Ulmus* *americana*), and slippery elm (*U. rubra*). Riparian forest provides food, cover, and reproductive habitat to wildlife. For example, during spring, forest depressions may collect water and form ephemeral pools that amphibians use for breeding and waterfowl and neotropical migrant birds use as stopover habitat. Riparian forest provides dispersal and seasonal migration corridors. Upland forest supports common tree species, such as white ash (*Fraxinus americana*), tulip poplar (*Liriodendron tulipifera*), red maple, chestnut oak (*Quercus prinus*), American elm, black walnut (*Juglans nigra*), slippery elm (*Ulmus rubra*), flowering dogwood (*Cornus florida*), bitternut hickory (*Carya cordiformis*), American beech (*Fagus grandifolia*), and red oak. Upland forest also provides food, cover, and reproductive habitat for wildlife (Exelon 2010a).

Small palustrine forested and emergent wetlands on the LGS site are important habitat for wildlife, especially amphibians. Red maple and silver maple typically dominate the palustrine forested wetlands on the LGS site. Common vegetation in palustrine emergent wetlands includes sedges (*Carex* spp.), microstegium (*Eulalia viminea*), bedstraws (*Galium* spp.), arrow-leaf tearthumb (*Polygonum sagittatum*), halberd-leaf tearthumb (*Polygonum arifolium*), flatsedges (*Cyperus* spp.), hollow joe-pye-weed (*Eupatoriadelphus fistulosus*), and swamp milkweed (*Ascelpias incarnata*) (Exelon 2010a).

Pioneer herbaceous habitat on the LGS site consists of plant communities that colonize areas following disturbances such as construction, grading, and periodic mowing. This plant community typically consists of wineberry (*Rubus phoenicolasius*), mugwort (*Artemisia vulgaris*), multiflora rose (*Rosa multiflora*), lesser celandine (*Ranunculus ficaria*), orchardgrass (*Dactylis glomerata*), foxtails (*Alopecurus* spp.), white goosefoot (*Chenopodium album*), spotted lady's thumb (*Polygonum persicaria*), Pennsylvania smartweed (*Polygonum pensylvanicum*), cespitose knotweed (*Polygonum cespitosum*), curly dock (*Rumex crispus*), wild carrot (*Daucus carota*), white amaranth (*Amaranthus albus*), butter-and-eggs (*Linaria vulgaris*), red clover (*Trifolium pretense*), yellow sweetclover (*Melilotus officinalis*), white sweetclover (*Melilotus alba*), and Deptford pink (*Dianthus armeria*). This habitat is of low value to native wildlife, but it is beneficial to some species such as white-tailed deer, eastern cottontail (*Sylvilagus floridanus*), and meadow vole (*Microtus pennsylvanicus*) (Exelon 2010a).

Old field habitat on the LGS site consists of abandoned agricultural areas that are either in the meadow (grasses and forbs) or scrub/shrub state of succession. Old field meadow habitat supports grasses such as fescue (*Festuca* spp.), Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pretense*), and orchardgrass, and forbs such as Canada goldenrod (*Solidago canadensis*), daisy fleabane (*Erigeron strigosus*), evening primrose (*Oenothera biennis*), dwarf cinquefoil (*Potentilla candensis*), wild carrot, teasel (*Dipsacus fullonum*), red clover, smartweeds (*Polygonum* spp.), and shrubs such as brambles (*Rubus* spp.). Common wildlife species include white-tailed deer, red fox (*Vulpes vulpes*), eastern cottontail, raccoon (*Procyon lotor*), and Virginia opossum (*Didelphis virginiana*) (Exelon 2010a).

Agricultural fields on the LGS site contain crops such as corn, wheat, barley, soybeans, and hay. Agricultural areas also support hedgerows of upland tree species such as black cherry (*Prunus serotina*), black walnut (*Juglans nigra*), Osage orange (*Maclura pomifera*), white ash (*Fraxinus americana*), red cedar (*Juniperus virginiana*), tulip poplar (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*), and common hackberry (*Celtis occidentalis*). These areas provide cover and food for wildlife species such as white-tailed deer that are adapted to edge habitats (Exelon 2010a).

Buildings, asphalted parking lots, roads, landscaping, and mowed lawns occupy the developed portions of the LGS site. Mowed lawns consist largely of non-native cool season grasses that are of minimal value to native wildlife species. Landscaped areas contain mostly non-native ornamental species, some of which may serve as nesting habitat, cover, and food sources for some native bird species (Exelon 2010a).

Common mammal species on the LGS site include the white-tailed deer, raccoon, striped skunk (*Mephitis mephitis*), red fox, Virginia opossum, eastern cottontail, gray squirrel (*Sciurus carolinensis*), groundhog (*Marmota monax*), and white-footed mouse (*Peromyscus leucopus*) (Exelon 2010a; Kriner and MacDonald 2009; NRC 1984).

Common bird species on the LGS site include game birds such as Canada goose (*Branta canadensis*) and mourning dove (*Zenaida macroura*); raptors such as red-tailed hawk (*Buteo jamaicensis*) and turkey vulture (*Cathartes aura*); resident songbird species such as northern cardinal (*Cardinalis cardinalis*); and neotropical migrant songbirds such as Baltimore oriole (*Icterus galbula*), indigo bunting (*Passerina cyanea*), and red-eyed vireo (*Vireo olivaceous*). Other avian species include eastern bluebird (*Sialia sialis*), American robin (*Turdus migratorius*), eastern towhee (*Pipilo erythrophthalmus*), tufted titmouse (*Baeolophus bicolor*), downy woodpecker (*Picoides pubescens*), blue jay (*Cyanocitta cristata*), American crow (*Corvus brachyrhynchus*), killdeer (*Charadrius vociferous*), barn swallow (*Hirundo rustica*), tree swallow (*Tachycineta bicolor*), purple martin (*Progne subis*), and the introduced European starling (*Sturnus vulgaris*) (Blye 1973; Exelon 2010a; Kriner and MacDonald 2009). The U.S. Geological Survey has also regularly recorded all of these species during its annual Breeding Bird Survey along the Schwenksville route (Sauer et al. 2011). This route, which runs near Pottstown (USGS 2001), lies about 3 miles to the northwest of the LGS site.

Reptiles that inhabit the riparian habitat bordering the Schuylkill River and its tributaries on the LGS site include the northern black racer (*Coluber constricter*), northern ring-necked snake (*Diadophis punctatus punctatus*), eastern garter snake (*Thamnophis sirtalis*), water snake (*Nerodia sipedon*), spotted turtle (*Clemmys guttata*), mud turtle (*Trachemys scripta*), eastern box turtle (*Terrapene carolina carolina*), and eastern painted turtle (*Chrysemys picta picta*). Amphibians that inhabit the LGS site include the red-backed salamander (*Plethodon cinereus*), long-tailed salamander (*Eurycea longicauda*), northern two-lined salamander (*Eurycea bislineata bislineata*), American toad (*Bufo americanus*), spring peeper (*Pseudacris crucifer*), bullfrog (*Rana catesbeiana*), leopard frog (*Rana pipiens*), and green frog (*Rana clamitans*) (Exelon 2010a, Kriner and MacDonald 2009). The amphibians range from fully aquatic (e.g., bullfrog) to semiaquatic (e.g., toad species) and are closely tied to water habitats, including streams, wetlands, and temporary pools where they reproduce. The frog and toad species, except the bullfrog, also make extensive use of adjacent terrestrial habitats, such as forest, grassland, and cropland as juveniles and adults. The turtle species leave the water to nest (egg deposition) in nearby soft substrates.

Exelon joined the Wildlife Habitat Council in 2005, and since that time has formed an Environmental Stewardship Committee that has developed a Wildlife Management Plan (Exelon 2010b). The Wildlife Management Plan is a comprehensive strategy that outlines the goals of the wildlife habitat program for the LGS site and describes projects and milestones to achieve these goals. As part of the program, Exelon places and monitors artificial avian nesting structures and bat roost boxes (WHC 2006). In 2007, Exelon installed structures around the perimeter of the LGS site for eastern blue birds, purple martins, owls, raptors, other perching birds, and bats. In addition, in 2010, Exelon installed a 300-ft-(90-m)-long barrier between Possum Hollow Run and an adjacent road and parking area on the east side of the LGS site to decrease the mortality of amphibians during post-natal dispersal (Exelon 2010b). Exelon staff continues to develop the wildlife habitat enhancement program and evaluate future projects that would enhance the quality of the natural environment on the site. In 2010, Exelon received WHC's Corporate Wildlife Habitat Certification in recognition of its implementation of the wildlife habitat enhancement program (Exelon 2011b).

2.2.7.3 Transmission Line Corridors

Section 2.1.5 describes the transmission lines that were built to connect the LGS to the regional electricity grid and that are within the scope of this SEIS. Section 2.1.5 also describes vegetation maintenance along the transmission line corridors. The NRC is not aware of any biological field surveys or studies of these transmission line corridors. Habitat within the corridors is highly variable and includes suburban, residential, agricultural, forested, wetland/floodplain, and open water. The lines also traverse several parks and natural heritage areas, including the Evansburg State Park and Schuylkill River National and State Heritage Area (Exelon 2011b).

The NRC staff did not identify any ecological surveys or studies that provide information on habitats and species along the transmission line corridors. However, some studies on the transmission lines in southeastern Pennsylvania provide information on common vegetation and species along the LGS transmission line corridors. Common tree species in transmission line corridors in the northern Piedmont ecoregion of Pennsylvania include white ash, red maple, and sassafras (Bramble et al. 1992; Yahner et al. 2001; Yahner RH and Yahner RT 2007). Common shrub species include multiflora rose, Japanese honeysuckle (*Lonicera japonica*), blackberry (*Rubus allegheniensis*), dewberry (*R. hispidus*), gray dogwood (*Cornus paniculata*), black haw (*Viburnum prunifolium*), and poison ivy (*Toxicodendron radicans*) (Bramble et al. 1992, 1997; Yahner RH and Yahner RT 2007). Common forb species include goldenrod (*Solidago* spp.), strawberry (*Fragaria virginiana*), common cinquefoil (*Potentilla simplex*), goosegrass (*Galium aparine*), sow-thistle (*Sonchus oleraceus*), and mile-a-minute (*Polygonum perfoliatum*) (Bramble et al. 1992, 1997; Yahner RH and Yahner RT 2007). Common grass species include fall panic grass (*Panicum* spp.), deertongue grass (*Panicum clandestinum*), foxtail grass (*Setaria glauca*), and broomsedge (*Andropogon virginicus*) (Bramble et al. 1992, 1997; Yahner RH and Yahner RT 2007).

Common breeding bird species in transmission line corridors in the northern Piedmont ecoregion of Pennsylvania include the field sparrow (*Spizella pusilla*), black-throated blue warbler (*Dendroica caerulescens*), gray catbird (*Dumetella carolinensis*), rufous-sided towhee (*Pipilo erythrophthalmus*), common yellowthroat (*Geothlypis trichas*), American goldfinch (*Carduelis tristis*), and indigo bunting (Bramble et al. 1992). Amphibian species include the Jefferson salamander (*Ambystoma jeffersonianum*), redbacked salamander (*Plethodon cinereus*), spotted salamander (*Ambystoma maculatum*), and the American toad (Yahner et al. 2001). Reptile species include the eastern garter snake, northern ringneck snake (*Diadophis punctatus edwards*), black rat snake (*Pantherophis obsoletus*), and eastern box turtle (Yahner et al. 2001). Small mammals include the white-footed mouse, northern short-tailed shrew (*Blarina brevicauda*), and meadow vole (Yahner RH and Yahner RT 2007). Common butterfly species include the cabbage white (*Pieris rapae*), little wood-satyr (*Megisto cymela*), and great spangled fritillary (*Speyaria cybele*) (Bramble et al. 1997).

2.2.8 Protected Species and Habitats

The U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) jointly administer the Endangered Species Act (ESA) of 1973 (16 USC 1531 *et seq.*). The FWS manages the protection of and recovery effort for listed terrestrial and freshwater species, while the NMFS manages the protection of and recovery effort for listed marine and anadromous species.

Within Pennsylvania, the PGC, the PFBC, and the PDCNR oversee the protection of Commonwealth-listed species under the Pennsylvania Endangered Species Program. The PGC, PFBC, and PDCNR manage the recovery efforts for wild birds and mammals

(34 Pa. Code 133); fish, amphibians, reptiles, and aquatic organisms (30 Pa. Code 75); and native plants (17 Pa. Code 45), respectively.

The Magnuson–Stevens Fishery Conservation and Management Act (MSA), as amended, is administered by the NMFS. The MSA requires Federal agencies to consider the impact of Federal actions on essential fish habitat (EFH) and to consult with the NMFS if any activities may adversely affect EFH. The NMFS has not designated any EFH under the MSA within the affected waterbodies. However, in a letter dated June 27, 2012, NMFS stated that the Schuylkill River and Perkiomen Creek provide habitat for a variety of prey species consumed by Federally managed species whose EFH has been designated in the mixing zone of the Delaware River (NMFS 2012c). The NRC staff's EFH assessment was issued separately as part of the staff's consultation with NMFS under the MSA (see ML14195A346).

The FWS and NMFS have not designated any critical habitat under the ESA within the action area, nor has either agency proposed the listing or designation of any new species or critical habitat within the action area (Exelon 2011b; FWS 2011, 2012d; NMFS 2012a, 2012c).

2.2.8.1 Action Area

The implementing regulations for section 7(a)(2) of the ESA define "action area" as all areas affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area effectively bounds the analysis of ESA-protected species and habitats because only species that occur within the action area may be affected by the Federal action. The action area includes the lands and waters described below. The NRC staff expects all direct and indirect effects of the proposed action to be contained within these areas.

The majority of the LGS site lies in Limerick Township, Montgomery County, although a portion of the property extends into the adjacent Lower Pottsgrove Township in Montgomery County, and East Coventry Township in Chester County, directly across the Schuylkill River. The proposed license renewal would include continued operation of the site. License renewal would not involve any new construction or refurbishment activities on either the developed or the undeveloped portions of the site. The proposed license renewal would not require the construction or modification of the existing transmission system.[1]

The makeup water supply system includes a number of waterbodies and facilities off site of the LGS site. These include the Perkiomen Pumphouse (Montgomery County); the Bradshaw

[1] The GEIS (NRC 1996) does not define the scope of transmission lines that should be considered for the site-specific (Category 2) issue, "Threatened or Endangered Species." In 1999, NRC staff made a policy decision to consider the scope of transmission lines for its Threatened or Endangered Species analyses to be that defined at 10 CFR 51.53(c)(3)(ii)(H), which states that "If the applicant's transmission lines that were constructed for the specific purpose of connecting the plant to the transmission line system do not meet the recommendations of the National Electric Safety Code for preventing electric shock from induced currents, an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines must be provided." (NRC 1999). The NRC has consistently applied this scope to its Threatened or Endangered Species license renewal analyses since that time. In preparing the GEIS, Revision 1 (NRC 2013), the NRC staff reviewed and incorporated lessons learned and knowledge gained from license renewal environmental reviews conducted by the NRC since 1996. The 2013 GEIS recognizes that since construction, many transmission lines have been incorporated into the regional power grid and that in many cases, lines are no longer owned or managed by NRC licensees, and would, thus, remain energized regardless of license renewal. The 2013 GEIS concludes that "only those transmission lines that connect the power plant to the switchyard where electricity is fed into the regional distribution system (encompassing those lines that connect the nuclear plant to the first substation of the regional electric power grid) and power lines that feed the plant from the grid during outages are considered within the regulatory scope of license renewal environmental review[s]." In the case of LGS, two onsite switchyards connect Unit 1 and Unit 2 into the regional distribution system. Lines beyond these switchyards are owned and operated by PECO and not the NRC applicant, Entergy. These lines would stay in service regardless of LGS license renewal, and thus, would not be affected by the proposed action. For these reasons, the NRC staff will consider the scope of the transmission lines for its Threatened or Endangered Species analysis to be that defined in the 2013 GEIS. Under this definition, all in-scope transmission lines are contained within the footprint of the LGS site.

Reservoir and Bradshaw Pumphouse (Bucks County), which are located on 42 ac (17 ha) of Exelon-owned property; and the Bedminster Water Processing Facility (Bucks County), which is located on a 3 ac (1.2 ha) Exelon-owned property. Section 2.1.6 describes the LGS makeup water supply system in detail.

2.2.8.2 Aquatic Species and Habitats

The aquatic species described in this section and summarized in Table 2–3 are Federally listed or Pennsylvania-listed threatened, endangered, or species of special concern that may occur in the action area, as defined above. The three Federally listed species appear in bold in Table 2–3.

FWS, NMFS, and/or PFBC list the species in Table 2–3 as occurring within Montgomery, Chester, or Bucks Counties, Pennsylvania, which are the three counties associated with LGS. LGS infrastructure and associated waterbodies within Montgomery County include the main plant site (e.g., power block), the Schuylkill River, Perkiomen Creek and Pumphouse, and the East Branch Perkiomen Creek. LGS infrastructure and associated waterbodies in Chester County include portions of the main plant site on the other side of the Schuylkill River and transmission lines. LGS infrastructure and associated waterbodies in Bucks County include the Delaware River and Point Pleasant Pumping Station, the Bradshaw Reservoir and Bradshaw Pumphouse, and the Bedminster Water Processing (Treatment) Facility.

In addition to the species listed in the above table, LGS collected bridle shiner (*Notropis bifrenatus*), a Pennsylvania-listed endangered species, through 1977. LGS has not observed bridle shiner since 1977 (Exelon 2011b). Furthermore, PNHP (2012a) does not list this species as occurring within Bucks, Chester, or Montgomery Counties and PBFC (2011b) did not identify the species as a concern regarding the proposed license renewal. Therefore, this species is not considered further within this SEIS.

Table 2–3. Federally and Pennsylvania-Listed Aquatic Species

Scientific Name	Common Name	Federal Status[a]	State Status[b]	County(ies) of Occurrence[c]
Fish				
Acipenser brevirostrum	**shortnose sturgeon**	**FE**	**PE**	**B**
Acipenser oxyrinchus oxyrinchus	**Atlantic sturgeon**	**FE**	**PE**	**B**
Alosa aestivalis	blueback herring	SC	—	B, C, M
Alosa pseudoharengus	alewife	SC	—	B, C, M
Enneacanthus obesus	banded sunfish	—	PE	B
Lepomis megalotis	longear sunfish	—	PE	B
Notropis chalybaeus	ironcolor shiner	—	PE	B, M
Invertebrates				
Alasmidonta heterodon	**dwarf wedgemussel**	**FE**	**PE**	**B, C, M[d]**
Stygobromus pizzinii	Pizzini's cave amphipod	—	SSC	C, M
Aquatic Plants				
Myriophyllum farwellii	Farwell's water-milfoil	—	PE	B
Myriophyllum heterophyllum	broad-leaved water milfoil	—	PE	B
Nymphoides cordata	floating-heart	—	PT	B
Potamogeton pulcher	spotted pondweed	—	PE	B

[a] Federal status determined by the FWS and NMFS under the authority of the Endangered Species Act; FE = endangered, FT = threatened, — = not listed. NMFS determines whether aquatic resources are SC = Species of Concern (NMFS 2012).

[b] Commonwealth of Pennsylvania status determined by the PFBC under the Pennsylvania Endangered Species Program; PE = endangered, PT = threatened, SSC = species of special concern; — = not listed (PNHP 2012a).

[c] The LGS site lies in Montgomery County; the in-scope transmission lines traverse Montgomery and Chester Counties; and the offsite facilities associated with the LGS makeup water system lie in Montgomery and Bucks Counties. B = Bucks County, C = Chester County, M = Montgomery County.

[d] FWS (2012d) lists the dwarf wedgemussel as known to or believed to occur in Monroe, Pike, and Wayne Counties, Pennsylvania, which do not contain LGS-related infrastructure or waterbodies. PNHP (2012a) lists the dwarf wedgemussel as potentially occurring in Bucks, Chester, and Montgomery Counties. PECO (1984) observed rare, unidentified species of the genus *Alasmidonta* in the Schuylkill River in the 1970s and it is unknown whether the specimen was the dwarf wedgemussel (Exelon 2011b).

<u>Fish</u>

Shortnose Sturgeon *(Acipenser brevirostrum)*

The shortnose sturgeon was initially listed as a Federally endangered species in 1967 and is designated as a Pennsylvania endangered species (NMFS 2012b; PNHP 2012a). Adult shortnose sturgeon use freshwater for spawning and estuarine and marine habitats for feeding. Juveniles migrate downriver to estuarine waters and may go back and forth between freshwater and estuarine habitats for several years before maturing to adults. Adults sometimes migrate to marine habitats for feeding, but primarily inhabit estuarine habitats (NMFS 2012b; Rohde et al. 1994). Spawning occurs in freshwaters characterized by low-to-moderate velocities and over substrates that include clay, sand, gravel, and woody debris. Eggs are adhesive and survival depends on water having little turbidity (Rohde et al. 1994). Sturgeon feed on benthic invertebrates such as snails, insect larvae, crustaceans, and worms (Gilbert 1989).

In Pennsylvania, populations of shortnose sturgeon inhabit the Delaware River (Hastings et al. 1987; O'Herron et al. 1993). Hastings et al. (1987) surveyed shortnose sturgeon movement in the Delaware River and estimated an overwintering population of about 6,000 to 14,000 fish in the upper tidal portion of the Delaware River near Trenton, NJ at river kilometer (RKm) 211.8 (river mile [RM] 131.6) (Hastings et al. 1987). Sturgeon moved upstream into the non-tidal reach of the river in late March presumably to spawn before traveling downstream to lower tidal waters near Philadelphia (O'Herron et al. 1993). Hastings et al. (1987) observed upstream movement to non-tidal water as far as Lambertville, NJ at RKm 238 (RM 147.9). This location is approximately 15 river km (9.1 river miles) from the Point Pleasant Pumping Station, which is located at RM 157 (RKm 253).

Shortnose sturgeon occur in Bucks County (PNHP 2012a, NMFS 2012a). On the Delaware River, LGS-related studies from 1979 to 1985 did not capture shortnose sturgeon eggs or larvae near the Point Pleasant Pumping Station and downriver to RM 138 (RKm 222.1) (Exelon 2011a; RMC 1984, 1985, 1986). NMFS (2012a) concluded that no species listed under the ESA occur within the action area.

Atlantic Sturgeon *(Acipenser oxyrinchus oxyrinchus)*

The Atlantic sturgeon is currently listed as a Federally endangered species for the New York Bight distinct population segment, which includes the Delaware River (77 FR 5880). The Atlantic Sturgeon is also designated as a Pennsylvania endangered species (PNHP 2012a). Atlantic sturgeon share many life-history characteristics with the shortnose sturgeon in that adults migrate to freshwater to spawn and feed on benthic invertebrates such as worms, crustaceans, and aquatic insects (Gilbert 1989). Unlike shortnose sturgeon, adult Atlantic sturgeon prefer more marine habitats and make extensive migrations away from natal estuaries beginning as subadults (Gilbert 1989).

Atlantic sturgeon occur in Bucks County (PNHP 2012a, NMFS 2012a). Historically, the Delaware River supported the largest population of Atlantic sturgeon along the Atlantic coast (Secor and Waldman 1999). Tagging studies in 2005 and 2006 indicated that Atlantic sturgeon followed similar migration patterns as shortnose sturgeon with spawning potentially occurring between mid-to-late June in the upper tidal Delaware reaches between Philadelphia, Pennsylvania, and Trenton, New Jersey (Simpson and Fox undated).

LGS-related studies from 1979 to 1985 did not observe Atlantic sturgeon eggs or larvae near the Point Pleasant Pumping Station and downriver to RM 138 (RKm 222.1) (Exelon 2011b; RMC 1984, 1985, 1986). NMFS concluded that no species listed under the ESA occur within the action area (NMFS 2012c).

Alewife and Blueback Herring *(Alosa pseudoharengus and A. aestivalis)*

In its June 2, 2012, letter to the NRC, NMFS stated that alewife (*Alosa pseudoharengus)* and blueback herring *(Alosa aestivalis)* occur in the project area and were under consideration for listing under the ESA. However, on August 12, 2013, NMFS published a *Federal Register* notice of a listing determination (78 FR 48943), which states that NMFS has determined that listing the alewife and blueback herring is not warranted at this time. Thus, these species are no longer candidates for listing. Blueback herring and alewife are still classified as NMFS species of concern. A species is designated as a species of concern if NMFS has some concerns about the species' status and threats, but there is insufficient information to indicate a need to list the species under the ESA (NMFS 2012). This status level does not carry any procedural or substantive protections under the ESA (NMFS 2012b).

Alewife and blueback herring are both part of the herring family, Clupeidae (PFBC 2012). The two species look similar to one another. However, blueback herring generally are more slender and darker in color than alewife (PFBC 2012c). Blueback herring grow to a maximum of 15 in. (38 cm) and 1 lb (0.45 kg). Herring are an important component of freshwater, estuarine, and marine food webs because they are prey for many predatory fish and help transport nutrients to freshwater systems. Alewife and blueback herring prey include zooplankton, shrimp, small fish, and fish eggs (PFBC 2012c).

Blueback herring and alewife spawn in freshwater during the spring and migrate to estuaries or marine waters during the summer and cooler months. Alewife begin their spring migration to freshwater earlier than blueback herring and alewife spawn earlier (Collette and Klein-MacPhee 2002). In Pennsylvania, blueback herring spawn in the lower Delaware River and the Delaware estuary (PFBC 2012c). Alewife spawn in similar areas, but they also may inhabit and spawn in freshwater lakes and impoundments. In streams and rivers, spawning habitat includes freshwater several miles upstream of the tidal line in the Delaware River and in areas with a rocky, firm bottom (PFBC 2012c). Eggs are demersal and adhesive (PFBC 2012). Adults return to salt water after spawning, although adult alewife also can inhabit freshwater. Historically, dams have severely limited movement of blueback herring and alewife to and from spawning grounds (NMFS 2012c).

In Pennsylvania, blueback herring only occur in the lower Delaware River and the Delaware estuary (PFBC 2012). LGS-related surveys did not observe blueback herring in the Schuylkill River, East Branch Perkiomen Creek, Perkiomen Creek, or the Delaware River near the Point Pleasant Pumping Station (Table 2–2; Exelon 2011b). LGS-related studies captured alewife in the Schuylkill and Delaware Rivers, but did not observe this species in the East Branch Perkiomen Creek or the Perkiomen Creek (Table 2–2; Exelon 2011b). Studies from 1979–80 indicated that American shad, alewife, and blueback herring used the Delaware River in the vicinity of Point Pleasant as a nursery area.

Banded Sunfish *(Enneacanthus obesus)*

The Commonwealth of Pennsylvania lists the banded sunfish as endangered (PNHP 2012a). Banded sunfish prefer a restricted home range in coastal habitats such as small ponds, backwaters of creeks and rivers, and slow-moving waters that have high acidity and abundant vegetation. Banded sunfish prey on insects and microcrustaceans (PNHP 2012b). Spawning over gravel or sand nests occurs in April through July, and the buoyant eggs drift with the slow current (Rohde et al. 1994).

Banded sunfish occur in Bucks County (PNHP 2012a). Waters in Bucks County associated with the LGS cooling system include the Delaware River at the Point Pleasant Pumping Station. However, this area is not a preferred habitat for the banded sunfish as it is far upriver from the coast and banded sunfish occur in the lower Delaware River (PNHP 2012b). LGS-related studies from 1979 to 1985 did not observe banded sunfish eggs or larvae in surveys in the Delaware River at the Point Pleasant Pumping Station and downriver to RM 138 (RKm 222.1) (Exelon 2011b; RMC 1984, 1985, 1986).

Longear Sunfish *(Lepomis megalotis)*

The Commonwealth of Pennsylvania lists the longear sunfish as endangered (PNHP 2012a). Longear sunfish prefer slow-moving, shallow, headwater streams where they prey on invertebrates, fish eggs, and smaller fish. Spawning occurs in spring and summer. Males defend eggs and fry (PNHP 2012c).

Before 1980, the longear sunfish occurred in Bucks County (PNHP 2012a). However, Pennsylvania records since 1980 do not list longear sunfish as occurring in Bucks County (PNHP 2012c). LGS-related studies from 1979 to 1985 did not observe longear sunfish eggs or larvae during surveys in the Delaware River at the Point Pleasant Pumping Station and downriver to RM 138 (RKm 222.1) (Exelon 2011b; RMC 1984, 1985, 1986).

Ironcolor Shiner *(Notropis chalybaeus)*

The Commonwealth of Pennsylvania lists the ironcolor shiner as endangered (PNHP 2012a). Little is known about the habitat preference and life cycle of ironcolor shiner in Pennsylvania. Rohde et al. (1994) assumes that ironcolor shiner prefer habitats of headwaters in creeks or small rivers with sandy or rocky bottoms. They likely spawn during spring months and prey on insect larvae and algae, as is common among many shiner species along the eastern U.S. coast.

PNHP (2012a) lists ironcolor shiners as possibly extirpated in both Bucks and Montgomery Counties. LGS-related studies from 1979 to 1985 did not observe ironcolor shiner eggs or larvae during surveys on the Delaware River at the Point Pleasant Pumping Station and downriver to RM 138 (RKm 222.1) (Exelon 2011b; RMC 1984, 1985, 1986). In the East Branch Perkiomen Creek, Perkiomen Creek, and the Schuylkill River, LGS-related studies did not observe ironcolor shiner eggs, larvae, juveniles, or adults during fish surveys between 1970 and 2009 (Exelon 2001, 2002, 2003, 2004, 2005, 2011; NAI 2010a, 2010b, 2010c; PECO 1984; RMC 1984, 1985, 1986, 1987, 1988, 1989).

<u>Invertebrates</u>

Dwarf Wedgemussel *(Alasmidonta heterodon)*

The dwarf wedgemussel is currently listed as a Federally endangered species wherever it occurs, and is designated as a Pennsylvania-endangered species (FWS 2012a; PNHP 2012a). The dwarf wedgemussel prefers habitat characterized by mud, sand, or gravel bottom in slow-to-moderate, clear flowing streams and rivers (FWS 1992). Reproduction requires mussel larvae (glochidia) to attach to host fish gills before completion of metamorphosis into juveniles. The dwarf wedgemussel uses a number of different fish host species for glochidial reproduction, including darter and sculpin fish species (FWS 2007b).

FWS lists the dwarf wedgemussel as known to or believed to occur in Monroe, Pike, and Wayne Counties, Pennsylvania, which do not contain any LGS-associated infrastructure or waterbodies (FWS 2012c). PNHP lists the dwarf wedgemussel as potentially occurring in Bucks, Chester, and Montgomery Counties (PNHP 2012a). PECO observed rare, unidentified species of the genus *Alasmidonta* in the Schuylkill River in the 1970s and it is unknown whether the specimens were the dwarf wedgemussel (PECO 1984, Exelon 2011b). Other than the rare *Alasmidonta* specimens observed in the 1970s in the Schuylkill River, LGS-related studies did not observe dwarf wedgemussels during benthic surveys in East Branch Perkiomen Creek, Perkiomen Creek, and the Schuylkill River between 1970 and 2009 (Exelon 2011b; NAI 2010c; PECO 1984; RMC 1984, 1985, 1986, 1987, 1989).

Pizzini's Cave Amphipod *(Stygobromus pizzinii)*

The Commonwealth of Pennsylvania lists the Pizzini's cave amphipod, previously named *Stygonectes pizzinii,* as a Pennsylvania species of concern. The Pizzini's cave amphipod is an invertebrate that occurs within a variety of groundwater habitats, such as seeps, small springs, small spring and seep-fed streams, mines, wells, and caves (Holsinger 1978). As of 1978, the Schuylkill River was the northern most portion of the known geographic range for this species (Holsinger 1978). Although the Pizzini's cave amphipod is not listed as a candidate, threatened, or endangered species, PFBC (2011b) noted that the species may be listed "in the not so distant future." This species is threatened by habitat destruction and poor water quality (PFBC 2011b).

Pizzini's cave amphipod is possibly extirpated in Montgomery and Chester Counties (PNHP 2012a). PECO (1984) observed *Stygonectes pizzinii* and *Stygonectes* sp. during surveys of the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek conducted between 1970 and 1976. RMC reported *Stygobromus* sp. (not specifically identified as *Stygobromus pizzinii*) during a survey in the East Branch Perkiomen Creek in 1983 (RMC 1984) and during surveys in the Schuylkill River in 1985 and 1986 (RMC 1986, 1987). However, from 1986 until 1988, LGS-related studies did not observe *Stygobromus* species in the East Branch Perkiomen Creek nor the Schuylkill River (Exelon 2011a; RMC 1987, 1988, 1989). Based on the Pennsylvania Natural Diversity Inventory (PNDI) database and PFBC files, PFBC (2011b) stated in its letter to the NRC that globally rare amphipod and/or isopod species are known to occur within the vicinity of the LGS site.

<u>Aquatic Plants</u>

Farwell's Water-Milfoil *(Myriophyllum farwellii)*

The Commonwealth of Pennsylvania lists the Farwell's water-milfoil as an endangered aquatic plant (PNHP 2012a). Farwell's water-milfoil is a submerged plant that will grow up to 1 ft (0.3 m) in length. This species of milfoil grows in lakes and ponds (PNHP 2012d). Farwell's water-milfoil is often confused with other invasive milfoil species (PNHP 2012d).

PNHP reports no current observations of Farwell's water-milfoil in the three counties associated with LGS. However, this plant was present in the coastal region of Bucks County before 1980 (PNHP 2012d). PECO (1984) did not observe Farwell's water-milfoil during aquatic surveys in the Delaware River near the Point Pleasant Pumping Station, East Branch Perkiomen Creek, Perkiomen Creek, or the Schuylkill River between 1970 and 1976.

Broad-Leaved Water-Milfoil *(Myriophyllum heterophyllum)*

The Commonwealth of Pennsylvania lists the broad-leaved water-milfoil as an endangered aquatic plant (PNHP 2012a). Broad-leaved water-milfoil colonizes slow-moving freshwater habitats and has both submerged and emergent foliage. Reproduction occurs when part of the plant breaks off, grows roots, and settles in a new location (NHDES 2010).

The broad-leaved water-milfoil is possibly extirpated in Bucks County (PNHP 2012a). PECO (1984) did not observe broad-leaved water-milfoil during aquatic surveys in the Delaware River at Point Pleasant Pumping Station, East Branch Perkiomen Creek, Perkiomen Creek, or the Schuylkill River between 1970 and 1976.

Floating-Heart *(Nymphoides cordata)*

The Commonwealth of Pennsylvania lists the floating-heart as a threatened aquatic plant (PNHP 2012a). Floating-heart grows in lakes and ponds and resembles a small water-lily (PNHP 2012e). In the spring, floating-heart propagates, or creates new plants, as rhizomes, tubers, or seeds sprout new growth.

Floating-heart is listed as possibly extirpated in Bucks County (PNHP 2012e). PECO (1984) did not observe floating-heart during aquatic surveys in the Delaware River at Point Pleasant Pumping Station, East Branch Perkiomen Creek, Perkiomen Creek, or the Schuylkill River between 1970 and 1976.

Spotted Pondweed *(Potamogeton pulcher)*

The Commonwealth of Pennsylvania lists the spotted pondweed as an endangered aquatic plant (PNHP 2012a). Leaves are floating or submerged and flowering occurs between June and September. Spotted pondweed grows in wetlands characterized by acidic, standing water (PNHP 2012f).

Spotted pondweed occurs within coastal regions of Bucks County (PNHP 2012f). PECO (1984) did not observe spotted pondweed during aquatic surveys in the Delaware River at Point Pleasant Pumping Station, or in East Branch Perkiomen Creek, Perkiomen Creek, or the Schuylkill River between 1970 and 1976.

2.2.8.3 Terrestrial Species and Habitats

Before LGS construction, PECO compiled lists of plants and animals likely to occur on the site and along the transmission line corridors based on species' ranges and habitat requirements. In the late 1970s, PECO conducted surveys to confirm the presence of these species on the site. The final environmental statement (FES) for construction of LGS (AEC 1973) includes tables of those species PECO observed on the site as well as those species not specifically observed during surveys but that are likely to occur on the site or along the transmission line corridors. The NRC published an FES for operation of LGS in 1984 (NRC 1984), although this FES did not document any new surveys or studies not already mentioned in the previous FES. Exelon staff and Normandeau Associates, Inc. (NAI), performed reconnaissance surveys to confirm the accuracy of the pre-construction site surveys in 2009 and 2010, and Exelon's ER (Exelon 2011b) and the LGS Wildlife Management Plan (Exelon 2010b) include information on the results of these reconnaissance surveys. The WHC's "Site Assessment and Wildlife Management Opportunities for Exelon Corporation's Limerick Generating Station" (WHC 2006) also provides information on LGS site habitats and species. The NRC staff did not identify any ecological surveys or studies that include the offsite facilities within the action area or that might provide additional information about the occurrence of protected species and habitats.

Neither the pre-construction surveys nor the recent reconnaissance surveys identified any Federally listed species on the LGS site. However, several Federally listed species (see Table 2–4) have the potential to occur in the action area. In pre-operational surveys and ongoing informal surveys, NAI has identified 10 Pennsylvania-listed bird species on the LGS site. The PDCNR (2011) identified eight Pennsylvania-listed plants that occur along or near the transmission line corridors. Exelon's LGS Wildlife Management Plan (Exelon 2010a) identifies two additional Pennsylvania-listed plants that occur on the LGS site. The PFBC (2011b) identified one reptile—the eastern redbelly turtle (*Pseudemys rubriventris*)—as occurring in the vicinity of the LGS site. Federally and Pennsylvania-listed species are discussed in more detail below.

Table 2–4 identifies the Federally and Pennsylvania-listed species that occur or have the potential to occur in the action area. The three Federally listed species appear in bold. The staff compiled this table from the FWS's online species search by county (FWS 2012a); the Pennsylvania Natural Heritage Program (PNHP)'s online species database (PNHP 2012a); and correspondence with the FWS (2011), the PGC (2011), the PFBC (2011b), and the PDCNR (2011). The NRC staff did not identify any proposed species, proposed critical habitat, or designated critical habitat in the action area. In its correspondence with the NRC, the FWS (2011) also did not identify these categories of species or habitats. The Pennsylvania Endangered Species Program does not designate insects or spiders as Pennsylvania endangered or threatened; therefore, no insects or spiders appear in Table 2–4.

In addition to the species listed in the Table 2–4, the NRC identified an additional 14 Pennsylvania-listed amphibians, birds, and reptile species and about 100 additional plant species that occur within Montgomery, Chester, or Bucks Counties (PNHP 2012a). The table does not include these species, and this section does not consider these species further because the PGC, PFBC, and PDCNR, which oversee the recovery efforts of Pennsylvania-listed species, did not identify these species as occurring in the action area in correspondence with Exelon or the NRC (PDCNR 2011; PFBC 2011b; PGC 2011).

Table 2–4. Federally and Pennsylvania-listed Terrestrial Species

Scientific Name	Common Name	Federal Status[(a)]	State Status[(b)]	County(ies) of Occurrence[(c)]
Amphibians				
Acris crepitans	northern cricket frog	—	PE	B, C, M
Lithobates sphenocephalus utricularius	southern leopard frog	—	PE	B, C
Pseudacris kalmi	New Jersey chorus frog	—	PE	B, M
Scaphiopus holbrookii	eastern spadefoot	—	PE	B
Birds				
Ardea alba	great egret	—	PE	M[(e)]
Asio flammeus	short-eared owl	—	PE	B
Asio otus	long-eared owl	—	PT	C
Bartramia longicauda	upland sandpiper	—	PT	B, C, M
Botaurus lentiginosus	American bittern	—	PE	C
Cistothorus platensis	sedge wren	—	PE	B, C
Dendroica striata	blackpoll warbler	—	PE	M[(e)]
Empidonax flaviventris	yellow-bellied flycatcher	—	PE	M[(e)]
Falco peregrinus	peregrine falcon	—	PE	B
Haliaeetus leucocephalus	bald eagle	—	PT	B, C, M
Ixobrychus exilis	least bittern	—	PE	C
Nyctanassa violacea	yellow-crowned night-heron	—	PE	M
Nycticorax nycticorax	black-crowned night-heron	—	PE	C
Pandion haliaetus	osprey	—	PT	B, C
Rallus elegans	king rail	—	PE	C
Spiza americana	dickcissel	—	PE	C
Mammals				
Cryptotis parva	least shrew	—	PE	C
Myotis leibii	eastern small-footed myotis	—	PT	B
Myotis sodalist	**Indiana bat**	**FE**	**PE**	**B, C, M[(d)]**
Plants				
Andropogon gyrans	Elliott’s beardgrass	—	PR	B, C, M
Arabis missouriensis	Missouri rock-cress	—	PE	M
Arabis patens	spreading rock-cress	—	PT	B, C, M
Cuscuta campestris	dodder	—	PT	B, C, M
Cyperus schweinitzii	Schweinitz’s flatsedge	—	PR	C, M
Ilex opaca	American holly	—	PT	B, C
Iris prismatica	slender blue Iris	—	PE	B, C, M
Isotria medeoloides	**small-whorled pogonia**	**FT**	**PE**	**C**
Ranunculus fascicularis	tufted buttercup	—	PE	C, M
Rotala ramosior	tooth-cup	—	PR	B, C, M
Viburnum nudum	wild raisin	—	PE	B, C, M

Scientific Name	Common Name	Federal Status[(a)]	State Status[(b)]	County(ies) of Occurrence[(c)]
Reptiles				
Glyptemys muhlenbergii	**bog turtle**	**FT**	**PE**	**B, C, M**
Opheodrys aestivus	rough green snake	—	PE	C
Plestiodon laticeps	broadhead skink	—	PC	C
Pseudemys rubriventris	eastern redbelly turtle	—	PT	B, C, M

(a)Federal status determined by the FWS under the authority of the Endangered Species Act; FE = endangered, FT = threatened, — = not listed.
(b)Commonwealth of Pennsylvania status determined by the PDCNR, PGC, and PFBC under the Pennsylvania Endangered Species Program; PE = endangered, PT = threatened, PR = rare (plants), PC = candidate (amphibians and reptiles).
(c)The LGS site lies in Montgomery County; the in-scope transmission lines traverse Montgomery and Chester Counties; and the offsite facilities associated with the LGS makeup water system lie in Montgomery and Bucks Counties. B = Bucks County, C = Chester County, M = Montgomery County.
(d)The FWS (2012a) identifies the species as occurring in Montgomery, Chester, or Bucks Counties; however, the PNHP (2012a) does not identify the Indiana bat as occurring in any of these three counties.
(e)The PNHP (2012a) does not identify the great egret, blackpoll warbler, or yellow-bellied flycatcher as occurring in Montgomery County. However, according to Exelon's Wildlife Management Plan (Exelon 2010a), NAI staff has observed these species on the LGS site.

Sources: FWS 2011, 2012a; PDCNR 2011; PFBC 2011b; PGC 2011; PNHP 2012a

Species and Habitats Protected under the Endangered Species Act

Bog Turtle *(Glyptemys muhlenbergii)*

The FWS listed the northern population of the bog turtle, which occurs from New York and Massachusetts south to Maryland, as threatened under the ESA in 1997 (62 FR 59605). The FWS has not designated critical habitat for this species (FWS 2012a). This species is also listed as endangered by the PFBC.

The bog turtle is one of the smallest turtles in North America. Its upper shell is 3 to 4 in. (8 to 10 cm) long and light brown to black in color. Each side of its black head has a distinctive patch of color that is bright orange to yellow. The bog turtle is diurnal and semiaquatic; it forages on land and in water for its varied diet of insects and other invertebrates, frogs, plants, and carrion. In Pennsylvania, the bog turtle usually is active from late March through late September and hibernates the remainder of the year under water in soft mud and crevices. Bog turtles construct nests in sphagnum moss or on tussock sedges, which allows them to deposit eggs above the wetland inundation level. Females lay one to six eggs in June and July. Eggs incubate unattended for 6 to 8 weeks, which often leaves them vulnerable to mice, raccoons, skunks, foxes, birds, and other predators. Young hatch during late August through early September (FWS 2001, 2010).

Northern bog turtles primarily inhabit early to mid-successional wetlands fed by groundwater or associated with the headwaters of streams and dominated by emergent vegetation (spring seeps and open marshy meadows) (FWS 2001). These habitats typically have shallow, cool, slow-flowing water, early to mid-successional vegetation, open canopies, and wet meadows of sedges (*Carex* spp.) (FWS 2001; PADEP 2006b). The species is also associated with spike rushes (*Eleocharis* spp.) and bulrushes (*Juncus* spp. and *Scirpus* spp.) (FWS 2001; PADEP 2006b). The species' continued existence is threatened by loss and fragmentation of wetlands; hydrologic alterations that affect groundwater and surface water quantity and quality;

livestock grazing and associated nutrient loading; habitat alterations associated with invasive plant species; and illegal collection and trade (FWS 2010).

In Pennsylvania, the bog turtle occurs in the southeastern part of the state. As of 2000, the FWS (2001) identified 14 Pennsylvania counties (including Montgomery, Chester, and Bucks Counties) with extant populations of bog turtles (FWS 2001). Two additional counties historically contained bog turtles, and the FWS (2001) considers a third county's population extirpated. In total, the FWS (2001) identified 75 extant populations, many of which occur within the Delaware River and Susquehanna River watersheds.

None of the available surveys or reports of the LGS site (described in the first paragraph of this section; AEC 1973; Exelon 2010a, 2011a; NRC 1984; WHC 2006) identified the bog turtle as occurring on the LGS site. However, no bog turtle habitat (Phase 1) surveys have been completed in the action area. Small sections of the LGS site along the Schuylkill River contain palustrine emergent and forested wetlands. Thus, the species may occur within suitable wetland habitat in these areas.

Indiana Bat *(Myotis sodalis)*

The FWS listed the Indiana bat as endangered wherever found in 1967 under the Endangered Species Preservation Act of 1966, the predecessor regulation to the ESA (32 FR 4001). The FWS has not designated critical habitat for the species in Pennsylvania (41 FR 41914). This species is also listed as endangered by the PGC.

The Indiana bat is an insectivorous, migratory bat that occurs within the central portion of the eastern United States and hibernates colonially in caves and mines. Menzel et al. (2005) concluded that habitat use is highly correlated with insect abundance, which means that Indiana bats often forage in riparian areas where insect densities are highest. Menzel et al. (2005) also found that Indiana bats were more closely associated with linear landscape features (forest corridors and roads) than open areas (agricultural land, grasslands, or meadows). Reproductive females migrate and form maternity colonies in wooded riparian areas, bottomlands, floodplains, wetlands, and upland areas. Males and nonreproductive females may stay close to their hibernation site or migrate to summer habitat, but they do not roost in colonies. Indiana bats create roosts in the exfoliating bark of large (often dead) trees. Both males and females return to hibernation sites in late summer or early fall to mate and enter hibernation. Destruction and degradation of caves from mining, tourism, and physical barriers (such as construction of doors or gates) threaten hibernation habitat (FWS 2007a). Loss and degradation of forest habitat, which affects migration pathways, maternity roosts, and breeding areas, also has contributed to the decline of the species (FWS 2007a).

The PGC (2010) reports that about 1,000 Indiana bats hibernate in 18 sites within 11 Pennsylvania counties. The PGC (2010) also has identified nine summer maternity sites in seven counties. According to the draft Indiana bat draft recovery plan (FWS 2007a), no hibernation or maternity sites occur in Montgomery, Chester, or Bucks Counties. The closest hibernation site is north of the LGS site in Luzerne County, and the closest maternity colony to the LGS site is in Berks County, which borders the northwest edges of Montgomery and Chester Counties (FWS 2007a; PGC 2010).

None of the available surveys or reports of the LGS site (described in the first paragraph of this section; AEC 1973; Exelon 2010a, 2011a; NRC 1984; WHC 2006) identified the Indiana bat as occurring on the LGS site. No FWS-qualified Indiana bat surveyor has conducted formal surveys on the site, and the NRC staff did not identify any other ecological studies that would provide information on the Indiana bat in the action area. Based on the species' historic distribution (FWS 2007a) and the lack of records for the action area, the NRC staff cannot preclude the potential presence of the Indiana bat in the action area. Therefore, the NRC staff assumes that the species may occur in areas of suitable habitat within the action area.

Small-Whorled Pogonia *(Isotria medeoloides)*

The FWS listed the small-whorled pogonia as threatened wherever found in 1982 (47 FR 39827). The FWS has not designated critical habitat for this species (FWS 2012b). This species is also listed as endangered by the PDCNR.

The small-whorled pogonia is a small, herbaceous, perennial orchid. Its primary range extends through the Atlantic seaboard states, but it also occurs in adjacent states, including Pennsylvania. The species generally grows in young and maturing stands of mixed-deciduous or mixed-deciduous/coniferous forests that are in second- or third-growth stages of succession. The species inhabits areas with sparse to moderate ground cover, a relatively open understory, or areas in proximity to logging roads, streams, or other features that create long-persisting breaks in the forest canopy. In the northern part of its range, it has been associated with the following canopy species that are also prevalent in the action area: red maple (*Acer rubrum*), northern red oak (*Quercus rubra*), and American beech (*Fagus grandifolia*) (see Section 2.2.7). Throughout its range, the small-whorled pogonia is associated with understories containing red maple and oak species (*Quercus* spp.) (FWS 1992). Habitat destruction, disease, and predation by deer and rabbits threaten the species' continued existence (FWS 1992, 2008).

None of the available surveys or reports of the LGS site (described in the first paragraph of this section; AEC 1973; Exelon 2010a, 2011a; NRC 1984; WHC 2006) identified the small-whorled pogonia as occurring on the LGS site. However, PECO conducted the last botanical surveys of the site before construction of LGS, and the FES for operation of LGS (NRC 1984) indicates that PECO did not complete any surveys along the transmission line corridors before its construction. During its license renewal application review, the staff did not identify any ecological surveys or studies of the offsite facilities within the action area since LGS began operating that might provide additional information about the occurrence of the small-whorled pogonia within the action area.

As of 2007, FWS (2008) reported three extant populations in Pennsylvania and an additional six populations that were historic, extirpated, or of unknown status. Historic populations occurred in both Montgomery and Berks Counties (FWS-PA 2012). Both the PNHP online species database (PNHP 2012a) and the FWS Pennsylvania Field Office Web site (FWS-PA 2012) indicate that the species occurs in Chester County. The NRC did not identify any more specific information on the location of the three extant populations; therefore, the NRC assumes that the species has the potential to occur in the action area in areas of suitable habitat at offsite facilities in Chester County.

<u>Species Protected under the Bald and Golden Eagle Protection Act</u>

The Bald and Golden Eagle Protection Act of 1940, as amended, prohibits anyone from taking bald eagles (*Haliaeetus leucocephalus*) or golden eagles (*Aquila chrysaetos*), including their nests or eggs, without an FWS-issued permit. The term "take" in the Act is defined as, among other things, to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, or disturb (50 CFR 22.3). "Disturb" means, among other things, to take action that causes or is likely to cause (1) injury to an eagle; (2) a decrease in its productivity, by substantially interfering with breeding, feeding, or sheltering behavior; or (3) nest abandonment, by substantially interfering with breeding, feeding, or sheltering behavior (50 CFR 22.3).

Pennsylvania maintains a Bald Eagle Management Plan (Gross and Brauning 2010), which lays out management goals and objectives to increase the number of successful nesting pairs and to delist the bald eagle from Pennsylvania-threatened to a secure, protected status. As of 2009, the PGC identified 174 active nests that produced 244 young in 48 Pennsylvania counties. In the same year, the PGC recorded three active nests in Bucks County, three in Chester County, and one in Montgomery County. Data from the 2008 FWS midwinter bald eagle survey indicate that the bald eagle is also present in Bucks and Chester Counties in the winter months (Gross and Brauning 2010). In its comments on the draft SEIS, Exelon (2013a) noted that a bald eagle was observed hunting waterfowl in the LGS spray pond in February 2013.

Species Protected under the Migratory Bird Treaty Act

The FWS administers the Migratory Bird Treaty Act of 1918, as amended (MBTA), which prohibits anyone from taking native migratory birds or their eggs, feathers, or nests. The MBTA definition of a “take” differs from that of the ESA. Under the MBTA, “take” means to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or make any attempt to carry out these activities (50 CFR 10.12). Unlike a take under the ESA, a take under the MBTA does not include habitat alteration or destruction. The MBTA protects a total of 1,007 migratory bird species (75 FR 9282). Of these 1,007, the FWS allows for the legal hunting of 58 species as game birds (FWS undated). Within Pennsylvania, the PGC manages migratory bird hunting seasons and associated licenses for woodcock, pheasant, ruffed grouse, and a number of waterfowl species. All Federally and Pennsylvania-listed bird species that appear in Tables 2–4 and 2–5 are protected under the MBTA. Additionally, the MBTA protects all U.S.-native bird species that belong to the families, groups, or species listed at 50 CFR 10.13.

Species Protected by the Commonwealth of Pennsylvania

This section only discusses those Pennsylvania-listed species from Table 2–4 for which the NRC has specific occurrence information within the action area. The remaining species in the table have the potential to occur in the action area, but were not identified during early surveys of the site (AEC 1973, NRC 1984), or in subsequent reports (Exelon 2010a, 2011a), or were not identified as species of specific concern in correspondence with the PDCNR (2011), PGC (2011), or PFBC (2011b) regarding the proposed LGS license renewal.

Birds

NAI conducted bird surveys on the LGS site from 1972 to 1985. Since 1985, NAI has maintained a running checklist of bird species on the site (Exelon 2010a). NAI has identified 10 State-listed bird species. These species and their habitat requirements appear in Table 2–5. Because more recent occurrence information is based on NAI’s running checklist, the year in which each bird species was last observed is not available (Exelon 2010a).

Table 2–5. Pennsylvania-listed Bird Species in the Action Area

Species	Habitat
American bittern (*Botaurus lentiginosus*)	dense freshwater marshes; wet meadows
bald eagle (*Haliaeetus leucocephalus*)	riparian areas near rivers or open water bodies
black-crowned night heron (*Nycticorax nycticorax*)	coastlines; swamps; river and stream riparian areas; canals; wet agricultural fields
blackpoll warbler (*Dendroica striata*)	second-growth scrub; woodlands; dense conifer forests
great egret (*Ardea alba*)	marshes; river margins; lakeshores; coastal swamps; lagoons
least bittern (*Ixobrychus exilis*)	dense marshland containing cattails and reeds
osprey (*Pandion haliaetus*)	lakes, ponds, rivers, and other open water bordered by trees
peregrine falcon (*Falco peregrines*)	cliffs, buildings, and other high structures overlooking rivers
yellow-bellied flycatcher (*Empidonax flaviventris*)	shady coniferous forests and forested wetlands at higher elevations; mossy, poorly drained swamps and bogs
yellow-crowned night heron (*Nyctanassa violacea*)	small, shallow streams often associated with sycamores

Plants

The PDCNR (2011) identified eight Pennsylvania-listed plants that occur along or near the LGS site or offsite facilities. None of the available surveys or reports (AEC 1973; Exelon 2010a, 2011a; NRC 1984; WHC 2006) indicate that these species occur on Exelon property; however, two additional Pennsylvania-listed plants occur on the LGS site. Exelon's Wildlife Management Plan (Exelon 2010a) identifies American holly (*Ilex opaca*) and wild raisin (*Viburnum nudum* var. *cassinoides*), which are Pennsylvania-listed as threatened and endangered, respectively, as having been identified on the site in 1978 during surveys associated with the construction of LGS. The continued occurrence of these species on the site today cannot be confirmed because no vegetation surveys have been completed on the site since the 1970s.

American Holly (*Ilex opaca*). American holly is an evergreen shrub or small tree that grows to 15 m (50 ft) in height. The species grows on wooded slopes and streambanks from coastal New England south and west into Florida and Texas (PNHP 2007a). Exelon's ER (Exelon 2011b) and the LGS Wildlife Management Plan (Exelon 2010a) identify American holly as having occurred on the LGS site in 1978 during surveys associated with the construction of the LGS. The continued occurrence of this species on the site today cannot be confirmed because no vegetation surveys have been completed on the site since the 1970s. A 2007 PNHP Pennsylvania distribution map does not indicate that the species occurs within Montgomery, Chester, or Bucks Counties (PNHP 2007a).

Dodder (*Cuscuta campestris*). Dodder is an annual stem parasitic plant that lacks normal roots and leaves, but bears flowers and fruits that inhabit thickets and waste ground. In its correspondence with Exelon, the PDCNR (2011) indicated that this species occurs in an old impounding basin near the Schuylkill River along the 220-63 and 220-64 transmission line corridors.

Elliott's Beardgrass (*Andropogon gyrans*). Elliott's beardgrass is an erect, bunched, perennial grass that may grow to 3 ft (1 m) in height. It grows in dry to damp grasslands, clearings, open slopes, and successional old fields from New Jersey to Illinois and south into Florida and Texas (PNHP 2011a). Though it has not been identified on the LGS site, a 2011 PNHP Pennsylvania distribution map indicates that the species occurs in southwestern Montgomery County and throughout Chester County (PNHP 2011a). Additionally, in its correspondence with Exelon, the PDCNR (2011) indicated that the species occurs in an old field near the 220-63 and 220-64 transmission line corridor.

Missouri Rock-Cress (*Arabis missouriensis*). Missouri rock-cress is an herbaceous biennial from a taproot, with stems 2 to 5 cm (0.8 to 2 in.) high. The species occurs on dry slopes across the central and eastern United States (NatureServe 2010a; PDCNR 2011). In its correspondence with Exelon, the PDCNR (2011) indicated that Missouri rock-cress occurs on a dry forested slope with scattered outcrops of Brunswick red shale located just east of the 220-60 and 220-61 transmission line corridors.

Schweinitz's Flatsedge (*Cyperus schweinitzii*). Schweinitz's flatsedge is a grass-like perennial with stems 10- to 40-cm (4- to 16-in.) high. The species occurs on dry or moist sand flats and dunes across much of the continental United States (NatureServe 2010b; PDCNR 2011). In its correspondence with Exelon, the PDCNR (2011) indicated that Schweinitz's flatsedge occurs in association with tooth-cup (described below) in a wet wooded area along the west side of the Schuylkill River near the 220-60 and 220-61 transmission line corridors.

Slender Blue Iris (*Iris prismatica*). Slender blue iris is a tall perennial forb with grass-like leaves and dark purple flowers. The species occurs in moist meadows and sandy or gravelly shores throughout the eastern seaboard of the United States from Maine to Georgia (NatureServe 2010c; PDCNR 2011). In its correspondence with Exelon, the PDCNR (2011) indicated that the species occurs on gently sloping land, open with scattered red maples in a mossy floodplain of Perkiomen Creek near the 220-62 and 5031 transmission line corridors.

Spreading Rock-Cress (*Arabis patens*). Spreading rock-cress is a slender, perennial herb. It occurs in moist, rocky woods over much of the central and southeastern portions of the eastern United States (NatureServe 2010d; PDCNR 2011). In its correspondence with Exelon, the PDCNR (2011) indicated that spreading rock-cress occurs in moist, shaded northwest-facing rock faces near the 220-60, 220-61, 220-62, 220-63, and 220-64 transmission line corridors.

Tooth-Cup (*Rotala ramosior*). Tooth-cup is a small annual herb that has smooth stems that may grow up to 12 in. (30 cm) in height. It grows on exposed shorelines, stream margins, streambed outcrops, and other damp, open places across much of the continental United States (PNHP 2011b). A 2011 PNHP Pennsylvania distribution map indicates that the species occurs in the Schuylkill River watershed between Montgomery and Chester Counties (PNHP 2011b). In its correspondence with Exelon, the PDCNR (2011) indicated that the species occurs in a wet wooded stretch along the west side of the Schuylkill River near the 220-60 and 220-61 transmission line corridors and on an exposed mud flat and sandy-cobbly shores of seasonally flooded shallow basins near the 220-63 and 220-64 transmission line corridors.

Tufted Buttercup (*Ranunculus fascicularis*). Tufted buttercup is a small perennial forb with five-petal yellow flowers. It inhabits dry, thick woods and exposed calcareous slopes and edges across the central and eastern United States (NatureServe 2010e). In its correspondence with Exelon, the PDCNR (2011) indicated that the species occurs in a ridgetop glade in a state park near the 220-62 and 5031 transmission line corridors.

Wild Raisin (*Viburnum nudum* var. *cassinoides*). Wild raisin (also called possum-haw) is a deciduous shrub or small tree that grows up to about 12 ft (4 m) in height. The species inhabits swamps, wet thickets, and pond margins from New York west and south into Texas and Florida (PNHP 2007b). The LGS Wildlife Management Plan (Exelon 2010a) identifies wild raisin as having occurred on the LGS site in 1978 during surveys associated with construction of LGS. The continued occurrence of this species on the site today cannot be confirmed because no vegetation surveys have been completed on the site since the 1970s. A 2007 PNHP Pennsylvania distribution map indicates that the species occurs in southwestern Montgomery County, northern Chester County, and central Bucks County (PNHP 2007b).

Reptiles

Eastern Redbelly Turtle (*Pseudemys rubriventris*). The eastern redbelly turtle is one of Pennsylvania's largest turtles. It occurs in large water bodies including lakes, ponds, marshes, slow-moving rivers, and creeks from New York to North Carolina (PNHP 2007c). Redbelly turtles prefer areas with deeper water with sandy or muddy substrate and aquatic vegetation in proximity to basking sites. Females nest in upland habitat within 100 m (330 ft) of water. A 2007 PNHP Pennsylvania distribution map indicates that the species occurs throughout Montgomery, Bucks, and Chester Counties. In its correspondence with the NRC, the PFBC (2011b) noted that the eastern redbelly turtle occurs in the vicinity of the LGS site.

2.2.9 Socioeconomics

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at LGS. LGS and the communities that support it can be described as a dynamic socioeconomic system. The communities provide the people, goods, and services required to operate the nuclear power plant. Power plant operations, in turn, provide wages and benefits for people and dollar expenditures for goods and services. The measure of a community's ability to support LGS operations depends on the ability of the community to respond to changing environmental, social, economic, and demographic conditions.

The socioeconomic region of influence (ROI) is defined by the area where LGS employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The ROI consists of a three-county area (Montgomery, Chester, and Berks Counties), where approximately 84 percent of LGS employees reside.

Exelon employs a permanent workforce of 821 full-time workers at LGS (Exelon 2011b). As previously discussed, approximately 84 percent live in Montgomery, Berks, and Chester Counties (see Table 2–6). Most of the remaining 16 percent of the workforce is divided among 12 counties across Pennsylvania and other states, with numbers ranging from 1 to 35 employees per county. Given the residential locations of LGS employees, the most significant impacts of plant operations are likely to occur in Montgomery, Berks, and Chester Counties. The focus of the socioeconomic impact analysis in this SEIS is therefore on the impacts of continued LGS operations on these three counties.

Refueling outages at LGS normally occur at 24-month intervals. During refueling outages, site employment increases by as many as 1,400 temporary workers for approximately 20 to 30 days (Exelon 2011b). Most of these workers are assumed to be located in the same geographic areas as LGS employees. The following sections describe the housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the socioeconomic ROI surrounding LGS.

Table 2–6. Limerick Generating Station, Employee Residence by County

County	Number of Employees	Percentage of Total
Pennsylvania		
Montgomery	339	41
Berks	249	30
Chester	105	13
Delaware	35	4
Bucks	18	2
Lancaster	18	2
Lehigh	13	2
Other	31	4
Other States	13	2
Total	**821**	**100**

Source: Exelon 2011a

2.2.9.1 Housing

Table 2–7 lists the total number of occupied and vacant housing units, vacancy rates, and median value in the three-county ROI. According to American Community Survey estimates, there were approximately 683,000 housing units in the socioeconomic region, of which approximately 648,000 were occupied. The median value of owner-occupied housing units in the socioeconomic region was: Berks County, $175,700; Chester County, $350,500; and Montgomery County, $295,300. All three counties had a homeowner vacancy rate of less than 2 percent (USCB 2011).

Table 2–7. Housing in Berks, Chester, and Montgomery Counties in 2010

	Berks	Chester	Montgomery	ROI
Total	164,861	192,614	325,733	683,208
Occupied housing units	155,329	184,160	308,233	647,722
Vacant units	9,532	8,454	17,540	35,526
Vacancy rate (percent)	1.2	1.2	1.6	1.3
Median value (dollars)*	175,700	350,500	295,300	273,833

Key: *estimated

Sources: USCB 2011; 2010 American Community Survey 1-Year Estimates

2.2.9.2 Public Services

This section presents information regarding public services including water supply, education, and transportation.

Water Supply

The discussion of public water supply systems is limited to major municipal water systems in Berks, Chester, and Montgomery Counties. Information about municipal water suppliers in these counties, their average daily production, system capacity, and population served are presented in Table 2–8.

Table 2–8. Public Water Supply Systems in Berks, Chester, and Montgomery Counties (in million gallons per day [mgd])

Water Supplier	Primary Water Source	Average Daily Production (mgd)	System Capacity (mgd)	Population Served
Berks County				
Reading Area Water Authority	SW	14.0	40.0	87,000
Paw Penn District	GW	2.5	3.7	29,552
Western Berks Water Authority	SW	3.5	8.0	25,000
Paw Glen Alsace Division	SW	1.4	28.1	23,251
Muhlenberg Township Municipal Authority	GW	4.1	8.5	21,000
Chester County				
PA American Water Company Main System	SW	2.5	5.8	44,000
PA American Coatesville	SW	3.8	8.0	35,600
Aqua PA West Chester	SW	5.0	8.0	35,000
Aqua PA Uwchlan	SW	2.0	3.2	22,000
Phoenixville Water Department	SW	2.5	10.3	16,438
Montgomery County				
Aqua Pennsylvania Main System	SW	87.6	125.0	784,939
North Penn Water Authority	SW	10.0	24.0	82,822
Pennsylvania American Water-Norristown	SW	9.6	16.9	91,000
North Wales Water Authority	SW	7.4	13.3	68,656
Pottstown Borough Water Department	SW	6.0	12.0	36,000

Key: SW = Surface Water, GW = Groundwater

Sources: EPA 2012; Exelon 2011a

Berks County is served by 75 water systems, with the Reading Area Water Authority serving the largest population at 87,000 (EPA 2012a). Water for this surface water system is primarily drawn from Lake Ontelaunee, a reservoir built and owned by the city of Reading. The system storage capacity is approximately 76 million gallons (Exelon 2011b).

Chester County is served by 83 water systems, with the Pennsylvania American Water Company serving the largest population at 44,000 (EPA 2012a). Montgomery County is served by 39 water systems, with Aqua Pennsylvania, Inc., serving the largest population at 785,000 (EPA 2011).

LGS withdraws cooling system makeup water primarily from the Schuylkill River; 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 DRBC. The DRBC has jurisdiction over withdrawals and uses of water in the Delaware River Basin, which includes the Schuylkill Valley Subbasin where LGS is located (Exelon 2011b).

<u>Education</u>

Montgomery County has 22 school districts with 155 schools. LGS is located in the Spring–Ford Area School District in Montgomery County, Pennsylvania. The Spring–Ford Area School District has 12 public schools and had a total enrollment of approximately 7,700 students in 2010–2011 (PDE 2011). Berks County has 18 school districts with 108 schools, and Chester County has 12 school districts with 92 schools (NCES 2011). During the 2010–2011 school year, public school enrollment in Montgomery County was 108,768 students, with 70,517 and 83,589 students in Berks and Chester Counties, respectively (PDE 2011).

Transportation

There is a high concentration of Interstates and major roadways in the vicinity of LGS. Highways and other major roadways within a 50-mile (80-km) radius of LGS include U.S. Interstates I-78, I-176, I-178, I-276, and I-476, as well as US-30, US-1, and US-422 (known as “the Pottstown Expressway”). US-422 provides a direct link to Philadelphia, to the east. To the west, US-422 connects Reading to Lebanon, Harrisburg, and the Capitol region.

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 15 miles (24.1 km) east of the LGS plant site. I-76, I-276, and I-476 are about 15 miles (24.1 km) south of LGS and can be accessed by US-422.

The LGS plant site can only be accessed by Evergreen Road, either directly from the Sanatoga exit of US-422 or indirectly from the Limerick Linfield exit of US-422 by 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.

Table 2–9 lists common commuting routes to LGS and average annual daily traffic (AADT) volume values. The AADT values represent traffic volumes for a 24-hour period factored by both day of week and month of year.

Table 2–9. Major Commuting Routes in the Vicinity of LGS, 2010 Average Annual Daily Traffic Count

Roadway and Location	Annual Average Daily Traffic (AADT)
Montgomery County	
US-422 east of Sanatoga Interchange	49,000
South Pleasantview/Linfield Road, between Evergreen Road and Ridge Pike	1,300–2,500
Linfield Road between Linfield and US-422	6,600
Sanatoga/Limerick Center Road between Evergreen Road and Limerick Road	1,600–1,900
North and South Lewis Road and Main Street from Royersford to US-422 Limerick-Linfield Interchange	14,000
Main Street Royersford from Linfield Road (bridge)	7,000
Evergreen Road	3,000
Berks County	
PA-82/PA-345 from PA-724 Birdsboro to US-422	8,400
PA 662 North of US-422 from Douglassville	8,900
PA-724 from Birdsboro	5,800–7,000
US-422 East of Douglassville/US-422 West of Douglassville	28,000–36,000
Chester County	
US-422 West of Armand Hammer Interchange	53,000
PA-100 from PA-23 North to PA-724	17,000–20,000
PA-724 West of PA-100	5,800–7,000
PA-724 East of PA-100	8,900–14,000
Linfield Road (bridge) to Main Street Royersford	5,700
PA-100 South of US-422	25,000

[a] All AADTs represent traffic volume during the average 24-hour day during 2009.

Source: PennDOT 2012

2.2.9.3 Offsite Land Use

Offsite land use conditions in Berks, Chester, and Montgomery Counties are described in this section. More than 84 percent of the LGS permanent workforce lives in these three counties. Within the region of the LGS, approximately 44 percent of the land is developed urban or rural land, 32 percent agricultural land, 23 percent woodlands, and 1 percent freshwater bodies (Exelon 2011b).

Montgomery County occupies approximately 483 square miles (1,251 square km) (USCB 2011). Agricultural land is used principally as cropland (68.2 percent) and pasture (20.0 percent). Crop sales (mostly nursery and floriculture products) comprise 63 percent of the total market value of products sold in the county while livestock products (mostly milk, hogs, and cattle) comprise the remaining 37 percent. The number of farms in Montgomery County decreased just over 1 percent from 2002 to 2007. Farmland acreage in the county decreased over 13 percent during the same period, and the average size of a farm decreased 12 percent to 58 ac (23 ha) (USDA 2009).

Chester County occupies approximately 751 square miles (1,945 square km) (USCB 2011). Agricultural land is used principally as cropland (70.2 percent) and pasture (18.6 percent). Crop sales (mostly nursery, greenhouse, floriculture, and sod) comprise 73 percent of the market value of agricultural products sold from the county while livestock sales (mostly milk and poultry products) comprise the remaining 27 percent. The number of farms in Chester County decreased from 2002 to 2007 by 9.6 percent. In the same period, the number of farmland acres decreased by less than 1 percent, however, the average size of farms increased by over 9 percent to 96 ac (39 ha) (NASS 2009).

Berks County occupies approximately 857 square miles (2,220 square km) (USCB 2011). Agricultural land is used principally as cropland (76.9 percent) and pasture (10.7 percent). Livestock sales (mostly milk and poultry products) comprise 55 percent of the market value of agricultural products sold from the county while crop sales (mostly nursery, greenhouse, floriculture, and sod) comprise the remaining 45 percent. The number of farms in Berks County increased from 2002 to 2007 by 10.2 percent. The number of farmland acres increased nearly 3 percent, however, the average size of farms decreased by over 6 percent to 112 ac (45 ha) (NASS 2009).

Even though population growth is projected to continue, there is ample urban and rural land to accommodate the anticipated growth over the next 20 years. Agriculture will continue to be the major land use outside urban areas.

2.2.9.4 Visual Aesthetics and Noise

LGS is situated in gently rolling countryside, traversed by numerous valleys containing small creeks or streams that empty into the Schuylkill River. LGS is surrounded by urbanized areas, the Borough of Pottstown being the closest at 1.7 miles. Predominate features of the site include the reactor enclosures, turbine enclosures, two cooling towers (154.2 m high), electrical substations, independent spent fuel storage installation, Schuylkill River Pumphouse, cooling tower blowdown discharge line and associated structures, spray pond (17.2 ac), administrative buildings, and miscellaneous supporting buildings (Exelon 2011b).

Noise from nuclear plant operations can be detected off site. Sources of noise at LGS include the turbines and large pump motors. Given the industrial nature of the station, noise emissions from the station are generally nothing more than an intermittent minor nuisance. However, noise levels may sometimes exceed the 55 dBA level that EPA uses as a threshold level to protect against excess noise during outdoor activities (EPA 1974). However, according to EPA this threshold does “not constitute a standard, specification, or regulation,” but was intended to provide a basis for State and local governments establishing noise standards (EPA 1974).

2.2.9.5 Demography

According to the 2010 Census, an estimated 1,365,850 people live within 32.2 km (20 miles) of the LGS plant site, producing a population density of 420 persons per square km (1,087 persons per square mile) (Exelon 2011b). This translates to a Category 4, “least sparse” population density using the GEIS measure of sparseness (greater than or equal to 120 persons per square mile within 20 miles). Approximately 8,311,616 people live within 80.4 km (50 miles) of LGS, which equates to a population density of 409 persons per square km (1,058 persons per square mile) (Exelon 2011b). As the ROI has a population greater than or equal to 190 persons per square mile within 80.4 km (50 miles), this translates to a Category 4 (greater than or equal to 190 persons per square mile within 50 miles). Therefore, LGS is classified as being located in a high population area based on the GEIS sparseness and proximity matrix.

Table 2–10 shows population projections and growth rates from 1970 to 2050 in Berks, Chester, and Montgomery Counties in Pennsylvania. All counties experienced an increased growth rate during the 2000 to 2010 time period. Montgomery County showed the smallest population increase between 2000 and 2010 (6.6 percent). All three county populations are expected to continue to increase at lower rates in the next decades through 2050.

Table 2–10. Population and Percent Growth in Berks, Chester, and Montgomery Counties from 1970 to 2000 and Projected for 2010–2050

	Berks		Chester		Montgomery	
Year	Population	Percent Change[(a)]	Population	Percent Change[(a)]	Population	Percent Change[(a)]
1970	296,382	–	278,311	–	623,799	–
1980	312,497	5.4	316,660	13.8	643,621	3.2
1990	336,523	7.7	376,396	18.9	678,111	5.4
2000	373,638	11.0	433,501	15.2	750,097	10.6
2010	411,442	10.1	498,886	15.1	799,874	6.6
2020	450,718	9.5	604,385	21.1	854,994	6.9
2030	491,914	9.1	692,054	14.5	888,265	3.9
2040	531,830	8.1	791,610	14.4	936,102	5.4
2050	572,066	7.6	888,194	12.2	980,298	4.7

[(a)] Percent growth rate is calculated over the previous decade.

Sources: Population data for 1970 through estimated population data for 2009 (USCB 2011); population projections for 2012 to 2030 by Pennsylvania State Data Center, October 2010 (PASDC 2010); 2040 to 2050 calculated.

Demographic Profile

The 2010 (estimate) demographic profiles of the three-county ROI population are presented in Table 2–11. In 2010, minorities (race and ethnicity combined) comprised 20.6 percent of the total three-county population. The largest minority populations in the three county area are Hispanic or Latino (7.8 percent) and Black or African American (6.6 percent).

Table 2–11. Demographic Profile of the Population in the Limerick Generating Station Socioeconomic Region of Influence in 2010

	Berks	Chester	Montgomery	Region of Influence
Population	411,142	498,886	799,874	1,710,202
Race (Not Hispanic or Latino) - percent of total population				
White	76.9	82.1	79.0	79.4
Black or African American	4.0	5.9	8.4	6.6
American Indian and Alaska Native	0.1	0.1	0.1	0.1
Asian	1.3	3.9	6.4	4.4
Native Hawaiian and Other Pacific Islander	0.0	0.0	0.0	0.0
Some other race	0.1	0.1	0.2	0.1
Two or more races	1.2	1.4	1.6	1.4
Ethnicity				
Hispanic or Latino	67,355	32,503	34,233	134,091
Percent of total population	16.4	6.5	4.3	7.8
Total minority	95,036	89,325	168,090	352,451
Percent minority	23.1	17.9	21.0	20.6

Source: USCB 2011

Transient Population

Within 50 miles (80 km) of LGS, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2010, there were approximately 354,728 students attending colleges and universities within 50 miles (80 km) of LGS (NCES 2011).

In 2010, all three counties in the direct ROI had a similar percentage of temporary housing for seasonal, recreational, or occasional use; Berks at 0.4 percent, Chester at 0.6 percent and Montgomery at 0.5 percent (USCB 2011). In comparison, the highest percent of temporary housing for seasonal, recreational, or occasional use in the counties located within 50 miles (80 km) of LGS is Monroe County, Pennsylvania, at 16.9 percent (USCB 2010). Table 2–12 provides information on seasonal housing for the 26 counties located all or partly within 50 miles (80 km) of LGS.

Table 2–12. Seasonal Housing in Counties Located within 50 Miles (80 Km) of the Limerick Generating Station[(a)]

County	Housing Units: Total	Vacant Housing Units: For Seasonal; Recreational; or Occasional Use	Percent
Pennsylvania			
Berks	164,827	724	0.4
Bucks	245,956	1,536	0.6
Carbon	34,299	5,033	14.7
Chester	192,462	1,064	0.6
Delaware	222,902	621	0.3
Lancaster	202,952	930	0.5
Lebanon	55,592	506	0.9
Lehigh	142,613	663	0.5
Monroe	80,359	13,590	16.9
Montgomery	325,735	1,498	0.5
Northampton	120,363	755	0.6
Philadelphia	670,171	2,228	0.3
Schuylkill	69,323	1,360	2.0
York	9,870	1,117	11.3
County Subtotal	**2,537,424**	**31,625**	**1.2**
Maryland			
Cecil	41,103	1,912	4.7
Harford	95,554	451	0.5
County Subtotal	**136,657**	**2,363**	**1.7**
New Jersey			
Burlington	175,615	696	0.4
Camden	204,943	551	0.3
Cumberland	55,834	627	1.1
Gloucester	109,796	316	0.3
Hunterdon	49,487	512	1.0
Mercer	143,169	558	0.4
Salem	27,417	150	0.5
Somerset	123,127	173	0.1
Warren	44,925	457	1.0
County Subtotal	**934,313**	**4,040**	**0.4**
Delaware			
New Castle	217,511	712	0.3
Total	**3,825,905**	**38,740**	**1.0**

[(a)] Counties within 50 miles (80 km) of LGS with at least one block group located within the 50-mile (80-km) radius

Source: USCB 2011

Migrant Farm Workers

Migrant farm workers are individuals whose employment requires travel to harvest agricultural crops. These workers may or may not have a permanent residence. Some migrant workers follow the harvesting of crops, particularly fruit, throughout rural areas of the United States. Others may be permanent residents near LGS who travel from farm to farm harvesting crops.

Migrant workers may be members of minority or low-income populations. Because they travel and can spend a significant amount of time in an area without being actual residents, migrant workers may be unavailable for counting by census takers. If uncounted, these workers would be "underrepresented" in USCB minority and low-income population counts.

Information on migrant farm and temporary labor was collected in the 2007 Census of Agriculture. Table 2–13 provides information on migrant farm workers and temporary farm labor (less than 150 days) within 50 miles (80 km) of the LGS. According to the 2007 Census of Agriculture, approximately 6,205 farm workers were hired to work for less than 150 days and were employed on 6,324 farms within 50 miles (80 km) of LGS. Pennsylvania had the largest number of farms hiring workers for less than 150 days (1,212), with Chester County containing the largest number of farms hiring workers for less than 150 days at 233.

In the 2002 Census of Agriculture, farm operators were asked for the first time whether or not they hired migrant workers, defined as a farm worker whose employment required travel that prevented the migrant worker from returning to their permanent place of residence the same day. A total of 528 farms in the 50-mile (80-km) radius of LGS reported hiring migrant workers in the 2007 Census of Agriculture. Chester County, Pennsylvania, had the largest number of farm operators that reported hiring migrant workers at 101, followed by Cumberland County, New Jersey (65) (USDA 2011).

In the direct ROI, 591 temporary farm workers (those working fewer than 150 days per year) were employed on 180 farms in Berks County; 653 temporary farm workers (those working fewer than 150 days per year) were employed on 233 farms in Chester County; 208 temporary farm workers (those working fewer than 150 days per year) were employed on 71 farms in Montgomery County (USDA 2011).

Table 2–13. Migrant Farm Workers and Temporary Farm Labor in Counties Located within 50 Miles (80 Km) of Limerick Generating Station

County[(a)]	Number of Farms with Hired Farm Labor[(b)]	Number of Farms Hiring Workers for Less Than 150 days[(b)]	Number of Farm Workers Working for Less Than 150 days[(b)]	Number of Farms Reporting Migrant Farm Labor[(b)]
Pennsylvania				
Berks	458	180	591	32
Bucks	265	100	375	23
Carbon	27	12	59	6
Chester	580	233	653	101
Delaware	25	8	15	2
Lancaster	1,716	60	138	7
Lebanon	324	137	317	6
Lehigh	118	44	161	5
Monroe	155	23	66	0
Montgomery	155	71	208	14
Northampton	97	24	89	2
Philadelphia	5	2	(D)	0
Schuylkill	165	100	323	12
York	404	218	657	22
County Subtotal	**4,494**	**1,212**	**3,652**	**232**
Maryland				
Cecil	128	52	213	5
Harford	155	62	154	12
County Subtotal	**283**	**114**	**367**	**17**
New Jersey				
Burlington	217	93	326	39
Camden	52	25	85	17
Cumberland	192	60	230	65
Gloucester	163	57	216	56
Hunterdon	283	144	353	18
Mercer	86	39	102	8
Salem	172	71	248	33
Somerset	132	52	147	6
Warren	169	94	321	27
County Subtotal	**1,466**	**635**	**2,028**	**269**
Delaware				
New Castle	81	34	158	10
Total	**6,324**	**1,995**	**6,205**	**528**

[(a)] Counties within 50 miles (80 km) of LGS with at least one block group located within the 50-mile (80-km) radius.
[(b)] Table 7. Hired farm Labor – Workers and Payroll: 2007.
(D) – Withheld to avoid disclosing data for individual farms.

Source: 2007 Census of Agriculture – County Data (USDA 2009)

2.2.9.6 Economy

This section contains a discussion of the economy, including employment and income, unemployment, and taxes.

Employment and Income

Between 2000 and 2010, the civilian labor force in Berks, Chester, and Montgomery Counties increased slightly. Chester County experienced the highest percentage of growth with 10.2 percent (229,469 civilian worker to 252,993), while Berks and Montgomery experienced a similar growth of civilian labor force by 1.4 percent (190,552 civilian workers to 193,364) and 2.2 percent (402,653 civilian workers to 411,517), respectively (USCB 2000, 2010).

In 2010, educational, health, and social services represented the largest sector of employment (24.4 percent) in the ROI followed by manufacturing (13.2 percent), and professional, scientific, management, administration, and waste management (13 percent). A list of some of the major employers by industry in each county in the ROI is provided in Table 2–14.

Table 2–14. Major Employers by Industry in the LGS ROI in 2010

Industry	Berks	Chester	Montgomery	Total	Percent
Total employed civilian workers	193,364	252,993	411,517	857,874	
Construction	10,555	12,814	23,472	46,841	5.5
Manufacturing	32,843	33,512	47,202	113,557	13.2
Wholesale Trade	6,246	7,384	12,669	26,299	3.1
Retail Trade	21,699	28,157	43,224	93,080	10.9
Transportation, warehousing, and utilities	9,077	8,482	14,631	32,190	3.8
Information	3,462	4,615	9,183	17,260	2.0
Finance, insurance, real estate, rental, and leasing	10,613	24,447	41,825	76,885	9.0
Professional, scientific, management, administrative, and waste management services	16,398	36,113	58,720	111,231	13.0
Educational, health, and social services	49,407	57,072	102,572	209,051	24.4
Arts, entertainment, recreation, accommodation, and food services	14,904	17,876	26,997	59,777	7.0
Other services (except public administration)	10,856	10,254	17,919	39,029	4.5
Public administration	4,021	5,522	11,353	20,896	13.2

Source: USCB 2011

The top eight employers in Montgomery County are listed in Table 2–15. King of Prussia currently houses the largest number of private sector employers (SGP 2007).

Table 2–15. Largest Private Sector Employers – Montgomery County – 2007

Company	Industry	Number of Employees
Merck & Company	Pharmaceutical and Vaccines: Global R&D HQ	12,000
Abington Memorial Hospital	Hospitals, General Market and Surgical	5,896
Allied Barton Security Services	Security, Integrated Asset Protection	5,160
Northwestern Human Services	Outpatient Mental Health and Substance Abuse Centers	4,000
Lockheed Martin	Systems Integrations, Systems Engineering, Software Development, and Program Management	3,700
Aetna	Managed Care, Health Insurance	3,000
Unisys	Information and Technology Solutions and Services	3,400
Citizens Bank	Commercial Banking	3,000

Source: SGP 2007

Estimated income information for the socioeconomic ROI and Pennsylvania is presented in Table 2–16. According to the U.S. Census Bureau's 2010 American Community Survey 1-Year Estimates, people living in the ROI had median household and per capita incomes above the state average. Chester County had the highest median household and per capita income among the three counties. Berks County has the highest percentages of persons (14.1 percent) living below the official poverty level when compared to the other two counties and the Commonwealth as a whole. Chester and Montgomery Counties had 6.2 and 5.5 percent, respectively, and the Commonwealth of Pennsylvania as a whole had 13.4 percent. The percentage of families living below the poverty level in Chester and Montgomery Counties (3.6 percent) was lower than the percentage of families in Berks County and the Commonwealth of Pennsylvania as a whole (10.9 percent and 9.3 percent, respectively) (USCB 2011).

Table 2–16. Estimated Income Information for the Limerick Generating Station Region of Influence in 2010

	Berks	Chester	Montgomery	Pennsylvania
Median household income (dollars)[a]	51,719	84,284	75,448	49,288
Per capita income (dollars)[a]	25,384	40,138	38,792	26,374
Individuals living below the poverty level (percent)	14.1	6.2	5.5	13.4
Families living below the poverty level (percent)	10.9	3.6	3.6	9.3

(a) In 2010 inflation-adjusted dollars.

Source: USCB 2011

Unemployment

According to the U.S. Census Bureau's 2010 American Community Survey 1-Year Estimates, the unemployment rates in 2010 were: Berks County, 10.2 percent; Chester County, 6.2 percent; and Montgomery County, 7.3 percent. Comparatively, the Commonwealth of Pennsylvania's unemployment rate during the same time period was 9.6 percent (USCB 2011).

Taxes

Exelon pays real estate taxes directly to local taxing authorities for the parcels of company-owned property located within their tax jurisdictions. The taxing authorities include the counties, municipalities, and school districts in which these properties are located. LGS parcels are located only in Montgomery, Chester, and Bucks Counties. There are no LGS parcels located in Berks County.

Exelon is the sole owner of the LGS plant site along with the following components of the LGS makeup water supply system, which include the Perkiomen Pumphouse, the Bradshaw Reservoir; the Bradshaw Pumphouse; and the Bedminster Water Processing Facility. PECO, rather than Exelon, owns or has rights to the LGS transmission system beyond the two onsite substations (Exelon 2011b).

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

Table 2–17 shows the tax payments made by Exelon for LGS from years 2006–2010. Table 2–18 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 (Exelon 2011b).

Currently, Exelon 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-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 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 (Exelon 2011b).

Real estate taxes paid by Exelon to the following taxing authorities represent less than 1 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.

Table 2–17. Limerick Generation Station Tax Distribution, 2006–2010

	Calendar Year				
	2006	**2007**	**2008**	**2009**	**2010**
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
Total	**2,721,114**	**2,599,823**	**2,685,956**	**2,938,382**	**2,751,672**
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
Total	**47,776**	**49,110**	**53,472**	**54,482**	**55,608**
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
Total	**50,412**	**52,243**	**54,033**	**55,426**	**57,820**
Total Taxes	**2,819,302**	**2,701,176**	**2,793,461**	**3,048,290**	**2,865,100**

Source: Exelon 2011

Table 2–18. Payment as a Percentage of Taxing Authority 2010 Adopted Budget

Taxing Authority	2010 Adopted Budget ($ millions)[a]	LGS Property Tax Payment as Percentage of Budget[b]
Montgomery County		
Montgomery County – Through Limerick Township	407.7	Less than 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	Less than 0.1%
Lower Pottsgrove Township	5.4	Less than 0.1%
Pottsgrove School District	56.8	Less than 0.1%
Chester County		
Chester County	420.7	Less than 0.1%
East Coventry Township	3.2	Less than 0.1%
Owen J. Roberts School District	103.0	Less than 0.1%
Bucks County		
Bucks County – Through Plumstead Township	460.1	Less than 0.1%
Plumstead Township	4.3	0.17%
Central Bucks School District	283.2	Less than 0.1%
Bucks County – Through Bedminster Township	460.1	Less than 0.1%
Bedminster Township	2.0	0.2%
Pennridge School District	111.4	Less than 0.1%

(a) Municipal budget is for calendar year; school district budget is for school year 2010–2011.
(b) Percentages are based on 2010 LGS property tax payments shown in Table 2–17.

Source: Exelon 2011a

2.2.10 Historic and Archaeological Resources

In accordance with 36 CFR 800.8(c), the NRC has elected to coordinate compliance with Section 106 of the National Historic Preservation Act (NHPA) with steps it has taken to meet its requirements under NEPA. In addition, NUREG–1555 (NRC 2000) provides guidance to staff on how to conduct historic and cultural resource analysis in its environmental reviews.

In the context of NHPA, the NRC has determined that the area of potential effect (APE) for a license renewal action is the area at the power plant site and its immediate environment that may be affected by post-license renewal and land-disturbing activities associated with the proposed action (NRC 2011a). The APE may extend beyond the immediate environs in instances where post-license renewal and land-disturbing activities or refurbishment activities specifically related to license renewal may potentially have an effect on historic properties (NRC 2011a). Figure 2–3 shows the area under review.

2.2.10.1 Cultural Background

This section discusses the cultural background and the known historic and archaeological resources at the LGS site and in the surrounding area. The cultural background for the Commonwealth of Pennsylvania has been characterized by the staff in the following license renewal environmental impact statements and therefore, will be briefly described in this section:

- Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 10, Regarding Peach Bottom Nuclear Reactor, Units 2 and 3, January 2003 (NRC 2003);
- Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 35, Regarding Susquehanna Steam Electric Station, Units 1 and 2, March 2009 (NRC 2009a);
- Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 36, Regarding Beaver Valley Power Station, Units 1 and 2, May 2009 (NRC 2009b); and
- Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 37, Regarding Three Mile Island Nuclear Station, Unit 1, June 2009 (NRC 2009c).

The Paleo-Indian Period occurred approximately 10,000 to 15,000 years ago. The Paleo-Indians were hunters and gathers and this period is largely characterized by the Clovis point (NRC 2009a).

The Early Archaic Period occurred approximately 3,000 to 10,000 years ago. As the glaciers retreated northward, larger fauna became extinct and people adapted to the resources in the surrounding environment. As the resources improved, the population of the Archaic people increased. Recent archaeological evidence suggests larger populations by the end of the Archaic era (NRC 2009a).

The Woodland Period occurred approximately 3,000 years ago until the point of European contact. The Woodland Period is characterized by being dependent on maize agriculture, people living in villages, and the introduction of the bow and arrow for hunting (NRC 2009a).

The Late Woodland peoples were known as the Delaware, Nanticoke, Shawnee, Iroquois, and Susquehannock (NRC 2009a). Early Native American contact with European colonists and events associated with that contact make it difficult to associate present-day tribal groups with the territory in the vicinity of the LGS site. The contacts led to tribal movements, alliances with either the French or English, armed conflicts, epidemics, shifting inter-tribal confederacies, and eventual removal, or extinction in some cases, as the European expansion took place (NRC 2003).

The historic period can be traced to 1681 when King Charles II granted William Penn a charter for a tract of land running from the Delaware River toward Maryland. William Penn founded the City of Philadelphia, which contained 600 houses by 1685. William Penn also established Chester, Bucks, and Philadelphia Counties in 1682. The earliest colonists were farmers. Milling, distilling, and other processing industries were established along streams. A dramatic increase in the development of political organization and infrastructure can be seen through the period of 1784 to 1870. Because efficient means of transportation were needed to support the movement of settlers westward, turnpikes, canals, and railways were built.

The Schuylkill Navigation Company constructed a canal system between Philadelphia and the coal fields of Schuylkill County. The canal opened in 1824 and ran from south of Reading to

Parker Ford, following the west bank of the Schuylkill River through land that is currently LGS property. The canal development spurred the farming industry in the area and, from 1857 to 1937, a farming and commercial center arose around the locks. Locks 54, 55, and a two-story stone lockkeeper's house (now part of Fricks Lock Historic District) were built by the canal company on property owned by John Frick (Exelon 2011b).

The Philadelphia and Reading Railroad, which also passed through land that is now on LGS property, ran along the east bank of the Schuylkill River. It was one of the first railroads built in the United States and was completed in 1843. The Reading Company, an owner of the railroad, operated until 1971 when it declared bankruptcy. Another railroad line, the Schuylkill Branch of the Pennsylvania Railroad, was built along the western bank of the river in 1884. It served primarily as a commuter line, but was abandoned by the 1950s (Exelon 2011b).

2.2.10.2 Historic and Cultural Resources at the Limerick Generating Station Site

The following information was used to identify the historic and cultural resources at the LGS site:

- original construction FES (NRC 1973);
- original operating FES (NRC 1984);
- Exelon, Applicant's Environmental Report, Operating License Renewal Stage, LGS Units 1 & 2 (Exelon 2011b);
- site audit (NRC 2012a);
- LGS, request for additional information (Exelon 2012b);
- consultation with Pennsylvania Bureau of Historic Preservation (BHP); and
- consultation with tribes.

Exelon's ER describes the cultural resources investigations that occurred on the LGS site for the initial construction and operation of LGS Units 1 and 2 (Exelon 2011b). An archaeological survey of the LGS plant site was conducted to identify prehistoric archaeological resources and, as a result, four areas of occupation were identified. Three were located on the western shores of the Schuylkill River, in the vicinity of Fricks Locks, and are identified as 36CH38, 36CH103, and 36CH364. The other site was recorded on the eastern side of the Schuylkill and is recorded as site 36MG37. The artifacts associated with these sites were those associated with the Archaic, Early Woodland, and Middle Woodland cultural periods (Exelon 2011b)

On October 5, 1983, the BHP stated 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" (Exelon 2011b). The mitigation measures were reviewed and approved by the BHP. Archaeological surveys were conducted for the five transmission system lines: Lines 220-60, 220-61, 220-62, 220-63/64, and 5031, and the results of these surveys are summarized in Exelon's ER (Exelon 2011b).

In 2011 the NRC performed a query of the Pennsylvania Cultural Resources Geographic Information System, a database maintained by the Commonwealth of Pennsylvania through its BHP office, to identify historic and archaeological resources and their National Register of Historic Places (NRHP) determinations within the APE and surrounding area. A total of 164 aboveground historic resources and 3 archeological sites are listed on the NRHP in Montgomery County, and 380 aboveground historic resources and 6 archeological sites are listed in Chester County. Directly within the APE, the query noted two aboveground historic resources and six archeological sites. All eight sites are located within the LGS owner-controlled area. The six archaeological resource sites are recorded as 36MG37, 36CH37, 36CH38, 36CH103, 36CH364, and 36CH382, and date to the prehistoric time period. The aboveground historic resources are recorded as the Fricks Locks Historic District and the Schuylkill Navigation Company Canal, and both could contain associated archaeological material (Exelon 2011a, 2012b).

Site 36MG37 (Underpass Site), a multi-component 44-ac site, extends along the eastern terrace of the Schuylkill River. The site reflects evidence from the Middle Archaic through Transitional Archaic periods, along with Late Woodland. Because of insufficient data, no determination has been made for eligibility for inclusion in the NRHP (Exelon 2012b).

Site 36CH37 (Warehouse Field) is located upland to the west of the Schuylkill River. Evidence suggests the site is from the Late and Transitional Archaic period. NRHP eligibility has not been determined (Exelon 2012b).

Site 36CH38 (Turkey Point House), an 8-ac prehistoric site, is located on the west side of the Schuylkill River and is commonly referred to as the Turkey Point House site. NRHP eligibility has not been determined (Exelon 2012b).

Site 36CH103 (Fricks Locks Site), a 22-ac site, is located on the west terrace of the Schuylkill River, directly east of the Fricks Lock Historic District. It is commonly referred to as the Fricks Lock site. Evidence collected from the site suggests Archaic and Early Woodland occupations. Data recovery was performed at the site; however, the NRHP status is listed as undetermined (Exelon 2012b).

Site 36CH364 (Payne #1) is located south of site 36CH103 and is approximately 2 ac. No specific components were noted, other than the site was prehistoric and the NRHP eligibility was undetermined (Exelon 2012b).

Site 36CH382 (Locus 25) was recorded through an archaeological survey for transmission line 220-61 and the site is listed as Late Archaic. Subsurface testing was conducted, but did not provide sufficient data for NRHP eligibility determination (Exelon 2012b).

The Fricks Locks Historic District is 18 ac. Its buildings were built between 1757 and 1937 as part of a farming hamlet. The site was listed on the NRHP in 2003 under Criteria A (local historical significance) and C (engineering significance) and the eligibility under Criterion D (information potential) has not been determined (Exelon 2012b). The district contains historic buildings, the Schuylkill Navigation Company's Girard Canal, the filled-in remains of Locks 54 and 55, and the Lock Keeper's House (Exelon 2012b). Currently, Exelon is working with East Coventry Township and Chester County to rehab and mothball the site. The rehabilitation and mothballing activities are specified to meet the Secretary of Interior's Standards for Rehabilitation and construction activity is expected to begin in 2012 (Exelon 2012b). In addition to historic archaeological deposits, prehistoric artifacts have been produced within the boundaries of the Fricks Locks Historic District (Exelon 2012b).

The Schuylkill Navigation Company Canal was determined eligible for listing in the NRHP in 2003 under Criteria A (local historical significance) and C (engineering significance) (Exelon 2012b). The 5-mile section of the canal, Locks 52-53 and Locks 54-55, originally was part of the 17-mile-long Girard Lock. There are several intact remnants of the canal in this NRHP-eligible linear resource. However, the canal prism (channel) and Fricks Locks Historic District are the only canal-related resources recorded within the LGS property (Exelon 2012b).

2.2.10.3 Consultation

In September 2011, the NRC initiated consultation on the proposed action with the Advisory Council on Historic Preservation, Pennsylvania's Bureau of Historic Preservation, and 15 Federally recognized tribes. An overview of consultation activities that occurred during the preparation of the SEIS is given in Section 4.9.6.

2.3 Related Federal and State Activities

The staff reviewed the possibility that activities of other Federal agencies might affect the renewal of the operating license for LGS. Any such activity could result in cumulative environmental impacts and the possible need for a Federal agency to become a cooperating agency in the preparation of NRC's SEIS for LGS.

There are no Federal projects that would make it necessary for another Federal agency to become a cooperating agency in the preparation of this SEIS. There are no known American Indian lands within 50 miles (80 km) of LGS. Federal lands, facilities, and national wildlife refuge and wilderness lands within 50 miles of LGS are listed below (FWS 2013; NPS 2013):

- U.S. Fish and Wildlife Service land
  - John Heinz National Wildlife Refuge and
  - Supawna Meadows National Wildlife Refuge;
- U.S. Department of the Interior, National Park Service land
  - Delaware & Lehigh National Heritage Corridor;
  - Germantown White House (Deshler-Morris House);
  - Edgar Allen Poe National Historic Site;
  - Hopewell Furnace National Historic Site;
  - Independence National Historical Park;
  - New Jersey Pineland National Reserve;
  - Thaddeus Kosciuszko National Memorial;
  - Valley Forge National Park; and
  - Washington-Rochambeau Revolutionary Route National Historic Trail.

The NRC is required, under Section 102(2)(c) of NEPA, to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved. The NRC has consulted with the FWS, the NMFS, and the Commonwealth of Pennsylvania State Historic Preservation Officer (SHPO). Federal agency consultation correspondence is listed in Appendix D.

2.4 References

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3.0 ENVIRONMENTAL IMPACTS OF REFURBISHMENT

Facility owners or operators may need to undertake or, for economic or safety reasons, may choose to perform refurbishment activities in anticipation of license renewal or during the license renewal term. The major refurbishment class of activities characterized in the *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants* (NRC 1996) is intended to encompass actions which typically take place only once in the life of a nuclear plant, if at all. Examples of these activities include, but are not limited to, replacement of boiling water reactor recirculation piping and pressurized water reactor steam generators. These actions may have an impact on the environment beyond those that occur during normal operations and may require evaluation, depending on the type of action and the plant-specific design. Table 3-1 lists the environmental issues associated with refurbishment that the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) determined to be Category 1 issues in the GEIS.

Table 3–1. Category 1 Issues Related to Refurbishment

Issue	**GEIS Section(s)**
Surface water quality, hydrology, and use (for all plants)	
Impacts of refurbishment on surface water quality	3.4.1
Impacts of refurbishment on surface water use	3.4.1
Aquatic ecology (for all plants)	
Refurbishment	3.5
Groundwater use and quality	
Impacts of refurbishment on groundwater use and quality	3.4.2
Land use	
Onsite land use	3.2
Human health	
Radiation exposures to the public during refurbishment	3.8.1
Occupational radiation exposures during refurbishment	3.8.2
Socioeconomics	
Public services: public safety, social services, and tourism and recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8
Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51	

Table 3-2 lists environmental issues related to refurbishment that the staff determined to be plant-specific or inconclusive in the GEIS. These issues are Category 2 issues. The definitions of Category 1 and 2 issues can be found in Section 1.4.

Table 3–2. Category 2 Issues Related to Refurbishment

Issue	GEIS Section(s)	10 CFR 51.53 (c)(3)(ii) Subparagraph
Terrestrial resources		
Refurbishment impacts	3.6	E
Threatened or endangered species (for all plants)		
Threatened or endangered species	3.9	E
Air quality		
Air quality during refurbishment (nonattainment and maintenance areas)	3.3	F
Socioeconomics		
Housing impacts	3.7.2	I
Public services: public utilities	3.7.4.5	I
Public services: education (refurbishment)	3.7.4.1	I
Offsite land use (refurbishment)	3.7.5	I
Public services, transportation	3.7.4.2	J
Historic and archaeological resources	3.7.7	K
Environmental justice		
Environmental justice[a]	Not addressed	Not addressed

[a] Guidance related to environmental justice was not in place at the time the U.S. Nuclear Regulatory Commission (NRC) prepared the GEIS and the associated revision to 10 CFR Part 51. If an applicant plans to undertake refurbishment activities for license renewal, the applicant's environmental report (ER) and the staff's environmental impact statement must address environmental justice.

Table source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51

Table B–2 of the GEIS identifies systems, structures, and components (SSCs) that are subject to aging and might require refurbishment to support continued operation during the license renewal period of a nuclear facility. In preparation for its license renewal application, Exelon Generation Company, LLC (Exelon) performed an evaluation of these SSCs pursuant to Title 10 of the *Code of Federal Regulation* (10 CFR 54.21), to identify the need to undertake any major refurbishment activities that would be necessary to support the continued operation of Limerick Generating Station Units 1 and 2 (LGS) during the proposed 20-year period of extended operation.

In its SSC evaluation, Exelon did not identify the need to undertake any major refurbishment or replacement actions associated with license renewal to support the continued operation of LGS beyond the end of the existing operating licenses (Exelon 2011). As part of the staff's independent review, the staff verified this Exelon finding that there were no required refurbishment activities associated with the license renewal of LGS. Since the staff has determined that there are no refurbishment actions required to support LGS operating during the extended period of operation, no evaluation is required of the above-listed Category 1 and Category 2 environmental issues associated with refurbishment. In short, the issue of refurbishment is not relevant to the proposed federal action of issuing renewed operating licenses to LGS.

3.1 References

10 CFR Part 51. *Code of Federal Regulations,* Title 10, *Energy,* Part 51, “Environmental protection regulations for domestic licensing and related regulatory functions.”

10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, “Requirements for renewal of operating licenses for nuclear power plants.”

[Exelon] Exelon Generation Company, LLC. 2011. *License Renewal Application, Limerick Generating Station, Units 1 and 2, Appendix E, Applicant’s Environmental Report, Operating License Renewal Stage*. Agencywide Documents Access and Management System (ADAMS) No. ML11179A104.

[NRC] U.S. Nuclear Regulatory Commission. 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG-1437. May 1996. ADAMS Nos. ML040690705 and ML040690738.

[NRC] U.S. Nuclear Regulatory Commission. 1999. Section 6.3 – Transportation, Table 9.1, Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants. In: *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Washington, DC: NRC. NUREG-1437, Volume 1, Addendum 1. August 1999. ADAMS No. ML04069720.

4.0 ENVIRONMENTAL IMPACTS OF OPERATION

This chapter addresses potential environmental impacts related to the period of extended operation of Limerick Generating Station, Units 1 and 2 (LGS). These impacts are grouped and presented according to resource. Generic issues (Category 1) rely on the analysis presented in the *Generic Environmental Impact Statement* (GEIS) *for License Renewal of Nuclear Plants* (NRC 1996, 1999a), unless otherwise noted. Site-specific issues (Category 2) have been analyzed for LGS and assigned a significance level of SMALL, MODERATE, or LARGE, accordingly. Some issues are not applicable to LGS because of site characteristics or plant features. For an explanation of the criteria for Category 1 and Category 2 issues, as well as the definitions of SMALL, MODERATE, and LARGE, refer to Section 1.4.

As described in Section 1.5, Exelon submitted its Environmental Report (ER) under NRC's 1996 rule governing license renewal environmental reviews (61 FR 28467, June 5, 1996, as amended), as codified in NRC's environmental protection regulations, 10 CFR Part 51. The 1996 GEIS (NRC 1996) and Addendum 1 to the GEIS (NRC 1999) provided the technical basis for the list of NEPA issues and associated environmental impact findings for license renewal contained in Table B–1 in Appendix B to Subpart A of 10 CFR Part 51. For Limerick, the NRC staff initiated its environmental review in accordance with the 1996 rule and GEIS (NRC 1996, 1999) and documented its findings in this chapter of the SEIS. General references within this SEIS that refer to the "GEIS" without stipulation are inclusive of the 1996 and 1999 GEIS (NRC 1996, 1999). Information and findings specific to the June 2013 final rule (78 FR 37282) or the June 2013 GEIS (NRC 2013), or both, are appropriately referenced as such.

4.1 Land Use

Section 2.2.1 of this supplemental environmental impact statement (SEIS) describes the land use around LGS.

Land use in the vicinity of nuclear power plants could be affected by the license renewal decision. However, as discussed in the GEIS, onsite land use and power line right of way (ROW) conditions are expected to remain unchanged during the license renewal term at all nuclear plants and any impacts would therefore be SMALL. These issues were classified as Category 1 issues in the GEIS and are listed in Table 4–1.

Exelon Generation Company, LLC's (Exelon) Environmental Report (ER) (Exelon 2011a), scoping comments, and other available information about land use in the vicinity of LGS, Units 1 and 2, were reviewed and evaluated for new and significant information. The review included a data gathering site visit to LGS. No new and significant information was identified during this review that would change the conclusions in the GEIS. Therefore, for these Category 1 issues, impacts during the renewal term are not expected to exceed those discussed in the GEIS.

Montgomery County has been working to develop an interconnected system of open space and trails along the Schuylkill River and within other natural resource areas of the county. The LGS site contains land along the Schuylkill River that has been identified as part of the Schuylkill River Greenway in the county plan. Onsite land use conditions at LGS are expected to remain unchanged during the license renewal term. Therefore, activities associated with continued reactor operations during the license renewal term are not expected to affect the use and management of LGS lands identified as part of the Schuylkill River Greenway.

Table 4–1. Land Use Issues

Issue	GEIS Section	Category
Onsite land use	4.5.3	1
Power line ROW	4.5.3	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

4.2 Air Quality

Section 2.2.2 of this report describes the meteorology and air quality in the vicinity of the LGS site. One Category 1 air quality issue is applicable to LGS—air quality effects of transmission lines. No Category 2 issues apply for air quality, as there is no planned refurbishment associated with license renewal. The U.S. Nuclear Regulatory Commission (NRC) staff did not identify any new and significant information related to the Category 1 air quality issue during the review of Exelon's ER, the site audit, during the scoping process, or during the draft SEIS comment period. Therefore, there are no impacts related to this issue beyond those discussed in the GEIS. For this issue, the GEIS concluded that the impacts are SMALL.

Table 4–2. Air Quality Issues

Issue	GEIS Section	Category
Air quality effects of transmission lines	4.5.2	1

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

4.3 Geologic Environment

4.3.1 Geology and Soils

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulations in 10CFR Part 51. With respect to the geologic environment of a plant site, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 1 issue, "Geology and soils." This new issue has an impact level of SMALL. This new Category 1 issue considers geology and soils from the perspective of those resource conditions or attributes that can be affected by continued operations during the renewal term. An understanding of geologic and soil conditions has been well established at all nuclear power plants and associated transmission lines during the current licensing term, and these conditions are expected to remain unchanged during the 20-year license renewal term for each plant. The impact of these conditions on plant operations and the impact of continued power plant operations and refurbishment activities on geology and soils are SMALL for all nuclear power plants and not expected to change appreciably during the license renewal term. Operating experience shows that any impacts to geologic and soil strata would be limited to soil disturbance from construction activities associated with routine infrastructure renovation and maintenance projects during continued plant operations. Implementing best management practices would reduce soil erosion and subsequent impacts on surface water quality. Information in plant-specific SEISs prepared to date and reference documents has not identified these impacts as being significant.

Section 2.2.3 of this SEIS describes the local and regional geologic environment relevant to LGS. The NRC staff did not identify any new and significant information with regard to this Category 1 (generic) issue based on review of the ER (Exelon 2011a), the public scoping process, the comments on the draft SEIS, or as a result of the environmental site audit. As discussed in Chapter 3 of this SEIS and as identified in the ER (Exelon 2011a), Exelon has no plans to conduct refurbishment or replacement actions associated with license renewal to support the continued operation of LGS. Furthermore, Exelon anticipates no new construction or other ground-disturbing activities or changes in operations and that its operation and maintenance activities would be confined to previously disturbed areas or existing ROWs. Based on this information, it is expected that any incremental impacts on geology and soils during the license renewal term would be SMALL.

4.4 Surface Water Resources

The Category 1 (generic) and Category 2 surface water use and quality issues applicable to LGS, Units 1 and 2, are discussed in the following sections and listed in Table 4–3. Surface water resources-related aspects and conditions relevant to the LGS site are described in Sections 2.1.7.1 and 2.2.4.

Table 4–3. Surface Water Resources Issues

Issues	GEIS Section	Category
Altered current patterns at intake and discharge structures	4.2.1.2.1	1
Altered salinity gradients	4.2.1.2.2	1
Temperature effects on sediment transport capacity	4.2.1.2.3	1
Scouring caused by discharged cooling water	4.2.1.2.3	1
Eutrophication	4.2.1.2.3	1
Discharge of chlorine or other biocides	4.2.1.2.4	1
Discharge of sanitary wastes and minor chemical spills	4.2.1.2.4	1
Discharge of other metals in wastewater	4.2.1.2.4	1
Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a river with low flow)	4.3.2.1	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51(61 FR 28467, June 1996)

4.4.1 Generic Surface Water Issues

The NRC staff did not identify any new and significant information with regard to the Category 1 (generic) surface water issues based on review of the ER (Exelon 2011a), the public scoping process, the comment period on the draft SEIS, or as a result of the environmental site audit. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS. Therefore, it is expected that there would be no incremental impacts related to these Category 1 issues during the renewal term beyond those discussed in the GEIS. For these surface water issues, the GEIS concludes that the impacts are SMALL.

4.4.2 Surface Water Use Conflicts

This section presents the NRC staff's review of plant-specific (Category 2) surface water use conflict issues as listed in Table 4–3.

4.4.2.1 Plants Using Makeup Water from a Small River with Low Flow

For nuclear power plants using cooling towers or cooling ponds supplied with makeup water from a small river, the potential impact on the flow of the river and related impacts on instream and riparian ecological communities is considered a Category 2 issue. This designation requires a plant-specific assessment. A small river is defined in 10 CFR 51.53(c)(3)(ii)(A) as one whose annual flow rate is less than 3.15×10^{12} ft^3/yr (9×10^{10} m^3/yr) or 100,000 cfs (2,820 m^3/s). LGS has a closed-cycle heat-dissipation system that uses natural draft cooling towers with makeup water pumped from the Schuylkill River (see Section 2.1.7). As noted in Section 2.2.4.1, the Schuylkill River near the LGS site has a mean annual flow rate of less than 6.3×10^{10} ft^3/yr (2,000 cfs). Therefore, an assessment of the impact of the proposed action on the flow of the river is required. In evaluating the potential impacts resulting from surface water use conflicts associated with license renewal, the NRC staff uses as its baseline the existing surface water resource conditions described in Sections 2.1.7.1 and 2.2.4 of this SEIS. These baseline conditions encompass the existing hydrologic (flow) regime of the surface water(s) potentially affected by continued operations, as well as the magnitude of surface water withdrawals for cooling and other purposes (as compared to relevant appropriation and permitting standards). The baseline also considers other downstream uses and users of surface water.

Flow conditions in the Schuylkill River have required Exelon to supplement LGS's water sources. As discussed in Section 2.2.4.1, the mean annual flow and 90 percent exceedance flow for the Schuylkill River, as measured at the U.S. Geological Survey (USGS) Pottstown, Pennsylvania, gage station, total 1,935 cfs (54.8 m^3/s) and 482 cfs (13.6 m^3/s), respectively. Against these measures of flow, the withdrawal of water at the maximum consumptive use permitted by the Delaware River Basin Commission (DRBC) (65 cfs (1.84 m^3/s)) represents a 3.4 percent and a 13 percent reduction, respectively, in the flow of the Schuylkill River downstream of LGS. To limit downstream, including aquatic and riparian, impacts in the Schuylkill River during low flow, the DRBC requires LGS to augment its consumptive use of water when the river flow falls to 560 cfs (15.9 m^3/s), based on two-unit operation. This is accomplished either through withdrawing makeup water directly from other DRBC-approved water sources or through augmentation of the flow in the Schuylkill River through surface water diversion, as described in Sections 2.1.6 and 2.1.7.1 of this SEIS.

Between 2003 and 2012, as part of a demonstration project approved by the DRBC, Exelon included water from Wadesville Mine Pool and the Still Creek Reservoir in its portfolio of water sources for flow augmentation. Nevertheless,. In May 2013, the DRBC issued a consolidated docket (No. D-1969-210 CP-13; DRBC 2013a, 2013b) for LGS operations and encompassing approval of the supplemental water sources for low flow augmentation, including releases from Wadesville Mine Pool to the Schuylkill River (see Section 2.1.7.1 of this SEIS for details). Before 2003, the frequency of water withdrawals by LGS for consumptive use was approximately 50 percent from the Schuylkill River, 4 percent from Perkiomen Creek natural flow, and 46 percent from Perkiomen Creek supplemented by water diverted from the Delaware River. Under the demonstration project with releases from the Wadesville Mine Pool to the Schuylkill River, the frequency of withdrawals from the Schuylkill River to support LGS consumptive uses increased (Exelon 2012a). With DRBC's approval of the consolidated docket, this trend toward an increasing reliance on augmented flows in the Schuylkill River would be expected to continue during the license renewal term. Regardless of the above considerations, the DRBC Comprehensive Plan (DRBC 2001) includes consideration of LGS operations. The DRBC's mission includes water conservation, control, use, and management, which is to be accomplished through the adoption and promotion of uniform and coordinated policies basin-wide (DRBC 1961). As reaffirmed in the consolidated docket, the DRBC requirement that LGS shift to alternative water sources when the flow of the Schuylkill River falls to 560 cfs (15.9 m^3/s) ensures that LGS cooling water withdrawals and associated consumptive use will not reduce river flow by more than 12 percent during low-flow periods. During average flows, LGS operations will reduce the flow by about 3 percent. Therefore, because DRBC imposes requirements to ensure that LGS's consumptive water use from the Schuylkill River remains within acceptable limits, the NRC staff concludes that the impact on surface water resources and downstream water availability from consumptive water use by LGS, Units 1 and 2, during the license renewal term would be SMALL.

4.5 Groundwater Resources

The Category 1 (generic) and Category 2 groundwater use and quality issues applicable to LGS are discussed in the following sections and listed in Table 4–4. Groundwater resources related aspects and conditions relevant to the LGS site are described in Sections 2.1.7.2 and 2.2.5.

Table 4–4. Groundwater Resources Issues

Issues	GEIS Section	Category
Groundwater use conflicts (potable and service water; plants that use less than 100 gpm)	4.8.1.1	1
Groundwater use conflicts (plants using cooling towers withdrawing makeup water from a small river)	4.8.1.3	2
Radionuclides released to groundwater	4.5.1.2[(a)]	2

[(a)] NRC 2013a; 78 FR 37282

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51(61 FR 28467, June 5, 1996)

4.5.1 Generic Groundwater Issues

Section 2.2.5 of this SEIS discusses groundwater use and quality at LGS. The NRC staff did not identify any new and significant information with regard to Category 1 (generic) groundwater issues based on the review of the ER (Exelon 2011a), the public scoping process, the comment period on the draft SEIS, or as a result of the environmental site audit. NRC staff also reviewed other sources of information, such as various permits and data reports. As a result, no information or impacts related to these issues were identified that would change the conclusions presented in the GEIS. Therefore, for the single issue found to be directly applicable to LGS, it is expected that there would be no incremental impacts related to this Category 1 issue during the renewal term beyond those discussed in the GEIS. For this groundwater issue, the GEIS concludes that the impacts are SMALL.

4.5.2 Groundwater Use and Quality Conflicts

This section presents the NRC staff's review of plant-specific (Category 2) groundwater resources issues as listed in Table 4–4.

4.5.2.1 Plants Using Cooling Towers Withdrawing Makeup Water from a Small River, Alluvial Aquifers

For nuclear power plants using cooling towers supplied with makeup water from a small river (as defined in Section 4.4.2.1), the potential impact on alluvial aquifers is also considered a Category 2 issue, thus, requiring a plant-specific assessment. This groundwater aspect was classified as a Category 2 issue in the GEIS because consumptive use of water withdrawn from a small river could adversely affect groundwater aquifer recharge. Low river flow conditions are of particular interest. In evaluating the potential impacts resulting from groundwater use conflicts associated with license renewal, the NRC staff uses as its baseline the existing groundwater resource conditions described in Sections 2.1.7.2 and 2.2.5.1 of this SEIS. These baseline conditions encompass the existing hydrogeologic framework and conditions (including aquifers) potentially affected by continued operations, as well as the nature and magnitude of groundwater withdrawals for cooling and other purposes (as compared to relevant appropriation and permitting standards). The baseline also considers other downgradient or in-aquifer uses and users of groundwater.

Based on the topography of the plant site and review of local groundwater elevations, NRC staff determined that groundwater flow across and in the vicinity of the plant site predominatelydischarges to the Schuylkill River and Possum Hollow Run. Groundwater provides baseflow to these surface waters. For groundwater use conflicts to occur due to reduced streamflow, the affected stream segments must also be a principal source of recharge to an affected aquifer, which is not the case. Recharge to the bedrock aquifer (Brunswick) in the region predominantly occurs in upgradient areas from precipitation and runoff, as described in Section 2.2.5.1 of the SEIS. In addition, the alluvial sediments and regolith overlying the area's bedrock are relatively thin and not used as a source of groundwater. A review of Pennsylvania water well records within a 1-mi (1.6-km) radius of the LGS site revealed that all recorded wells are in the Brunswick Formation rather than in surficial materials. Therefore, the NRC staff concludes that continued withdrawals of surface water for the operation of LGS, Units 1 and 2, during low-flow periods would have a SMALL impact on groundwater recharge during the license renewal term.

4.5.2.2 Radionuclides Released to Groundwater

In its ER (Exelon 2011a), Exelon identified the presence of tritium in groundwater as new, but not significant, information based on site groundwater monitoring. In response, the NRC staff specifically reviewed information relating to the current state of knowledge on groundwater quality beneath and downgradient of LGS, as detailed in Section 2.2.5.2 and summarized below.

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to groundwater quality, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, "Radionuclides released to groundwater," with an impact level range of SMALL to MODERATE, to evaluate the potential impact of discharges of radionuclides from plant systems into groundwater. This new Category 2 issue has been added to evaluate the potential impact to groundwater quality from the discharge of radionuclides from plant systems, piping, and tanks. This issue was added because, within the past several years, there have been events at nuclear power reactor sites that involved unknown, uncontrolled, and unmonitored releases of radioactive liquids into the groundwater. In evaluating the potential impacts on groundwater quality associated with license renewal, the NRC staff uses as its baseline the existing groundwater conditions described in Section 2.2.5 of this SEIS. These baseline conditions encompass the existing quality of groundwater potentially affected by continued operations (as compared to relevant state or U.S. Environmental Protection Agency (EPA) primary drinking water standards), as well as the current and potential onsite and offsite uses and users of groundwater for drinking and other purposes. The baseline also considers other downgradient or in-aquifer uses and users of groundwater.

Exelon commissioned a hydrogeologic investigation in 2006 (CRA 2006), in part, to evaluate the potential impacts on groundwater quality of any inadvertent releases of tritium or other LGS-related radionuclides and to identify and eliminate contributing sources of radionuclides to groundwater. The investigation provided the basis for the site's current Radiological Groundwater Protection Program (RGPP).

As part of the 2006 investigation, a network of 15 onsite groundwater monitoring wells was installed in the Brunswick Formation (bedrock aquifer) at LGS. From the initial 2006 sampling, no strontium-90 or gamma-emitting radionuclides were detected in groundwater or surface water above analytical detection limits. Tritium was detected in five of the monitoring wells at relatively low levels, but one well (P12), located immediately south and downgradient of the power block, had a concentration of 4,360 ± 494 pCi/L. At the same time, a sample from the power block foundation sump had tritium at 2,020 ± 154 pCi/L. As noted in Section 2.2.5.2, well P12 was replaced with well no. MW-LR-9 in August 2006, to be more representative of water table conditions beneath the site. Sampling of this new well yielded tritium at 1,500 ± 210 pCi/L.

Under the ongoing RGPP at LGS, groundwater and surface water samples are collected and analyzed for tritium and other radionuclides at least semi-annually. The results are reported in annual radiological environmental operating (REOP) reports (Exelon 2008a, 2009a, 2010a, 2011b, 2012b, 2013) that are submitted to the NRC. Since 2006, there have been no detections in groundwater of gamma-emitting radionuclides or strontium-90 associated with LGS operations. Until 2012, the peak tritium level observed in groundwater was 1,750 pCi/L in well MW-LR-9 in 2009. Exelon traced this to a condensate release in February 2009, which was corrected (see Section 2.2.5.2). Tritium in MW-LR-9 had decreased to a maximum of 872 pCi/L by August 2012.

As further described in Section 2.2.5.2, LGS's cooling tower discharge line overflowed through its relief vent in March 2012. This overflow was ongoing as a radwaste tank batch discharge was being performed. The resulting overflow of contaminated water impacted shallow groundwater. Exelon pumped out the remaining standing water and completed remediation of the area within 1 day of the overflow. Groundwater sampling results from the closest well (MW-LR-5) located along the flow path of the spill revealed a maximum tritium concentration of 14,200±1,450 pCi/L. By October 2012, tritium levels had fallen to 215 pCi/L (Exelon 2013).

Tritium concentrations have exceeded 2,000 pCi/L in samples from the power block foundation sump since 2006 (Exelon 2011a). Regardless, monitoring data indicates that there is no migration of tritium in groundwater at LGS at concentrations exceeding 20,000 pCi/L, the EPA primary drinking water standard, and observed tritium levels had fallen to below 1,000 pCi/L in all onsite monitoring wells by the end of 2012. In addition, there are no potable water wells downgradient of the LGS power block and no drinking water pathway. The plant's potable water supply well (well 1) is located about 1,000 ft (300 m) upgradient and slightly cross-gradient (northeast) of MW-LR-9 and the power block sump pit and some 1,500 ft (460 m) upgradient from MW-LR-5 and blowdown relief vent. Based on the information presented and the NRC staff's review, NRC staff concludes that inadvertent releases of tritium have not substantially impaired site groundwater quality or affected groundwater use downgradient of the LGS site. The NRC staff further concludes that groundwater quality impacts would remain SMALL during the license renewal term.

4.6 Aquatic Resources

Section 2.1.6 of this SEIS describes the LGS cooling-water system; Section 2.2.5 describes the aquatic resources. Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B–1, which are applicable to the operation of the LGS cooling-water systems during the renewed license term, are listed in Table 4–5. There are no Category 2 issues that apply to aquatic resources at LGS. The NRC staff did not find any new and significant information during the review of the applicant's ER (Exelon 2011a), the site audit, the scoping process, the comment period on the draft SEIS, or the evaluation of other available information; therefore, the NRC staff concludes that there are no impacts related to aquatic resource issues beyond those discussed in the GEIS (NRC 1996, 2013a) and the final rule (78 FR 37282, June 20, 2013). Consistent with the GEIS, the NRC staff concludes that the impacts are SMALL.

Table 4–5. Aquatic Resources Issues

Issues	GEIS Section	Category
For all plants		
Accumulation of contaminants in sediments or biota	4.2.1.2.4	1
Entrainment of phytoplankton and zooplankton	4.2.2.1.1	1
Cold shock	4.2.2.1.5	1
Thermal plume barrier to migrating fish	4.2.2.1.6	1
Distribution of aquatic organisms	4.2.2.1.6	1
Premature emergence of aquatic insects	4.2.2.1.7	1
Gas supersaturation (gas bubble disease)	4.2.2.1.8	1
Low dissolved oxygen in the discharge	4.2.2.1.9	1
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.2.2.1.10	1
Stimulation of nuisance organisms	4.2.2.1.11	1
Exposure of aquatic organisms to radionuclides	4.6.1.2[a]	1
For plants with cooling tower-based heat dissipation systems		
Entrainment of fish and shellfish in early life stages	4.3.3	1
Impingement of fish and shellfish	4.3.3	1
Heat shock	4.3.3	1

[a] NRC 2013a; 78 FR 37282

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51(61 FR 28467, June 5, 1996)

4.6.1 Exposure of Aquatic Organisms to Radionuclides

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the aquatic organisms, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 1 issue, "Exposure of aquatic organisms to radionuclides," among other changes. This new Category 1 issue considers the impacts to aquatic organisms from exposure to radioactive effluents discharged from a nuclear power plant during the license renewal term. An understanding of the radiological conditions in the aquatic environment from the discharge of radioactive effluents within NRC regulations has been well established at nuclear power plants during their current licensing term. Based on this information, the NRC concluded that the doses to aquatic organisms are expected to be well below exposure guidelines developed to protect these organisms and assigned an impact level of SMALL.

The NRC staff has not identified any new and significant information related to the exposure of aquatic organisms to radionuclides during its independent review of LGS's ER, the site audit, and the scoping process. Section 2.1.2 of this SEIS describes the applicant's radioactive waste management program to control radioactive effluent discharges to ensure that they comply with NRC regulations in 10 CFR Part 20, "Standards for protection against radiation." Section 4.9.3 of this SEIS contains the NRC staff's evaluation of the LGS's radioactive effluent and radiological environmental monitoring programs. LGS's radioactive effluent and radiological environmental monitoring programs provide further support for the conclusion that the impacts of aquatic organisms from radionuclides are SMALL. The NRC staff concludes that there would be no impacts to aquatic organisms from radionuclides beyond those impacts contained in Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 of the final rule and, therefore, the impacts to aquatic organisms from radionuclides are SMALL.

4.7 Terrestrial Resources

The Category 1 (generic) and Category 2 (site-specific) terrestrial resources issues applicable to LGS are discussed in the following sections and listed in Table 4–6. Terrestrial resources issues that apply to LGS are described in Sections 2.2.7 and 2.2.8.

Table 4–6. Terrestrial Resources Issues

Issue	GEIS Section	Category
Cooling tower impacts on crops and ornamental vegetation	4.3.4	1
Cooling tower impacts on native plants	4.3.5.1	1
Bird collisions with cooling towers	4.3.5.2	1
Power line right-of-way management (cutting herbicide application)	4.5.6.1	1
Bird collisions with power lines	4.5.6.2	1
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3	1
Floodplains and wetland on power line right-of-way	4.5.7	1
Exposure of terrestrial organisms to radionuclides	4.6.1.1[a]	1
Effects on terrestrial resources (non-cooling system impacts)	4.6.1.1[a]	2

[a] NRC 2013a; 78 FR 37282

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

4.7.1 Generic Terrestrial Resources Issues

For the Category 1 terrestrial resources issues listed in Table 4–6, the NRC staff did not identify any new and significant information during the review of the ER (Exelon 2011a), the NRC staff's site audit, the scoping process, the comment period on the draft SEIS, or the evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS and the final rule (78 FR 37282, June 20, 2013). For these issues, the GEIS concludes that the impacts are SMALL.

4.7.1.1 Exposure of Terrestrial Organisms to Radionuclides

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the terrestrial organisms, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 1 issue, “Exposure of terrestrial organisms to radionuclides,” among other changes. This new issue has an impact level of SMALL. This new Category 1 issue considers the impacts to terrestrial organisms from exposure to radioactive effluents discharged from a nuclear power plant during the license renewal term. An understanding of the radiological conditions in the terrestrial environment from the discharge of radioactive effluents within NRC regulations has been well established at nuclear power plants during their current licensing term. Based on this information, the NRC concluded that the doses to terrestrial organisms are expected to be well below exposure guidelines developed to protect these organisms and assigned an impact level of SMALL.

The NRC staff has not identified any new and significant information related to the exposure of terrestrial organisms to radionuclides during its independent review of LGS’s ER, the site audit, the scoping process, and the comment period on the draft SEIS. Section 2.1.2 of this SEIS describes the applicant’s radioactive waste management program to control radioactive effluent discharges to ensure that they comply with NRC regulations in 10 CFR Part 20. Section 4.9.3 of this SEIS contains the NRC staff’s evaluation of LGS’s radioactive effluent and radiological environmental monitoring programs, which provide further support for the conclusion that the impacts from radioactive effluents are SMALL.

Therefore, the NRC staff concludes that there would be no impact to terrestrial organisms from radionuclides beyond those impacts contained in Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 of the final rule and, therefore, the impacts to terrestrial organisms from radionuclides are SMALL.

4.7.2 Effects on Terrestrial Resources (Non-cooling System Impacts)

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the terrestrial organisms, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by expanding the Category 2 issue, “Refurbishment impacts,” among others, to include normal operations, refurbishment, and other supporting activities during the license renewal term. This issue remains a Category 2 issue with an impact level range of SMALL to LARGE; however, the final rule renames this issue “Effects on terrestrial resources (non-cooling system impacts).”

The geographic scope for the assessment of this issue is the LGS site and area near the site, The assessment starts with a description of the terrestrial resources as they currently extist, as decribed in Section 2.2.7, and will forecast impacts of operating the units for 20 years beyond the current license dates. Section 2.2.7 describes the terrestrial resources on and in the vicinity of the LGS site and vicinity, and Section 2.2.8 describes protected species and habitats. During construction of LGS, approximately 42 percent of the plant site (270 ac (110 ha)) was cleared for buildings, parking lots, roads, and other infrastructure. The remaining terrestrial habitats have not changed significantly since construction. As discussed in Chapter 3 of this SEIS and according to the applicant’s ER (Exelon 2011a), Exelon has no plans to conduct refurbishment or replacement actions associated with license renewal to support the continued operation of LGS. Further, Exelon (2011a) anticipates no new construction or other ground-disturbing activities, changes in operations, or changes in existing land use conditions because of license renewal. Exelon (2011a) reports that operation and maintenance activities would be confined to previously disturbed areas or existing ROWs. As a result, Exelon (2011a) anticipates no new impacts on the terrestrial environment on the LGS site or along the in-scope transmission line corridors during the license renewal term. Based on the staff's independent review, the staff concurs that operation and maintenance activities that Exelon might undertake during the renewal term, such as maintenance and repair of plant infrastructure (e.g., roadways, piping installations, onsite transmission lines, fencing, and other security infrastructure), likely would be confined to previously disturbed areas of the LGS site. Therefore, the staff expects non-cooling system impacts on terrestrial resources during the license renewal term to be SMALL.

4.8 Protected Species and Habitats

Section 2.2.7 of this SEIS describes the action area, as defined by the Endangered Species Act (ESA) regulations at 50 CFR 402.02, and describes the protected species and habitats within the action area associated with the LGS license renewal. The baseline for the assessment is the condition of protected species and habitats under the no-action alternative. This assessment starts with a description of the protected species and habitats as they currently exist, as described in Section 2.2.8, and will forecast impacts of operating the units for 20 years beyond current license expiration dates. Table 4–7 lists the one Category 2 issue related to protected species and habitats that is applicable to LGS.

Table 4–7. Protected Species and Habitats Issues

Issue	GEIS Section	Category
Threatened or endangered species	4.1	2

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

4.8.1 Correspondence with Federal and State Agencies

In accordance with Section 7 of the ESA, in a letter to the U.S. Fish and Wildlife Service (FWS), dated September 8, 2011, the NRC staff requested information regarding Federally listed species in the action area (NRC 2011d). Also in accordance with Section 7 of the ESA, the NRC staff sent a similar request regarding Federally listed species to the National Marine Fisheries Service (NMFS) (NRC 2012a). The NRC staff sent further requests to the Pennsylvania Fish and Boat Commission (PFBC) (NRC 2011e), Pennsylvania Game Commission (PGC) (NRC 2011g), and Pennsylvania Department of Conservation and Natural Resources (PDCNR) (NRC 2011f) regarding the presence of Pennsylvania-listed species in the action area. The PFBC, PGC, FWS, and NMFS responded to the NRC staff in letters dated October 5, 2011 (PFBC 2011b); November 17, 2011 (PGC 2011); November 22, 2011 (FWS 2011b); and June 2, 2012 (NMFS 2012c), respectively. The PFBC noted that the eastern redbelly turtle (*Pseudemys rubriventris*) and globally rare amphipods and/or isopods may be in the project area (PFBC 2011b); Section 4.8.2 considers the potential effects to this species. The PGC determined that no impacts to Pennsylvania-listed threatened or endangered birds or mammals under PGC responsibility would be likely from the proposed license renewal (PGC 2011).

In its November 22, 2011, letter, the FWS indicated that the proposed project is within the known range of the bog turtle (*Clemmys muhlenbergii*) (FWS 2011b); Section 4.8.2 considers the potential effects to this species as well as the Indiana bat (*Myotis sodalis*) and small-whorled pogonia (*Isotria medeoloides*). Following the issuance of the draft SEIS and under section 7 of the ESA, the NRC requested the FWS's concurrence with its determination of "not likely to adversely affect" these three species in a letter dated May 7, 2013 (NRC 2013b). The FWS responded in a letter dated August 16, 2013 (FWS 2013). The FWS stated that it had determined that the proposed license renewal would have no effect on Federally listed species. This letter concluded section 7 consultation between the NRC and FWS for LGS license renewal.

In its June 2, 2012, letter, NMFS stated that no species listed under the ESA occur within the action area (NMFS 2012c). NMFS also stated that two candidate species—alewife (*Alosa pseudoharengus)* and blueback herring *(Alosa aestivalis)*—occur in the project area. However, on August 12, 2013, NMFS published a *Federal Register* notice of a listing determination (78 FR 48943), which states that NMFS has determined that listing the alewife and blueback herring is not warranted at this time. Thus, these species are no longer candidates for listing. Blueback herring and alewife are still classified as NMFS species of concern. A species is designated as a species of concern if NMFS has some concerns about the species' status and threats, but there is insufficient information to indicate a need to list the species under the ESA (NMFS 2012). This status level does not carry any procedural or substantive protections under the ESA (NMFS 2012b). No further consultation with NMFS under section 7 of the ESA is required for LGS license renewal.

The NRC staff has not received a response from the PDCNR to date. However, in a March 9, 2011, letter to Exelon, the PDCNR identified several plant species that occur within the action area near LGS transmission line corridors (PDCNR 2011). The PDCNR indicated that because the proposed license renewal does not involve new construction, refurbishment, ground disturbance, or changes to operations or existing land-use conditions, no impact is likely to occur to species under the PDCNR's jurisdiction (PDCNR 2011).

4.8.2 Aquatic Species and Habitats

For purposes of its protected species and habitat discussion and analysis, the NRC staff considers the action area, as defined by 50 CFR 402.02, to include the lands and waterbodies associated with LGS, as defined in Section 2.2.7. Two fish species and one aquatic invertebrate protected under the ESA may occur in the Delaware River or in small waterbodies throughout Pennsylvania (FWS 2012, NMFS 2012a). Two fish within the action area are considered candidate species and species of concern by NMFS (NMFS 2012c). Three additional fish species, one additional aquatic invertebrate, and four aquatic plant species listed as a species of special concern, endangered, or threatened by the Commonwealth of Pennsylvania may occur in waterbodies in Bucks, Chester, or Montgomery Counties (PNHP 2012a).

4.8.2.1 Federally Protected Species

<u>Shortnose Sturgeon (*Acipenser brevirostrum*)</u>

The endangered shortnose sturgeon uses the tidal, estuarine, and lower portion of the Delaware River in Bucks County, Pennsylvania (NMFS 2012b). LGS-related studies from 1979-1985 did not observe shortnose sturgeon eggs or larvae at the Point Pleasant Pumping Station and downriver to river mi (RM) 138 (river km (RKm) 222.1) (Exelon 2011a; RMC 1984, 1985, 1986). The most recent population studies observed the farthest upriver migration up to 9 RM (15 RKm) below the Point Pleasant Pumping Station, which is located at RM 157 (RKm 253) (Hastings et al. 1987; O'Herron et al. 1993). NMFS stated that no species listed under the ESA occur within the action area (NMFS 2012c).

The NRC staff concludes that the proposed LGS license renewal would have no effect on the shortnose sturgeon because:

- NMFS (2012c) stated that no species listed under the ESA occur within the action area.
- The LGS intake at the Point Pleasant Pumping Station is approximately 9 RM (15 RKm) upriver of the farthest known upriver occurrence of this species.
- LGS-related studies from 1979–1985 did not observe Shortnose sturgeon eggs or larvae near the Point Pleasant Pumping Station.
- No new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at the Point Pleasant Pumping Station would occur.

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

The endangered Atlantic sturgeon uses the tidal, estuarine, and lower portion of the Delaware River in Bucks County, Pennsylvania (NMFS 2012b). LGS-related studies from 1979 to 1985 did not observe Atlantic sturgeon eggs or larvae at the Point Pleasant Pumping Station and downriver to 138 RM (222.1 RKm) (Exelon 2011a; RMC 1984, 1985, 1986). Tagging studies in 2005 and 2006 indicated that Atlantic sturgeon followed similar migration patterns as shortnose sturgeon with spawning potentially occurring in the upper tidal Delaware reaches between Philadelphia, Pennsylvania, and Trenton, New Jersey (Simpson and Fox undated). NMFS (2012c) stated that no species listed under the ESA occur within the action area.

The NRC staff concludes that the proposed LGS license renewal would have no effect on Atlantic sturgeon because:

- NMFS (2012) stated that no species listed under the ESA occur within the action area.
- LGS-related studies from 1979 to1985 did not observe Atlantic sturgeon eggs or larvae near the Point Pleasant Pumping Station.
- No new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at the Point Pleasant Pumping Station would occur.

Dwarf Wedgemussel (*Alasmidonta heterodon*)

FWS (2012b) lists the endangered dwarf wedgemussel as known to or believed to occur in Monroe, Pike, and Wayne Counties, Pennsylvania, which is not part of the action area. PNHP (2012a) lists the dwarf wedgemussel as potentially occurring in Bucks, Chester, and Montgomery Counties. The Philadelphia Electric Company (PECO 1984) observed rare, unidentified species of the genus *Alasmidonta* in the Schuylkill River in the 1970s and it is unknown whether the specimens were the dwarf wedgemussel (Exelon 2011a). Other than the rare *Alasmidonta* specimens observed in the 1970s in the Schuylkill River, LGS-related studies did not observe dwarf wedgemussels during benthic surveys in East Branch Perkiomen Creek, Perkiomen Creek, and the Schuylkill River between 1970 and 2009 (Exelon 2011a; NAI 2010c; PECO 1984; RMC 1984, 1985, 1986, 1987, 1989).

Both Exelon and the NRC staff contacted FWS to request information on potential impacts to Federally protected species. In a March 22, 2011, letter to Exelon, FWS (2011a) did not identify the dwarf wedgemussel as a concern in regard to LGS's proposed license renewal. In a November 22, 2011, letter to the NRC, the FWS (2011b) confirmed that the conclusions in their previous letter to Exelon were still appropriate.

Therefore, the NRC staff concludes that the proposed LGS license renewal would have no effect on dwarf wedgemussel because effects to the species would be insignificant, discountable, or beneficial.

4.8.2.2 Pennsylvania-Protected Species, Candidate Species, and Species of Concern

<u>Fish</u>

The Commonwealth of Pennsylvania lists the banded sunfish (*Enneacanthus obesus*) and the longear sunfish (*Lepomis megalotis*) as endangered in Bucks County (PNHP 2012a). The Pennsylvania endangered ironcolor shiner (*Notropis chalybaeus*) occurs in Bucks and Montgomery Counties (PNHP 2012a). Blueback herring and alewife are considered NMFS species of concern (NMFS 2012).

LGS-related activity in Bucks County that could affect the blueback herring, alewife, banded sunfish, longear sunfish, or ironcolor shiner and their habitat is the intermittent withdrawal of Delaware River water for the LGS cooling system. Direct impacts could include impingement or entrainment and indirect impacts could include impingement or entrainment of prey. Blueback herring and alewife eggs are demersal and adhesive, which make them less likely to be entrained. Eggs and larvae entrained in the Point Pleasant Pumping Station would be transported from the Delaware River to the East Branch Perkiomen Creek. Eggs and larvae would experience sudden pressure fluctuations, velocity shear forces, and physical abrasion in the pumps at Point Pleasant and Bradshaw Reservoir and throughout the pipeline. If any eggs or larvae survive the transport, successful development would depend on organisms finding suitable habitat. Prey species that survive the transport would no longer be available as prey for fish in the Delaware River.

LGS license renewal would include continued operation at the Point Pleasant Pumping Station. However, as described in Section 2.1.6, Exelon's withdrawal of water from the Delaware River is secondary to its withdrawal of water from the Schuylkill River, and Exelon plans to continue to rely less on the Delaware River and more on the Schuylkill River in the future (Exelon 2012a). LGS license renewal would not involve new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at the Point Pleasant Pumping Station. Transmission lines associated with LGS do not cross any portion of the Delaware River (Exelon 2011a).

In addition to Bucks County, blueback herring, alewife, and the ironcolor shiner may occur in Montgomery County. Waters in Montgomery County associated with LGS include East Branch Perkiomen Creek, Perkiomen Creek, and the Schuylkill River. LGS license renewal would include continued operation at the Perkiomen Pumphouse, the Schuylkill Pumphouse, and the Schuylkill River discharge structure. Direct effects could include mortality if fish are impinged or entrained. Blueback herring and alewife eggs are demersal and adhesive, which make them less likely to be entrained. Indirect effects could include a decrease in habitat quality from thermal discharge in the Schuylkill River. However, the flow, temperature, and other conditions of the discharge are regulated by LGS's NPDES permit, which would limit changes in water quality. Indirect effects could also occur from the Delaware River intrabasin transfer of water, which involves diversion of Delaware River water to the East Branch Perkiomen Creek that discharges by gravity flow to Perkiomen Creek to augment the flow in Perkiomen Creek. As described in Section 2.2.6, NAI (2010a) sampled aquatic biota between 2001 and 2009 as part of an analysis to examine post-operational effects of the water diversion effort (Exelon 2011a). Species diversity remained relatively consistent and samples continued to be dominated by midges and oligochaetes. In addition, less variability existed along the stream gradient and over time; NAI noted that pollution-sensitive species increased in abundance (NAI 2010a, 2010c).

The LGS license renewal would include continued operation and maintenance of four transmission lines that extend from the Limerick site and travel and cross portions of the Schuylkill River and Perkiomen Creek (Section 2.1.5 describes the in-scope transmission lines in more detail). The transmission lines associated with LGS cross rivers and streams that have the potential to be blueback herring, alewife, or ironcolor shiner habitat. PECO must maintain the transmission lines and associated structures and manage vegetation along the transmission line corridors to prevent interference with the lines. Line and vegetation maintenance may result in a temporary decline in habitat quality from increased sedimentation and turbidity during maintenance activities.

If PECO needs to perform maintenance in or near waterbodies, it takes a number of precautions to avoid impacts to blueback herring, alewife, and ironcolor shiners or their habitat. First, PECO typically performs mechanical vegetation maintenance activities on foot and does not operate heavy machinery near wetlands and water bodies. This type of maintenance avoids the potential for heavy machinery to affect fish habitat by reducing the amount of sedimentation and turbidity in the stream. Foot traffic could result in some minimal disturbance of fish habitat. However, foot traffic would create impacts that are insignificant (i.e., those impacts that would never reach the scale where fish mortality would occur) or discountable (i.e., those impacts that cannot be meaningfully measured, detected, or evaluated). In addition, PECO must obtain several permits and certifications for maintenance activities in wetlands or near waterbodies, which for a given work area may include: (1) a General Permit or Water Obstruction and Encroachment General Permit issued jointly by the USACE and PADEP, (2) a CWA 404 permit issued by the USACE, or (3) an erosion and sedimentation control plan from the appropriate county conservation district.

LGS license renewal would not involve new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at LGS-associated facilities or transmission lines.

The NRC staff contacted PFBC to request information on potential impacts to Pennsylvania-protected species. In an October 5, 2011, letter to the NRC, PFBC (PFBC 2011b) did not identify the banded sunfish, longear sunfish, or the ironcolor shiner as a concern in regard to LGS's proposed license renewal.

<u>Pizzini's Amphipod</u>

The Pizzini's cave amphipod (*Stygobromus pizzinii*), previously named *Stygonectes pizzinii,* is a Pennsylvania species of concern and is possibly extirpated in Montgomery and Chester Counties (PNHP 2012a). Based on the Pennsylvania Natural Diversity Inventory (PNDI) database and PFBC files, PFBC (2011) stated in its letter to the NRC that globally rare amphipod and/or isopod species are known to occur within the vicinity of the LGS site.

LGS license renewal would include continued operation at the Perkiomen Pumphouse, the Schuylkill Pumphouse, and the Schuylkill River discharge structure. Direct effects could include mortality if amphipods are entrained. Indirect effects could include a decrease in habitat quality from thermal discharge in the Schuylkill River. However, the flow, temperature, and other conditions of the discharge are regulated by LGS's NPDES permit, which would limit changes in water quality. Indirect effects could also occur from the Delaware River intrabasin transfer of water, which involves diversion of Delaware River water to the East Branch Perkiomen Creek that discharges by gravity flow to Perkiomen Creek to augment the flow in Perkiomen Creek. As described in Section 2.2.6, NAI (2010a) sampled aquatic biota between 2001 and 2009 as part of an analysis to examine post-operational effects of the water diversion effort (Exelon 2011a). Species diversity remained relatively consistent and samples continued to be dominated by midges and oligochaetes. In addition, less variability existed along the stream gradient and over time; NAI noted that pollution-sensitive species increased in abundance (NAI 2010a, 2010c).

The LGS license renewal would include continued operation and maintenance of four transmission lines that extend from the Limerick site and travel and cross portions of the Schuylkill River and Perkiomen Creek (Section 2.1.5 describes the in-scope transmission lines in more detail). The transmission lines associated with LGS cross rivers and streams that have the potential to be Pizzini's cave amphipod habitat. PECO must maintain the transmission lines and associated structures and manage vegetation along the transmission line corridors to prevent interference with the lines. Line and vegetation maintenance may result in direct impacts to Pizzini's cave amphipod if instream work is required that could crush the amphipods. Potential indirect effects could include a temporary decline in habitat quality from increased sedimentation and turbidity during maintenance activities. In PFBC's (2011) letter to the NRC, PFBC noted that the Pizzini's cave amphipod is threatened by habitat destruction and poor water quality. If PECO needs to perform maintenance in or near waterbodies, it takes a number of precautions to reduce the likelihood of crushing amphipods and to reduce sedimentation and water quality impacts. These actions, such as performing mechanical vegetation maintenance activities on foot and obtaining necessary permits, are described in more detail earlier in this section.

LGS license renewal would not involve new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at LGS-associated facilities or transmission lines.

The NRC staff contacted PFBC to request information on potential impacts to Pennsylvania-protected species. In an October 5, 2011, letter to the NRC, PFBC (2011) identified Pizzini's cave amphipod as potentially occurring in the vicinity of the LGS site. However, given that license renewal would not involve new construction, earth disturbances, or changes to existing land uses, PFBC did not anticipate any significant adverse impacts to this species (PFBC 2011b).

<u>Aquatic Plants</u>

Pennsylvania lists Farwell's water-milfoil (*Myriophyllum farwellii*), broad-leaved water-milfoil (*Myriophyllum heterophyllum*), floating-heart (*Nymbphoides cordata*), and spotted pondweed (*Potamogeton pulcher*) as either threatened or endangered as described in Section 2.2.7. All four plants have historic or current records of occurrence in coastal portions of Bucks County (PNHP 2012a).

LGS-related activity that could affect the Farwell's water-milfoil, broad-leaved water-milfoil, floating-heart, and spotted pondweed and their habitat is the intermittent withdrawal of Delaware River water for the LGS cooling system. Direct impacts could include mortality if the plants were sucked into the intake at the Point Pleasant Pumping Station. As described above, preferred habitat does not occur near the Point Pleasant Pumping Station. LGS license renewal would include continued operation at the Point Pleasant Pumping Station. However, as described in Section 2.1.6, Exelon's withdrawal of water from the Delaware River is secondary to its withdrawal of water from the Schuylkill River, and Exelon plans to continue to rely less on the Delaware River and more on the Schuylkill River in the future (Exelon 2012a). LGS license renewal would not involve new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at the Point Pleasant Pumping Station. Transmission lines associated with LGS do not cross any portion of the Delaware River (Exelon 2011a).

The NRC staff contacted PFBC to request information on potential impacts to Pennsylvania-protected species. In an October 5, 2011, letter to the NRC, PFBC (2011b) did not identify the Farwell's water-milfoil, broad-leaved water-milfoil, floating-heart, and spotted pondweed aquatic plants as a concern in regard to LGS's proposed license renewal.

4.8.2.3 Conclusion for Aquatic Species

The NRC staff evaluated the three ESA-listed species, two candidate species, and eight additional Pennsylvania-protected species and species of special concern that could be present in the action area defined in Section 2.2.8. In its evaluation, NRC staff examined the known distributions and habitat ranges of those species, the ecological impacts of the operation of LGS on the species, and the LGS-related occurrence and monitoring studies described above. In addition, no critical habitat occurs within the action area. Given that LGS license renewal would not involve new construction, refurbishment, ground-disturbing activities, or changes to existing land use conditions at LGS-associated facilities or transmission lines, the continued operation of LGS is not likely to noticeably affect these species. Thus, the NRC staff concludes that the impact on protected aquatic species from the proposed license renewal would be SMALL.

4.8.3 Terrestrial Species and Habitats

4.8.3.1 Species and Habitats Protected Under the Endangered Species Act

<u>Bog Turtle (*Clemmys muhlenbergii*)</u>

The following analysis of the impacts of LGS license renewal on the bog turtle constitutes the biological assessment for that species required by the ESA. Under the ESA, an agency's preparation of a biological assessment is intended to support consultation, but is an independent requirement under the ESA and can be completed through the NEPA process.

Section 2.2.8 concludes that the bog turtle could occur in suitable wetland habitat on the LGS site or within palustrine emergent and forested wetlands along the Schuylkill River.

Small sections of the LGS site contain suitable habitat for bog turtles. According to Figure 10, "Habitat Map of Limerick Generating Station," in Exelon's Wildlife Management Plan (Exelon 2012a), palustrine emergent and forested wetlands lie along the Schuylkill River adjacent to riparian forest, old field, and agricultural land. Within the LGS site, the LGS license renewal would include maintenance and operation activities within developed or previously disturbed areas and would not involve new construction, refurbishment, ground-disturbing activities, changes to conduct of operations, or changes to existing land use conditions in either natural or developed areas. The proposed license renewal would have no measurable direct or indirect adverse impacts to LGS site wetlands; therefore, it would have no measurable direct or indirect adverse effects on the bog turtle. As noted in Section 2.2.7, poaching and loss of habitat are two of the primary threats to the species. Continued operation of LGS during the license renewal term would preserve the existing wetlands on the LGS site. Site security would prevent public access to the site, and thus, prevent poaching. Therefore, continued operation of the LGS could result in beneficial effects to the species.

The LGS license renewal would include Exelon's continued operation and maintenance of the Perkiomen Pumphouse, Bradshaw Reservoir and Pumphouse, and the Bedminster Water Processing Facility. Exelon would only perform maintenance and operation activities within developed or previously disturbed areas during the license renewal period. Thus, the proposed license renewal would have no direct or indirect adverse impacts to habitat at these offsite facilities and no direct or indirect adverse effects on the bog turtle.

Both Exelon and the NRC staff have contacted FWS to request information on potential impacts to Federally protected species. In a March 22, 2011, letter to Exelon, FWS (2011a) indicated that the bog turtle occurs or may occur in or near the project area, but that the proposed action is not likely to have an adverse effect on the bog turtle based on the FWS's review of the project description and location. In a November 22, 2011, letter to the NRC, the FWS (2011b) confirmed that the conclusion in its previous letter to Exelon was still appropriate. In 2013, after reviewing the draft SEIS for LGS license renewal, the FWS concluded in an August 16, 2013, letter (FWS 2013) that the proposed license renewal would have no effect on the bog turtle. This letter concluded section 7 consultation between FWS and NRC for LGS license renewal. Accordingly, the NRC is revising its previous conclusion of "may affect, but not likely to adversely affect."

The NRC staff concludes that the proposed LGS license renewal would have no effect on the bog turtle.

Indiana Bat (*Myotis sodalis*)

Section 2.2.8 concludes that the Indiana bat could occur in suitable forest habitat within the action area. Potential types of Indiana bat habitat that occur in the action area include summer roosting habitat, foraging habitat, and commuting habitat. Summer roosting habitat includes trees with exfoliating bark, cracks, or crevices in trees or snags (dead trees) that are greater than 3-in. (8-cm) diameter-at-breast height (FWS 2012a). Foraging habitat includes forest patches, wooded riparian corridors, and natural vegetation adjacent to such habitats (FWS 2012a). Commuting habitat includes wooded tracts, tree lines, wooded hedgerows, streams, or other linear pathways within or connected to roosting or foraging habitat (FWS 2012a).

The LGS license renewal would not disturb or alter any natural habitats within the LGS site or offsite facilities associated with the LGS makeup water system. Thus, no direct or indirect adverse effects would result from continued operation and maintenance of these facilities. If the Indiana bat occurs on the LGS site, continued operation of LGS would be beneficial to the species because it would preserve forest habitat that might otherwise be developed or converted to some other land use.

Both Exelon and the NRC staff have contacted FWS to request information on potential impacts to Federally protected species. The FWS did not mention that the Indiana bat was of particular concern in either its March 22, 2011, letter to Exelon (FWS 2011a) or its November 22, 2011, letter to the NRC (FWS 2011b). In 2013, after reviewing the draft SEIS for LGS license renewal, the FWS concluded in an August 16, 2013, letter (FWS 2013) that the proposed license renewal would have no effect on the Indiana bat. This letter concluded section 7 consultation between FWS and NRC for LGS license renewal. Accordingly, the NRC is revising its previous conclusion of "may affect, but not likely to adversely affect."

The NRC staff concludes that the proposed LGS license renewal would have no effect on the Indiana bat.

Small-Whorled Pogonia (*Isotria medeoloides*)

Section 2.2.8 indicates that three extant populations of the small-whorled pogonia occur in Pennsylvania, and at least one of these populations occurs in Chester County. Thus, Section 2.2.8 conservatively concludes that the small-whorled pogonia could occur in areas of suitable habitat at offsite facilities in Chester County.

Because the small-whorled pogonia does not occur in Montgomery or Bucks Counties, continued operation and maintenance of the LGS site and offsite facilities associated with the LGS makeup water system would have no direct or indirect effects on the small-whorled pogonia.

Both Exelon and the NRC staff have contacted FWS to request information on potential impacts to Federally protected species. The FWS did not mention the small-whorled pogonia was of particular concern in either its March 22, 2011, letter to Exelon (FWS 2011a) or its November 22, 2011, letter to the NRC (FWS 2011b). In 2013, after reviewing the draft SEIS for LGS license renewal, the FWS concluded in an August 16, 2013, letter (FWS 2013) that the proposed license renewal would have no effect on the the small-whorled pogonia. This letter concluded section 7 consultation between FWS and NRC for LGS license renewal. Accordingly, the NRC is revising its previous conclusion of "may affect, but not likely to adversely affect."

The NRC staff concludes that the proposed LGS license renewal would have no effect on the small-whorled pogonia.

Designated Critical Habitat

The NRC staff did not identify any Federally designated critical habitat within the action area during its review (see Section 2.2.7). Additionally, in its correspondence with Exelon and the NRC, the FWS (2011a, 2011b) did not identify any designated critical habitat. Thus, the NRC staff concludes that the proposed license renewal would have no effect on designated critical habitat.

Proposed Species and Proposed Critical Habitat

The NRC staff did not identify any Federally proposed species or proposed critical habitat within the action area during its review (see Section 2.2.7). Additionally, in its correspondence with Exelon and the NRC, the FWS (2011a, 2011b) did not identify any proposed species or proposed critical habitat. Thus, the NRC staff concludes that the proposed license renewal would have no effect on Federally proposed species or proposed critical habitat.

4.8.3.2 Species Protected Under the Bald and Golden Eagle Protection Act

Although bald eagles occur throughout the action area, no known nests are in close proximity to any of the LGS site buildings, parking lots, or other structures, the LGS makeup water system offsite facilities, or along the transmission line corridors that could be disturbed by operations or maintenance activities associated with the proposed license renewal. Because the proposed license renewal does not involve construction or land disturbances, the proposed license renewal would not affect any bald eagle habitat. The NRC staff concludes that the impacts of the proposed LGS license renewal on the bald eagle would be SMALL.

4.8.3.3 Species Protected Under the Migratory Bird Treaty Act

As discussed in Section 2.2.7, a variety of migratory birds inhabit the LGS site and surrounding region. Because the proposed license renewal does not involve construction or land disturbances, the NRC staff concludes that the impacts of the proposed LGS license renewal on migratory birds would be SMALL.

4.8.3.4 Species Protected by the Commonwealth of Pennsylvania

Section 2.2.8.3 discusses species protected under the Pennsylvania Endangered Species Program. Ten Pennsylvania-listed birds and two Pennsylvania-listed plants occur or have occurred on the LGS site since the plant began operating. An additional eight plant species occur near the transmission line corridors. One Pennsylvania-listed reptile, the eastern redbelly turtle (*Pseudemys rubriventris*), occurs in the vicinity of the LGS site. Because the proposed license renewal does not involve construction or land disturbances, the NRC staff concludes that the impacts of the proposed LGS license renewal on Pennsylvania-protected species on the LGS site or at offsite facilities associated with the LGS makeup water system would be SMALL.

Continued transmission line maintenance would not adversely affect any of the Pennsylvania-listed birds or the eastern redbelly turtle. As discussed in Section 2.1.5, PECO has implemented an avian management program to ensure that it does not unnecessarily disturb or harm birds or nests and to ensure compliance with applicable Federal and state bird regulations. The mitigative measures described above for the bog turtle would also be protective of the eastern redbelly turtle. Because the eastern redbelly turtle inhabits aquatic and wetland habitats, the likelihood of habitat disturbance or direct effects to this species is lower because PECO follows more stringent procedures when performing work in these areas. Additionally, in its February 11, 2011, letter to Exelon, the PFBC (2011a) noted that it does not anticipate that the proposed license renewal will have any significant adverse impacts on Pennsylvania-listed species of concern under the PFBC's jurisdiction.

Some of the Pennsylvania-listed plants discussed in Section 2.2.8.3 occur in woodlands or other habitats near, but not directly within, the transmission line corridors. Continued transmission line maintenance would not affect these plant species because PECO only manages vegetation within the corridor. The other plant species occur in habitats compatible with transmission lines, such as old fields or other early successional communities, and PECO likely would not perform intensive maintenance or use herbicides in these areas because these habitats already contain low-growing vegetation. The NRC staff concludes that the impacts of the proposed license renewal on Pennsylvania-listed plants along the transmission line corridors would be SMALL.

4.8.3.5 Conclusion

The NRC staff concludes that the impacts of the proposed LGS license renewal on protected terrestrial species and habitats would be SMALL as defined by the NRC for the purposes of NEPA.

4.9 Human Health

Table 4–8 lists the Category 1 and 2 issues related to human health that are applicable to LGS.

Table 4–8. Human Health Issues

Issue	GEIS Section	Category
Radiation exposure to the public during refurbishment	3.8.1[(a)]	1
Occupational radiation exposures during refurbishment	3.8.2[(a)]	1
Microbiological organisms (occupational health)	4.3.6	1
Microbiological organisms (public health)	4.3.6[(b)]	2
Noise	4.3.7	1
Radiation exposures to public (license renewal term)	4.6.2	1
Occupational radiation exposures (license renewal term)	4.6.3	1
Electromagnetic fields—acute effects (electric shock)	4.5.4.1	2
Electromagnetic fields—chronic effects	4.5.4.2	Uncategorized
Human health impact from chemicals	4.9.1.1.2[(c)]	1
Physical occupational hazards	4.9.1.1.5[(c)]	1

[(a)] Issues apply to refurbishment, an activity that LGS does not plan to undertake
[(b)] Issue applies to plants with features such as cooling lakes or cooling towers that discharge to a small river. The issue applies to LGS.
[(c)] NRC 2013a; 78 FR 37282

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

4.9.1 Generic Human Health Issues

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B–1, applicable to LGS in regard to human health impacts are listed in Table 4–8. Exelon stated in its ER (Exelon 2011a) that it was aware of one new radiological issue associated with the renewal of the LGS operating license: tritium in groundwater. Exelon's groundwater monitoring program for radioactive material is discussed in Sections 2.2.5, 4.5.2, and 4.11 of this document. Based on its review of LGS's groundwater monitoring data, the NRC staff concluded that the issue, while new, is not significant. The NRC staff has not identified any new and significant information during its independent review of Exelon's ER, the site visit, the scoping process, the comment period on the draft SEIS, or its evaluation of other available information.

4.9.1.1 New Category 1 Human Health Issues

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to the human health, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding two new Category 1 issues, "Human health impacts from chemicals" and "Physical occupational hazards." The first issue considers the impacts from chemicals to plant workers and members of the public. The second issue only considers the nonradiological occupational hazards of working at a nuclear power plant. An understanding of these nonradiological hazards to nuclear power plant workers and members of the public have been well established at nuclear power plants during those plants' current licensing terms. The impacts from chemical hazards are expected to be minimized through the licensee's use of good industrial hygiene practices as required by permits and Federal and state regulations. Also, the impacts from physical hazards to plant workers will be of small significance if workers adhere to safety standards and use protective equipment as required by Federal and state regulations. The impacts to human health for each of these new issues from continued plant operations are SMALL.

The NRC staff has not identified any new and significant information related to these non-radiological issues during its independent review of LGS's ER, the site audit, the scoping process, and the comment period on the draft SEIS. Therefore, the NRC staff concludes that there would be no impact to human health from chemicals or physical hazards beyond those impacts described in Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 of the final rule and, therefore, the impacts are SMALL.

4.9.2 Radiological Impacts of Normal Operations

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B–1, applicable to LGS in regard to radiological impacts to human health are listed in Table 4–8. The NRC staff has not identified any new and significant information related to radiological issues during its independent review of Exelon's ER, the site audit, the scoping process, the comment period on the draft SEIS, or its evaluation of other available information. Therefore, the NRC staff concludes that there would be no impact from radiation exposures to the public or to workers during the license renewal term beyond those discussed in the GEIS.

The findings in the GEIS are as follows:

- Radiation exposures to public (license renewal term)—Radiation doses to the public would continue at current levels associated with normal operations.
- Occupational exposures (license renewal term)—Occupational doses during the license renewal term are within the range of doses experienced during

normal operations and normal maintenance outages and would be well below regulatory limits.

According to the GEIS, the impacts to human health are SMALL.

There are no Category 2 issues related to radiological impacts of routine operations.

The information presented below is a discussion of selected radiological programs conducted at LGS.

4.9.2.1 Limerick Generating Station Radiological Environmental Monitoring Program

LGS conducts a Radiological Environmental Monitoring Program (REMP) to assess the radiological impact, if any, to its employees, the public, and the environment from the operations at LGS, Units 1 and 2. The REMP measures the aquatic, terrestrial, and atmospheric environment for radioactivity, as well as the ambient radiation. In addition, the REMP measures background radiation (i.e., cosmic sources, global fallout, and naturally occurring radioactive material, including radon). The REMP supplements the radioactive effluent monitoring program by verifying that any measurable concentrations of radioactive materials and levels of radiation in the environment are not higher than those calculated using the radioactive effluent release measurements and transport models.

An annual radiological environmental operating report (REOP) is issued, which contains a discussion of the results of the monitoring program. The report contains data on the monitoring performed for the previous year. The REMP collects samples of environmental media to measure the radioactivity levels that may be present. The media samples are representative of the radiation exposure pathways that may affect the public.

The LGS REMP is made up of three categories based on the exposure pathways to the public. They are as follows: atmospheric, aquatic, and ambient gamma radiation. The atmospheric samples taken around LGS are airborne particulate, airborne iodine, milk, and broad leaf vegetation. Airborne iodine and particulate samples are taken using vacuum pumps and glass fiber filters. The aquatic pathway samples are taken from surface water and drinking water sources. Also included in this pathway are sediment samples and fish samples. The ambient gamma radiation pathway measures direct exposure using dosimeters, which are typically thermoluminescent dosimeters.

In addition to the REMP, LGS has a groundwater protection program designed to monitor the onsite plant environment for the detection of leaks from plant systems and pipes containing radioactive liquid (see Sections 2.2.5.2 and 4.5.2.2).

The NRC staff reviewed the LGS annual REOPs for 2007 through 2012 to look for any significant impacts to the environment or any unusual trends in the data (Exelon 2008a, 2009a, 2010a, 2011b, 2012b, 2013). A 5-year period provides a data set that covers a broad range of activities that occur at a nuclear power plant, such as refueling outages, routine operation, and years in which there may be significant maintenance activities. Based on the NRC staff's review, no adverse trends (i.e., steadily increasing buildup of radioactivity levels) were observed and the data showed that there was no measurable impact to the environment from LGS operations.

4.9.2.2 Groundwater Protection Program

A radioactive groundwater protection program was established at LGS in 2006 to assess potential impacts to groundwater from plant operation.

In 2007, the Nuclear Energy Institute (NEI) established a standard for monitoring and reporting radioactive isotopes in groundwater: NEI 07-07, "Industry Ground Water Protection Initiative–

Final Guidance Document" (NEI 2007). LGS implemented the recommendations of this industry standard. Data from the groundwater monitoring program are contained in the annual radiological environmental operating report submitted to the NRC in May of each year. These reports are available for review by the public through the Agencywide Documents Access and Management System (ADAMS) electronic reading room available through the NRC website.

Additional information on the groundwater protection program is discussed in Sections 2.2.5.2 and 4.5.2.2 of this SEIS.

4.9.2.3 Pennsylvania Department of Environmental Protection Bureau of Radiation Detection Environmental Monitoring Program

The Bureau of Radiation Protection (BRP) performs its own independent environmental monitoring around the LGS site and other nuclear facilities located in Pennsylvania. All analyses of environmental media (i.e., soil, air, water, and vegetation) are performed by its Bureau of Laboratories (BOL). The state's BRP performs the monitoring of direct radiation from a facility using thermoluminescent dosimeters (TLDs).

The NRC staff reviewed the state's environmental summary reports for 2003 through 2004 (the most recent reports available at the time of the NRC's review) (PADEP undated). In each of the reports, the state concluded that the sample data indicated no release of radioactive material to the environment that exceeded the regulatory or license limits of the PADEP or the NRC.

4.9.2.4 Limerick Generating Station Radioactive Effluent Release Program

All nuclear plants were licensed with the expectation that they would release radioactive material to both the air and water during normal operation. However, NRC regulations require that radioactive gaseous and liquid releases from nuclear power plants must meet radiation dose-based limits specified in 10 CFR Part 20, and the as low as is reasonably achievable (ALARA) criteria in Appendix I to 10 CFR Part 50. Regulatory limits are placed on the radiation dose that members of the public can receive from radioactive effluents released by a nuclear power plant. In addition, nuclear power plants are required by 10 CFR 50.36(a)(2) to submit an annual report to the NRC that lists the types and quantities of radioactive effluents released into the environment. The radioactive effluent release reports are available for review by the public through the ADAMS electronic reading room available through the NRC website.

The NRC staff reviewed the annual radioactive effluent release reports for 2007 through 2011 (Exelon 2008b, 2009b, 2010b, 2011c, 2012c). The review focused on the calculated doses to a member of the public from radioactive effluents released from LGS. The doses were compared to the radiation protection standards in 10 CFR 20.1301 and the ALARA dose design objectives in Appendix I to 10 CFR Part 50.

Dose estimates for members of the public are calculated based on radioactive gaseous and liquid effluent release data and atmospheric and aquatic transport models. The 2011 annual radioactive effluent release report (Exelon 2012d) contains a detailed presentation of the radioactive discharges and the resultant calculated doses. The following summarizes the calculated dose to a member of the public located outside the LGS site boundary from radioactive gaseous and liquid effluents released during 2011:

- The combined total-body dose to an offsite member of the public from LGS, Units 1 and 2, radioactive liquid effluents was 8.38×10^{-2} mrem (8.38×10^{-4} mSv), which is well below the combined 6 mrem (0.06 mSv) dose criterion for two reactor units in Appendix I to 10 CFR Part 50.

- The organ (liver) dose to an offsite member of the public from LGS, Units 1 and 2, radioactive liquid effluents was 8.38×10^{-2} mrem (8.38×10^{-4} mSv), which is well below the combined 20 mrem (0.20 mSv) dose criterion for two reactor units in Appendix I to 10 CFR Part 50.

- The air dose at the site boundary from gamma radiation in gaseous effluents from LGS, Units 1 and 2, was 1.46×10^{-2} mrad (1.46×10^{-4} mGy), which is well below the combined 20 mrad (0.2 mGy) dose criterion for two reactor units in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents from LGS, Units 1 and 2, was 8.73×10^{-3} mrad (8.73×10^{-5} mGy), which is well below the combined 40 mrad (0.4 mGy) dose criterion for two reactor units in Appendix I to 10 CFR Part 50.
- The dose to an organ (bone) from radioactive iodine, radioactive particulates, and carbon-14 from LGS, Units 1 and 2, was 4.13×10^{-1} mrem (4.13×10^{-3} mSv), which is well below the combined 30 mrem (0.3 mSv) dose criterion for two-reactor units in Appendix I to 10 CFR Part 50.
- No radiation above background was detected at the site boundary from direct radiation. There is no dose criterion for direct radiation in Appendix I to 10 CFR Part 50. The data is included in the summation of doses from all radioactive effluent release pathways to determine compliance with EPA's 40 CFR Part 190 dose standard of 25 mrem (0.25 mSv) for the total dose to members of the public from the reactor units at the LGS site.
- The NRC staff summed the applicant's data on the individual total body doses from radioactive gaseous and liquid effluents from both units and added it to the dose from direct radiation to obtain the maximum all pathways dose to an offsite member of the public from the operation of LGS, Units 1 and 2. The dose to a member of the public from all radioactive releases in 2011 was 1.30×10^{-1} mrem (1.30×10^{-3} mSv), which is well below the 25 mrem (0.25 mSv) dose standard in EPA's 40 CFR Part 190.

The NRC staff's review of the LGS radioactive effluent control program showed that radiation doses to members of the public were controlled within Federal radiation protection standards contained in Appendix I to 10 CFR Part 50, 10 CFR Part 20, and 40 CFR Part 190.

- The applicant has no plans to conduct refurbishment activities during the license renewal term; however, routine plant refueling and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system to maintain the dose from radioactive effluents to be ALARA, similar performance is expected during the license renewal term. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents to the public would be SMALL.

4.9.3 Microbiological Organisms

The effects of thermophilic microbiological organisms on human health (see Table 4–8), are categorized as a Category 2 issue and require a plant-specific evaluation during the license renewal process for plants using closed-cycle cooling, located on a small river. The Schuylkill River is considered a small river because its average annual flow is approximately 6.3×10^{10} cubic feet per year (ft^3/yr) (1.7×10^8 cubic meters per year (m^3/yr)), which is less than the threshold value of 3.15×10^{12} ft^3/yr (9×10^{10} m^3/yr) in 10 CFR 51.53(c)(3)(ii)(G) (Exelon 2011a). Therefore, the effects of the LGS cooling water discharge on microbiological organisms must be addressed for LGS license renewal.

The Category 2 designation is based on the magnitude of the potential public health impacts associated with thermal enhancement of enteric pathogens such as *Salmonella* spp. and *Shigella* spp., the *Pseudomonas aeruginosa* bacterium, the pathogenic strain of the free-living amoebae *Naegleria* spp., and *Legionella* spp. bacteria (NRC 1996). Thermophilic microorganisms generally occur at temperatures of 77 °F to 176 °F (25 °C to 80 °C) with an optimal growth temperature range of 122 °F to 150 °F (50 °C to 66 °C), and minimum and maximum temperature tolerances of 68 °F (20 °C) and 158 °F (70 °C), respectively. However, thermal preferences and tolerances vary across bacterial groups. Pathogenic thermophilic microbiological organisms of concern during nuclear reactor operation typically have optimal growing temperatures of approximately 99 °F (37 °C) (Joklik and Smith 1972).

Pseudomonas aeruginosa is an opportunistic pathogen that causes serious and sometimes fatal infections in immunocompromised individuals. The organism produces toxins harmful to humans and animals. It has an optimal growth temperature of 99 °F (37 °C) (Todar 2012). *Legionella* spp. consists of at least 46 species and 70 serogroups. It is responsible for Legionnaires' disease, with the onset of pneumonia in the first 2 weeks of exposure. Risk groups for *Legionella* spp. include elderly, cigarette smokers, persons with chronic lung or immunocompromising disease, and persons receiving immunosuppressive drugs.

The LGS NPDES permit (No. PA0051926) requires the temperature in the thermal discharge to be monitored at least once weekly for compliance with an instantaneous maximum limit of 110 °F (43.3 °C) for the protection of human health. Although thermophilic microbiological organisms of concern during nuclear reactor operation could grow at that stated instantaneous maximum temperature limit, there are several years of Discharge Monitoring Report (DMR) data showing that maximum summer discharge temperatures range from 90 °F to 95 °F (32.2 °C to 35.0 °C) (Exelon 2011a). These temperatures are below the stated optimal growing temperature of approximately 99°F (37°C); therefore, ambient river conditions are not likely to support the proliferation of the pathogenic organisms of concern.

Exelon requested PADEP to provide comments or concerns about LGS's contribution to potential health effects resulting from thermophilic organisms. Exelon 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 it does not have any data associated with thermophilic organisms 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 thermophilic organisms in the Schuylkill River (Exelon 2011a).

DRBC designated that 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.

LGS currently discharges sanitary sewage to the local publicly owned treatment works 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.

The NRC staff reviewed all documents applicable to this Category 2 issue, including Exelon's ER and the LGS NPDES permit. The NRC staff concludes that for the reasons above, thermophilic microbiological organisms are unlikely to present a public health hazard as a result of LGS discharges to the Schuylkill River. The NRC staff concludes that impacts on public health from thermophilic microbiological organisms from continued operation of LGS in the license renewal period would be SMALL.

4.9.4 Electromagnetic Fields—Acute Effects

Based on the GEIS, the Commission found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been found to be a problem at most operating plants and generally is 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 along the portions of the transmission lines that are within the scope of this SEIS.

In the GEIS (NRC 1996), the Commission found that without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code (NESC) criteria, it was not possible to determine the significance of the electric shock potential (IEEE 2002). Additionally, the Commission found that evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed, or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), Exelon must provide an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents. The NRC uses the NESC criteria as its baseline to assess the potential human health impact of the induced current from an applicant’s transmission lines. As discussed in the GEIS, the issue of electric shock is of small significance for transmission lines that are operated in adherence with the NESC criteria.

Limerick, Units 1 and 2, electrical outputs are delivered to the PJM Interconnection by the LGS transmission system. Each Limerick unit is provided with an independent substation, which is 230 kilovolts (kV) for Unit 1 and 500 kV for Unit 2. Four 230-kV transmission lines, the Limerick–Cromby 220-60 line, the Limerick–Cromby 220-61 line, the Cromby–North Wales 220-62 line, and the Cromby-Plymouth Meeting 220-63/64 line, were constructed to connect the Limerick Unit 1 substation to the electric grid. One 500-kV transmission line, the Limerick–Whitpain 5031 line, was constructed to connect the Limerick Unit 2 substation to the electric grid. These are the lines that are within scope of license renewal. Exelon developed an electric field strength policy for the design and operation of its transmission system. The policy is intended to minimize shock hazards consistent with the NESC criteria. Exelon used the Electric Power Research Institute (EPRI) HERB 2.0 software to determine NESC compliance. Their analysis determined that there are no locations within the right-of-way under these transmission lines that have the capacity to induce more than 5 milliamperes (mA) to a vehicle parked beneath the lines. Therefore, the lines meet the NESC 5 mA criterion. The maximum induced current calculated for the power lines was 4.6 mA on the Cromby–Plymouth Meeting 220-63/64 line (Exelon 2011a).

The LGS transmission line corridor crosses over highways, streets, other public places, or property owned by others for which PECO, a subsidiary of Exelon Corporation, has permits, grants, easements, or licenses. PECO as the owners and operator of the transmission lines, conducts surveillance and maintenance activities to verify that design ground clearances will not change. These procedures include routine inspection for clearance problems by aircraft periodically. Ground inspections are conducted yearly for clearance problems, which are brought to the attention of the appropriate organizations for maintenance. Exelon expects that PECO, a subsidiary of Exelon Corporation, will continue to use these or similar processes during the period of extended operation. No land use changes are anticipated in the vicinity of the corridor. PECO's periodic surveillance of the transmission system assures that ground clearances would remain in compliance with NESC criteria (Exelon 2011a).

The NRC staff reviewed the available information, including Exelon's evaluation and results. Based on this information, the NRC staff concludes that the potential impacts from electric shock during the renewal period would be SMALL.

4.9.5 Electromagnetic Fields—Chronic Effects

In the GEIS, the effects of chronic exposure to 60 Hertz electromagnetic fields from power lines were not designated as Category 1 or 2 and will not be until a scientific consensus is reached on the health implications of these fields.

The potential effects of chronic exposure from these fields continue to be studied and are not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE).

The report by NIEHS (NIEHS 1999) contains the following conclusion:

> The NIEHS concludes that ELF EMF (extremely low frequency electromagnetic field) exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In our opinion, this finding is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF EMF, passive regulatory action is warranted such as continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

This statement is not sufficient to cause the NRC staff to change its position with respect to the chronic effects of electromagnetic fields. The NRC staff considers the GEIS finding of "UNCERTAIN" still appropriate and will continue to follow developments on this issue.

4.10 Socioeconomics

The socioeconomic issues applicable to LGS, Units 1 and 2 are shown in Table 4–9 for Category 1 and Category 2 issues. Section 2.2.9 of this SEIS describes socioeconomics in the vicinity of the LGS site.

Table 4–9. Socioeconomics Issues

Issues	GEIS Section	Category
Aesthetic impacts of transmission lines (license renewal term)	4.5.8	1
Housing impacts	4.7.1	2
Public services: public safety, social services, and tourism and recreation	4.7.3, 4.7.3.3, 4.7.3.4, 4.7.3.6	1
Public services: education (license renewal)	4.7.3.1	1
Public services: transportation	4.7.3.2	2
Public services: public utilities	4.7.3.5	2
Offsite land use (license renewal term)	4.7.4	2
Aesthetic impacts (license renewal term)	4.7.6	1
Historic and archaeological resources	4.7.7	2
Environmental justice minority and low-income populations	4.10[a]	2

[a] NRC 2013a; 78 FR 37282

Source: Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 (61 FR 28467, June 5, 1996)

4.10.1 Generic Socioeconomic Issues

NRC staff reviewed the Exelon ER (Exelon 2011a), scoping comments, comments on the draft SEIS, and other available data records on LGS, Units 1 and 2 for anynew and significant information. The review included a data gathering site visit to LGS. No new and significant information was identified during this review that would change the conclusions presented in the GEIS. Therefore, for these Category 1 issues, impacts during the renewal term are not expected to exceed those discussed in the GEIS. For LGS, Units 1 and 2, the NRC incorporates the GEIS conclusions by reference. In evaluating the potential socioeconomic impacts resulting from license renewal, the NRC uses as its baseline the existing socioeconomic conditions described in Section 2.2.9 of this SEIS. These baseline socioeconomic conditions include existing housing, transportation, offsite land use, demographic, public services, and economic conditions affected by ongoing operations at the nuclear power plant. Impacts for Category 2 and the uncategorized issue (environmental justice) are discussed in Sections 4.10.2 through 4.10.7.

4.10.2 Housing

Appendix C of the GEIS presents a population characterization method based on two factors, sparseness and proximity (GEIS Section C.1.4). Sparseness measures population density within 20 mi (32 km) of the site, and proximity measures population density and city size within 50 mi (80 km). Each factor has categories of density and size (GEIS Table C.1). A matrix is used to rank the population category as low, medium, or high (GEIS Figure C.1).

According to the 2010 Census, an estimated 1,365,850 people live within 32.2 km (20 mi) of the LGS plant site, producing a population density of 420 persons per square kilometer (1,087 persons per square mile) (Exelon 2011a). This translates to a Category 4, “least sparse” population density using the GEIS measure of sparseness (greater than or equal to 120 persons per square mile within 20 miles). 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) (Exelon 2011a). As the region of influence (ROI) has a population greater than or equal to 190 persons per square mile within 80.4 kilometers

(50 miles), this translates to a Category 4 (greater than or equal to 190 persons per square mile within 50 miles). Therefore, LGS is classified as being located in a high population area based on the GEIS sparseness and proximity matrix.

Table B–1 of 10 CFR Part 51, Subpart A, Appendix B, states that impacts on housing availability are expected to be of small significance in a medium or high density population area where growth-control measures are not in effect. Since LGS is located in a high population area and Montgomery, Berks, and Chester Counties are not subject to growth-control measures that would limit housing development; any changes in employment at LGS, Units 1 and 2, would have little noticeable effect on housing availability in these counties. Since Exelon has no plans to add non-outage employees during the license renewal period, employment levels at LGS, Units 1 and 2, would remain relatively constant with no new demand for permanent housing during the license renewal term. Based on this information, there would be no additional impact on housing during the license renewal term beyond what has already been experienced.

4.10.3 Public Services—Public Utilities

Impacts on public utility services (e.g., water, sewer) are considered SMALL if the public utility has the ability to respond to changes in demand and would have no need to add or modify facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if additional system capacity is needed to meet ongoing demand.

Analysis of impacts on the public water systems considered both plant demand and plant-related population growth. Section 2.1.7 describes the permitted withdrawal rate and actual use of water for reactor cooling at LGS, Units 1 and 2.

Since Exelon has no plans to add non-outage employees during the license renewal period, employment levels at LGS, Units 1 and 2, would remain relatively unchanged with no additional demand for public water services. Public water systems in the region are adequate to meet the demands of residential and industrial customers in the area. Therefore, there would be no impact to public water services during the license renewal term beyond what is currently being experienced.

4.10.4 Offsite Land Use

Offsite land use during the license renewal term is a Category 2 issue (10 CFR Part 51, Subpart A, Appendix B, Table B–1). Table B–1 notes that "significant changes in land use may be associated with population and tax revenue changes resulting from license renewal." Section 4.7.4 of the GEIS defines the magnitude of land-use changes as a result of plant operation during the license renewal term as SMALL when there will be little new development and minimal changes to an area's land-use pattern, as MODERATE when there will be considerable new development and some changes to the land-use pattern, and LARGE when there will be large-scale new development and major changes in the land-use pattern.

Tax revenue can affect land use because it enables local jurisdictions to provide the public services (e.g., transportation and utilities) necessary to support development. Section 4.7.4.1 of the GEIS states that the assessment of tax-driven land-use impacts during the license renewal term should consider: (1) the size of the plant's tax payments relative to the community's total revenues, (2) the nature of the community's existing land-use pattern, and (3) the extent to which the community already has public services in place to support and guide development. If the plant's tax payments are projected to be small relative to the community's total revenue, tax-driven land-use changes during the plant's license renewal term would be SMALL, especially where the community has pre-established patterns of development and has provided public services to support and guide development. Section 4.7.2.1 of the GEIS states that if tax payments by the plant owner are less than 10 percent of the taxing jurisdiction's revenue, the significance level would be SMALL. If tax payments are 10 to 20 percent of the community's total revenue, new tax-driven land-use changes would be MODERATE. If tax payments are greater than 20 percent of the community's total revenue, new tax-driven land-use changes would be LARGE. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development.

4.10.4.1 Population-Related Impacts

Since Exelon has no plans to add non-outage employees during the license renewal period, there would be no plant operations-driven population increase in the vicinity of LGS, Units 1 and 2. Therefore, there would be no population-related offsite land use impacts during the license renewal term beyond those already being experienced.

4.10.4.2 Tax Revenue–Related Impacts

As discussed in Chapter 2, Exelon pays property taxes for LGS to the following entities in Montgomery and Chester Counties: Limerick Township, Spring–Ford Area School District, Lower Pottsgrove Township, Pottsgrove School District, Chester County, East Coventry Township, and Owen J. Roberts School District. Exelon also makes tax payments to taxing authorities in Bucks County, but the amounts are relatively minor. Since Exelon started making property tax payments to local jurisdictions, population has increased steadily and land has continued to be converted to residential and commercial uses in the affected counties—adding to the tax base of affected jurisdictions. Therefore, tax revenue from LGS as a proportion of total tax revenue has had little or no effect on land use conditions within these counties.

Since employment levels would remain relatively unchanged with no increase in the assessed value of LGS, annual property tax payments also would be expected to remain relatively unchanged throughout the license renewal period. Based on this information, there would be no tax-revenue–related offsite land use impacts during the license renewal term beyond those already being experienced.

4.10.5 Public Services—Transportation

Table B–1 of Appendix B to Subpart A of 10 CFR Part 51 states the following:

Transportation impacts (level of service) of highway traffic generated during the term of the renewed license 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.

The regulation in 10 CFR 51.53(c)(3)(ii)(J) requires all applicants to assess the impacts of highway traffic generated by the proposed project on the level of service of local highways during the term of the renewed license. Since Exelon has no plans to add non-outage employees during the license renewal period; traffic volume and levels of service on roadways in the vicinity of LGS, Units 1 and 2, would not change. Therefore, there would be no transportation impacts during the license renewal term beyond those already being experienced.

4.10.6 Historic and Archaeological Resources

This section provides the NRC staff's assessment of the effects on historic and archaeological resources from the proposed license renewal action for LGS, Units 1 and 2. The National Historic Preservation Act (NHPA) requires Federal agencies to consider the effects of their undertakings on historic properties. Historic properties are defined as resources that are eligible for listing on the National Register of Historic Places (NRHP). The criteria for NRHP eligibility are listed in 36 CFR 60.4 and include, among other things, (1) association with significant events that have made a significant contribution to the broad patterns of history, (2) association with the lives of persons significant in the past, (3) embodiment of distinctive characteristics of type, period, or method of construction, and (4) sites or places that have yielded or may be likely to yield important information in history or prehistory. The historic preservation review process (Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA)) is outlined in regulations issued by the Advisory Council on Historic Preservation (ACHP) in 36 CFR Part 800. In accordance with 36 CFR 800.8(c), the NRC has elected to use the National Environmental Policy Act of 1969, as amended (NEPA), process to comply with its obligations under Section 106 of the NHPA.

In accordance with 36 CFR 800.8(c), on September 16, 2011, and September 15, 2011, respectively, the NRC staff initiated consultations on the proposed action by writing to the Advisory Council on Historic Preservation and the Pennsylvania Bureau of Historic Preservation (BHP), which houses the Pennsylvania State Historic Preservation Office (NRC 2011a, 2011b). Previously, Exelon, outside of the NHPA process, consulted with the BHP on January 19, 2011, regarding the renewal of operating licenses for LGS, Units 1 and 2. Exelon stated in its letter to the BHP that there would be no effect on historic properties from license renewal and associated operation and maintenance activities (Exelon 2011a). The BHP responded to LGS on February 16, 2011, concluding that "due to the nature of the activity, it is our opinion that there will be no effect on these properties" (Exelon 2011a).

On September 13, 2011, the NRC staff initiated consultation with 15 Federally recognized tribes: the Absentee Shawnee Tribe of Oklahoma, the Heron Clan, the Delaware Nation (located in Anadarko, Oklahoma), the Delaware Tribe (located in Emporia, Kansas), the Eastern Shawnee Tribe of Oklahoma, the Oneida Indian Nation, the Oneida Nation of Wisconsin, the Onondaga Nation, the Seneca Nations of Indians, the Seneca-Cayuga Tribe of Oklahoma, the St. Regis Mohawk Tribe, the Shawnee Tribe, the Stockbridge-Munsee Band of the Mohican Tribe, the Tonawanda Seneca Nation, and the Tuscarora Nation (see Appendix D for a list of these letters). In its letters, the NRC staff provided information about the proposed action, the definition of the Area of Potential Effect (APE), and indicated that the NHPA review would be integrated with the NEPA process, according to 36 CFR 800.8(c). The NRC staff invited participation in the identification and possible decisions concerning historic properties and also invited participation in the scoping process.

Before the site audit in May 2011, the NRC staff contacted the BHP concerning license renewal for LGS and concluded there was no need to meet during the environmental audit to discuss cultural resources (NRC 2011c).

The NRC staff received scoping comments from two tribes, the Delaware Tribe and the Stockbridge Munsee Tribe, in September 2011, and one comment from the Onondaga Nation in October 2011. The tribes did not raise any concerns in their scoping comments and indicated there are no religious or culturally significant sites in the project area (see Appendix D). The NRC responded to the tribes concerning their scoping comments.

Section 2.2.10 describes the historic and cultural resources at the LGS site. Exelon currently has no planned changes or ground-disturbing activities associated with license renewal at LGS site (Exelon 2011a). Exelon is presently working with East Coventry Township and Chester County to rehabilitate and mothball the Fricks Lock Historic District located on its property. The rehabilitation and mothballing activities are specified to meet the Secretary of Interior's Standards for Rehabilitation and have been approved by the Pennsylvania Historical and Museum Commission Bureau for Historic Preservation (BHP 2011). Construction activity, which began in 2012, was completed in May 2013 (Exelon 2011a). Exelon has also developed a cultural resources management plan to manage known and potentially existing, or discovered archaeologically or historically significant cultural resources within the Owner-Controlled Area (OCA) of the LGS. The Plan addresses possible impacts from land-disturbing activities or other actions within the OCA that could introduce new noise, air, or visual element impacts to known cultural resources outside the OCA. The plan describes the process for initiating informal consultation with BHP and provides guidance on how to manage an unexpected discovery (Exelon 2012a).

For the purposes of NHPA Section 106 consultation, based on the (1) historic and cultural resources located within the APE, (2) tribal input, (3) Exelon's Cultural Resources Management Plan and the status of the Fricks Lock rehabilitation and mothball project, (4) the fact that there will be no changes or ground-disturbing activities that will occur as part of the relicensing of LGS, Units 1 and 2, (5) BHP finding of "no effect," and (6) the NRC staff's cultural resource analysis and consultation, the NRC staff concludes that license renewal will have no effect on historic properties (36 CFR 800.4(d)(1)).

For the purposes of the NRC staff's NEPA analysis, based on the items that lead to the above finding of no effect, the NRC staff concludes that potential impacts on historic and cultural resources related to operating LGS, Units 1 and 2, during the renewal term would be SMALL.

4.10.7 Environmental Justice

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to environmental justice concerns, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, "Minority and low-income populations," to evaluate the impacts of continued operations and any refurbishment activities during the license renewal term on minority populations and low-income populations living in the vicinity of the plant. Environmental justice was listed in Table B–1 as an issue before this final rule, but it was not evaluated in the 1996 GEIS and, therefore, is addressed in each SEIS.

Under Executive Order (E.O.) 12898 (59 FR 7629, February 16, 1994), Federal agencies are responsible for identifying and addressing, as appropriate, potential disproportionately high and adverse human health and environmental impacts on minority and low-income populations. In 2004, the NRC issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040, August 24, 2004), which states that "[t]he Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA review process."

The Council of Environmental Quality (CEQ) provides the following information in *Environmental Justice: Guidance under the National Environmental Policy Act* (CEQ 1997):

> **Disproportionately High and Adverse Human Health Effects.** Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death.

> Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as employed by NEPA) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group.
>
> **Disproportionately High and Adverse Environmental Effects.** A disproportionately high environmental impact that is significant (as defined by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as employed by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian tribes are considered.

The environmental justice analysis assesses the potential for disproportionately high and adverse human health or environmental effects on minority populations and low-income populations that could result from the operation of LGS during the renewal term. In assessing the impacts, the following definitions of minority individuals and populations and low-income population were used (CEQ 1997):

- **Minority individuals.** Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or two or more races—meaning individuals who identified themselves on a Census form as being a member of two or more races (e.g., Hispanic and Asian).
- **Minority populations.** Minority populations are identified when the minority population of an affected area exceeds 50 percent or the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
- **Low-income population.** Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series P60, on Income and Poverty.

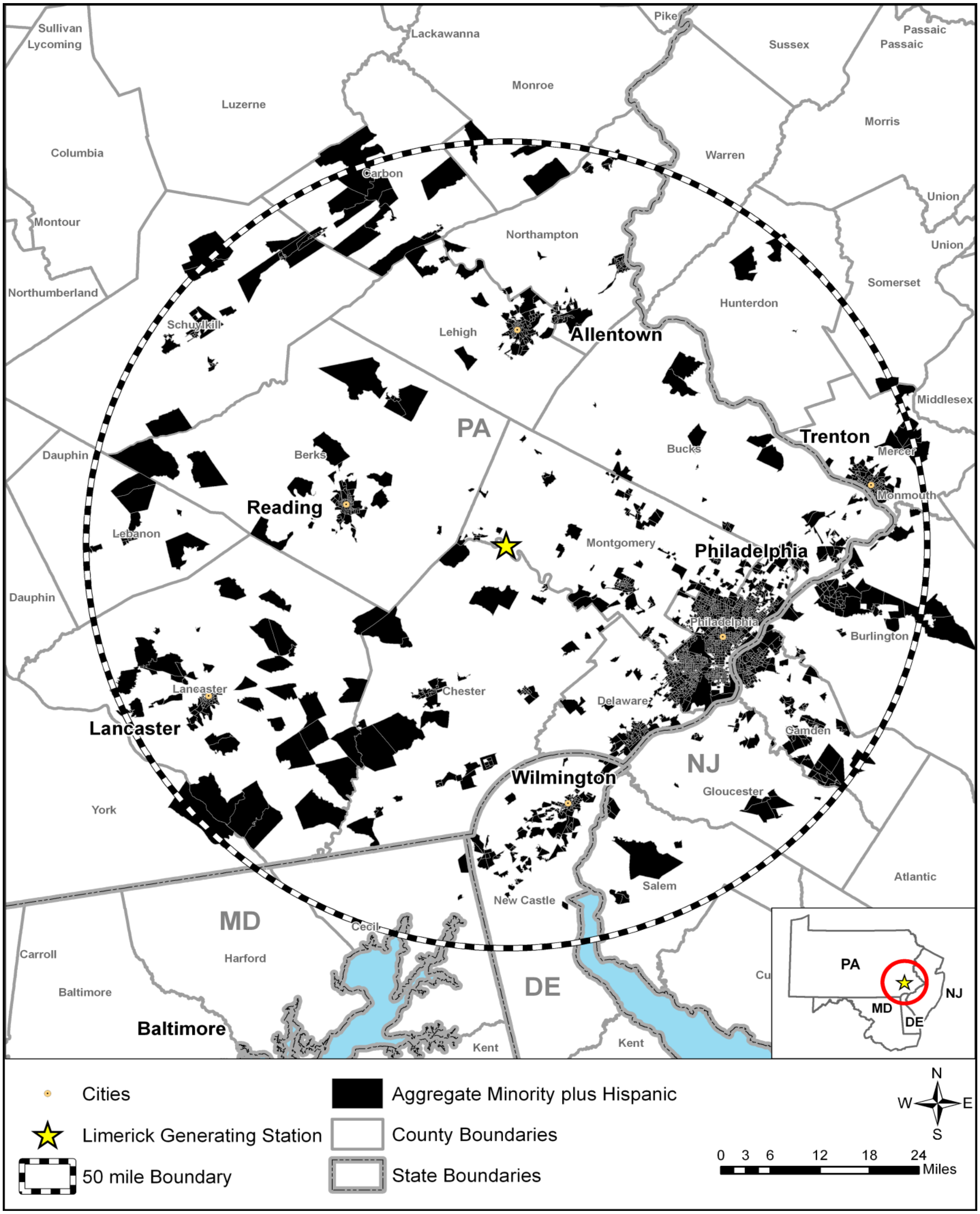
4.10.7.1 Minority Population

According to 2010 Census data, 34.5 percent of the population residing within a 50-mi (80-km) radius of LGS identified themselves as minority individuals. The largest minority group was Black or African American (17 percent), followed by Hispanic or Latino (of any race) (9.1 percent) (CAPS 2012). According to 2010 Census data, minority populations in the socioeconomic ROI (Berks, Chester, and Montgomery Counties) comprised 20.6 percent of the total three-county population (see Table 2–9) (USCB 2011).

Census block groups were considered minority population block groups if the percentage of the minority population within any block group exceeded 34.5 percent (the percent of the minority population within the 50-mi radius of LGS). A minority population block group exists if the percentage of the minority population within the block group is meaningfully greater than the minority population percentage in the 50-mi (80-km) radius. Approximately 2,030 of the

5,800 census block groups located within the 50-mi (80-km) radius of LGS were determined to have meaningfully greater minority populations. Figure 4–1 shows minority population block groups, using 2010 Census data for race and ethnicity, within a 50-mile (80-kilometer) radius of LGS.

Figure 4–1. 2010 Census Minority Block Groups within a 50-mi Radius of the LGS



Source: USCB 2011

Minority population block groups are concentrated in the Philadelphia Metropolitan Area, with smaller concentrations in Reading and Allentown, Pennsylvania. The minority population block group nearest to LGS is located in Sanatoga, Limerick Township, Pennsylvania. According to the 2010 Census, approximately 20.7 percent of the total Sanatoga population (which includes more than one census block group) identified themselves as minority.

4.10.7.2 Low-Income Population

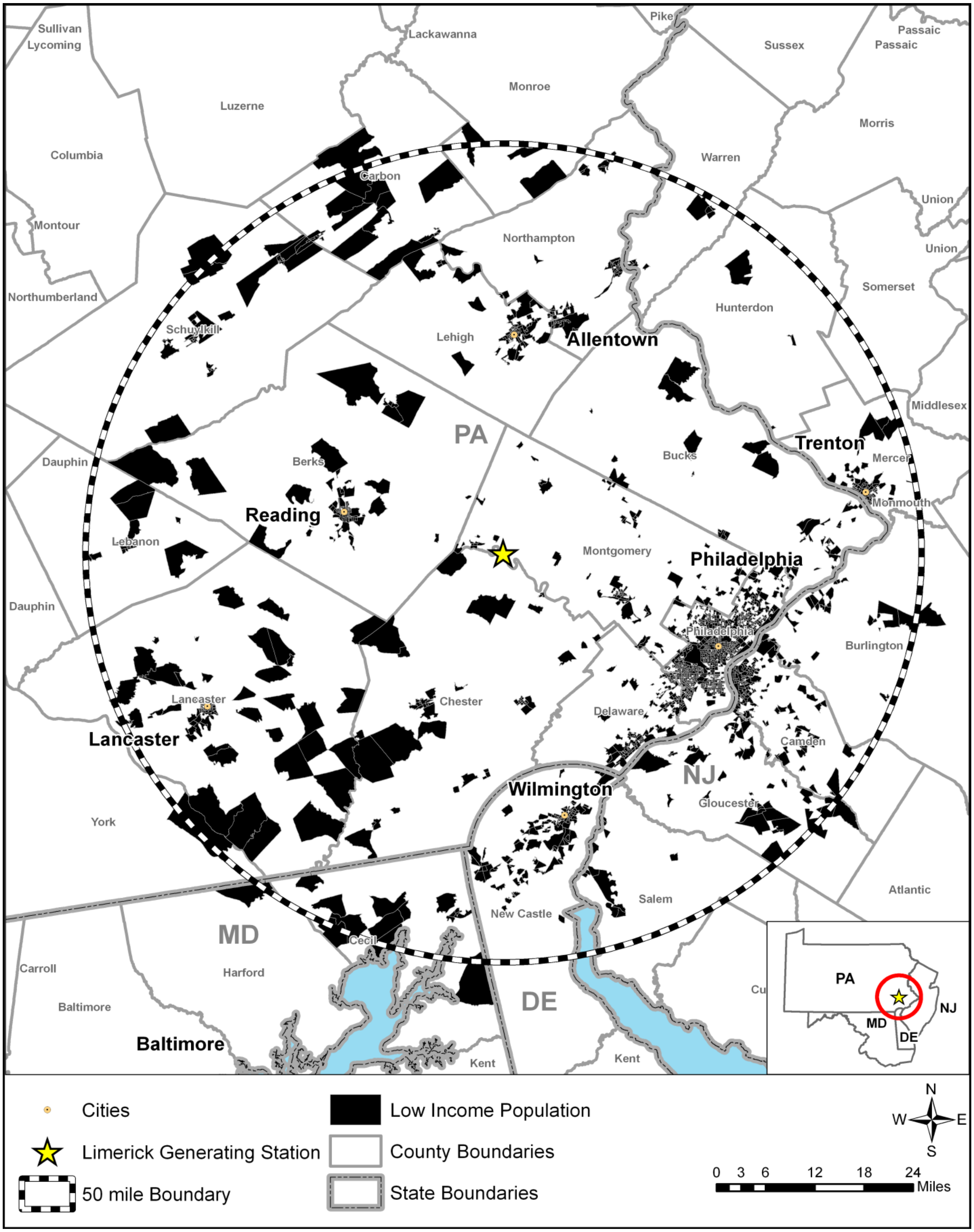
According to 2010 American Community Survey Census data, an average of 7.7 percent of families and 10.4 percent of individuals residing in counties within a 50-mile radius of LGS (Burlington, Camden, Gloucester, Hunterdon, Mercer, Salem, Somerset, and Warren, New Jersey; Berks, Bucks, Carbon, Chester, Delaware, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Philadelphia, and Schuylkill, Pennsylvania; Cecil, Maryland; and New Castle, Delaware) were identified as living below the Federal poverty threshold in 2010. The 2010 Federal poverty threshold was $22,314 for a family of four (USCB 2011).

According to the 2010 Census, 9.3 percent of families and 13.4 percent of individuals in Pennsylvania were living below the Federal poverty threshold in 2010, and the median household income for Pennsylvania was $49,288 (USCB 2011). All three counties in the immediate ROI of LGS had higher median household incomes and Montgomery and Chester Counties had lower percentages of families and individuals living below the poverty level when compared to the state average. Berks County had a median household income average of $51,719 and 14.1 percent of individuals and 10.9 percent of families living below the poverty level. Chester County had a median household income average of $82,284 and 6.2 percent of individuals and 3.6 percent of families living below the poverty level. Montgomery County had a median household income of $75,448 and 5.5 percent of individuals and 3.6 percent of families living below the poverty level (USCB 2011).

Figure 4–2 shows low-income census block groups within a 50-mile (80-kilometer) radius of LGS. Census block groups were considered low-income population block groups if the percentage of individuals living below the Federal poverty threshold within any block group exceeded the percent of the individuals living below the Federal poverty threshold within the 50-mile radius of LGS. Approximately 2,070 of the 5,800 census block groups located within the 50-mile (80-kilometer) radius of LGS were determined to have meaningfully greater low-income populations.

Similar to the locations of minority population block groups, the majority of low-income population block groups are located in the Philadelphia metropolitan area, with smaller concentrations in Reading and Allentown, Pennsylvania. The nearest low-income population to LGS is located in Sanatoga, Limerick Township, Pennsylvania.

Figure 4–2. 2010 Census Low-Income Block Groups within a 50-mi Radius of LGS



Source: USCB 2011

4.10.7.3 Analysis of Impacts

The NRC addresses environmental justice matters for license renewal through (1) identifying the location of minority and low-income populations that may be affected by the continued operation of the nuclear power plant during the license renewal term, (2) determining whether there would be any potential human health or environmental effects to these populations and special pathway receptors, and (3) determining if any of the effects may be disproportionately high and adverse.

Figures 4–1 and 4–2 identify the location of minority and low-income block group populations residing within a 50-mi (80-km) radius of LGS. This area of impact is consistent with the impact analysis for public and occupational health and safety, which also focuses on populations within a 50-mi (80-km) radius of the plant. Chapter 4 presents the assessment of environmental and human health impacts for each resource area. The analyses of impacts for all environmental resource areas indicated that the impact from license renewal would be SMALL.

Potential impacts to minority and low-income populations (including migrant workers or Native Americans) would mostly consist of socioeconomic and radiological effects; however, radiation doses from continued operations during the license renewal term are expected to continue at current levels and would remain within regulatory limits. Socioeconomic effects were likewise found to be SMALL. Chapter 5 of this SEIS discusses the environmental impacts from postulated accidents that might occur during the license renewal term, which include both design-basis and severe accidents. The Commission has generically determined that impacts associated with design-basis accidents are small because nuclear plants are designed and operated to successfully withstand such accidents, and the probability weighted impact risks associated with severe accidents are also small.

Therefore, based on this information and the analysis of human health and environmental impacts presented in Chapters 4 and 5 of this SEIS, there would be no disproportionately high and adverse impacts to minority and low-income populations from the continued operation of LGS during the license renewal term.

As part of addressing environmental justice concerns associated with license renewal, the NRC also assessed the potential radiological risk to special population groups (such as migrant workers or Native Americans) from exposure to radioactive material received through their unique consumption and interaction with the environment patterns, including subsistence consumption of fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of airborne radioactive material released from the plant during routine operation. This analysis is presented below.

<u>Subsistence Consumption of Fish and Wildlife</u>

The special pathway receptors analysis is an important part of the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area, such as migrant workers or Native Americans.

Section 4-4 of E.O. 12898 (1994) directs Federal agencies, whenever practical and appropriate, to collect, maintain, and analyze information on the consumption patterns of populations that rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this SEIS, the NRC staff considered whether there were any means for minority or low-income populations to be disproportionately affected, and it considered this by examining impacts to American Indians, Hispanics, migrant workers, and other traditional lifestyle special pathway receptors. Special pathways took into account the levels of radiological and nonradiological contaminants in native vegetation, crops, soils and sediments, groundwater, surface water, fish, and game animals on or near LGS were considered.

The following is a summary discussion of the NRC staff's evaluation from Section 4.9.2 of the radiological environmental monitoring programs (REMPs) that assess the potential impacts for subsistence consumption of fish and wildlife near the LGS site.

Exelon has an ongoing comprehensive REMP to assess the impact of LGS operations on the environment. To assess the impact of nuclear power plant operations, samples are collected annually from the environment and analyzed for radioactivity. A plant effect would be indicated if the radioactive material detected in a sample was significantly larger than background levels. Two types of samples are collected. The first type, control samples, are collected from areas that are beyond the measurable influence of the nuclear power plant or any other nuclear facility. These samples are used as reference data to determine normal background levels of radiation in the environment. These samples are then compared with the second type of samples, indicator samples, collected near the nuclear power plant. Indicator samples are collected from areas where any contribution from the nuclear power plant will be at its highest concentration. These samples are then used to evaluate the contribution of nuclear power plant operations to radiation or radioactivity levels in the environment. An effect would be indicated if the radioactivity levels detected in an indicator sample was significantly larger than the control sample or background levels.

Samples of environmental media are collected from the aquatic and terrestrial pathways in the vicinity of LGS. Nine hundred and twenty-six radiological environmental samples were collected and analyzed in 2010. The aquatic pathways include groundwater, surface water, drinking water, fish, and shoreline sediment. The terrestrial pathways include airborne particulates, milk, food products (i.e., leafy vegetables, such as cabbage, collards, Swiss Chard, collected from gardens in the vicinity of LGS), and wild animal feed (i.e., broad leaf vegetation). During 2010, analyses performed on samples of environmental media at LGS showed no significant or measurable radiological impact above background levels from site operations (Exelon 2011b).

Therefore, based on the radiological environmental monitoring data from LGS, no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

4.11 Evaluation of New and Potentially Significant Information

New and significant information is: (1) information that identifies a significant environmental issue not covered in the GEIS and codified in Table B–1 of 10 CFR Part 51, Subpart A, Appendix B, or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding that is substantially different from the finding presented in the GEIS and codified in 10 CFR Part 51.

The new and significant assessment that Exelon conducted during the preparation of the license renewal application included: (1) interviews with Exelon subject-matter experts on the validity of the conclusions in the GEIS as they relate to LGS, (2) 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, (3) a review of correspondence with state and Federal agencies to determine if agencies had concerns relevant to their resource areas that had not been addressed in the GEIS, (4) a review for issues relevant to the LGS application of certain license renewal applications that operators of other nuclear plants have previously submitted to the NRC, (5) an extensive review of documents related to environmental issues at LGS, (6) a review of comments received during the scoping process and the draft SEIS comment period, and (7) a review of information related to severe accident mitigation.

The NRC also has a process for identifying new and significant information, which is described in NUREG–1555, Supplement 1, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1; Operating License Renewal" (NRC 1999b, 2013c). The search for new information includes: (1) review of an applicant's ER and the process for discovering and evaluating the significance for new information, (2) review of records for public comments, (3) review of environmental quality standards and regulations, (4) coordination with Federal, state, and local environmental protection and resource agencies, and (5) review of the technical literature. New information discovered by the NRC staff is evaluated for significance using criteria set forth in the GEIS. For Category 1 issues in which new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to the assessment for the relevant new and significant information; the scope of the assessment does not include other facets of an issue that are not affected by the new information.

Exelon reported in its ER (Exelon 2011a) that it was aware of one new radiological issue associated with the renewal of the LGS operating license—tritium in groundwater. In 2006, Exelon implemented a fleet-wide program to proactively review the environmental status of its nuclear power generating stations, specifically to identify the potential for releases of radionuclides. The program is consistent with the guidance provided in NEI 07-07, "Industry Ground Water Protection Initiative–Final Guidance Document." As part of this program, Exelon commissioned a hydrogeologic investigation of LGS to evaluate any groundwater impact from radionuclides that may have been released from the plant. Exelon also developed its RGPP during this time.

A groundwater monitoring well network for LGS's groundwater protection program was designed and installed to gather any radionuclide release data. Monitoring was initiated in 2006 and performed at least semi-annually on each monitoring well. The results of the program, including trending data, program modifications, reporting protocols, and other information are included in the annual LGS radiological environmental operating reports. 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 Offsite Dose Calculation Manual (ODCM) is equal to the EPA drinking water standard of 20,000 picocuries per liter (pCi/L). The ODCM specifies a detection capability of 200 pCi/L for analyzing tritium concentrations in groundwater samples.

The groundwater monitoring data are reported in the annual LGS REMP reports. Sampling of the monitoring well network at LGS has not identified any tritium concentration greater than 20,000 pCi/L. Tritium was detected during a 2006 site investigation at a concentration of 2,020 ± 154 pCi/L in a sample collected from the power block foundation sump, which accumulates water from the drain system around the power block. This water is not in direct contact with groundwater and, therefore, also is not reflective of groundwater quality beneath LGS. Tritium concentrations greater than 2,000 pCi/L, but below the reporting level of 20,000 pCi/L, have been detected in power block foundation sump samples on other occasions since 2006.

Exelon's evaluation of the groundwater monitoring data concluded that there are no significant impacts associated with tritium in groundwater downgradient of LGS. This conclusion is based on the following information. Sampling of the monitoring well network at LGS has not identified tritium concentrations greater than the reporting level of 20,000 pCi/L. None of the wells that have detectable tritium are used by workers or members of the public for drinking water. The applicant's groundwater protection monitoring program and REMP will continue to monitor the groundwater and report the results in the annual radioactive effluent operating reports. Also, NRC inspectors will periodically review the REMP data for compliance with NRC radiation protection standards. Based on the above, the NRC staff concludes that the issue of tritium contamination of the groundwater on the LGS site is not significant.

4.12 Cumulative Impacts

As described in Section 1.4 of this SEIS, the NRC has approved a revision to its environmental protection regulation, 10 CFR Part 51. With respect to cumulative impacts, the final rule amends Table B–1 in Appendix B, Subpart A, to 10 CFR Part 51 by adding a new Category 2 issue, "Cumulative impacts," to evaluate the potential cumulative impacts of license renewal.

The NRC staff considered potential cumulative impacts in the environmental analysis of continued operation of the LGS nuclear plant during the 20-year license renewal period. Cumulative impacts may result when the environmental effects associated with the proposed action are overlaid or added to temporary or permanent effects associated with other past, present, and reasonably foreseeable actions. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time. It is possible that an impact that may be SMALL by itself could result in a MODERATE or LARGE cumulative impact when considered in combination with the impacts of other actions on the affected resource. Likewise, if a resource is regionally declining or imperiled, even a SMALL individual impact could be important if it contributes to or accelerates the overall resource decline.

For the purposes of this cumulative analysis, past actions are those before the receipt of the license renewal application. Present actions are those related to the resources at the time of current operation of the power plant, and future actions are those that are reasonably foreseeable through the end of plant operation, including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms as well as the 20-year renewal license term. The geographic area over which past, present, and reasonably foreseeable actions would occur depends on the type of action considered and is described below for each resource area.

To evaluate cumulative impacts, the incremental impacts of the proposed action, as described in Sections 4.1 to 4.10, are combined with other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such actions. The NRC staff used the information provided in the ER; responses to requests for additional information; information from other Federal, state, and local agencies; scoping comments; comments on the draft SEIS; and information gathered during the visits to the LGS site to identify other past, present, and reasonably foreseeable actions. To be considered in the cumulative analysis, the NRC staff determined if the project would occur within the noted geographic areas of interest and within the period of extended operation, was reasonably foreseeable, and if there would be potential overlapping effect with the proposed project. For past actions, consideration within the cumulative impacts assessment is resource and project-specific. In general, the effects of past actions are included in the description of the affected environment in Chapter 2, which serves as the baseline for the cumulative impacts analysis. However, past actions that continue to have an overlapping effect on a resource potentially affected by the proposed action are considered in the cumulative analysis.

Other actions and projects identified during this review and considered in the NRC staff's independent analysis of the potential cumulative effects are described in Appendix F. Examples of other actions that were considered in this analysis include the following:

- Cromby Generating Station,
- Titus coal plant,
- independent spent fuel storage installation,
- transmission lines,
- future urbanization, and
- Schuylkill River greenway.

4.12.1 Air Quality

This section addresses the direct and indirect effects of license renewal on air quality resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Section 4.2, the incremental impacts on air quality from the proposed license renewal would be SMALL, as there is no planned refurbishment associated with the LGS license renewal. The geographic area considered in the cumulative air quality analysis is the county of the proposed action because air quality designations for criteria air pollutants are generally made at the county level. Counties are further grouped together based on a common air shed—known as an air quality control region (AQCR)—to provide for the attainment and maintenance of the National Ambient Air Quality Standards (NAAQS). The LGS site is located in Montgomery and Chester Counties, Pennsylvania, and is part of the Metropolitan Philadelphia Intrastate AQCR (40 CFR 81.15). Additional counties in this AQCR include Bucks, Delaware, and Philadelphia Counties.

Section 2.2.2 presents a summary of the air quality designation status for Montgomery and Chester Counties. As noted in Section 2.2.2, EPA regulates six criteria pollutants under the NAAQS, including carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter. Montgomery and Chester Counties are designated unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339). All other counties in this AQCR are similarly designated with respect to the NAAQS criteria pollutants.

Criteria pollutant air emissions from the LGS site are presented in Section 2.2.2.1; these emissions are principally from standby diesel generators, boilers, two cooling towers, and a spray pond. Air pollutants from these sources are permitted under a Title V operating permit (TVOP-46-00038) (Exelon 2011a). In Section 4.2, it was noted that there would be no new air emissions associated with the LGS license renewal because there is no planned site refurbishment. Therefore, cumulative changes to air quality in Montgomery and Chester Counties would be the result of changes to present-day emissions from other existing facilities as well as future projects and actions within the county.

Appendix F provides a list of present and reasonably foreseeable projects that could contribute to cumulative impacts to air quality. Continued air emissions from existing projects and actions listed in Appendix F as well as proposed new source activities would contribute to air emissions in Montgomery and Chester Counties and will affect air quality within the region. Development and construction activities associated with regional growth of housing, business, and industry, as well as associated vehicular traffic, also will result in additional air emissions. Project timings and locations, which are difficult to predict, affect cumulative impacts to air quality. However, permitting and licensing requirements, efficiencies in equipment, cleaner fuels, and various mitigation measures can be used to minimize cumulative air quality impacts.

The U.S. Global Climate Research Program (USGCRP), reports that from 1895 to 2012, U.S. average surface temperatures have increased by 1.3 °F to 1.9 °F (0.72 to 1.06 °C) (USGCRP 2014). Climate change research indicates that the cause of the observed warming is due to the buildup of greenhouse gases in atmosphere resulting from human activities (USGCRP 2014). The effects of global climate change are already being felt in the northeastern United States, where Limerick is located. For the Northeast region, average air temperatures between 1895 and 2011 increased by 2 °F (1.1 °C) and precipitation increased by more than 10 percent (USGCRP 2014). Between 1958 and 2010, the Northeast experienced a 70 percent increase in heavy precipitation events, the largest increase of any region in the U.S. (USGCRP 2014) other climate-related changes in the Northeast include sea level rise by 1 ft (0.3 m) since 1900, a rate that exceeds the global average of 8 in. (20 cm) (USGCRP 2014). The Northeast is projected to face continued warming and more extensive climate-related changes. For the license renewal period of Limerick, climate models (between 2021-2050 relative to the reference period (1971-1999)) indicate an increase in annual mean temperature for the Northeast Region of 1.5 °F to 3.5 °F (0.83 to 1.94°C) (NOAA 2013). The predicted increase in temperature during this time period occurs for all seasons with the largest increase occurring in the summertime (June, July, and August). Climate model simulations (for the time period 2021-2050) suggest spatial differences in annual mean precipitation changes for the Northeast; Pennsylvania may experience an 3 percent increase in precipitation, and winter and spring precipitation will have the greatest increase (NOAA 2013, USGCRP 2014).

Changes in climate can impact air quality as a result of the changes in meteorological conditions. The formation, transport, dispersion, and deposition of air pollutants are sensitive to winds, temperature, humidity, and precipitation. Sunshine, high temperatures, concentration of precursors and air stagnation are favorable meteorological conditions to higher levels of ozone (USGCRP 2014). The emission of ozone precursors (nitrogen oxides and volatile organic compounds) also depends on temperature, wind, and solar radiation (IPCC 2007). The hottest days in the Northeast have been associated with high concentrations of ozone (USGCRP 2014). The combination of higher temperatures, stagnant air masses, sunlight, and emissions of precursors may make it difficult to meet ozone National Ambient Air Quality Standards (Karl et al. 2009). Regional air quality modeling indicates that the Northern regions of the U.S. can experience a decrease in ozone concentration by the year 2050 (Tagaris 2009). However, air quality projections (particularly ozone) are uncertain and indicate that concentrations are driven primarily by emissions rather than by physical climate change (IPCC 2013). States, however, must continue to comply with the Clean Air Act, so it is likely that additional limitations on ozone precursors could help counteract impacts to air quality. Furthermore, in accordance with the Pennsylvania Climate Change Act, the Pennsylvania Department of Environmental Protection (PADEP), prepares and updates a climate change action plan. The Pennsylvania Climate Change Action Plan identifies, among other actions, strategies to reduce greenhouse gas emissions (PADEP 2013a). Additionally, in 2011 the PDEP developed a climate adaptation plan that identifies recommendations and adaptation strategies in response to climate change (PADEP 2011).

Given that there is no planned plant refurbishment associated with the LGS license renewal, and therefore no expected changes in air emissions, cumulative air quality impacts in Montgomery and Chester Counties would be the result of changes to present-day emissions and emissions from reasonably foreseeable projects and actions. As NRC staff noted above, project timings and locations, which are difficult to predict, affect cumulative impacts to air quality. However, various strategies and techniques are available to limit air quality impacts. Therefore, the NRC staff concludes that the cumulative air quality impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be SMALL.

4.12.2 Water Resources

This section addresses the direct and indirect effects of license renewal on water resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. As described in Sections 4.4 and 4.5, the incremental impacts on water resources from continued operations of LGS, Units 1 and 2, during the license renewal term would be SMALL. NRC staff also conducted an assessment of other projects and actions for consideration in determining their cumulative impacts on water resources (see Appendix F). The geographic area considered for the surface water resources component of the cumulative impacts analysis spans the Delaware River Basin. For groundwater, the area considered encompasses the local groundwater basin relative to LGS in which groundwater is recharged and flows to discharge points, or is withdrawn through wells. As such, this review focused on those projects and activities that would (1) withdraw water from or discharge wastewater to the Delaware River or its tributaries (i.e., the Schuylkill River) and/or (2) would use groundwater or could otherwise affect the bedrock aquifer beneath the LGS site.

4.12.2.1 Cumulative Impacts on Surface Water Resources

Water resource managers must balance multiple conflicting water management objectives. Within the Delaware River Basin, this includes demands for power generation, municipal water, industrial water, agricultural water, mining, recreation, flood protection, and instream flow requirements to sustain aquatic life (see Section 4.12.3). The Delaware River Basin Commission (DBRC) was formed to balance these objectives. These tradeoff decisions reflect an understanding of the inevitable uncertainty in regulated flows that result from inter-annual and intra-annual variability. Based on the USGS gage on the Schuylkill River at Pottstown, Pennsylvania, for water years 1928 to 2010, the highest annual mean flow and lowest annual mean flow recorded are 3,211cfs (90.7 m^3/s) and 843 cfs (23.8 m^3/s), respectively. The highest daily mean flow and the lowest daily mean flow recorded are 71,200 cfs (2,011 m^3/s) and 175 cfs (4.9 m^3/s), respectively (USGS 2010). This magnitude of variability reflects climate variability and no other projects within the basin.

To support full operations of LGS, Units 1 and 2, Exelon must withdraw up to 42 mgd or 29,200 gpm (65 cfs or 1.8 m^3/s) of water from either the Schuylkill River or other sources for consumptive cooling water use, as further described in Section 2.1.7.1 of this SEIS. Surface water withdrawals by LGS, like other similar surface water users in the basin, are subject to limits and conditions imposed by DRBC dockets. Relative to the cited magnitude of variability of flows in the Schuylkill River, the hydrologic impacts of surface water withdrawals associated with LGS operations are very small.

In general, water quality across the Delaware River Basin has dramatically improved over the past several decades. The water quality of the Delaware River and its main tributaries, such as the Schuylkill River, was profoundly impaired by municipal and industrial waste discharges and mining activities. Regulatory changes, including implementation of the Clean Water Act, have eliminated many of the largest point and nonpoint sources of water quality degradation. Still, within this context, the trend in urban and suburban development in the immediate LGS region (see Sections 4.12.3 and 4.12.4) and associated corridor-type development (e.g., roads) to keep pace with overall population growth in the Delaware River Basin has introduced a different impact dynamic. From the perspective of water quality, these types of development generally substitute more diffuse sources of pollution (i.e., nonpoint) and their impacts for point sources traditionally associated with industry.

Nevertheless, the segment of the Schuylkill River near LGS meets all established water quality standards at present, as further described in Section 2.2.4.2. The DRBC is responsible for classifying all waters in the basin as to use, setting basin-wide water quality standards, establishing pollutant treatment and control regulations, and reviewing projects or other undertakings with the potential to affect basin water resources for conformance with the DRBC Comprehensive Plan (DRBC 2001). DRBC acts in coordination with the states and other parties that are signatories to the DRBC Compact (DRBC 1961) to include the imposition of necessary effluent limitations on industrial wastewater discharges to surface water.

In addition, the NRC staff considered the U.S. Global Change Research Program's (USGCRP's) most recent compilation of the state of knowledge relative to global climate change effects (USGCRP 2014). As discussed in Section 4.12.1, average air temperatures between 1895 and 2011 increased by 2 °F (1.1°C) and precipitation increased by more than 10 percent in the Northeast region. Temperatures, precipitation and runoff are projected to continue to increase and sea level is expected to continue to rise. While there is great uncertainty, global sea levels are expected to rise an additional 0.5 to 1.0 ft (0.15 to 0.3m) by 2050 and between 1 to 4 ft (0.3 to 1.2 m) by the end of this century; sea level rise along the Northeast coast is expected to exceed the global rate due to local land subsidence (USGCRP 2014). . Meanwhile, precipitation and runoff are projected to increase in the winter and spring across the Northeast. Increased runoff generally equates to increased streamflow (Karl et al. 2009).

Without an offsetting increase in discharge in the Delaware River, any sea level rise associated with climate change will cause increased upstream saltwater migration and potentially affect fresh water withdrawals upstream of the salt line (see Section 2.2.4.1). This could lead to fresh water availability and water use conflicts. Moreover, permitting agencies, principally the PADEP and the DRBC, could have to consider imposing more stringent effluent limits on power plant discharges, should water temperatures rise. These predictions, if borne out, have important implications for the Delaware River Basin as a whole, but the overall interaction of predicted hydrologic changes and their effect on water users in the Delaware River Basin is highly speculative at the present time.

Surface water withdrawals for LGS operations are a small fraction of the mean annual flow of the Schuylkill River, and the discharge of cooling tower blowdown has not significantly affected ambient surface water quality. The NRC staff did not identify any exceptional limitations to water resources. The NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions on surface water resources during the license renewal term would be SMALL. This conclusion is based on the regulatory framework established by the DBRC and PADEP in managing surface water use and quality and the generally improving trend in conditions in the Schuylkill River and within the Delaware River Basin.

4.12.2.2 Cumulative Impacts on Groundwater Resources

The Brunswick bedrock aquifer is the most widespread source of groundwater in the plant region and across the Triassic lowlands of the Newark Basin. LGS's four groundwater production wells are completed in the Brunswick aquifer system along with over 50 domestic and several other commercial/industrial supply wells within a 1-mi (1.6-km) radius of LGS (see Section 2.2.5.1).

The DRBC promulgated its Ground Water Protected Area Regulations (18 CFR 430; DRBC 1999) to manage groundwater resources in the Triassic lowland and adjacent areas in southeastern Pennsylvania. LGS and its regulated production wells are located in the Schuylkill-Sprogels Run Subbasin, as delineated by the DRBC (DRBC 1999; Exelon 2011a).

The DRBC has established a total maximum withdrawal limit of 1,455 million gal/yr (mgy) (5.49 million m^3/yr) for the subbasin. It has also set a withdrawal level of 1,091 mgy (4.12 million m^3/yr) as that level where groundwater resources of the subbasin would be "potentially stressed" (DRBC 1999; 18 CFR 430.13). Nonetheless, total net annual groundwater withdrawals in the subbasin are currently well below the DRBC limits at 174.89 mgy (0.66 million m^3/yr) (DRBC 2011). As described in Section 2.1.7.2, total LGS site groundwater withdrawals have averaged about 31,500 gpd or 11.5 mgy (0.04 million m^3/yr). This withdrawal is about 0.8 and 1.1 percent, respectively, of the DRBC established thresholds for groundwater withdrawals in the Schuylkill-Sprogels Run Subbasin.

LGS operations have resulted in inadvertent releases of liquids containing tritium to the bedrock aquifer, as described in Sections 4.5.2 and 2.2.5.2 of this SEIS. However, there has been no migration of tritium in groundwater exceeding the EPA primary drinking water standard (i.e., 20,000 pCi/L). In addition, there are no potable water users downgradient of the LGS power block that have been affected by the inadvertent releases. As site groundwater locally discharges to the Schuylkill River and Possum Hollow Run where rapid mixing and dilution occurs, there is no drinking water pathway to other groundwater users. Meanwhile, Exelon maintains an ongoing RGPP at LGS to detect and correct the source of inadvertent releases of radionuclide-containing liquids.

In summary, the DRBC has established limits on total groundwater withdrawals in the local groundwater subbasin and on LGS groundwater withdrawals (see Section 2.1.7.2), and current total withdrawals for all projects identified in this review are a small percentage of the established thresholds for the subbasin. LGS groundwater withdrawals are not expected to increase during the license renewal term. Further, inadvertent releases of liquids containing tritium have not impacted groundwater quality beyond the site boundary, and there is no pathway to other drinking water users. Tritium levels as measured in groundwater on site are well below the EPA drinking water standard and a program is in place to safeguard groundwater quality. Based on the above considerations, the NRC staff concludes that the cumulative impacts from past, present, and reasonably foreseeable future actions on groundwater use and quality during the license renewal term would be SMALL.

4.12.3 Aquatic Resources

This section addresses the direct and indirect effects of license renewal on aquatic resources, including protected aquatic resources, when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The cumulative impact is the total effect on the aquatic resources of all actions taken, no matter who has taken the actions. The geographic area considered in the cumulative aquatic resources analysis includes the LGS cooling water sources in the vicinity of intake and discharge structures on the Schuylkill River, the Perkiomen Creek, the Delaware River, and along the East Branch Perkiomen Creek and Perkiomen Creek where water from the Delaware River is discharged to augment flows to the Perkiomen Creek. As described in Section 4.6, the incremental impacts on aquatic biota from the proposed license renewal would be SMALL.The geographic area considered in the cumulative aquatic resources analysis includes the LGS cooling water sources in the vicinity of intake and discharge structures on the Schuylkill River, the Perkiomen Creek, the Delaware River, and along the East Branch Perkiomen Creek and Perkiomen Creek where water from the Delaware River is discharged to augment flows to the Perkiomen Creek.

The benchmark for assessing cumulative impacts on aquatic resources takes into account the preoperational environment as recommended by the EPA (1999), for its review of NEPA documents, as follows:

> Designating existing environmental conditions as a benchmark may focus the environmental impact assessment too narrowly, overlooking cumulative impacts of past and present actions or limiting assessment to the proposed action and

> future actions. For example, if the current environmental condition were to serve as the condition for assessing the impacts of relicensing a dam, the analysis would only identify the marginal environmental changes between the continued operation of the dam and the existing degraded state of the environment. In this hypothetical case, the affected environment has been seriously degraded for more than 50 years with accompanying declines in flows, reductions in fish stocks, habitat loss, and disruption of hydrologic functions. If the assessment took into account the full extent of continued impacts, the significance of the continued operation would more accurately express the state of the environment and thereby better predict the consequences of relicensing the dam.

Sections 2.2.4 and 2.2.6 present an overview of the condition of the Schuylkill River, Perkiomen Creek, East Branch Perkiomen Creek, and the Delaware River at the Point Pleasant Pumping Station, and the history and factors that led to current conditions. The direct and indirect impacts from water use and industrial discharge, such as mining waste water, are some of the most influential human activities on the Delaware River Basin (DRBC 2010a). Within the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek, increased urbanization over the past 100 years has also led to increased runoff and elevated levels of pollutants within (Rhoads and Block 2008). On the Schuylkill River, the construction of dams beginning in the early 1800s blocked anadromous fish migrations and resulted in the decline of American shad, river herring, and blueback herring, which require movement between freshwater and marine waters to complete their life cycles (Perillo and Butler 2009).

Many natural and anthropogenic activities can influence the current and future aquatic biota in the area surrounding the LGS site and the Delaware River Basin. Potential biological stressors include operational impacts from LGS (as described in Section 4.6), increasing urbanization, energy development, and climate change.

4.12.3.1 Urbanization and Water Quality

Interlandi and Crockett (2003) reported an increase in residential and commercial development for the area surrounding LGS along the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek, and a decrease in population near Philadelphia. Increased urbanization has led to increases in dissolved nitrate and chloride levels in the Schuylkill River. Urbanization will likely continue to contribute significant organic and metal pollutants to the river through runoff (Interlandi and Crockett 2003). The DRBC and EPA manage and set total maximum daily load (TMDL) limits for contaminants, such as polychlorinated biphenyl (PCBs), to help control future pollution of waters within the Delaware River Basin (DRBC 2008; EPA 2007).

Several other facilities within 10 miles (16 km) of LGS have NPDES permits to discharge into the Schuylkill River, which contributes to the cumulative impacts to aquatic habitats (EPA 2012a). For example, six municipal wastewater treatment facilities discharge treated wastewater to the Schuylkill River for a total discharge of less than 9 mgd (Appendix F). In addition, at least seven major industrial facilities, such as industrial laundry facilities, chemical production facilities, and aluminum die casting facilities, discharge into the Schuylkill River. Two municipal and one industrial treatment facilities discharge to Perkiomen Creek with a maximum total discharge of 2.0 mgd (Appendix F). Three major industrial facility NPDES permits for water discharge to Perkiomen Creek exist within a 10-mi (16-km) radius of LGS. Little effect to aquatic habitats from industrial and wastewater discharges is expected assuming that facilities comply with NPDES permit limitations.

4.12.3.2 Energy Development

A number of energy plants withdraw water from the Schuylkill and Delaware Rivers. Within 30 miles (48 km) of LGS, one oil plant and one natural-gas plant also withdraw and discharge to the Schuylkill River. In 2011, Exelon decommissioned two coal-fired units on the Schuylkill River at Cromby Generating Station (Appendix F). Two coal and two natural-gas plants operate near the confluence of the Delaware and Schuylkill Rivers, and use tidal Delaware River water as the main water source. In 2005, DRBC annual consumptive surface water use records show Eddystone Generating Station Coal Plant at 897 million gallons per year (MGY) (3.4 million m^3), Florida Power & Light Energy Marcus Hook gas plant at 1,018 MGY (3.85 million m^3), and Fairless Energy at 495 MGY (1.87 million m^3) (DRBC 2012a). These energy plants use water resources shared by LGS, but do not affect habitats or aquatic biota directly associated with the LGS cooling system.

Marcellus shale formation underlies approximately 36 percent of the Delaware River Basin and energy companies are actively seeking to mine the natural gas deposits within the Marcellus Shale (DRBC 2012b; PADEP 2013). Several impacts to aquatic habitat could occur during the mining process, including physical habitat disturbance at the drill site; the potential to add, discharge, or cause the release of pollutants into waterbodies near the drill site; reduced water flow where water is withdrawn to support mining operations; and degradation of aquatic habitat if recovered "frac water" is not properly treated before discharge into waterbodies (DRBC 2012b). Direct impacts to aquatic biota could occur if aquatic organisms are immobile or unable to avoid the drill site. On May 5, 2010, DRBC voted to postpone its consideration of well pad dockets until DRBC has developed and implemented regulations for natural gas development within Marcellus Shale. As of May 2012, DRBC was in the process of developing these regulations, which would likely provide protection of aquatic resources during drilling activities (DRBC 2012b).

4.12.3.3 Climate Change

Within the northeast region, climate models predict increasing average annual temperatures that foster rising sea surface temperatures and sea levels, increased heavy precipitation, reduced snowpack, and earlier spring peak river flows (Karl et al. 2009). The impacts of climate change on aquatic communities within the Delaware River Basin may be substantial and subsequently affect aquatic resources in the region. For example, seasonal spawning may shift earlier to coincide with earlier spring flows from higher temperatures melting snowpack earlier in the season. Increased water temperatures and higher sea levels may result in anadromous fish migrations further up the Delaware or Schuylkill Rivers. Further degradation of water quality from increased runoff following heavy precipitation events may compromise sensitive life stages of aquatic species in associated watersheds and have noticeable effects on aquatic populations.

Interlandi and Crockett (2003) examined the relative influences of climate change and stormwater discharge on the Schuylkill River Basin from 1895 to 1999 using temperature, precipitation, and river discharge data. While seasonal variations exist, the overall influence of long-term climate change showed marginal influence as increasing urbanization and increased stormwater discharge had a larger direct effect on water quality (Interlandi and Crockett 2003). Therefore, stormwater discharges may play a larger role than climate change in cumulative changes to aquatic biota in the future.

4.12.3.4 Conclusion

The stresses from past river flow alterations, increasing urbanization, and demand for water resources across the geographic area of interest depend on many factors that the NRC staff cannot quantify, but they are likely to noticeably alter aquatic resources when all stresses on the aquatic communities are assessed cumulatively. Therefore, the NRC staff concludes that the cumulative impacts from the proposed license renewal and other past, present, and reasonably foreseeable projects would be SMALL to MODERATE.

4.12.4 Terrestrial Resources

This section addresses past, present, and future actions that could result in cumulative impacts on the terrestrial species and habitats described in Section 2.2.7 and protected terrestrial species discussed in Section 2.2.8. For purposes of this analysis, the geographic area considered in the evaluation includes the LGS site, the in-scope transmission line corridors, and the offsite facilities associated with the LGS makeup water system. See Section 2.2.8.1 for a description of these areas.

4.12.4.1 Historic Conditions

Section 2.2.7 discusses the ecoregion in which the LGS site is located—the Triassic Lowlands portion of the Northern Piedmont ecoregion—which is dominated by Appalachian oak forest. In the region surrounding the LGS site, much of what would be forest has been cleared and cultivated for crops, hayfields, and pastureland. Forest remains on marginal land, such as steep slopes and land with poorer quality soils. From 1973 to 2000, about 6.2 percent of land in the Northern Piedmont ecoregion changed in land use type. New development surrounding urban areas accounted for about 70 percent of this change. This rate of land development is one of the highest in the Eastern ecoregions over the time period (Auch 2003).

On the immediate site, PECO cleared about 270 ac (110 ha; 42 percent of the current LGS site) for construction of the facility's buildings, parking lots, roads, and other infrastructure (AEC 1973). The terrestrial habitats on the undeveloped portions of the site have not changed significantly since LGS's construction (Exelon 2011a).

4.12.4.2 Energy-Producing Facilities

A number of operating energy-producing facilities within the vicinity of the LGS site could affect the terrestrial environment now and in the future.

Two coal plants operate near LGS: the Titus Coal Plant (18 mi [29 km] northwest) and the Chester Operational Coal Plant (29 mi [47 km] southeast). Coal-fired plants are a major source of air pollution in the United States because they release sulfur dioxide, nitrogen oxides, mercury, carbon dioxide, and particulates. Nitrous oxides and sulfur dioxides combine with water to form acid rain, which can lead to erosion and changes in soil pH levels. Mercury deposits onto soil and surface water, which may then be taken up by terrestrial and aquatic plant or animal species and poses the risk of bioaccumulation.

Several gas and natural gas plants operate in the region as well (see Table F–1 in Appendix F). Natural gas plants emit nitrous oxides and sulfur dioxides, though at much lower levels than coal plants. Methane, a primary component of natural gas and also a greenhouse gas, can be released when natural gas is not burned completely or as a result of leaks or losses during transportation. The release of methane contributes to climate change, the terrestrial resource impacts of which are discussed below.

Additionally, a number of distillate oil facilities in the area contribute to air emissions, which can result in bioaccumulation of chemicals and contribute to climate change, as discussed above.

4.12.4.3 Urbanization and Habitat Fragmentation

As the region surrounding the LGS site becomes more developed, habitat fragmentation will increase. Species that require larger ranges, especially predators, will likely suffer reductions in their populations. In contrast, herbivores will experience less predation pressure and their populations are likely to increase. Edge species will benefit from the fragmentation, while species that require interior forest or swamp habitat will likely suffer. The transmission line corridors established for LGS's transmission lines represent habitat fragmentation, though all of the LGS transmission lines were constructed along existing utility or railroad corridors; therefore, these lines likely did not contribute measurable cumulative impacts.

4.12.4.4 Agricultural Runoff

As of 2000, agriculture accounted for about 20 percent of Montgomery County's land acreage (MCPCB 2005). As development continues, the county's agricultural lands are being converted to residential and commercial uses; however, a significant portion of the county continues to be used for agriculture. The 2000 National Water Quality Inventory reported that agricultural nonpoint source pollution accounted for the second largest source of impairments to wetlands (EPA 2012b). Fertilizers and pesticides can affect wetlands in a variety of ways. Because wetlands are often at lower elevation than surrounding land, they receive much of the runoff first, and that runoff persists because it is unable to drain to lower ground. This can result in pollutant loadings and bioaccumulation and changes to species composition and abundance and increases. Species that rely on wetlands, such as birds and amphibians, are more sensitive to environmental stressors, which exacerbate these effects.

4.12.4.5 Parks and Conservation Areas

Eleven National and state parks occur within 30 mi (50 km) of the LGS site (see Appendix F). These areas will continue to provide valuable habitat to native wildlife and migratory birds. As habitat fragmentation resulting from various types of development occurs, these areas will become ecologically more important because they will provide large areas of natural habitat.

The Montgomery County Planning Commission (MCPC) has designated about 24 percent of the county as conservation landscapes. Conservation landscapes provide a focus for the county's restoration and native habitat management efforts. The MCPC has designated 13 of these landscapes, which total about 75,000 ac (30,000 ha). These conservation landscapes include relatively large forested tracts, stream corridors, wetlands, known sites of rare plant and animal species, and areas of high natural biodiversity. The large tracts of forest support native bird and wildlife diversity throughout the county, and the wetland habitats are critical to maintaining native amphibian and reptile populations (Rhoads and Block 2008). In addition, terrestrial habitats within the Schuylkill River corridor are protected by the Schuylkill River National and State Heritage Area.

4.12.4.6 Climate Change

As discussed in Section 4.12.1, temperature within the Northeast are projected (between 2021-2050) to increase 1.5 °F to 3.5 °F (0.83 to 1.94°C) and summer months will experience the greatest increase. Annual mean precipitation and the frequency of heavy rainfall events will also increase resulting in wetter conditions in the future for the Northeast (USGCRP 2014).. Changes in the climate will shift many wildlife population ranges and alter migratory patterns. Such changes could favor non-native invasive species and promote the population increases of insect pests and plant pathogens. For instance, it has been found that migratory birds are arriving sooner and bird species and insect species (e.g. hemlock woolly adelgid) have expanded their ranges northward (USGCRP 2014). Climate change will likely alter disturbance regimes as the severity or frequency of precipitation, flooding, and fire change. Climate change may also exacerbate the effects of existing stresses in the natural environment, such as those caused by habitat fragmentation, invasive species, nitrogen deposition and runoff from agriculture, and air emissions. Furthermore, the Northeast region may be susceptible to crop damage from continued increasing intense precipitation events and heat stress (USGCRP 2014).

4.12.4.7 Conclusion

The NRC staff examined the cumulative effects of the construction of LGS, neighboring energy-producing facilities, continued urbanization and habitat fragmentation, agricultural runoff, nearby parks and conservation areas, and climate change. As stated in Section 4.7, the impacts of continued LGS operations are SMALL. The NRC staff concludes that the minimal terrestrial impacts from the continued LGS operations would not contribute to the overall decline in the condition of terrestrial resources. The NRC staff believes that the cumulative impacts of other and future actions during the term of license renewal on terrestrial habitat and associated species, when added to past, present, and reasonably foreseeable future actions, would be MODERATE.

4.12.5 Human Health

The radiological dose limits for protection of the public and workers have been developed by the NRC and EPA to address the cumulative impact of acute and long-term exposure to radiation and radioactive material. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. For the purpose of this analysis, the area within a 50-mi (80-km) radius of LGS was included. The REMP conducted by Exelon in the vicinity of the LGS site measures radiation and radioactive materials from all sources (i.e., hospitals and other licensed users of radioactive material); therefore, the monitoring program measures cumulative radiological impacts. Within the 50-mi (80-km) radius of the LGS site there are currently no other nuclear power reactors or uranium fuel cycle facilities.

Radioactive effluent and environmental monitoring data for the 5-year period from 2006 to 2010 were reviewed as part of the cumulative impacts assessment. In Section 4.9.2 of this SEIS, the NRC staff concluded that impacts of radiation exposure to the public and workers (occupational) from operation of LGS during the renewal term are SMALL. The NRC and the State of Pennsylvania would regulate any future actions in the vicinity of the LGS site that could contribute to cumulative radiological impacts.

Exelon constructed an Independent Spent Fuel Storage Installation (ISFSI) on the LGS site in 2008 for the storage of its spent fuel. The installation and monitoring of this facility is governed by NRC requirements in 10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste.” Radiation from this facility, as well as from the operation of LGS, is required to be within the radiation dose limits in 10 CFR Part 20, 40 CFR Part 190, and 10 CFR Part 72. The NRC carries out periodic inspections of the ISFSI to verify its compliance with its licensing and regulatory requirements.

The cumulative radiological impacts from LGS, Units 1 and 2, and the ISFSI are required to meet the radiation dose limits in 10 CFR Part 20, 10 CFR Part 72, and 40 CFR Part 190. Therefore, the NRC staff concludes that cumulative radiological impacts would be SMALL.

4.12.6 Socioeconomics

4.12.6.1 Socioeconomics

This section addresses socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at LGS, Units 1 and 2, in addition to the aggregate effects of other past, present, and reasonably foreseeable future actions. The primary geographic areas of interest considered in this cumulative analysis include Montgomery, Berks, and Chester Counties where approximately 84 percent of LGS, Units 1 and 2, employees reside (see Section 2.2.9). This is where the economy, tax base, and infrastructure would most likely be affected since LGS workers and their families reside, spend their income, and use their benefits within these counties. As previously discussed in Section 4.1, onsite land use conditions at LGS are expected to remain unchanged during the license renewal term. Therefore, activities associated with continued reactor operations during the license renewal term are not expected to affect the use and management of LGS lands identified as part of the Schuylkill River Greenway.

As discussed in Section 4.10 of this SEIS, continued operation of LGS would have no impact on socioeconomic conditions in the region during the license renewal term beyond what is already being experienced.Since Exelon has no plans to hire additional workers during the license renewal term, overall expenditures and employment levels at LGS, Units 1 and 2, would remain relatively unchanged with no new, additional, or increased demand for permanent housing and public services. In addition, since employment levels and tax payments would not change, there would be no population or tax revenue-related land use impacts. Based on this and other information presented in Chapter 4 of this SEIS, there would be no contributory effect from continued operations of LGS, Units 1 and 2, on socioeconomic conditions in the region beyond what is currently being experienced. Therefore, the only cumulative contributory effects would come from the other planned activities in the region independent of LGS, Units 1 and 2, operations.

4.12.6.2 Environmental Justice

The environmental justice cumulative impact analysis assesses the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from past, present, and reasonably foreseeable future actions including LGS, Units 1 and 2, operations during the renewal term. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas presented in Chapter 4 of this SEIS. Minority and low-income populations are subsets of the general public residing in the area and all would be exposed to the same hazards generated from LGS operations. As previously discussed in this chapter, the impact from license renewal for all resource areas (e.g., land, air, water, ecology, and human health) would be SMALL.

As discussed in Section 4.10.7 of this SEIS, there would be no disproportionately high and adverse impacts to minority and low-income populations from the continued operation of LGS, Units 1 and 2, during the license renewal term. Since Exelon has no plans to hire additional workers during the license renewal term, employment levels at LGS, Units 1 and 2, would remain relatively constant with no new, additional, or increased demand for housing or increased traffic. Based on this information and the analysis of human health and environmental impacts presented in Chapters 4 and 5, it is not likely there would be any disproportionately high and adverse contributory effect on minority and low-income populations from the continued operation of LGS during the license renewal term. Therefore, the only contributory effects would come from the other activities in the region unrelated to the proposed action (license renewal).

4.12.7 Cultural Resources

This section addresses the direct and indirect effects of license renewal on historic and cultural resources when added to the aggregate effects of other past, present, and reasonably foreseeable future actions. The geographic area considered in this analysis is the Area of Potential Effect (APE) associated with the proposed undertaking, as described in Section 2.2.10.

Substantial archeological records indicate that there was historic occupation of the LGS area. Surveys were performed in the 1970s and 1980s. Section 2.2.10 presents an overview of the existing historic and archaeological resources located on the LGS site. Past land development has resulted in impacts on and the loss of cultural resources near and at the LGS site. As described in Section 4.10.6, no cultural resources would be affected by license renewal activities associated with the LGS site because there will be no changes or ground-disturbing activities that will occur as part of the relicensing of LGS, Units 1 and 2 (Exelon 2011a). Cultural resources are being managed through Exelon's Cultural Resources Management Plan and the Fricks Lock rehabilitation and mothball project (Exelon 2012a).

The present and reasonably foreseeable projects reviewed in conjunction with license renewal are noted in Appendix F of this document. Direct impacts would occur if archaeological sites in the APE are physically removed or disturbed. The following projects are located within the geographic area considered for cumulative impacts:

- decommissioning of LGS, Units 1 and 2,
- transmission lines, and
- future urbanization.

Decommissioning of LGS, Units 1 and 2, transmission lines, and future urbanization have the potential to result in impacts on cultural resources through inadvertent discovery during ground-disturbing activities. However, as discussed above in Section 4.10.6, the contribution from the proposed license renewal action would not incrementally affect historic or cultural resources. Therefore, the NRC staff concludes that the cumulative impacts of the proposed license renewal plus other past, present, and reasonable foreseeable future activities on historic and cultural resources would be SMALL.

4.12.8 Summary of Cumulative Impacts

The NRC staff considered the potential impacts resulting from the operation of LGS during the period of extended operation and other past, present, and reasonably foreseeable future actions near LGS. The determination is that the potential cumulative impacts would range from SMALL to MODERATE, depending on the resource. Table 4–10 summarizes the cumulative impacts on resources areas.

Table 4–10. Summary of Cumulative Impacts on Resource Areas

Resource Area	Cumulative Impact
Air Quality	Because there are no planned site refurbishments with the LGS license renewal, and no expected changes in air emissions, cumulative impacts in Montgomery and Chester Counties would be the result of changes to present-day emissions and emissions from reasonably foreseeable projects and actions. Various strategies and techniques are available to limit air quality impacts. Therefore, the cumulative impacts from the continued operation of LGS would be SMALL.
Water Resources	Surface water withdrawals by LGS and other surface water users in the basin are subject to limits and conditions imposed by DRBC. The DRBC and PADEP established a regulatory framework to manage surface water use and quality. The water quality of Delaware River and its main tributaries, such as the Schuylkill, has improved over the past several decades. The annual net groundwater withdrawals in the Schuylkill–Sprogels Run Subbasin are currently below the DRBC limits. Therefore, the cumulative impacts from the continued operations of LGS would be SMALL.
Aquatic Ecology	The stresses from past river flow, alterations, increasing urbanization, and demand of water resources across the geographic area of interest are likely to alter aquatic resources when stresses on the aquatic communities are assessed cumulatively. Therefore, the cumulative impacts from the continued operation of LGS would be SMALL to MODERATE.
Terrestrial Ecology	A number of operating energy-producing facilities within the vicinity of LGS have the potential to affect terrestrial resources. Habitat fragmentation will increase as the region surrounding the LGS site becomes more developed. Therefore, the cumulative impacts from the continued operation of LGS would be MODERATE.
Human Health	The NRC staff reviewed the radioactive effluent and environmental monitoring data from 2006 to 2010, and concluded the impacts of radiation exposure to the public from operation of LGS during the renewal term are SMALL. The cumulative radiological impacts from LGS and the Independent Spent Fuel Storage Installation would be required to meet radiation dose limits in 10 CFR Part 20 and 40 CFR Part 190. Therefore, the cumulative impacts from the continued operation of LGS would be SMALL.
Socioeconomics	As discussed in Section 4.9, continued operation of LGS during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already experienced. Exelon has no plans to hire additional workers during the license renewal term; employment levels at LGS would remain relatively constant with no new demands for housing or increased traffic. Combined with other past, present, and reasonably foreseeable future activities, there will be no additional contributory effect on socioeconomic conditions from the continued operation of LGS during the license renewal period beyond what is currently being experienced.
Cultural Resources	Transmission lines, future urbanization, and decommissioning of LGS have the potential to affect cultural resources through inadvertent discovery during ground-disturbing activities. However, no cultural resources would be affected by license renewal activities associated with the LGS site because there will be no changes or ground-disturbing activities that will occur as part of the relicensing of LGS, Units 1 and 2. Therefore, combined with other past, present, and reasonable foreseeable future activities, the potential cumulative impacts on historic and cultural resources would be SMALL.

4.13 References

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5.0 ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

This chapter describes the environmental impacts from postulated accidents that Limerick Generating Station, Units 1 and 2 (LGS or Limerick) might experience during the period of extended operation. The term "accident" refers to any unintentional event outside the normal plant operational envelope that results in a release or the potential for release of radioactive materials into the environment. The two classes of postulated accidents listed in Table 5–1 are evaluated in detail in the generic environmental impact statement (GEIS). These two classes of accidents are:

- design-basis accidents (DBAs), and
- severe accidents.

Table 5–1. Issues Related to Postulated Accidents

Issues	GEIS Section	Category
DBAs	5.3.2; 5.5.1	1
Severe accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	2

5.1 Design-Basis Accidents

To receive U.S. Nuclear Regulatory Commission (NRC) approval to operate a nuclear power plant, an applicant for an initial operating license must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that prevent and mitigate accidents. The NRC staff (the staff) reviews the application to determine if the plant design meets the NRC's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

Design-basis accidents (DBAs) are those accidents that both the licensee and the staff evaluate to ensure that the plant can withstand normal and abnormal transients and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. Many of these postulated accidents are not expected to occur during the life of the plant but are evaluated to establish the design basis for the preventive and mitigative safety systems of the nuclear power plant. Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 and 10 CFR Part 100 describe the acceptance criteria for DBAs.

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the nuclear power plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license. The results of these evaluations are found in license documentation such as the applicant's final safety analysis report (FSAR), the staff's safety evaluation report (SER), the final environmental statement (FES), and Section 5.1 of this supplemental environmental impact statement (SEIS). A licensee is required to maintain the acceptable design and performance criteria throughout the life of the nuclear power plant, including any period of extended operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for license renewal, the environmental impacts, as calculated for DBAs, should not differ significantly from initial licensing assessments over the life of the nuclear power plant, including the license renewal period. Accordingly, the design of the nuclear power plant, relative to DBAs during the extended period, is considered to remain acceptable; therefore, the environmental impacts of those accidents were not examined further in the GEIS.

The NRC has determined in the GEIS that the environmental impacts of DBAs are of SMALL significance for all nuclear power plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, DBAs are designated as a Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The early resolution of the DBAs makes them a part of the current licensing basis (CLB) of the plant; the CLB of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal. This issue is applicable to LGS.

Exelon Generation Company, LLC (Exelon) stated in its environmental report (ER) (Exelon 2011c) that it is not aware of any new and significant information related to DBAs associated with the renewal of the LGS. The staff did not find any new and significant information during its independent review of Exelon's ER, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts related to DBAs beyond those discussed in the GEIS (NRC 2013a).

5.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the effects of severe accidents during the period of extended operation, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the period of extended operation.

The impacts from severe accidents initiated by external phenomena such as tornadoes, floods, earthquakes, fires, and sabotage were specifically considered in the GEIS. The GEIS evaluated existing impact assessments—performed by the staff and by the industry at 44 nuclear power plants (including LGS) in the United States—and concluded that the risk from beyond design-basis earthquakes at existing nuclear power plants is SMALL. The GEIS also performed a discretionary analysis of sabotage, in connection with license renewal, and concluded that the core damage and radiological release from such acts would be no worse than the damage and release expected from internally initiated events. In the GEIS, the NRC concludes that the risk from sabotage at existing nuclear power plants is SMALL and, additionally, that the risks from other external events are adequately addressed by a generic consideration of internally initiated severe accidents (NRC 1996, 2013a).

Based on information in the GEIS, the NRC determined in its regulations that:

> The probability-weighted consequences of 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.

The staff found no new and significant information related to severe accidents during the review of Exelon's ER (Exelon 2011c), the scoping process, the review of public comments, NRDC's waiver petition, or evaluation of other available information. Therefore, there are no impacts related to these issues, beyond those already discussed in the GEIS.

5.3 Severe Accident Mitigation Alternatives

The purpose of the evaluation of severe accident mitigation alternatives (SAMAs) is to identify design alternatives, procedural modifications, or training activities that are cost-beneficial and further reduce the risks of severe accidents (NRC 1999a). The analysis of SAMAs includes the identification and evaluation of alternatives that reduce the radiological risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment in the event that substantial core damage occurs (i.e., mitigating the impacts of a severe accident) (NRC 1999b). In accordance with 10 CFR 51.53(c)(3)(ii)(L) and Table B-1 of Part 51, license renewal ERs must provide a consideration of alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment.

The staff has previously performed a site-specific analysis of severe accident mitigation in a National Environmental Policy Act of 1969 (NEPA) document for LGS in the Final Environmental Statement Related to Operation of LGS, Units 1 and 2 in NUREG-0974, Supplement 1 (NRC 1989) ("1989 SAMDA Analysis"). Therefore, no analysis of SAMAs for LGS is required in Exelon's ER or the staff's SEIS. The NRC staff uses the term SAMA to refer to SAMAs at the license renewal phase. In contrast, the term severe accident mitigation design alternative (SAMDA) refers to SAMAs at the initial licensing phase. The site-specific SAMDAs reviewed for applicability to LGS were evaluated in the 1989 SAMDA Analysis and also documented in GEIS Table 5.35. The staff examined each SAMDA (individually and, in some cases, in combination) to determine the potential SAMDA individual risk reduction potential. This risk reduction was then compared with the cost of implementing the SAMDA to provide cost-benefit evidence of its value. The staff concluded that:

> The risks of early fatality from potential accidents at the site are small in comparison with risks of early fatality from other human activities in a comparably sized population, and the accident risk will not add significantly to population exposure and cancer risks. Accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources. Further, the best estimates show that the risks of potential reactor accidents at Limerick are within the range of such risks from other nuclear power plants.

However, in the LGS specific 1989 SAMDA Analysis, the staff acknowledged:

> In the longer term, these same severe accident issues are currently being pursued by the NRC in a systematic way for all utilities through the Severe Accident Program described in SECY-88-147, "Integration Plan for Closure of Severe Accident Issues." The plan includes provisions for an Individual Plant Examination (IPE) for each operating reactor, a Containment Performance Improvement (CPI) program, and an Accident Management (AM) program. These programs will produce a more complete picture of the risks of operating plants and the benefits of potential design improvements, including SAMDAs. The staff believes that the severe accident program is the proper vehicle for further review of severe accidents at nuclear power plants, including Limerick.

Therefore, the Commission considers ways to mitigate severe accidents at a given site more than once. The Commission has considered alternatives for mitigating severe accidents at many sites, including LGS, multiple times through a variety of NRC programs. When it promulgated Table B-1 of 10 CFR Part 51, the Commission explained:

> The Commission has considered containment improvements for all plants pursuant to its Containment Performance Improvement (CPI) program…and the Commission has additional ongoing regulatory programs whereby licensees

> search for individual plant vulnerabilities to severe accidents and consider cost-beneficial improvements [(the individual plant examination "IPE" and individual plant examination of external events "IPEEE" programs)]. [61 FR 28467]

In light of these studies, the Commission believed that if the staff has already considered severe accident mitigation under NEPA once for a facility, it was "unlikely that any site-specific consideration of SAMAs for license renewal will identify major plant design changes or modifications that will prove to be cost-beneficial for reducing severe accident frequency or consequences" (61 FR 28467). In CLI-13-7, the Commission reaffirmed the conclusions in Table B-1 and 10 CFR 51.53(c)(3)(ii)(L) and stated that it promulgated those regulations "because we determined that one SAMA analysis would uncover most cost-beneficial measures to mitigate both the risk and the effects of severe accidents, thus satisfying our obligations under NEPA" (NRC 2013d).. Given the significant costs of a major plant design change, such an improvement must result in a substantial reduction in risk to be cost-beneficial. As discussed below, the NRC has thoroughly considered severe accidents and ways to mitigate their impacts, in the original SAMDA analysis for Limerick and other studies, and did not identify cost-beneficial major plant design changes or modifications for mitigating the impacts of severe accidents.

5.3.1 Containment Performance Improvement Program

One of the programs the Commission relied on in determining that SAMAs need not be performed at license renewal if the staff had already performed a SAMA review in an earlier NEPA document is the CPI program. With this program, the NRC examined each of five U.S. reactor containment types (BWR Mark I, II, and III; PWR Ice Condenser; and PWR Dry) with the purpose of examining the potential failure modes, potential fixes, and the cost benefit of such fixes. Tables 5.32 through 5.34 in the GEIS summarize the results of this program. As can be seen from these tables, many potential changes were evaluated but only a few containment improvements were identified for site-specific review. The items evaluated in the CPI program were also included in the list of plant-specific SAMDAs examined in the LGS FES supplement (NRC 1996). Furthermore, the CPI program issues applicable to Limerick were effectively subsumed into the IPE process in Supplements 1 and 3 to Generic Letter 88-20. Additionally, the Emergency Procedure Guidelines (EPG) and Severe Accident Management Guidelines (SAMGs) developed by the BWR Owners' Group (BWROG) and implemented at Limerick incorporate the accident management strategies identified in the CPI program (Exelon 2014a).

5.3.2 Individual Plant Examination

Another program the Commission relied on in determining that SAMAs need not be performed at license renewal if the staff had already performed a SAMA review in an earlier NEPA document is the Individual Plant Examination (IPE). The IPE's specific objective was to develop an appreciation of severe accident behavior, and to identify ways in which the overall probabilities of core damage and fission product releases could be reduced if deemed necessary. In general, the IPEs have resulted in plant procedural and programmatic improvements (i.e., accident management) and, in only a few cases, minor plant modifications, to further reduce the risk and consequences of severe accidents (NRC 1996).

In accordance with NRC's policy statement on severe accidents, the licensee performed an IPE to look for vulnerabilities to both internal and external initiating events (NRC 1988a). This examination considered potential improvements on a plant-specific basis. The core damage frequency (CDF) was found to be considerably less in the LGS IPE (4.3×10^{-6}) than in the original CDF value provided in NUREG-1068 (1.0×10^{-5}) for LGS and the 1989 PRA Update (1.0×10^{-5}) used in the 1989 SAMDA Analysis review. The staff further notes that the 2009 PRA Update (3.2×10^{-6}) is approximately an order of magnitude less than the 1989 PRA Update (Exelon ER) used in the 1989 SAMDA Analysis review. Plant improvements identified and implemented for LGS as a result of the IPE included: (1) relaxing restrictions on the drywell spray initiation curve in the Emergency Operating Procedures; (2) creating a procedure to cross-tie the 4-kilovolt (kV) safeguards electrical buses; (3) creating a procedure to power Unit 2 emergency service water (ESW) pumps from Unit 1; and (4) creating a cross-connection between the fire water and residual heat removal (RHR) systems (PECO 1992). Exelon request for additional information (RAI) response dated March 12, 2014, confirms these and other improvements were implemented to reduce risk at LGS as a result of the IPE (Exelon 2014a). These results at Limerick are also consistent with other IPEs in that they have resulted in only plant procedural and programmatic improvements (i.e., accident management) and, in only a few cases, minor plant modifications to further reduce the risk and consequences of severe accidents.

5.3.3 Individual Plant Examination of External Events

Another program the Commission relied on in determining that SAMAs need not be performed at license renewal if the staff had already performed a SAMA review in an earlier NEPA document is the Individual Plant Examination of External Events (IPEEE) program. While the IPE takes into account events that could challenge the design from things that could go awry internally (in the sense that equipment might fail because components do not work as expected), the IPEEE considers challenges such as earthquakes, internal fires, and high winds. The IPEEE program was initiated in the early 1990s. All operating plants in the United States (including LGS) performed an assessment to identify vulnerabilities to severe accidents initiated by external events and reported the results to the NRC, along with any identified improvements and/or corrective actions. *Perspectives Gained from the Individual Plant Examination of External Events (IPEEE) Program*, NUREG–1742 documents the perspectives derived from the technical reviews of the IPEEE results (NRC 2002). As a result of conducting the LGS IPEEE, PECO Energy identified seismic event and fire event findings. Actions were taken to address minor housekeeping and maintenance issues related to the seismic analysis such as unrestrained tools, lockers, hoist controllers and lifting devices for low voltage switchgear. In addition, fire brigade drill activities and fire brigade awareness were increased for three areas in the common control structure. Furthermore, actions credited in the fire analysis such as improved transient combustible controls, creation of transient combustible free zones and formal designation of certain fire rated doors as “fire” doors were implemented at LGS (PECO 1995). Exelon RAI response dated March 12, 2014, confirms these and other improvements were implemented to reduce risk at LGS as a result of the IPEEE (Exelon 2014a). These results at Limerick are also consistent with other IPEEEs in that they have resulted in only plant procedural and programmatic improvements (i.e., accident management) and, in only a few cases, minor plant modifications to further reduce the risk and consequences of severe accidents.

5.3.4 Accident Management Program

The staff specifically relied on the Accident Management Program as the proper avenue for addressing the improvements considered in the 1989 SAMDA Analysis. Accident management involves the development of procedures that promote the most effective use of available plant equipment and staff in the event of an accident. The staff indicated its intent (NRC 1988a) that licensees develop an accident management framework that will include implementation of accident management procedures, training, and technical guidance. Exelon developed an accident management program at LGS which factored insights gained as a result of the IPE. As discussed earlier, the improvements identified from the completed IPEs to date have been in the area of accident management or other procedural and programmatic improvements (NRC 1996 and NRC 1997). Additionally the EPG and SAMGs developed by the BWROG and implemented at Limerick incorporate the accident management strategies identified in the CPI program. Exelon RAI response dated March 12, 2014, confirms these and other improvements were implemented to reduce risk at LGS as a result of the IPE (Exelon 2014a).

5.3.5 NRC Efforts to Address Severe Accident-Related Issues Since the Publication of the 1996 GEIS

The evaluation of Limerick's 1989 SAMDA analysis is summarized in the 1996 GEIS. The NRC has continued to address severe accident-related issues since the GEIS was published and 10 CFR Part 51 changes related to license renewal were promulgated. The NRC and licensee efforts have reduced risks from accidents beyond that considered in the 1996 GEIS (summarized below) and the 2013 GEIS (NRC 2013a). In some cases, such as the agency response to Fukushima, these activities are ongoing. Each of the activities applied or continues to apply to all reactors, including LGS. The specific requirement for any given reactor was based either on a site-specific evaluation or a design-specific requirement.

5.3.6 10 CFR 50.54(hh) Conditions of License Regarding Loss of Large Areas of the Plant Caused by Fire or Explosions

Following September 11, 2001, the Commission issued Order EA-02-026 and ultimately a new regulation (10 CFR 50.54(hh)), which required commercial power reactor licensees to, among other things, adopt mitigation strategies using readily available resources to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities to cope with the loss of large areas of the facility because of large fires and explosions from any cause, including beyond-design-basis aircraft impacts (See 74 FR 13926). The final rule also added several new requirements developed as a result of insights gained from implementation of the security orders, reviews of site security plans, and implementation of the enhanced baseline inspection program, and updated the NRC's security regulatory framework for the licensing of new nuclear power plants. Compliance with the final rule was required by March 31, 2010, for licensees, including Exelon, currently licensed to operate under 10 CFR Part 50. Exelon has updated its plant and procedures accordingly, and the NRC has inspected the guidelines and strategies that Exelon has implemented to meet the requirements of 10 CFR 50.54(hh)(2). The specifics of the enhancements are security related and not publicly available but are described, in general, in the 2013 GEIS. These enhancements include: (1) significant reinforcement of the defense capabilities for nuclear facilities, (2) better control of sensitive information, (3) enhancements in emergency preparedness (EP) to further strengthen the NRC's nuclear facility security program, and (4) implementation of mitigating strategies to deal with postulated events potentially causing loss of large areas of the plant caused by explosions or fires, including those that an aircraft impact might create. These measures are outlined in greater detail in NUREG/BR-0314 (NRC 2004), NUREG-1850 (NRC 2005), and Sandia National Laboratory's "Mitigation of Spent Fuel Loss-of-Coolant Inventory Accidents and Extension of Reference Plant Analyses to Other Spent Fuel Pools" (Wagner and Gaunt 2006).

As discussed in Section 5.3.3.1 of the 1996 GEIS, security-related events are addressed via deterministic criteria in 10 CFR Part 73, rather than by risk assessments or SAMAs. However, as provided above in the severe accident introduction (Section 5.3), the purpose of the evaluation of SAMAs is to identify design alternatives, procedural modifications, or training activities that are cost-beneficial and further reduce the risks of severe accidents (NRC 1999a). The analysis of SAMAs includes the identification and evaluation of alternatives that reduce the radiological risk from a severe accident by preventing substantial core damage (i.e., preventing a severe accident) or by limiting releases from containment in the event that substantial core damage occurs (i.e., mitigating the impacts of a severe accident) (NRC 1999b). Exelon's efforts to implement the deterministic requirements of 10 CFR 50.54(hh) and 10 CFR Part 73 were similar to the purpose of evaluating SAMAs because they mitigate the consequences of a beyond design basis accident. However, the implementation of deterministic 10 CFR 50.54(hh) and 10 CFR Part 73 requirements are required regardless of whether they are cost-beneficial or not. Nevertheless, these activities have further contributed to the reduction of risk at Limerick.

5.3.7 Severe Accident Management Guidelines

Exelon has also developed and implemented severe accident mitigation guidelines (SAMGs) at LGS, which further reduce risk at the facility. SAMGs were developed by the industry during the 1980s and 1990s in response to the Three Mile Island (TMI) Nuclear Station accident and follow-up activities. SAMGs are meant to "enhance the ability of the operators to manage accident sequences that progress beyond the point where emergency operating procedures (EOPs) and other plant procedures are applicable and useful" (NRC 2011a). The CPI program issues applicable to Limerick were effectively subsumed into the IPE process in Supplements 1 and 3 to Generic Letter 88-20. Additionally, the EPG and SAMGs developed by the BWROG and implemented at Limerick incorporate the accident management strategies identified in the CPI program and elsewhere (Exelon 2014a). The development and implementation of these guidelines are similar to SAMAs in that they are procedural modifications that further reduce the risks of severe accidents.

5.3.8 Fukushima-Related Activities

On March 11, 2011, a massive earthquake off the east coast of Honshu, Japan, produced a tsunami that struck the coastal town of Fukushima. The six-unit Fukushima Dai-ichi nuclear power plant was directly impacted by these events. The resulting damage caused the failure of several of the units' safety systems needed to maintain cooling water flow to the reactors. As a result of the loss of cooling, the fuel overheated, and there was a partial meltdown of the fuel contained in three of the reactors. Damage to the systems and structures containing reactor fuel resulted in the release of radioactive material to the surrounding environment (NRC 2013a).

In response to the earthquake, tsunami, and resulting reactor accidents at Fukushima Dai-ichi (hereafter referred to as the "Fukushima events"), the Commission directed the staff to convene an agency task force of senior leaders and experts to conduct a methodical and systematic review of the relevant NRC regulatory requirements, programs, and processes, including their implementation, and to recommend whether the agency should make near-term improvements to its regulatory system. As part of the short-term review, the task force concluded that, while improvements are expected to be made as a result of the lessons learned from the Fukushima events, the continued operation of nuclear power plants and licensing activities for new plants do not pose an imminent risk to public health and safety. During the time that the task force was conducting its review, groups of individuals and nongovernmental organizations petitioned the Commission to suspend all licensing decisions in order to conduct a separate, generic NEPA analysis to determine whether the Fukushima events constituted "new and significant information" under NEPA that must be analyzed as part of environmental reviews. The Commission found the request premature and noted, "In short, we do not know today the full implications of the [Fukushima] events for U.S. facilities." However, the Commission found that if "new and significant information comes to light that requires consideration as part of the ongoing preparation of application-specific NEPA documents, the agency will assess the significance of that information, as appropriate." The Federal courts of appeal and the Commission have interpreted NEPA such that an EIS must be updated to include new information only when that new information provides "a seriously different picture of the environmental impact of the proposed project from what was previously envisioned" (NRC 2013a).

The NRC also ensured U.S. nuclear power plants took action to prepare for a Fukushima-like event. The NRC told its inspectors to independently assess each plant's level of preparedness. The inspections covered procedures that compensate for extensive onsite damage, loss of all alternating current (AC) power, and seismic and flooding issues, as well as procedures for dealing with a damaged reactor.

The agency also created the Japan Lessons Learned-Project Directorate, or JLD, to lead the NRC efforts relating to Fukushima. The JLD's approximately 20 full-time employees work with experts from across the agency. The JLD is directed by a steering committee made up of NRC senior managers.

The agency issued three Orders in March 2012 requiring U.S. reactors to:

- Obtain and protect additional emergency equipment, such as pumps and generators, to support all reactors at a given site simultaneously following a natural disaster
- Install enhanced equipment for monitoring water levels in each plant's spent fuel pool.
- Improve/install emergency venting systems that can relieve pressure in the event of a serious accident (only for reactors with designs similar to the Fukushima plant).

The NRC strengthened the venting Order in 2013, requiring the vents to handle the pressures, temperatures, and radiation levels from a damaged reactor. The revised Order also calls for plants to ensure their personnel could operate the vents under those conditions (NRC 2013b).

The NRC has also asked all U.S. reactors to reconfirm their flooding and earthquake preparedness, as well as reanalyze their earthquake and flooding hazards. Other NRC activities include creating or revising rules related to maintaining key safety functions, if a plant loses all AC power, and several aspects of EP. The NRC's Web site includes more information on Fukushima-related actions.

Significantly, while the Commission did impose additional safety requirements on operating reactors following Fukushima as provided in the preceding paragraphs, the Commission did so on the basis of a safety analysis conducted under the Backfit Rule, not the results of a SAMA analysis conducted for NEPA purposes. Those SAMA analyses had long assumed that prolonged station blackouts, such as the one experienced by the Fukushima reactors, could yield devastating consequences. Therefore, subsequent events, including the Fukushima events, have confirmed the Commission's twin expectations that (1) future SAMA analyses would not likely find major plant improvements cost-beneficial and that (2) the NRC would continue to reduce risk at regulated facilities through its ongoing safety oversight (61 FR 28467; NRC 1996).

Given the many ways the NRC has and continues to address severe accident-related issues since the publication of the 1996 GEIS (Sections 5.3.5 to 5.3.8) and the 1989 SAMDA, the NRC concludes that the NRC does not need to reconsider SAMAs for LGS at the license renewal phase. See 10 CFR 51.53(c)(3)(ii)(L) and 10 CFR Part 51 Table B–1. As provided above, 10 CFR 51.53(c)(3)(ii)(L) and 10 CFR Part 51 Table B–1 rely on more than just the prior 1989 SAMDA Analysis; they also rest on the IPE, IPEEE, and CPI programs, to consider SAMAs in cases like LGS in which the NRC has already analyzed SAMAs. These plant-specific analyses did not identify major cost-beneficial mitigation measures that could substantially reduce offsite risk. Rather, they mostly uncovered minor improvements and programmatic fixes. The volume of plant-specific analyses cited by the Commission, and their ongoing nature, provide the type of "hard look" the Commission understood it must apply to the issue of SAMAs in its NEPA review for every license renewal proceeding (61 FR 28481). This approach is all the more reasonable in light of the Commission's finding that the probability-weighted environmental impacts of severe accidents are small.

Furthermore, the 2013 GEIS mentions the vast operating experience to support the safety of U.S. nuclear power plants. As with any technology, experience generally leads to improved plant performance and public safety. This additional experience has contributed to improved plant performance (e.g., as measured by trends in plant-specific performance indicators), a reduction in operating events, and lessons learned that improve the safety of all of the operating nuclear power plants. The items above contribute to improved safety as do those safety improvements not related to license renewal such as generic safety issues (e.g., Generic Safety Issue 191 on sump performance). Thus, the performance and safety record of nuclear power plants operating in the United States, including Limerick, continues to improve. This is also confirmed by analysis which indicates that, in many cases, improved plant performance and design features have resulted in reductions in initiating event frequency, CDF, and containment failure frequency (NRC 2013a).

5.3.9 Evaluation of Other New Information

Additionally, both the applicant and the NRC must consider whether new and significant information affects environmental determinations in the NRC's regulations, including the determination in 10 CFR 51.53(c)(3)(ii)(L) and Table B-1 that the agency need not reconsider SAMAs at license renewal if it has already done so in a NEPA document for the plant. See 61 FR 28467 to 28468; see *Marsh* v. *Oregon Natural Resources Council*, 490 U.S. 360, 373–374 (1989). As the Commission observed in CLI-13-7, the staff must consider whether there is new and significant information pertaining to the 1989 SAMDA analysis for Limerick's original operating licenses in the SEIS. If new and significant information is available, "then the original SAMA analysis may be inadequate to satisfy NEPA at the license renewal stage, and may require supplementation."

The 1989 SAMDA concluded, "The risks and environmental impacts of severe accidents at Limerick are acceptably low." We have found no new information that would call into question the FES conclusion that:

> [T]he risks of early fatality from potential accidents at the site are small in comparison with risks of early fatality from other human activities in a comparably sized population, and the accident risk will not add significantly to population exposure and cancer risks. Accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources. Further, the best estimate calculations show that the risks of potential reactor accidents at Limerick are within the range of such risks.

Furthermore, the 1989 SAMDA stated, "In light of these considerations, the staff has no clear basis at this time for concluding that modifications to the plant are justified for the purpose of further mitigating severe accident risks" and "The staff believes that the severe accident program is the proper vehicle for further review of severe accidents at nuclear power plants, including Limerick."

New information is significant if it provides a seriously different picture of the impacts of the Federal action under consideration. Thus, for mitigation alternatives such as SAMAs, new information is significant if it indicates that a mitigation alternative would substantially reduce an impact of the Federal action on the environment. Consequently, with respect to SAMAs, new information may be significant if it indicated a given cost-beneficial SAMA would substantially reduce the impacts of a severe accident or the probability or consequences (risk) of a severe accident occurring. As discussed below, none of the information identified by the applicant, commenters on the EIS, waiver petitions, or the staff indicates that any SAMAs would be cost-beneficial and likely to result in such a reduction of risk. Rather, new information indicates that further SAMA analyses are unlikely to identify a SAMA that substantially reduces the risk of a severe accident, such as major, cost-beneficial plant improvements, and that the overall probability of a severe accident has decreased at LGS. The following evaluation for new and significant information is to determine whether any new and significant information exists that provides a “seriously different picture of the environmental impacts than what was previously envisioned” regarding the determination in 10 CFR 51.53(c)(3)(ii)(L) Table B-1 and the clarifications in the statement of considerations.

The applicant relied on these requirements and did not submit a new SAMA analysis for license renewal. Specifically, the applicant cited 10 CFR 51.53(c)(3)(ii)(L) and stated that no SAMA was submitted as none was required as a matter of law (Exelon 2011c). Because the Commission stated in the statements of consideration for 10 CFR 51.53(c)(3)(ii)(L) that the 1989 SAMDA was a SAMA for purposes of the rule (61 FR 28481), the staff concluded that Exelon’s treatment of SAMA in its ER was in accordance with the Commission’s regulations. Exelon evaluated whether there was new and significant information with respect to the Commission’s regulation (Exelon 2011c). Specifically, Exelon analyzed whether potentially new and significant information would change the results of its 1989 SAMDA Analysis review. The Commission stated in CLI-12-19 that if the staff identifies new information that could invalidate the 1989 SAMDA Analysis, it should evaluate whether that information is significant under NEPA. The staff reviewed the applicant’s submitted information to assess if any of that information invalidated the 1989 SAMDA and also assessed if any new and significant information has been found that would change the generic conclusion codified by the NRC that Exelon need not reassess SAMAs at LGS for license renewal (10 CFR 51.53(c)(3)(ii)(L)) and the staff need not reconsider SAMAS at this stage (10 CFR 51, Table B-1). The following summarizes Exelon’s evaluation and the staff’s review of this information. In addition, the staff’s independent assessment did not identify any other new and significant information with respect to those regulations or the 1989 SAMDA. Hence, no new and significant information has been found with respect to the generic conclusion codified by the NRC that LGS need not reassess SAMAs for license renewal (10 CFR 51.53(c)(3)(ii)(L)) because neither the staff nor applicant uncovered any new and significant information that suggested another cost-beneficial SAMA that could substantially reduce the risk of a severe accident at Limerick.

5.3.10 The Applicant’s Evaluation of New and Significant Information

The applicant explained the process it used to identify any potentially new and significant information related to its existing 1989 SAMDA review in Section 5.3.1 of the ER (Exelon 2011c). As provided in Section 5.1 of Appendix E of the ER (Exelon 2011c), the new and significant assessment that Exelon 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. The significance and materiality of the new information identified through this process was discussed further in ER Section 5.3.2, "Significance of New Information." Exelon used a methodical approach to identify new and significant information and the staff finds Exelon's process adequate to ensure a reasonable likelihood that the applicant would be aware of any new and significant information.

The following four items of new information were identified and evaluated by the applicant by comparing assumptions for the 1989 SAMDA Analysis with assumptions used for current-day assessments of SAMAs:

(1) population increase;

(2) consideration of offsite economic cost risk;

(3) changed criteria for assigning cost per person-rem averted; and

(4) changed seismic hazard proposed by GI-199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants."

Each item of new information was evaluated by the applicant and reviewed by the staff to determine whether it would materially alter the NRC's conclusions, as documented in the 1989 SAMDA Analysis. None of the items of new information led to the identification of a SAMA that was cost-beneficial. Consequently, the applicant's and staff's review of new and significant information with respect to the 1989 SAMDA review did not uncover any cost-beneficial plant improvements or SAMAs that would substantially decrease the risk of a severe accident. Instead, it indicated that no plant improvements that led to a substantial reduction in risk would be cost-beneficial. Therefore, the staff finds that none of the new information identified by the applicant affects the generic conclusion codified by the NRC that applicants need not reassess SAMAs for license renewal at facilities like LGS (10 CFR 51.53(c)(3)(ii)(L)) or the 1989 SAMDA analysis.

5.3.11 Risk

As provided in the discussion earlier regarding LGS's IPE, the CDF in the 2009 PRA Update (3.2×10^{-6}) is more than an order of magnitude less than the 1989 PRA Update (Exelon ER). Any change in the likelihood of accidents that release substantial amounts of radioactive material to the environment not only affects the human impact but also any environmental impact. For LGS, this decrease in CDF would demonstrate less impact to dose, economic, and environmental impact. The overall reduction in risk indicates that further SAMA analyses for LGS would be unlikely to uncover cost-beneficial major plant improvements or plant improvements that could substantially reduce risk. Furthermore, as improvements are implemented and risk decreases, not only is it more difficult to find a SAMA that yields significant reduction in CDF, but SAMAs which lead to a small reduction in risk are more likely not to be cost-beneficial. In light of the significant reductions in CDF at Limerick, no new information is likely to significantly affect the Commission's generic determination that the NRC need not reanalyze SAMAs at LGS for license renewal or invalidate the 1989 SAMDA.

5.3.12 Population Increase

A summary of Exelon's evaluation of population increase provided in the ER is as follows. Exelon provided population values within 50 miles growing from 6,819,505 in 1980 to 9,499,925 in 2030. They further assumed that this 39 percent increase in population would yield an approximate 39 percent increase in total off-site dose values. Assuming 2030 population numbers, the applicant determined that the highest benefit/cost ratio SAMDA (ATWS Vent) based on cost per person-rem averted would still not be cost-beneficial in the 1989 SAMDA Analysis.

There were also public comments that provided site specific information regarding population increases and economics around Limerick Generating Station. Comment 30-39-PA indicates that the impact of a severe accident at Limerick erroneously relies on data from an analysis done at TMI, a site that involves a markedly different and less economically developed area than the area within 50 miles of Limerick, which includes the densely populated urban environments of Philadelphia, PA; Camden and Trenton, NJ; and Wilmington, DE.

The staff reviewed the calculation provided by the applicant and considered the public comments regarding population growth.

GEIS section E.3.9.2 provides an evaluation of the population increase for multiple plants to determine the effect of population increases on the plants evaluated in the GEIS. The 2013 GEIS states,

> To adjust the impacts estimated in the NUREGs and NUREG/CRs to the mid-year of the assessed plant's license renewal period, the information (i.e., exposure indexes [EIs]) in the 1996 GEIS can be used. The EIs adjust a plant's airborne and economic impacts from the year 2000 to its mid-year license renewal period based on population increases. These adjustments result in anywhere from a 5- to a 30-percent increase in impacts, depending upon the plant being assessed. Given the range of uncertainty in these types of analyses, a 5- to 30-percent change is not considered significant. Therefore, the effect of increased population around the plant does not generally result in significant increases in impacts.

Exelon's population calculation was reviewed by the staff and found to be reasonable. Furthermore, the 39-percent increase in impacts determined at Limerick was more conservative than any of the other plants evaluated in the GEIS (a maximum of a 30-percent increase). Thus the Exelon calculation was determined to be reasonable and found acceptable by the staff. The staff also confirmed that the population increase would not make any of the 1989 SAMDAs cost-effective.

The staff acknowledges that a more precise estimate of this relationship could be obtained by using the MACCS2 code, performing a level 3 PRA, and completing a new SAMA analysis. However, the staff notes that improvements or mitigating strategies as a result of population increases at Limerick would be implemented as part of the current licensing basis in the plant's emergency plan. A key component of the mission of the NRC is to ensure adequate protective actions are in place to protect the health and safety of the public. Protective actions are taken to avoid or reduce radiation dose and are sometimes referred to as protective measures. The overall objective of emergency preparedness (EP) is to ensure that the nuclear power plant operator is capable of implementing adequate measures to protect public health and safety in the event of a radiological emergency. As a condition of their license, operators of these nuclear power plants must develop and maintain EP plans that meet comprehensive NRC EP requirements. Increased confidence in public protection is obtained through the combined inspection of the requirements of EP and the evaluation of their implementation. The NRC assesses the capabilities of the nuclear power plant operator to protect the public by requiring the performance of a full-scale exercise at least once every 2 years that includes the participation of government agencies. These exercises are performed in order to maintain the skills of the emergency responders and to identify and correct weaknesses. They are evaluated by NRC inspectors and FEMA evaluators. Between these 2-year exercises, additional drills are conducted by the nuclear power plant operators that are evaluated by NRC inspectors (NRC Website). An example where population is evaluated in the current term is found in the Limerick Generating Station Evacuation Time and Plume Exposure Pathway Estimates using 2010 Census population data (Exelon 2013b). Thus, Limerick's population-related mitigating alternatives are considered in the current term regardless of whether they are pursuing license renewal or not. The 2013 GEIS evaluation of population and economic consequences is described in Section 5.3.13.

Since Limerick's calculation was reasonable, more conservative than any of the population increase evaluations in the GEIS, and mitigation alternatives as a result of population increases are implemented in the current term, the staff finds Limerick's evaluation acceptable and population increases at Limerick are not new and significant information. Moreover, even if population increase led to another SAMA becoming cost-beneficial, that SAMA would still not likely result in a substantial reduction in offsite risk, given the substantial reduction in CDF at Limerick since the 1989 SAMDA analysis. In addition, the implementation of Limerick's improvements to reduce the CDF makes it more difficult to identify additional cost beneficial SAMAs, thus, it is unlikely that further consideration of economic risk would yield many cost-beneficial SAMAs. Consequently, the population increase within 50 miles of LGS does not suggest that additional cost-beneficial SAMAs could substantially reduce the risk of severe accidents and therefore does not constitute new and significant information with respect to the 1989 SAMDA or the generic conclusion codified by the NRC that SAMAs need not be reassessed at facilities like LGS for license renewal (10 CFR 51.53(c)(3)(ii)(L)).

5.3.13 Consideration of Offsite Economic Cost Risk

The applicant indicated that the 1989 SAMDA Analysis did not consider offsite economic cost risk. To account for the offsite economic cost risk, the applicant estimated these impacts by using data from the TMI license renewal application (Amergen 2008; Exelon 2011b). Using TMI data, the applicant determined offsite economic cost risk was approximately 70 percent larger than the offsite exposure cost risk at TMI. In order to apply the TMI data to LGS, the applicant applied a factor of 3 (300 percent) to analyze the impact on the 1989 SAMDA Analysis for LGS. Applying a factor of 3 reduction to the closest potential cost-beneficial SAMDA (ATWS Vent) would not result in a cost-beneficial SAMDA (Exelon 2011c).

The staff assessed the calculation provided by the applicant. The staff confirmed the applicant's value by using similar ratios to evaluate the cost impact of onsite exposure and economic costs for LGS ($2,000 and $400,000, respectively) to obtain the total offsite and onsite economic and exposure cost. The net value was determined by the staff to be −$284,000, indicating that the ATWS Vent SAMDA was still not cost-effective. Since this was applied to the SAMDA (ATWS Vent) that was closest to being cost-effective, none of the SAMDAs identified in the 1989 SAMDA Analysis would be cost-effective.

Additional conservatisms not mentioned by the applicant include converting the $3,000,000 cost of the ATWS Vent SAMA to 2012 dollars that would increase the cost of the SAMDA to over $5,000,000 (assuming similar engineering and construction practices). Considering the large conservatisms in the Exelon analysis, it is reasonable. Moreover, even if consideration of offsite economic risk increase led to another SAMA becoming cost-beneficial, that SAMA would still not likely result in a substantial reduction in offsite risk, given the substantial reduction in CDF at

Limerick since the 1989 SAMDA analysis. In addition, the implementation of Limerick's improvements to reduce the CDF makes it more difficult to identify additional cost beneficial SAMAs, therefore, it is unlikely that further consideration of economic risk would yield many cost-beneficial SAMAs. Therefore, consideration of offsite costs would not likely lead to discovery of a cost-beneficial SAMA that would substantially reduce risk of severe accidents and, therefore, does not constitute new and significant information with respect to the 1989 SAMDA or the generic conclusion codified by the NRC that applicants need not reassess SAMAs for facilities such as LGS for license renewal.

There were also public comments that provided site-specific information regarding offsite economic cost risk around Limerick Generating Station. Comment 30-39-PA indicates that the impact of a severe accident at Limerick erroneously relies on data from an analysis done at TMI. The commenter states that it was erroneous to rely on TMI data because TMI involves a markedly different and less economically developed area than the area within 50 miles of Limerick, which includes the densely populated urban environments of Philadelphia, PA; Camden and Trenton, NJ; and Wilmington, DE. The commenter also stated that the ER ignores new and significant information regarding the likely cost of cleanup from a severe accident in a metropolitan area like Philadelphia and thus understates the impact of a properly conducted economic analysis on the environmental consequences of a severe accident at Limerick.

The GEIS evaluated the economic impacts of accidents using plant-specific information. Chapter 5 of the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), Volumes 1 and 2 (NRC 1996), assessed the impacts of postulated accidents at nuclear power plants on the environment. The postulated accidents included design-basis accidents and severe accidents (e.g., those with core damage). The impacts considered included dose and health effects of accidents (Sections 5.3.3.2 through 5.3.3.4), economic impacts of accidents (Section 5.3.3.5), and the effect of uncertainties on the results (Section 5.3.4). Similar to Limerick:

> …the performance and safety record of nuclear power plants operating in the United States continues to improve. This is also confirmed by analysis which indicates that, in many cases, improved plant performance and design features have resulted in reductions in initiating event frequency, core damage frequency, and containment failure frequency (NRC 2013a).

To assess the impacts from the airborne pathway, the 1996 GEIS relied on severe accident analyses provided in 28 nuclear power plants (including Limerick) that included severe accident analyses in their plant-specific EISs. These 28 nuclear power plants are provided in Table 5-1 in the 1996 GEIS. These plant-specific EISs used site-specific meteorology, land topography, population distributions, and offsite emergency response parameters, along with generic or plant-specific source terms, to calculate offsite health and economic impacts. The offsite health effects included those from airborne releases of radioactive material and contamination of surface water and groundwater. The 1996 GEIS used the environmental impact information from the 28 plant-specific EISs and a metric called the exposure index (EI) to (1) scale up the radiological impact of severe accidents on the population due to demographic changes from the time the original EIS was done until the year representing the mid-license renewal period and (2) estimate the severe accident environmental impacts for the earlier plants (whose EISs did not include a quantitative assessment of severe accidents). The EI method uses the projected population distribution around each nuclear power plant site at the middle of its license renewal period and meteorology data for each site to provide a measure of the degree to which the population would be exposed to the release of radioactive material resulting from a severe accident (i.e., the EI method weights the population in each of 16 sectors around a nuclear power plant by the fraction of time the wind blows in that direction on an annual basis). The EI metric was also used to project economic impacts at the mid-year of the license renewal period. A more detailed description of the EI method is contained in Appendix G of the 1996 GEIS. The use of the EI method remains valid. Regarding economic impacts, the GEIS specifically provides that 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.”

The 2013 GEIS compares the CDFs that formed the basis for the 1996 GEIS, and offsite doses directly from the 1996 GEIS, to the newer information. The comparison is done for pressurized water reactors (PWRs) and boiling water reactors (BWRs) and covers each of the plants listed in Table 5.1 of the 1996 GEIS, which included Limerick Units 1 and 2. Changes in source terms (i.e., the quantity, form, and timing of radioactive material released to the environment) are assessed in Section E.3.3 of the 2013 GEIS. The 2013 GEIS concluded, “Given the discussion in this appendix, the staff concludes that the reduction in environmental impacts from the use of new information (since the 1996 GEIS analysis) outweighs any increases resulting from this same information.”

Therefore, the 2013 GEIS analysis using plant-specific information was consistent with the evaluation for Limerick. The staff acknowledges that a more precise estimate of this relationship could be obtained by using the MACCS2 code, performing a Level 3 PRA, and completing a new SAMA analysis using site-specific data. However, most mitigation alternatives are identified at the Level 1 and Level 2 stages because relevant Level 1 and Level 2 improvements are physical or process changes to the plant to protect the reactor core in the case of Level 1 PRA, or containment in the case of Level 2 PRA. The Level 3 portion deals with the magnitude of the consequences. The change in magnitude of the consequences could possibly make some mitigation alternatives cost-beneficial. However, most of the benefit is ascertained by focusing on protecting the reactor core and the containment in the Level 1 and Level 2 stages. As provided in Section 5.3.17, specific improvements at Limerick have been implemented to drive the risk downward. Furthermore, if there is higher economic cost and dose consequence, more SAMAs could become cost-effective, however no SAMA is expected to be a major design change that will reduce the risk significantly because of the continuous implementation of improvements since the 1989 SAMDA.

The result of the applicant’s and staff’s analysis in this case is consistent with the GEIS. As provided in GEIS Table 3.8-8, the populations at both Limerick and TMI are considered high. Furthermore, the GEIS states, “The expected costs resulting from a severe accident at nuclear power plants during their renewal periods have been predicted from evaluations presented in 27 FESs. Estimates of the extent of land contamination have also been presented. In both cases, the conditional impacts are judged to be of small significance for all plants” (NRC 2013a).

5.3.14 Changed Criterion for Assigning Cost Per Person-Rem Averted

The 1989 SAMDA Analysis 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 1989 SAMDA Analysis, changing the cost/benefit threshold using the $2,000 per person-rem averted conversion would still not result in this or any other of the 1989 SAMDAs becoming cost-beneficial. Therefore, Exelon 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 1989 SAMDA Analysis. Hence, the new information represented by the changed criterion for assigning cost per person-rem averted was judged not to be significant by Exelon.

The staff reviewed the LGS analysis provided in the License Renewal ER and agrees that changing the criterion for assigning cost per person-rem averted would not result in a cost-beneficial SAMDA or change the conclusions in the 1989 SAMDA. As provided above, the ATWS Vent has 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. Since this was applied to the SAMDA (ATWS Vent) closest to being cost-effective, none of the 1989 SAMDAs are cost-effective. This conclusion is even more reasonable given that the 2013 GEIS concluded that the population dose estimates presented in Table E-3 demonstrate the conservatism in the older studies, both from the standpoint of reduced population dose from more recent estimates and the conservatism built into the earlier methodology (NRC 2013a). Additional conservatisms not mentioned by the applicant include that converting the $3,000,000 cost of the ATWS Vent SAMA to 2012 dollars would increase the cost of the SAMDA to over $5,000,000 (assuming similar engineering and construction practices). Considering all of the large conservatisms in the analysis, the applicant's analysis is reasonable. Moreover, even if the increase in cost per person-rem averted led to another SAMA becoming cost-beneficial, that SAMA would still not likely result in a substantial reduction in offsite risk, given the substantial reduction in CDF at Limerick since the 1989 SAMDA analysis. Therefore, consideration of the increased costs per person-rem averted would not likely lead to discovery of a cost-beneficial SAMA, let alone one that would substantially reduce offsite risk and therefore does not constitute new and significant information with respect to the generic conclusion codified by the NRC that Exelon need not reassess LGS SAMAs for license renewal.

5.3.15 Changed Seismic Hazard Proposed in GI-199

On June 9, 2005, the NRC opened GI-199 to assess the implications of updated seismic data and methods for Central and Eastern U.S. (CEUS) operating plants. The staff's confirmatory analysis of the seismic hazard concluded that the calculated seismic hazard for some operating plants in the CEUS had increased. The NRC issued IN 2010-18 to nuclear power plants and independent spent fuel storage installations. This information notice stated that the NRC would follow the appropriate regulatory process to request that operating plants provide specific information about their facilities to enable the staff to complete the regulatory assessment and to identify and evaluate candidate backfits. NRR developed a draft Generic Letter to request needed data from power reactor licensees. The NRC originally intended the request to apply only to power reactor licensees in the CEUS, but, in light of the March 2011 Japanese earthquake, NRR expanded the scope of the request to include all U.S. power reactor licensees. On March 12, 2012, the NRC issued a request for information pursuant to 10 CFR 50.54(f) (hereafter referred to as the 50.54(f) letter) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML 12053A340). The purpose of that request was, in part, to gather updated information concerning the seismic hazards at operating reactor sites and to enable the NRC staff to determine whether licenses should be modified, suspended, or revoked. The "Required Response" section of Enclosure 1 of the 50.54(f) letter indicated that licensees and construction permit holders should provide a Seismic Hazard Evaluation and Screening report within 1.5 years from the date of the 50.54(f) letter for CEUS nuclear power plants and within 3 years of the 50.54(f) for western United States plants (NRC 2012f).

Limerick provided its submittal regarding the new seismic hazard. Limerick's response concluded:

> For LGS, the Safe Shutdown Earthquake envelopes the ground motion response spectra (GMRS) in the frequency range from 1 to 10 Hz. Therefore per the SPID Sections 3.2 and 7 (Reference 3), LGS screens out of further seismic risk assessments in response to NTTF 2.1: Seismic, including seismic probabilistic risk assessment (SPRA) or seismic margin assessment (SMA), as well as spent fuel pool integrity evaluations. Additionally, LGS screens out of the Expedited Seismic Evaluation Process (ESEP) interim action per the 'Augmented Approach' guidance document, Section 2.2 (Reference 4). Due to the GMRS exceeding the SSE in the frequency range above 10 Hz, high-frequency confirmations are needed for LGS in accordance with the SPID Sections 3.2 and 3.4 (Reference 3). Actions to address NTTF 2.1: Seismic for central and eastern United States nuclear plants will be performed in accordance with the schedule provided in the April 9, 2013, letter from the industry to the NRC (Reference 5), as agreed to by the NRC in the May 7, 2013, letter to the industry (Reference 23).
> [Exelon 2014b]

In a May 9, 2014, letter titled, "Screening And Prioritization Results Regarding Information Pursuant To Title 10 Of The *Code Of Federal Regulations* 50.54(F) Regarding Seismic Hazard Re-Evaluations For Recommendation 2.1 Of The Near-Term Task Force Review Of Insights From The Fukushima Dai-Ichi Accident," Limerick is conditionally screened in as a group 3 plant which means:

> Group 3 plants have GMRS to SSE ratios that are greater than 1, but the amount of exceedance in the 1–10 Hz range is relatively small, and the maximum ground motion in the 1–10 Hz range is also not high. Given the limited level of exceedance of the Group 3 plants, staff is evaluating the need for licensees to conduct a seismic risk evaluation in order for the staff to complete its regulatory decision making. However, the staff has had insufficient review time with the recently submitted seismic hazard submittals to reach a conclusion. After further review of the seismic hazard re-evaluations and the Expedited Approach submittals, the staff will decide which Group 3 plants need to complete a risk evaluation. Risk evaluations for Group 3 plants are due by December 31, 2020.
> [NRC 2014b]

As provided above, these evaluations and actions are ongoing and the regulatory response is independent of whether or not the plant is seeking license renewal or not. The applicant indicated that GI-199 issues related to the seismic hazard will not result in postulated accident scenarios not already considered for LGS. Seismologists are frequently refining seismic methodologies and results, which may increase the estimated frequency of seismic events with very low probability. Results from the LGS June 1989 PRA Update indicate that the contribution from seismic risk to the total CDF is approximately 25 percent, with fire risk contributing 31 percent to the total risk (Exelon 2011c). 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 the ER, 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=3.2×10^{-6}), the revised CDF that accounts for both internal and external hazards (CDF=6.4×10^{-6}) would still be a factor of 6.5 below the value used in the 1989 SAMDA Analysis (CDF=4.2×10^{-5}). This demonstrates the excess margin in the 1989 SAMDA Analysis. A possible increase in risk beyond this assumption caused by an even larger seismic CDF would be more than offset by the factor of 6.5 reduction in the current CDF. Therefore, Exelon 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 1989 SAMDA (Exelon 2011c).

The staff reviewed the method the applicant used in determining the external events multiplier and its use and determined that it was consistent with the guidance provided in Nuclear Energy Institute (NEI) 05-01. Limerick's analysis is also consistent with similar analyses provided in section E.3.2.3 of the 2013 GEIS. The staff also confirmed that the risk has decreased since the 1989 SAMDA and agrees with Exelon's analysis 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 1989 SAMDA Analysis. Considering the large conservatism in the 1989 SAMDA Analysis, the applicant's approach is reasonable. Moreover, even if the change in seismic hazard led to another SAMA becoming cost-beneficial, that SAMA would still not likely result in a substantial reduction in offsite risk, given the substantial reduction in CDF at Limerick since the 1989 SAMDA analysis. Therefore, consideration of GI-199 is not likely to lead to the discovery of a cost-beneficial SAMA that would substantially reduce offsite risk and, therefore, does not constitute new and significant information with respect to the generic conclusion codified by the NRC that SAMAs need not be reassessed at LGS for license renewal.

However, the NRC continues to review earthquakes as part of the reactor oversight process. As provided in the conclusions in Exelon's response to the 50.54(f) letter regarding Near-Term Task Force (NTTF) recommendation 2.3 (NRC 2011c):

> In response to NTTF 2.3, the 50.54(f) letter (Reference 1) also requested licensees to perform seismic walkdowns in order to, in the context of seismic response: (1) verify that the current plant configuration is consistent with the licensing basis; (2) verify the adequacy of current strategies, monitoring, and maintenance programs; and (3) identify degraded, nonconforming, or unanalyzed conditions. Exelon committed to and performed seismic walkdowns in accordance with the seismic walkdown guidance (Reference 27) as initially documented and supplemented in Exelon Correspondence Numbers RS-12-171 and RS-13-138 (References 11 and 29), respectively. The remaining walkdowns for initially inaccessible equipment are scheduled to be completed during the next Unit 1 Refueling Outage, 1 R 15, or during the next scheduled system outage window, whichever is applicable. The results will be reported to the NRC after completion of the follow-on walkdowns. [Exelon 2014b]

Exelon further confirmed that seismic vulnerabilities (similar to SAMAs) identified in the Limerick IPEEE have been implemented:

> Based on the successful completion of seismic walkdowns for all components to date in response to NTTF 2.3, and the lack of adverse seismic conditions identified, Exelon has directly concluded that the LGS current plant configuration is consistent with the plant licensing basis and can safely shut down the reactor and maintain containment integrity following the design-basis SSE event. Additionally, the findings of the seismic walkdown program indirectly verify that the current LGS strategies, monitoring, and maintenance programs are adequate for ensuring seismic safety consistent with the licensing basis. Plant vulnerabilities and commitments identified in the LGS IPEEE (Reference 10) were reviewed as part of the NTTF 2.3 seismic walkdowns (References 11 and 29). The seismic walkdown reports confirmed that there are no outstanding IPEEE vulnerabilities or commitments, and all previously identified IPEEE vulnerabilities and commitments have been resolved (References 11 and 29). [Exelon 2014b]

Exelon also confirmed that Limerick has significant seismic margin beyond design basis.

> An evaluation of beyond-design-basis ground motions was performed for LGS as part of the IPEEE program. The LGS IPEEE program demonstrated plant-level seismic capacity, which can be expressed in terms of a HCLPF. This plant-level

> seismic capacity is defined in Section 3.3.2 of the SPID (Reference 3) as the IHS. The LGS IPEEE seismic evaluation was initially submitted as a reduced scope SMA (Reference 10). Subsequent to the IPEEE submittal, LGS responded to a series of Requests for Additional Information (RAI) and provided additional information that justified the LGS IPEEE SMA as achieving the intent of a focused-scope EPRI SMA anchored at 0.3g PGA (References 19, 20, and 21). The IHS for LGS is defined by the median-shaped NUREG/CR-0098 spectra for rock sites per LGS IPEEE seismic demand analysis (Reference 22). As a result of the LGS IPEEE seismic evaluations, plant processes for seismic housekeeping were made to enhance the reliability and safety of the plant. There are no outstanding IPEEE vulnerabilities or commitments, and all previously identified IPEEE vulnerabilities and commitments have been resolved (Reference 11). The results of the LGS IPEEE showed there were no vulnerabilities to severe accident risk from external events, including seismic events (Reference 10). Based on the results of the IPEEE program for LGS, it may be qualitatively concluded that the plant has significant seismic margin beyond the design basis (Reference 28, Section 2.3.4) as evidenced by a comparison between the site SSE and the IHS in Figure 5.4-1. [Exelon 2014b]

Exelon's confirmation regarding Limerick having significant seismic margin beyond the design basis reinforces the NRC staff conclusion that further evaluation of GI-199 related issues is not likely to lead to the discovery of a cost-beneficial SAMA that would substantially reduce offsite risk and, therefore, does not constitute new and significant information with respect to the 1989 SAMDA or the generic conclusion codified by the NRC that SAMAs need not be reassessed at LGS for license renewal.

The staff has also estimated the seismic CDFs (ADAMS No. ML100270756) using various seismic hazard curves. The values cited for Limerick indicate that the seismic CDF is higher than used in the 1989 SAMDA. Note that these values were calculated using a simplified conservative methodology and have very large uncertainties, and more realistic values may be calculated by Limerick as a result of the NRC letter dated May 9, 2014, "Seismic Screening and Prioritization Results Regarding Information Pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) Regarding Seismic Hazard Reevaluations for Recommendation 2.1 of the Near-Term Task Force Review of Insights" (NRC 2014c). Even though the new seismic CDF is larger than the seismic value used in 1989, Fukushima orders have essentially bounded anything seismically the NRC could do as a result of SAMA analysis since Limerick has implemented the IPEEE seismic recommendations and performed a recent thorough formal seismic walkdown as provided above. Thus, it is unlikely that Exelon will identify any cost-beneficial SAMAs that would substantially reduce the off-site seismic risk and, therefore, does not constitute new and significant information with respect to the generic conclusion codified by the NRC that SAMAs need not be reassessed at LGS for license renewal.

5.3.16 Additional Staff Evaluation for New and Significant Information

The staff reviewed records of public meetings and correspondence related to the application and compared information presented by the public with information considered in NUREG-1437 to determine if there was any new and significant information with respect to the generic conclusion codified by the NRC, which indicates that SAMAs need not be reassessed at LGS for license renewal (10 CFR 51.53(c)(3)(ii)(L)). This consideration included an evaluation of whether any new information invalidated the 1989 SAMDA analysis.

5.3.17 Cost-Effective SAMAs Identified at Other Plants

SAMA evaluations have been completed for operating plant license renewal applications that were approved for over 75 nuclear power plants. Numerous potentially cost-beneficial SAMAs have been identified in U.S. operating nuclear power plant license renewal applications that have been approved. Most of these SAMAs are low-cost improvements such as modifications to plant procedures or training, minimal hardware changes to enable cross-tying existing pipes or electrical buses, and using portable equipment (e.g., generators and pumps) as backups.

Many of the SAMA recommendations identified from other plants are compiled in an NRC published paper entitled “Perspectives on Severe Accident Mitigation Alternatives for U.S. Plant License Renewal” (NRC 2009). The paper concludes, “SAMAs that are found to be potentially cost-beneficial tend to be low-cost improvements such as modifications to plant procedures or training, minimal hardware changes, and use of portable equipment.” These potential cost-beneficial SAMAs are further evaluated and many times not found cost-beneficial because sufficient risk is not eliminated by the modification (which was assumed) or other factors. Furthermore, the staff found that SAMA analyses that have been performed to date have found SAMAs that were cost-beneficial, or at least possibly cost-beneficial subject to further analysis, in approximately half of the plants. In general, the cost-beneficial SAMAs were identified and considered by the licensee under the current operating license. In several cases, SAMA-related modifications were implemented at LGS, further reducing that probability of an additional SAMA substantially reducing severe accident risk (PECO 1992)(Exelon 2014). Examples are provided below.

As provided in the statement of considerations for 10 CFR 51.53(c)(3)(ii)(L), in forming its basis for determining which plants needed to submit a SAMA, the Commission noted that all licensees had undergone, or were in the process of undergoing, more detailed site-specific severe accident mitigation analyses through processes separate from license renewal, specifically the CPI, IPE, and IPEEE programs (61 FR 28467). These programs for LGS were discussed earlier. In light of these studies, the Commission stated that it did not expect future SAMA analyses in the license renewal stage to uncover “major plant design changes or modifications that will prove to be cost-beneficial” (61 FR 28467). As discussed above, the NRC’s experience in completed license renewal proceedings has confirmed this assumption (NRC 2009). As a result, potentially cost-beneficial SAMAs at other facilities do not constitute new and significant information with respect to the 1989 SAMDA or the NRC’s determination not to perform a second SAMA analysis at license renewal in the event the agency has previously considered such analysis, because even if cost-beneficial the NRC staff’s experience shows that a new SAMA analysis will not likely yield a major reduction of risk, particularly in light of the many improvements already implemented at Limerick.

From the public comments (NRDC 2011) there was a recommendation that potential cost-effective SAMAs identified at other similar plants be addressed at LGS. Specifically, comment 30-38 from NRDC stated that Exelon omitted a required analysis of new and significant information regarding the potential new SAMAs previous considered for other BWR Mark II Containment reactors from its ER. In response, the staff sent a letter dated February 12, 2014 (NRC 2014a), to Exelon requesting additional information regarding potentially new SAMAs previously considered for other BWR Mark II Containment reactors. Exelon responded in a letter dated March 12, 2014 (Exelon 2014). In their response, Exelon provided a summary of the evaluation of each potentially cost-beneficial SAMA identified in the February 12, 2014, RAI. The evaluation identifies and eliminates from further consideration SAMAs that have already been implemented at Limerick. Then, the percent change in the maximum averted cost-risk (MACR) from implementing each remaining SAMA at the plant for which it was potentially cost-beneficial is estimated using cost benefit information from the respective plant's ER from which the SAMA was taken, and/or the GEIS. To determine whether the SAMA should be considered "new and significant information" with respect to the 1989 Limerick SAMDA analysis, the percent change in the MACR was verified to be less than 50 percent. Exelon selected a 50-percent reduction in the MACR as the threshold for what may be "significant" based on criteria provided in the American Society of Mechanical Engineers (ASME)/American Nuclear Society PRA Standard, NUMARC 93-01 and NEI 00-04 (Exelon 2014).

Changes at Limerick that are functionally equivalent but not identical to those named in a SAMA are also identified in the RAI response. Exelon determined that either the SAMA had already been implemented at Limerick or that there were no SAMAs that exceeded the 50-percent reduction in the MACR. Thus, there were no SAMAs identified at other plants with Mark II containments that were determined to be "new and significant" at Limerick. Hence, further assessment of such information was not needed (Exelon 2014).

The staff reviewed the information provided by Exelon. The staff determined that either the SAMA had already been implemented at Limerick or that there were no SAMAs that exceeded the 50-percent reduction in the MACR. The staff also found exceeding a 50-percent reduction in the MACR was a reasonable significance value based on the guidance provided in the ASME standard, NUMARC 93-01, and NEI 00-04. This determination is particularly reasonable in light of the already significant reductions achieved in severe accident risk at Limerick since 1989. Even 50-percent reduction in current MACR would represent a small reduction in estimated risk at the facility in 1989 because the CDF today is an order of magnitude smaller than used in the 1989 SAMDA. . Thus, there were no SAMAs identified at other plants with Mark II containments that were determined to be "new and significant" at Limerick.

The staff noted that many of the potential cost-beneficial SAMAs identified at the other Mark II containment plants were for SAMAs relating to loss of power. According to the LGS IPE, loss of power provided 31 percent of the CDF at Limerick (PECO 1992).

Table 6.2-2 of the Limerick IPE (PECO 1992) listed four improvement items that were planned as part of the IPE and which were implemented prior to or shortly after the 1992 IPE submittal. Three of the improvements related to loss of power. These improvements are listed below along with their current status.

(1) Create procedure to crosstie 4-kV electrical buses. (Capability maintained in current site response procedures which allow for alignment of alternate power supply for any 4-kV safeguard bus using any diesel generator.)

(2) Create procedure to power C & D ESW pumps from Unit 1, Division 3 & 4 respectively. (Capability maintained in a current station procedure.)

(3) Create cross connection between diesel driven fire pump and fire water system and RHR. (Capability maintained in a current station procedure.)

Thus Limerick has continued to improve the risk associated with loss of power by implementing related items.

The staff further notes that Limerick is implementing the Fukushima orders and provided the Limerick Generating Station, Units 1 and 2, "Overall Integrated Plan in Response to March 12, 2012 Commission Order Modifying Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events (Order Number EA-12-049)," dated February 28, 2013 (RS-13-022). This order specified that these strategies must be capable of mitigating a simultaneous loss of all AC power and loss of normal access to the ultimate heat sink and have adequate capacity to address challenges to core cooling, containment, and SFP cooling capabilities at all units on a site subject to the Order.

By letter dated January 10, 2014, the NRC staff determined that, based on a review of Exelon's plan, including the 6-month update dated August 28, 2013, and information obtained through the mitigation strategies audit process, the NRC concludes that the licensee has provided sufficient information to determine that there is reasonable assurance that the plan, when properly implemented, will meet the requirements of Order EA-12-049 at Limerick Generating Station, Units 1 and 2 (NRC 2014b). Thus, as a result of this order, Limerick will be implementing several improvements or mitigation alternatives whether they are cost-beneficial or not.

Therefore, the staff does not expect further SAMA analyses at the license renewal stage to uncover major plant design changes or modifications that will prove to be cost-beneficial. As discussed above, the NRC's experience in completed license renewal proceedings has confirmed this assumption (Ghosh 2009). As a result, potentially cost-beneficial SAMAs at other facilities do not constitute new and significant information with respect to Limerick's 1989 SAMDA or the NRC's determination not to perform a second SAMA analysis at license renewal in the event the agency has previously considered the issue, because, even if cost-beneficial, the NRC staff's experience shows that they will not likely yield a major reduction of risk, particularly in light of the many improvements already implemented at Limerick. Moreover, in light of Limerick's reduction in CDF and the propensity of cost-beneficial SAMAs to further eliminate risk and thereby make it less likely for other SAMA candidates to be cost-beneficial, it is unlikely that further consideration of these other SAMA candidates would yield many cost-beneficial SAMAs.

5.3.18 Current State of the Art Knowledge for Performing SAMA Analysis

Modern SAMA analysis has evolved over the years. Currently, SAMA analyses typically follow the guidance provide in NEI guidance (NEI O5-01), which is endorsed by the NRC in Regulatory Guide 4.2, supplement 1 (NRC 2013c). Offsite consequence codes used in SAMA analyses use plant-specific inputs related to core inventory, meteorology, population, evacuation, and economic impacts.

A current detailed SAMA analysis has the ability to analyze numerous plant-specific variables and the sensitivity of a SAMA analysis to these variables. In the scoping comments, numerous variables were identified that could potentially cast doubt on the results of the initial 1989 SAMDA Analysis. To thoroughly evaluate all of these variables would require a *de novo* SAMA analysis, which is not required by 51.53(c)(3)(ii)(L) and Table B-1. However, the applicant evaluated some of the changes at LGS that could have a significant impact on the SAMDA analysis such as population increase, consideration of offsite economic cost risk, changed criteria for assigning cost per person-rem averted, and changed seismic hazard proposed by GI-199 and found that none of the items of new information was found to be significant. As provided earlier, the staff independently reviewed the applicant's information, independently evaluated other potentially new and significant information, and determined that they would not lead to identification of a SAMA that would significantly reduce offsite risks, but acknowledges that a more precise answer could be found with a detailed modern SAMA analysis. However, the staff believes that this more precise answer would still not identify significant cost-beneficial SAMAs. As explained above, new and significant information must provide a seriously different picture of the consequences of the Federal action under consideration. With respect to SAMAs, new information may be significant if it indicated a given SAMA would substantially reduce the probability or consequences of a severe accident. None of the information identified by the applicant or the staff indicates that any SAMAs would be likely to lead to such results. Instead, as discussed above, new information indicates that further SAMA analyses are unlikely to identify many cost-beneficial SAMAs or major, cost-beneficial plant improvements, particularly in light of the substantial reduction in the CDF for Limerick since the 1989 SAMDA analysis.

The GEIS evaluated some of the differences in older methods and newer methods for performing risk analysis, which is the basis for SAMAs. The data selected for use in the 1996 GEIS analysis were taken from the FESs published since 1981, which is near the time of Limerick's 1989 SAMDA analysis. As discussed previously, these FES analyses are based upon source terms resulting from the Reactor Safety Study (NUREG-75/014, formerly WASH-1400), rebaselined in NUREG-0773. As such, these source terms (and the resulting risk and environmental impacts calculated using them) reflect the plant designs used in WASH-1400. However, this approach is considered conservative because the source terms developed in WASH-1400 generally reflect a 1970s-era plant and, as such, do not reflect the improvements that have been made in nuclear industry plant design and operations since the early 1980s. Accordingly, the use of WASH-1400 source terms in the FESs may, in many cases, tend to overestimate the actual environmental consequences and risks.

Furthermore, as provided in Section 5.3.3.1 of the 1996 GEIS, the source terms (i.e., the magnitude, timing, and characteristics of the radioactive material released to the environment) used in the EIS analyses for the 28 sites, including Limerick, were generally based on the 95 percent upper confidence bound (UCB) and analysis documented in NUREG-0773 . The NUREG-0773 source terms represented an update (re-baseline) of the source terms used in WASH-1400 (NRC 1996).

NUREG-0773 indicates that the provided source terms are based on models that tend to give overestimates of the magnitude of the releases." Based on the comparisons with newer information such as NUREG/CR 6295, the expected impacts (i.e., the frequency-weighted consequences) from the airborne pathway using the updated source term information would be much lower than previously predicted (NRC 2013). Therefore, the source terms used in the 1989 SAMDA were more conservative than the source terms used today. This provides additional support for the conclusion that SAMA analyses for LGS would be unlikely to uncover cost-beneficial major plant improvements or plant improvements that could substantially result in lower doses to offsite populations in the event of a severe accident.

5.3.19 Enrichment of Fuel (Power Uprates)

Another potentially new and significant item that could impact the 1989 SAMDA analysis is increases in the enrichment of the fuel in the core. The following is the staff's review for any substantial changes to the fuel enrichment design basis at LGS by reviewing LGS docketed information regarding power uprates. Extended power uprates require using fuel with a higher percentage of uranium-235 or additional fresh fuel to derive more energy from the operation of the reactor. This results in a larger radionuclide inventory (particularly short-lived isotopes, assuming no change in burnup limits) in the core, than the same core at a lower power level. The larger radionuclide inventory represents a larger source term for accidents and can result in higher doses to offsite populations in the event of a severe accident. Typically, short-lived isotopes are the main contributor to early fatalities. As stated in NUREG-1449 (NRC 1993), short-lived isotopes make up 80 percent of the dose following early release. The staff found that LGS had received two power uprate approvals since 1989. One uprate occurred in 1995, and was based on a1993 license amendment request that requested an increase in the licensed thermal power level of the reactor from 3,293 megawatts thermal (MWt) to 3,458 MWt, primarily by increasing the licensed core flow. In the staff's Environmental Assessment and Finding of No Significant Impact related to the LGS application for the amendment, the staff found, "the radiological and nonradiological environmental impacts associated with the proposed small increase in power are very small and do not change the conclusion in the FES that the operation of LGS, Units 1 and 2, would cause no significant adverse impact upon the quality of the human environment." Furthermore, in the January 23, 1995 submittal relating to increasing core flow, the licensee indicated that while fuel burnup and enrichment levels may increase as a result of operation at uprated power, the burnup and enrichment will remain within the 5 percent enrichment and 60,000 MWd/MT value previously evaluated by the staff. Thus, the fuel enrichment did not exceed the previously licensed value (NRC 1995).

By application dated March 25, 2010 (Exelon 2010), Exelon submitted a license amendment request for the LGS Units 1 and 2 Facility Operating Licenses and Technical Specifications. The proposed amendment consisted of a 1.65 percent measurement uncertainty recapture (MUR) power uprate that will increase each unit's rated thermal power from 3,458 megawatts (MWt) to 3,515 MWt. The proposed amendment was characterized as a MUR power uprate, which uses a Cameron International (formerly Caldon) CheckPlus™ Leading Edge Flow Meter (LEFM) system to improve plant calorimetric heat balance measurement accuracy. This flowmeter provides a more accurate measurement of feedwater (FW) flow and thus reduces the uncertainty in the FW flow measurement. This submittal did not change the fuel enrichment design basis (NRC 2011b).

Neither of these power uprates increased the fuel enrichment any higher than was previously evaluated by the staff before the 1989 SAMDA Analysis was completed. Since the fuel enrichment was not increased, further SAMA analyses for LGS would be unlikely to uncover cost-beneficial major plant improvements or plant improvements that could substantially result in lower doses to offsite populations in the event of a severe accident.

Furthermore, as provided in Section 5.3.3.1 of the 1996 GEIS, the source terms (i.e., the magnitude, timing, and characteristics of the radioactive material released to the environment) used in the GEIS analyses for the 28 sites, including Limerick, were generally based on the 95-percent UCB and analysis documented in NUREG-0773 (NRC 1996).

NUREG-0773 states that the provided source terms are based on models that tend to give overestimates of the magnitude of the releases. Based on the comparisons with newer information such as NUREG/CR 6295, the expected impacts (i.e., the frequency-weighted consequences) from the airborne pathway using the updated source term information would be much lower than previously predicted (NRC 2013a). Therefore, the source terms used in the 1989 SAMDA were more conservative than the source terms used today, providing additional confidence that SAMA analyses for LGS would be unlikely to uncover cost-beneficial major plant improvements or plant improvements that could substantially result in lower doses to offsite populations in the event of a severe accident. Also, it reinforces the Commission's generic determinations that the NRC need not reanalyze SAMAs at LGS for license renewal and that a subsequent SAMA analysis would not likely uncover many cost-beneficial SAMAs.

5.3.20 Conclusion

In conclusion, 10 CFR 51.53(c)(3)(ii)(L) states that, "[i]f the staff has not previously considered SAMAs for the applicant's plant, in an environmental impact statement or related supplement or in an environmental assessment, a consideration of alternatives to mitigate severe accidents must be provided." Table B-1 in 10 CFR Part 51, which governs the scope of the staff's environmental review for license renewal, echoes this regulation. Applicants for plants that have already had a SAMA analysis considered by the NRC as part of an EIS, supplement to an EIS, or EA, do not need to have a SAMA analysis reconsidered for license renewal. In forming its basis for determining which plants needed to submit a SAMA at license renewal, the

Commission noted that all licensees had undergone, or were in the process of undergoing, more detailed site-specific severe accident mitigation analyses through processes separate from license renewal, specifically the CPI, IPE, and IPEEE programs (61 FR 28467). In light of these studies, the Commission stated that it did not expect future SAMA analyses to uncover "major plant design changes or modifications that will prove to be cost-beneficial" (61 FR 28467). The NRC's experience in completed license renewal proceedings has confirmed this assumption.

LGS is a plant that had a previous SAMA documented in a NEPA document. Therefore, Exelon was not required to, and did not, submit a SAMA in its license renewal ER. Exelon and staff did evaluate whether there was new and significant information with respect to the Commission's prior determination not to require a SAMA analysis at license renewal for those plants that were already the subject of a SAMA analysis by the staff. This evaluation included an evaluation of whether any new information invalidated the 1989 SAMDA. The staff analyzed information in the applicant's ER with respect to the 1989 SAMDA Analysis for LGS, public comments, and its own review of information relevant to LGS to search for new and significant information with respect to the NRC's determination not to conduct a second SAMA analysis at LGS for license renewal and the studies and assumptions underlying that determination. In conducting that search, the staff considered whether new information provided a seriously different picture of the environmental impact of the proposed project from what was previously envisioned. For a mitigation analysis, such as a SAMA analysis, such information would need to demonstrate a substantial change in the environmental impact sought to be mitigated, in this case severe accidents. In doing its review of new information, the staff found that since the 1989 SAMDA Limerick's CDF has decreased, past current licensing bases initiatives have addressed known weaknesses, and implementation costs are high for design retrofits.

Given the discussion above, it is unlikely that further SAMA analyses for LGS could uncover many cost-beneficial SAMAs or cost-beneficial SAMAs that would substantially reduce the risk of severe accidents because of implementation of programs to reduce the severe accident risk outweighs any increases resulting from the new considerations described above. Therefore, the staff did not identify any new and significant information that would invalidate the 1989 SAMDA.

The staff also did not identify any new and significant information that rises to a level that requires staff to seek Commission approval to conduct a new SAMA analysis (similar to the waiver requirement that applies for Category 1 issues when staff identifies new and significant information). The impacts of all other new information do not contribute sufficiently to the environmental impacts to warrant their inclusion in a SAMA analysis, since the likelihood of finding cost-effective plant improvements that substantially reduce risk is small. Additionally, the staff did not identify a significant environmental issue not covered in the GEIS, or that was not considered in the analysis in the GEIS and leads to an impact finding that is different from the finding presented in the GEIS.

The staff identified no new and significant information related to postulated accidents during the review of LGS's ER (Exelon 2011c) or evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. In accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff did not repeat the review of SAMAs for LGS.

Therefore, as provided in the 1989 SAMDA, "The risks and environmental impacts of severe accidents at Limerick are acceptably low."

The staff has found no new information that would call into question the FES conclusion that:

> [T]he risks of early fatality from potential accidents at the site are small in comparison with risks of early fatality from other human activities in a comparably sized population, and the accident risk will not add significantly to population

exposure and cancer risks. Accident risks from Limerick are expected to be a small fraction of the risks the general public incurs from other sources. Further, the best estimate calculations show that the risks of potential reactor accidents at Limerick are within the range of such risks.

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[NRC] U.S. Nuclear Regulatory Commission. 2012a. Order EA-12-049, Issuance of Order to Modify Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events. March 12, 2012. ADAMS No. ML012054A735

[NRC] U.S. Nuclear Regulatory Commission. 2012b. Order EA-12-050, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents." March 12, 2012. ADAMS No. ML012054A694.

[NRC] U.S. Nuclear Regulatory Commission. 2012c. Order EA-12-051, "Subject: Issuance of Order to Modify Licenses With Regard to Reliable Spent Fuel Pool Instrumentation." March 12, 2012. ADAMS No.ML012054A679.

[NRC] U.S. Nuclear Regulatory Commission. 2012d. "Request For Information Pursuant to Title 10 of The *Code of Federal Regulations* 50.54(F) Regarding Recommendations 2.1,2.3, and 9.3, of The Near-Term Task Force Review of Insights From the Fukushima Dai-Ichi Accident." March 12, 2012. ADAMS No. ML012053A340.

[NRC] U.S. Nuclear Regulatory Commission. 2012e. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Columbia Generating Station (NUREG-1437, Supplement 47) Final Report for Comment.* Washington, DC: NRC. NUREG-1437. April 2012. ADAMS No. ML11227A007.

[NRC] U.S. Nuclear Regulatory Commission. 2012f. Letter from E. Leeds, Director, to all power reactor licensees and holders of construction permits in active or deferred status. Subject: Request for information pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force review of insights from the Fukushima Dai-ichi accident. March 12, 2012. ADAMS No. ML12053A340.

[NRC] U.S. Nuclear Regulatory Commission. 2013a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Washington, DC: NRC. NUREG–1437, Revision 1, Volume 3. June 2013. ADAMS No. ML13106A244.

[NRC] U.S. Nuclear Regulatory Commission. 2013b. NRC Order Number EA-13-109, "Issuance of Order to Modify Licenses with Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions." June 6, 2013. ADAMS No. ML13130A067.

[NRC] U.S. Nuclear Regulatory Commission. 2013c. *Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications.* Revision 1. Regulatory Guide 4.2, Supplement 1. June 20, 2013. 60 p. ADAMS No. ML13067A354.

[NRC] U.S. Nuclear Regulatory Commission. 2013d. Memorandum and Order In the Matter of EXELON GENERATION COMPANY, LLC (Limerick Generating Station, Units 1 and 2) CLI-13-07 October 31, 2013 (ADAMS No. ML13304B417)

[NRC] U.S. Nuclear Regulatory Commission. 2014a. Letter from L. Perkins, Environmental Project Manager, to M. Gallagher, Vice President License Renewal Projects, Exelon Generation Company, LLC. Subject: Requests for additional information for the review of the Limerick Generating Station license renewal application. February 12, 2014. ADAMS No. ML14029A162.

[NRC] U.S. Nuclear Regulatory Commission. 2014b. Interim Staff Evaluation and Audit Report and Technical Evaluation Report Related To Order EA-12-049 Modifying Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, Exelon Generation Company, LLC, Limerick Generating Station, Units 1 and 2. Washington, DC: NRC. January 10, 2014. 72 p. ADAMS No. ML13337A600.

[NRC] U.S. Nuclear Regulatory Commission. 2014c. Letter from E. Leeds, Director, to all power reactor licensees and holders of construction permits in active or deferred status. Subject: Screening and prioritization results regarding information pursuant to Title 10 of the *Code of Federal Regulations* 50.54(f) regarding seismic hazard reevaluations for Recommendation 2.1 of the Near-Term Task Force review of insights from the Fukushima Dai-ichi accident. May 9, 2014. ADAMS No. ML14111A147.

[NRDC] Natural Resources Defense Council. 2011. Letter from NRDC to C. Bladey. "Natural Resources Defense Council comments on Limerick EIS scoping process." October 28, 2011. ADAMS No. ML11307A456.

[PECO] Philadelphia Electric Company. 1992. Limerick Generating Station, Units 1 and 2: Individual plant examination volume 1. July 1992. ADAMS No. ML080030106 and ML080030104.

[PECO] Philadelphia Electric Company. 1995. Limerick Generating Station, Units 1 and 2 response to NRC Generic Letter 88-20, supplement 4, "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities." June 1995. ADAMS No. ML073610238.

[PECO] Philadelphia Electric Company. 1996. Letter from G.A. Hungar, Jr., Director–Licensing, to NRC Document Control Desk. Limerick Generating Station, Units 1 and 2: Response to request for additional information regarding review of individual plant examination of external events. June 28, 1996. ADAMS No. ML073610237.

6.0 ENVIRONMENTAL IMPACTS OF THE URANIUM FUEL CYCLE, SOLID WASTE MANAGEMENT, AND GREENHOUSE GAS EMISSIONS

6.1 The Uranium Fuel Cycle

This chapter addresses issues related to the uranium fuel cycle, solid waste management, and greenhouse gas emissions during the period of extended operation (listed in Table 6-1). The uranium cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level wastes and high-level wastes related to uranium fuel cycle activities. The generic potential impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in NUREG–1437, *Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants* (NRC 1996, 1999) based, in part, on the generic impacts given in Table S–3, "Table of Uranium Fuel Cycle Environmental Data," located in Title 10 of the *Code of Federal Regulations* 51.51 and in 10 CFR 51.52, Table S–4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water–Cooled Nuclear Power Reactor."

In the GEIS, the U.S. Nuclear Regulatory Commission staff (the staff) identified nine Category 1 issues related to the fuel cycle and waste management, which appear in Table 6–1. There are no Category 2 issues related to the fuel cycle and waste management.

Table 6–1. Issues Related to the Uranium Fuel Cycle and Waste Management

Issues	GEIS Sections	Category
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1; 6.2.1; 6.2.2.1; 6.2.2.3; 6.2.3; 6.2.4; 6.6	1
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6	1
Offsite radiological impacts (spent fuel and high-level waste disposal)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6	1
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6	1
Low-level waste storage and disposal	6.1; 6.2.2.2;6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.3; 6.4.4.4; 6.4.4.5; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6;6.6	1
Mixed waste storage and disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4; 6.6	1
Onsite spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6	1
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6	1
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6, Addendum 1	1

The NRC staff's evaluation of the environmental impacts associated with spent nuclear fuel is addressed in two issues in Table 6-1, "Offsite radiological impacts (spent fuel and high-level waste disposal)" and "Onsite spent fuel." However, as explained later in this section, the scope of the evaluation of these two issues in this SEIS has been revised. The issue, "Offsite radiological impacts (spent fuel and high-level waste disposal)," is not evaluated in this SEIS. In addition, the issue, "Onsite spent fuel" only evaluates the environmental impacts during the licensed life for operation of the reactor, i.e. the license renewal term. As discussed below, the Waste Confidence Continued Storage of Spent Nuclear Fuel Rule and supporting generic EIS are expected to provide the necessary NEPA analyses of the environmental impacts at an onsite or offsite spent nuclear fuel storage facility.

For the term of license renewal, the staff did not find any new and significant information related to "Onsite spent fuel" and the remaining uranium fuel cycle and solid waste management issues listed in Table 6–1 during its review of the Limerick Generating Station environmental report (ER) (Exelon 2011), the site visit, the scoping process, and the comment period on the draft SEIS. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are SMALL, except for the issue, "Offsite radiological impacts (collective effects)," which the NRC has not assigned an impact level. This issue assesses the 100-year radiation dose to the U.S. population (i.e., collective effects or collective dose) from radioactive effluents released as part of the uranium fuel cycle for nuclear power plant during the license renewal term compared to the radiation dose from natural background exposure. There are no regulatory limits applicable to collective doses to the public from fuel-cycle facilities. The Commission has determined that the practice of estimating health effects on the basis of collective doses may not be meaningful. Fuel-cycle facilities are designed and operated to meet regulatory limits and standards. Therefore, the Commission has concluded that the collective impacts are acceptable and would not be sufficiently large to require the NEPA conclusion that the option of extended operation should be eliminated (78 FR 37282).

Historically, the NRC's Waste Confidence Decision and Rule represented the Commission's generic determination that spent fuel can continue to be stored safely and without significant environmental impacts for a period of time after the end of a reactor's licensed life for operation. This generic determination meant that the NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life for operation in NEPA documents that supported its reactor and spent fuel storage application reviews. The NRC first adopted the Waste Confidence Decision and Rule in 1984. The NRC amended the Decision and Rule in 1990, reviewed it in 1999, and amended it again in 2010 (49 FR 34658 and 34694; 55 FR 38474; 64 FR 68005; and 75 FR 81032 and 81037). The Waste Confidence Decision provided a regulatory basis and NEPA analysis to support the Waste Confidence Rule (10 CFR 51.23).

On December 23, 2010, the Commission published in the *Federal Register* a revision of the Waste Confidence Rule, supported again by a Waste Confidence Decision, to reflect information gained from experience in the storage of spent fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel and high-level waste (75 FR 81032 and 81037). In response to the 2010 Waste Confidence Rule, the States of New York, New Jersey, Connecticut, and Vermont—along with several other parties—challenged the Commission's NEPA analysis in the decision, which provided the regulatory basis for the rule. On June 8, 2012, the United States Court of Appeals, District of Columbia Circuit in New York v. NRC, 681 F.3d 471 (D.C. Cir. 2012) vacated the NRC's Waste Confidence Rule, after finding that it did not comply with NEPA.

In response to the court's ruling, the Commission, in CLI-12-16 (NRC 2012a), determined that it would not make final decisions for licensing actions that depend upon the Waste Confidence

Rule until the court's remand is appropriately addressed. The Commission also noted that all licensing reviews and proceedings should continue to move forward. In addition, the Commission directed in SRM-COMSECY-12-0016 (NRC 2012b) that the NRC staff proceed with a rulemaking that includes the development of a generic EIS.

The generic EIS, which provides a regulatory basis for the revised rule, would provide NEPA analyses of the environmental impacts of spent fuel storage at a reactor site or at an away-from-reactor storage facility after the end of a reactor's licensed life for operation ("continued storage"). As directed by the Commission, the NRC will not make final decisions regarding renewed license applications until the court's remand is appropriately addressed. This will ensure that there would be no irretrievable or irreversible resource commitments or potential harm to the environment before the impacts of continued storage have been appropriately considered.

On September 13, 2013, the NRC published a proposed revision of 10 CFR 51.23 (i.e., the Waste Confidence Rule), which, if adopted as a final rule, would generically address the environmental impacts of continued storage (78 FR 56776). The NRC also prepared a draft generic EIS to support this proposed rule (NRC 2013) (78 FR 56621). The final rule is scheduled to be published by October 2014. Upon issuance of the final rule and GEIS, the NRC staff will consider whether additional NEPA analysis of continued storage is warranted before taking any action on the LGS license renewal application.

6.2 Greenhouse Gas Emissions

This section discusses the potential impacts from greenhouse gases (GHGs) emitted from the nuclear fuel cycle. The GEIS does not directly address these emissions, and its discussion is limited to an inference that substantial carbon dioxide (CO_2) emissions may occur if coal-, or oil-, fired alternatives to license renewal are carried out.

6.2.1 Existing Studies

Since the development of the GEIS, the relative volumes of GHGs emitted by nuclear and other electricity generating methods have been widely studied. However, estimates and projections of the carbon footprint of the nuclear power lifecycle vary depending on the type of study done. Additionally, considerable debate also exists among researchers on the relative effects of nuclear and other forms of electricity generation on GHG emissions. Existing studies on GHG emissions from nuclear power plants generally take two different forms:

(1) qualitative discussions of the potential to use nuclear power to reduce GHG emissions and mitigate global warming, and

(2) technical analyses and quantitative estimates of the actual amount of GHGs generated by the nuclear fuel cycle or entire nuclear power plant life cycle and comparisons to the operational or life cycle emissions from other energy generation alternatives.

6.2.1.1 Qualitative Studies

The qualitative studies consist primarily of broad, large-scale public policy, or investment evaluations of whether an expansion of nuclear power is likely to be a technically, economically, or politically workable means of achieving global GHG reductions. Studies the staff found during the subsequent literature search include the following:

- Evaluations to determine if investments in nuclear power in developing countries should be accepted as a flexibility mechanism to assist industrialized nations in achieving their GHG reduction goals under the Kyoto Protocols (IAEA 2000, NEA 2002, Schneider 2000). Ultimately, the parties to the Kyoto Protocol did not approve nuclear power as a component under the clean development mechanism (CDM) because of safety and waste disposal concerns (NEA 2002).

- Analyses developed to assist governments, including the United States, in making long-term investment and public policy decisions in nuclear power (Hagen et al. 2001, Keepin 1988, MIT 2003).

Although the qualitative studies sometimes reference and critique the existing quantitative estimates of GHGs produced by the nuclear fuel cycle or life cycle, their conclusions generally rely heavily on discussions of other aspects of nuclear policy decisions and investment, such as safety, cost, waste generation, and political acceptability. Therefore, these studies typically are not directly applicable to an evaluation of GHG emissions associated with the proposed license renewal for a given nuclear power plant.

6.2.1.2 Quantitative Studies

A large number of technical studies, including calculations and estimates of the amount of GHGs emitted by nuclear and other power generation options, are available in the literature and were useful in the staff's efforts to address relative GHG emission levels. Examples of these studies include—but are not limited to—Mortimer (1990), Andseta et al. (1998), Spadaro (2000), Storm van Leeuwen and Smith (2008), Fritsche (2006), Parliamentary Office of Science and Technology (POST) (2006), Atomic Energy Authority (AEA) (2006), Weisser (2006), Fthenakis and Kim (2007), and Dones (2007). In addition, Sovacool (2008) provides a review and synthesis of studies in existence through 2008; however, the Sovacool synthesis ultimately uses only 19 of the 103 studies initially considered (the remaining 84 were excluded because they were more than 10 years old, not publicly available, available only in a language other than English, or they presented methodological challenges by relying on inaccessible data, providing overall GHG estimates without allocating relative GHG impacts to different parts of the nuclear lifecycle, or they were otherwise not methodologically explicit).

Comparing these studies and others like them is difficult because the assumptions and components of the lifecycles that the authors evaluate vary widely. Examples of areas in which differing assumptions make comparing the studies difficult include the following:

- energy sources that may be used to mine uranium deposits in the future,
- reprocessing or disposal of spent nuclear fuel,
- current and potential future processes to enrich uranium and the energy sources that will power them,
- estimated grades and quantities of recoverable uranium resources,
- estimated grades and quantities of recoverable fossil fuel resources,
- estimated GHG emissions other than CO_2, including the conversion to CO_2 equivalents per unit of electric energy produced,
- performance of future fossil fuel power systems,
- projected capacity factors for alternatives means of generation, and
- current and potential future reactor technologies.

In addition, studies may vary with respect to whether all or parts of a power plant's lifecycle are analyzed (i.e., a full lifecycle analysis will typically address plant construction, operations, resource extraction—for fuel and construction materials, and decommissioning), whereas a partial lifecycle analysis primarily focuses on operational differences. In addition, as Sovacool (2008) noted, studies vary greatly in terms of age, data availability, and methodological transparency.

In the case of license renewal, a GHG analysis for the portion of the plant's lifecycle attributable to license renewal (operation for an additional 20 years) would not involve GHG emissions associated with construction because construction activities already have been completed at the time of relicensing. In addition, the proposed action of license renewal also would not involve additional GHG emissions associated with facility decommissioning because that decommissioning must occur whether the facility is relicensed or not. However, in many studies, the specific contribution of GHG emissions from construction, decommissioning, or other portions of a plant's lifecycle cannot be clearly separated from one another. In such cases, an analysis of GHG emissions would overestimate the GHG emissions attributed to a specific portion of a plant's lifecycle. As Sovacool (2008) noted, many of the available analyses provide markedly lower GHG emissions per unit of plant output when one assumes that a power plant operates for a longer period of time. Nonetheless, available studies supply some meaningful information on the relative magnitude of the emissions among nuclear power plants and other forms of electric generation, as discussed in the following sections.

In Tables 6–2, 6–3, and 6–4, the staff presents the results of the above-mentioned quantitative studies to supply a weight-of-evidence evaluation of the relative GHG emissions that may result from the proposed license renewal compared to the potential alternative use of coal-fired, natural gas-fired, and renewable generation. Most studies from Mortimer (1990) onward (through Sovacool 2008) indicate that uranium ore grades and uranium enrichment processes are leading determinants in the ultimate GHG emissions attributable to nuclear power generation. These studies show that the relatively lower order of magnitude of GHG emissions from nuclear power, when compared to fossil-fueled alternatives (especially natural gas), could potentially disappear if available uranium ore grades drop sufficiently while enrichment processes continued to rely on the same technologies.

Sovacool's synthesis of 19 existing studies found that nuclear power generation causes carbon emissions in a range of 1.4 grams of carbon equivalent per kilowatt-hour (g C_{eq}/kWh) to 288 g C_{eq}/kWh, with a mean value of 66 g C_{eq}/kWh. The results of his synthesis and the results of others' efforts are included in the tables in this section.

6.2.1.3 Summary of Nuclear Greenhouse Gas Emissions Compared to Coal

Considering that coal fuels the largest share of electricity generation in the United States and that its burning results in the largest emissions of GHGs for any of the likely alternatives to nuclear power generation, including CGS, many of the available quantitative studies focused on comparing the relative GHG emissions of nuclear to coal-fired generation. The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear lifecycle), as compared to an equivalent coal-fired plant, are presented in Table 6–2. The following table does not include all existing studies, but it gives an illustrative range of estimates that various sources have developed.

Table 6–2. Nuclear Greenhouse Gas Emissions Compared to Coal

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2/year Coal—5,912,000 tons CO_2/year Note: Future GHG emissions from nuclear to increase because of declining ore grade to less than 0.01% uranium oxide.
Andseta et al. (1998)	Nuclear energy produces 1.4% of the GHG emissions compared to coal. Note: Future reprocessing and use of nuclear-generated electrical power in the mining and enrichment steps are likely to change the projections of earlier authors, such as Mortimer (1990).
Spadaro (2000)	Nuclear—2.5–5.7 g C_{eq}/kWh Coal—264–357 g C_{eq}/kWh
Storm van Leeuwen and Smith (2008)	Authors did not evaluate nuclear versus coal.
Fritsche (2006) (values estimated from graph in Figure 4)	Nuclear—33 g C_{eq}/kWh Coal—950 g C_{eq}/kWh
POST (2006) (nuclear calculations from AEA, 2006)	Nuclear—5 g C_{eq}/kWh Coal—>1,000 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would raise nuclear to 6.8 g C_{eq}/kWh. Future improved technology and carbon capture and storage could reduce coal-fired GHG emissions by 90%.
Weisser (2006) (compilation of results from other studies)	Nuclear—2.8–24 g C_{eq}/kWh Coal—950–1,250 g C_{eq}/kWh
Fthenakis and Kim (2007)	Authors did not evaluate nuclear versus coal.
Dones (2007)	Author did not evaluate nuclear versus coal.
Sovacool (2008)	Nuclear—66 g C_{eq}/kWh Coal —960 to 1,050 g C_{eq}/kWh (coal adopted from Gagnon et al. 2002)

6.2.1.4 Summary of Nuclear Greenhouse Gas Emissions Compared to Natural Gas

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear lifecycle), as compared to an equivalent natural gas-fired plant, are presented in Table 6–3. The following table does not include all existing studies, but it gives an illustrative range of estimates various sources have developed.

Table 6–3. Nuclear Greenhouse Gas Emissions Compared to Natural Gas

Source	GHG Emission Results
Mortimer (1990)	Author did not evaluate nuclear versus natural gas.
Andseta et al. (1998)	Author did not evaluate nuclear versus natural gas.
Spadaro (2000)	Nuclear—2.5–5.7 g C_{eq}/kWh Natural gas—120–188 g C_{eq}/kWh
Storm van Leeuwen and Smith (2008)	Nuclear fuel cycle produces 20–33% of the GHG emissions compared to natural gas (at high ore grades). Note: Future nuclear GHG emissions will increase because of ore grade declining to less than 0.01% uranium oxide.
Fritsche (2006) (values estimated from graph in Figure 4)	Nuclear—33 g C_{eq}/kWh Cogeneration combined cycle natural gas—150 g C_{eq}/kWh
POST (2006) (nuclear calculations from AEA, 2006)	Nuclear—5 g C_{eq}/kWh Natural gas—500 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would raise nuclear to 6.8 g C_{eq}/kWh. Future improved technology and carbon capture and storage could reduce natural gas GHG emissions by 90%.
Weisser (2006) (compilation of results from other studies)	Nuclear—2.8–24 g C_{eq}/kWh Natural gas—440–780 g C_{eq}/kWh
Fthenakis and Kim (2007)	Authors did not evaluate nuclear versus natural gas.
Dones (2007)	Author critiqued methods and assumptions of Storm van Leeuwen and Smith (2005), and concluded that the nuclear fuel cycle produces 15-27% of the GHG emissions of natural gas.
Sovacool (2008)	Nuclear—66 g C_{eq}/kWh Natural gas—443 g C_{eq}/kWh (natural gas adopted from Gagnon et al. 2002)

6.2.1.5 Summary of Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear lifecycle), as compared to equivalent renewable energy sources, are presented in Table 6–4. Calculation of GHG emissions associated with these sources is more difficult than the calculations for nuclear energy and fossil fuels because of the large variation in efficiencies and capacity factors because of their different technologies, sources, and locations. For example, the efficiency of solar and wind energy is highly dependent on the wind or solar resource in a particular location. Similarly, the range of GHG emissions estimates for hydropower varies greatly depending on the type of dam or reservoir involved (if used at all). Therefore, the GHG emissions estimates for these energy sources have a greater range of variability than the estimates for nuclear and fossil fuel sources. As noted in Section 6.2.1.2, the following table does not include all existing studies, but it gives an illustrative range of estimates various sources have developed.

Table 6–4. Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO2/year Hydropower—78,000 tons CO2/year Wind power—54,000 tons CO2/year Tidal power—52,500 tons CO2/year Note: Future GHG emissions from nuclear are expected to increase because of declining ore grade.
Andseta et al. (1998)	Author did not evaluate nuclear versus renewable energy sources.
Spadaro (2000)	Nuclear—2.5–5.7 g C_{eq}/kWh Solar PV—27.3–76.4 g C_{eq}/kWh Hydroelectric—1.1–64.6 g C_{eq}/kWh Biomass—8.4–16.6 g C_{eq}/kWh Wind—2.5–13.1 g C_{eq}/kWh
Storm van Leeuwen and Smith (2008)	Author did not evaluate nuclear versus renewable energy sources.
Fritsche (2006) (values estimated from graph in Figure 4)	Nuclear—33 g C_{eq}/kWh Solar PV—125 g C_{eq}/kWh Hydroelectric—50 g C_{eq}/kWh Wind—20 g C_{eq}/kWh
POST (2006) (nuclear calculations from AEA, 2006)	Nuclear—5 g C_{eq}/kWh Biomass—25–93 g C_{eq}/kWh Solar PV—35–58 g C_{eq}/kWh Wave/Tidal—25–50 g C_{eq}/kWh Hydroelectric—5–30 g C_{eq}/kWh Wind—4.64–5.25 g C_{eq}/kWh Note: Decrease of uranium ore grade to 0.03% would raise nuclear to 6.8 g C_{eq}/kWh.
Weisser (2006) (compilation of results from other studies)	Nuclear—2.8–24 g C_{eq}/kWh Solar PV—43–73 g C_{eq}/kWh Hydroelectric—1–34 g C_{eq}/kWh Biomass—35–99 g C_{eq}/kWh Wind—8–30 g C_{eq}/kWh
Fthenakis and Kim (2007)	Nuclear—16–55 g C_{eq}/kWh Solar PV—17–49 g C_{eq}/kWh
Dones (2007)	Author did not evaluate nuclear versus renewable energy sources.
Sovacool (2008) (adopted from other studies)	Nuclear—66 g C_{eq}/kWh Wind—9–10 g C_{eq}/kWh Hydroelectric (small, distributed)—10–13 g C_{eq}/kWh Biogas digester—11 g C_{eq}/kWh Solar thermal—13 g C_{eq}/kWh Biomass—14–35 g C_{eq}/kWh Solar PV—32 g C_{eq}/kWh Geothermal (hot, dry rock)—38 g C_{eq}/kWh (solar PV value adopted from Fthenakis et al. 2008; all other renewable generation values adopted from Pehnt 2006)

6.2.2 Conclusions: Relative Greenhouse Gas Emissions

The sampling of data presented in Tables 6–2, 6–3, and 6–4 demonstrates the challenges of any attempt to determine the specific amount of GHG emission attributable to nuclear energy production sources because different assumptions and calculation methods will yield differing results. The differences and complexities in these assumptions and analyses will further increase when they are used to project future GHG emissions. Nevertheless, several conclusions can be drawn from the information presented.

First, the various studies show a general consensus that nuclear power currently produces fewer GHG emissions than fossil-fuel-based electrical generation (e.g., GHG emissions from a complete nuclear fuel cycle currently range from 2.5–66 grams of carbon equivalent per kilowatt hour (g C_{eq}/kWh), as compared to the use of coal plants (264–1,250 g C_{eq}/kWh) and natural gas plants (120-780 g C_{eq}/kWh)). The studies also provide estimates of GHG emissions from five renewable energy sources based on current technology. These estimates included solar-photovoltaic (17–125 g C_{eq}/kWh), hydroelectric (1–64.6 g C_{eq}/kWh), biomass (8.4–99 g C_{eq}/kWh), wind (2.5–30 g C_{eq}/kWh), and tidal (25–50 g C_{eq}/kWh). The range of these estimates is wide, but the general conclusion is that current GHG emissions from nuclear power generation are of the same order of magnitude as from these renewable energy sources.

Second, the studies show no consensus on future relative GHG emissions from nuclear power and other sources of electricity. There is substantial disagreement among the various authors about the GHG emissions associated with declining uranium ore concentrations, future uranium enrichment methods, and other factors, including changes in technology. Similar disagreement exists about future GHG emissions associated with coal and natural gas for electricity generation. Even the most conservative studies conclude that the nuclear fuel cycle currently produces fewer GHG emissions than fossil-fuel-based sources and is expected to continue to do so in the near future. The primary difference between the authors is the projected cross-over date (the time at which GHG emissions from the nuclear fuel cycle exceed those of fossil-fuel-based sources) or whether cross-over will actually occur.

Considering current estimates and future uncertainties, it appears that GHG emissions associated with the proposed Limerick Generating Station, Units 1 and 2 (LGS) relicensing action are likely to be lower than those associated with fossil-fuel–based energy sources. The staff bases this conclusion on the following rationale:

- As shown in Tables 6–2 and 6–3, current estimates of GHG emissions from the nuclear fuel cycle are far below those for fossil-fuel-based energy sources.
- License renewal of a nuclear power plant such as LGS may involve continued GHG emissions caused by uranium mining, processing, and enrichment, but will not result in increased GHG emissions associated with plant construction or decommissioning (since the plant will have to be decommissioned at some point whether the license is renewed or not).
- Few studies (e.g., Mortimer 1990, Storm van Leeuwen and Smith 2008) predict that nuclear fuel cycle emissions will exceed those of fossil fuels as a result of declining ore grade; however, this is not expected to occur within the timeframe that includes the period of extended operation of LGS.

With respect to the comparison of GHG emissions among the proposed LGS license renewal action and renewable energy sources:

- It appears likely that there will be future technology improvements and changes in the type of energy used for mining, processing, manufacturing, and constructing facilities of all types.
- Currently, the GHG emissions associated with the nuclear fuel cycle and renewable energy sources are within the same order of magnitude.
- Because nuclear fuel production is the most significant contributor to possible future increases in GHG emissions from nuclear power—and since most renewable energy sources lack a fuel component—it is likely that GHG emissions from renewable energy sources will be lower than those associated with LGS at some point during the period of extended operation.

The staff provides additional discussion on the contribution of GHG to cumulative air quality impacts in Section 4.11.2 of this supplemental EIS.

6.3 References

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7.0 ENVIRONMENTAL IMPACTS OF DECOMMISSIONING

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in NUREG-0586, *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors* (NRC 2002). The U.S. Nuclear Regulatory Commission (NRC) staff's evaluation of the environmental impacts of decommissioning–presented in NUREG–0586, Supplement 1–notes a range of impacts for each environmental issue.

Additionally, the incremental environmental impacts associated with decommissioning activities resulting from continued plant operation during the renewal term are discussed in NUREG-1437, *Generic Environmental Impact Statement* (GEIS) *for License Renewal of Nuclear* Plants (NRC 1996, 1999). The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. The NRC staff then assigned these issues a Category 1 or a Category 2 designation. Section 1.4 of this SEIS explains the criteria for Category 1 and Category 2 issues and defines the impact designations of SMALL, MODERATE, and LARGE. The NRC staff analyzed site-specific issues (Category 2) for Limerick Generating Station, Units 1 and 2 (LGS) and assigned them a significance level of SMALL, MODERATE, or LARGE, or not applicable to LGS because of site characteristics or plant features. The NRC staff determined that there are no Category 2 issues related to decommissioning, only the Category 1 issues discussed below.

Regarding the offsite radiological impacts resulting from spent fuel and high level waste disposal and the onsite storage of spent fuel, which will occur after the reactors have been permanently shut down, the NRC's Waste Confidence Rule (i.e., 10 CFR 51.23) represented the Commission's generic determination that spent fuel can continue to be stored safely and without significant environmental impacts for a period of time after the end of the licensed life for operation. This generic determination meant that the NRC did not need to consider the storage of spent fuel after the end of a reactor's licensed life for operation in National Environmental Policy Act (NEPA) documents that support the NRC's reactor and spent fuel storage application reviews.

However, as discussed in Chapter 6 of this SEIS, the Commission's Waste Confidence Rule was vacated on June 8, 2012, by the United States Court of Appeals for the District of Columbia Circuit. In response to the court's ruling, the Commission directed the NRC staff to proceed with a rulemaking that includes the development of a generic environmental impacts statement (EIS) to support a revised Waste Confidence Rule. The revised rule and supporting EIS are expected to provide the necessary NEPA analyses of offsite radiological impacts resulting from spent fuel and high level waste disposal and the onsite storage of spent fuel, which will occur after the reactors have been permanently shut down, so that these impacts do not need to be separately considered in this SEIS. The issue of spent nuclear fuel and the Waste Confidence Rule is discussed in more detail in Chapter 6 of this SEIS.

7.1 Decommissioning

Table 7–1 lists the Category 1 issues in Table B–1 of Appendix B to Subpart A of Title 10 of the *Code of Federal Regulations*, Part 51 (10 CFR Part 51) that are applicable to LGS decommissioning following the proposed renewal term.

Table 7–1. Issues Related to Decommissioning

Issues	GEIS section	Category
Radiation doses	7.3.1; 7.4	1
Waste management	7.3.2; 7.4	1
Air quality	7.3.3; 7.4	1
Water quality	7.3.4; 7.4	1
Ecological resources	7.3.5; 7.4	1
Socioeconomic impacts	7.3.7; 7.4	1

Decommissioning would occur either if LGS were shut down at the end of its current operating license or at the end of the proposed period of extended operation. There are no site-specific (Category 2) issues related to decommissioning.

A brief description of the NRC staff's review and the GEIS conclusions, as codified in Table B–1 of Appendix B to Subpart A of 10 CFR Part 51, for each of the issues follows:

Radiation Doses

Based on information in the GEIS, the NRC found that "[d]oses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem caused by buildup of long-lived radionuclides during the license renewal term."

Waste Management

Based on information in the GEIS, the NRC found that "[d]ecommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected."

Air Quality

Based on information in the GEIS, the NRC found that "[a]ir quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term."

Water Quality

Based on information in the GEIS, the NRC found that "[t]he potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts."

Ecological Resources

Based on information in the GEIS, the NRC found that "[d]ecommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts."

Socioeconomic Impacts

Based on information in the GEIS, the NRC found that "[d]ecommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth."

7.2 Staff Review of the Exelon ER

Exelon Generation Company, LLC (Exelon) stated in its environmental report (ER) (Exelon 2011) that it is not aware of any new and significant information on the environmental impacts of LGS license renewal. The NRC staff did not find any new and significant information during its independent review of Exelon's ER, its site visit, the scoping process, or its evaluation of other available information.

7.3 Conclusion

In the GEIS, the NRC staff determined that the environmental impacts of decommissioning at the end of a 20-year relicense period are SMALL and that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted. Since there is no new and significant information related to this determination, the NRC staff concludes that there are no environmental impacts related to decommissioning beyond those discussed in the GEIS, which are all SMALL.

7.4 References

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental protection regulations for domestic licensing and related regulatory functions."

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8.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The National Environmental Policy Act (NEPA) requires that Federal agencies consider reasonable alternatives to the proposed action in an environmental impact statement (EIS). In this case, the proposed action is the issuance of renewed licenses for the Limerick Generating Station (LGS), which will allow the plant to operate for 20 years beyond its current license expiration dates.

An operating license, however, is just one of a number of authorizations that an applicant must obtain to operate a nuclear plant. Energy-planning decisionmakers and owners of the nuclear power plant ultimately decide whether the plant will continue to operate, and economic and environmental considerations play important roles in this decision. In general, the U.S. Nuclear Regulatory Commission's (NRC's) responsibility is to ensure the safe operation of nuclear power facilities and not to formulate energy policy or encourage or discourage the development of alternative power generation.

The license renewal review process is designed to ensure safe operation of the nuclear power plant during the license renewal term. Under the NRC's environmental protection regulations in Title 10 of the *Code of Federal Regulations* Part 51 (10 CFR Part 51), which implement Section 102(2) of NEPA, renewal of a nuclear power plant operating license also requires the preparation of an EIS.

To support the preparation of these EISs, the NRC prepared the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG–1437, in 1996. The license renewal GEIS was prepared to assess the environmental impacts of continued nuclear power plant operations during the license renewal term. The intent was to determine which environmental impacts would result in essentially the same impact at all nuclear power plants and which ones could result in different levels of impacts at different plants and would require a plant-specific analysis to determine the impacts. For those issues that could not be generically addressed, the NRC develops a plant-specific supplemental environmental impact statement (SEIS) to the GEIS.

NRC regulations in 10 CFR 51.71(d) implementing NEPA for license renewal require that a SEIS must, among other things, do the following:

> …include a preliminary analysis that considers and weighs the environmental effects of the proposed action [license renewal]; the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental effects….

While the 1996 GEIS reached generic conclusions on many environmental issues associated with license renewal, it did not determine which alternatives are reasonable and did not reach conclusions about site-specific environmental impact levels. As such, the NRC must evaluate the environmental impacts of alternatives on a site-specific basis. This SEIS contains that evaluation.

As stated in Chapter 1 of this document, alternatives to renewing the LGS operating licenses must meet the purpose and need for the proposed action; they must do the following:

> …provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet other future system generating needs, as such needs may be determined by State, utility, and where authorized, Federal (other than NRC) decision makers. (NRC 1996)

The NRC ultimately makes no decision about which alternative (or the proposed action) to carry out because that decision falls to utility, state, or other Federal officials. Comparing the environmental effects of these alternatives, however, will help the NRC decide whether the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable (10 CFR 51.95(c)(4)). If the NRC acts to issue a renewed license, then all of the alternatives considered in this SEIS, including the proposed action, will be available to energy-planning decisionmakers. If the NRC decides not to renew the license (or takes no action at all), then energy-planning decisionmakers may no longer elect to continue operating LGS and will have to resort to another alternative (or combination of alternatives)—which may or may not be one of the alternatives considered in this section—to meet the energy needs that LGS now satisfies.

Alternatives Evaluated In-Depth:

- natural-gas-fired combined-cycle (NGCC)
- supercritical pulverized coal (SCPC)
- new nuclear
- wind
- purchased power

Other Alternatives Considered:

- solar power,
- combination alternative of wind, solar, and NGCC,
- combination alternative of wind and compressed-air energy storage (CAES),
- wood waste,
- conventional hydroelectric power,
- ocean wave and current energy,
- geothermal power,
- municipal solid waste (MSW),
- biofuels,
- oil-fired power,
- fuel cells,
- demand-side management (DSM), and
- delayed retirement.

In evaluating alternatives to license renewal, the NRC considered energy technologies or options currently in commercial operation, as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current LGS operating licenses expire. The current operating licenses for LGS reactors will expire on October 26, 2024, and June 22, 2029, and reasonable alternatives must be available (constructed, permitted, and connected to the grid) by the time the current LGS licenses expire to be considered likely to become available.

Alternatives that cannot meet future system needs by providing amounts of baseload power equivalent to LGS's current generating capacity and, in some cases, those alternatives whose costs or benefits do not justify inclusion in the range of reasonable alternatives, were eliminated from detailed study. The staff evaluated the environmental impacts of the remaining alternatives and discusses them in depth in this chapter. Each alternative eliminated from detailed study is briefly discussed, and a basis for its removal is provided at the end of this section. In total, 18 alternatives to the proposed action were considered (see text box) and then narrowed to the 5 alternatives considered in Sections 8.1–8.5.

The 1996 GEIS presents an overview of some energy technologies but does not reach any conclusions about which alternatives are most appropriate. Since 1996, many energy technologies have evolved significantly in capability and cost while regulatory structures have changed to either promote or impede development of particular alternatives.

As a result, the analyses may include updated information from the following sources:

- Energy Information Administration (EIA),
- other offices within the U.S. Department of Energy (DOE),
- U.S. Environmental Protection Agency (EPA),
- industry sources and publications,
- information submitted by Exelon Generation Company, LLC (Exelon) in its environmental report (ER), and
- public comments on the draft SEIS.

The evaluation of each alternative considers the environmental impacts across several impact categories: air quality, groundwater use and quality, surface water use and quality, terrestrial ecology, aquatic ecology, human health, land use, socioeconomics, transportation, aesthetics, historic and archaeological resources, environmental justice, and waste management. A three-level standard of significance—SMALL, MODERATE, or LARGE—is used to indicate the intensity of environmental effects for each alternative undergoing in-depth evaluation. The order of presentation is not meant to imply increasing or decreasing level of impact. Nor does it imply that an energy-planning decisionmaker would be more likely to select any given alternative.

In some cases, the NRC considers the environmental effects of locating a replacement power alternative at the existing nuclear plant site. Selecting the existing plant site allows for the maximum use of existing transmission and cooling system infrastructures and minimizes the overall environmental impact. However, LGS does not have a sufficient amount of land available for all the replacement power alternatives because LGS would continue to operate while the replacement alternative is being built to prevent a gap in energy generation during the period of construction, which would take several years. As a result, the NRC evaluated the impacts of locating replacement power facilities at other existing power plant sites within the PJM Interconnection (PJM). Installing replacement power facilities at existing power plants and connecting to existing transmission and cooling system infrastructure would reduce the overall environmental impact.

To ensure that the alternatives analysis is consistent with state or regional energy policies, the NRC reviewed energy-related statutes, regulations, and policies within the Commonwealth of Pennsylvania and PJM, including, for example, state renewable portfolio standards (RPSs). As a result, the staff considers several alternatives that include wind or solar photovoltaic power, as well as combinations that include them.

Exelon is wholly-owned by Exelon Corporation, which also owns companies that provide electric transmission, power marketing, and energy delivery. Exelon Generation does not directly serve any customers, but sells its output through existing markets, and in particular, through PJM.

The NRC considered the current generation capacity and electricity production within the Commonwealth of Pennsylvania, as well as, where pertinent, the territory covered by PJM. Pennsylvania is similar to the U.S. average in reliance on coal, natural gas, and nuclear power as its primary electric generation fuels. Pennsylvania is slightly more reliant on coal, less reliant on natural gas, and more reliant on nuclear power than the U.S. average. Pennsylvania diverged most from national averages in renewable generation. Pennsylvania hydropower and other renewables provided 2.8 percent of electricity in the Commonwealth compared to 10.4 percent nationwide (EIA 2012).

Pennsylvania is one of the nation's top generators of electricity and a net exporter of power. While the staff generally considers alternatives located within Pennsylvania, it acknowledges that alternatives could also be located elsewhere in PJM.

The Commonwealth of Pennsylvania has established an alternative energy portfolio standard (AEPS, similar to a renewable portfolio standard) that requires electricity providers to obtain a minimum percentage of their power through renewable energy resources, energy efficiency measures, or one of several nonconventional coal-fired or natural-gas–fired alternatives, including waste coal, coal-mine methane, coal gasification, and combined-heat-and-power generation. The AEPS also includes a solar-power set-aside. Pennsylvania first adopted the AEPS requirement in 2004. It currently requires 18 percent of all electricity sold in the Commonwealth to come from qualifying sources by 2020–2021. The standard allows renewable energy credit trading within PJM (DSIRE 2011). Other states in PJM also have similar policies, which typically take the form of binding standards. Some, however, have implemented non-binding goals, as Virginia has done.

Sections 8.1–8.7 describe the environmental impacts of alternatives to license renewal. These include a natural-gas-combined-cycle (NGCC) in Section 8.1; a supercritical pulverized coal (SCPC) alternative in Section 8.2; a new nuclear alternative in Section 8.3; and a wind-power alternative in Section 8.4. A summary of these alternatives considered in depth is provided in Table 8–1. In Section 8.5, the staff discusses purchased power as an alternative, and in Section 8.6, the staff addresses alternatives considered but dismissed. Finally, the environmental effects that may occur if NRC takes no action and does not issue renewed licenses for LGS are described in Section 8.7. Section 8.8 summarizes the impacts of each of the alternatives considered.

Table 8–1. Summary of Alternatives Considered In Depth

	Natural Gas (NGCC) Alternative	Supercritical Pulverized Coal (SCPC) Alternative	New Nuclear Alternative	Wind Alternative
Summary of Alternative	Four 530-MW units, for a total of 2,120 MW (about 10 percent less than LGS)	Two to four SCPC Units, for a total of 2,120 MW (about 10 percent less than LGS)	Two unit nuclear plant	2,250 to 9,000 2-MW wind turbines, for a total of 4,500 to 18,000 MW
Location	An existing power plant site (other than LGS) in PJM. Some infrastructure upgrades may be required; would require construction of a new or upgraded pipeline.	An existing power plant site (other than LGS) in PJM. Some infrastructure upgrades may be required.	An existing nuclear plant site (other than LGS) in PJM. Some infrastructure upgrades may be required.	Spread across multiple sites throughout PJM.
Cooling System	Closed-cycle with mechanical-draft cooling towers. Consumptive water use would be approximately 1/3 less than LGS.	Closed-cycle with natural-draft cooling towers. Consumptive water use would be slightly less than LGS.	Closed-cycle with natural-draft cooling towers. Consumptive water use would be similar to LGS.	N/A
Land Requirements	35 ac (14 ha) for the plant (Exelon 2011); 7,630 ac (3,090 ha) for wells, collection site, pipeline (NRC 1996)	280 ac (113 ha) for the plant (Exelon 2011); 49,600 ac (20,100 ha) for coal mining and waste disposal (NRC 1996); 464 ac (188 ha) for ash and scrubber sludge (Exelon 2011)	630 ac to 1,260 ac (255 ha to 510 ha) (Exelon 2011); 1,000 ac (400 ha) for uranium mining and processing (NRC 1996)	Wind farms would be spread across 130,000 to 534,000 ac (53,000 to 216,000 ha) of land, but only 3,200 to 13,300 ac (1,300 to 5,400 ha) would be directly affected by the wind turbines (Exelon 2011, NREL 2009)
Work Force	800 during construction; 45 during operations (Exelon 2011)	2,500 during construction; 141 during operations (Exelon 2011)	3,650 during construction; 820 during operations (Exelon 2011)	200 during construction; 50 during operations (Exelon 2011)

8.1 Natural Gas Combined-Cycle Alternative

Natural gas combined-cycle (NGCC) systems represent the large majority of the total number of plants currently under construction or planned in the United States. Factors that contribute to the popularity of NGCC facilities include high capacity factors, low relative construction costs, low gas prices, and relatively low air emissions. Development of new NGCC plants may be affected by uncertainties about the continued availability and price of natural gas (though less so than in the recent past) and future regulations that may limit greenhouse gas (GHG) emissions. A gas-fired power plant, however, produces markedly fewer GHGs per unit of electrical output than a coal-fired plant of the same electrical output.

Combined-cycle power plants differ significantly from most coal fired and all existing nuclear power plants. Combined-cycle plants derive the majority of their electrical output from a gas turbine and then generate additional power—without burning any additional fuel—through a second, steam turbine cycle. The exhaust gas from the gas turbine is still hot enough to boil water to steam. Ducts carry the hot exhaust to a heat recovery steam generator, which produces steam to drive a steam turbine and produce additional electrical power. The combined-cycle approach is significantly more efficient than any one cycle on its own; thermal efficiency can exceed 60 percent versus 38 percent for conventional single-cycle facilities (NETL 2007, Siemens 2007). In addition, because the natural gas-fired alternative derives much of its power from a gas-turbine cycle, and because it wastes less heat than the existing LGS unit, it requires significantly less cooling water.

While nuclear reactors, on average, operate with capacity factors above 90 percent (LGS Units 1 and 2 operated at 97 percent and 96 percent capacity factors, respectively, from 2003 to 2010 [NRC 2011]), the staff expects that an NGCC alternative would operate with roughly an 85 percent capacity factor. Nonetheless, the staff assumes that a similar-sized NGCC facility would be capable of providing adequate replacement power for the purposes of this NEPA analysis.

Typical power trains for large-scale NGCC power generation would involve one, two, or three combined-cycle units, available in a variety of standard sizes, mated to a heat-recovery steam generator. To complete the assessment of an NGCC alternative, the NRC presumes that appropriately sized units could be assembled to annually produce electrical power in amounts equivalent to LGS. For purposes of this review, the staff evaluated an alternative that consists of four General Electric (GE) Advanced F Class units, 530 MW(e) each, equipped with dry-low-nitrogen-oxide combustors to suppress nitrogen oxide formation and selective catalytic reduction (SCR) of the exhaust with ammonia for post-combustion control of nitrogen oxide emissions. This alternative provides 2,120 MW(e) of capacity, and thus underestimates the potential environmental impacts of replacing the full 2,340 MW(e) produced by LGS by about 10 percent.

While siting an alternative on the LGS site would allow for the fullest use of existing ancillary infrastructure, such as transmission and support buildings, and would minimize the use of undisturbed land, space constraints on the LGS site preclude that option. In its ER, Exelon proposed that the NGCC alternative could be constructed at another existing power plant site elsewhere in Pennsylvania or PJM, which would mitigate construction impacts in a similar way to building the alternative at the LGS site (Exelon 2011). The staff finds this to be a reasonable approach and adopts it for purposes of this analysis. It is possible that an NGCC alternative constructed at an existing power plant site would require some infrastructure upgrades, such as improved transmission lines or modifications to existing intake or cooling systems, but the staff expects that these impacts would be smaller than those necessary to support an NGCC alternative constructed on an undeveloped site.

Wherever the NGCC alternative is constructed, it is likely to require a new or upgraded pipeline to supply natural gas to the facility. Some of the natural gas supplied to this alternative is likely to come from Pennsylvania or neighboring states, but the NGCC alternative is unlikely to directly trigger new natural gas development in Pennsylvania or the region.

NGCC power plants are feasible, commercially available options for providing electric generating capacity sufficient to replace the output of LGS beyond the current LGS license expiration dates. Environmental impacts from the NGCC alternative are summarized in Table 8–2 and discussed in depth in Sections 8.1.1–8.1.9.

8.1.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, which is part of the Metropolitan Philadelphia Interstate Air Quality Control Region (AQCR, 40 CFR 81.15). With regard to the National Ambient Air Quality Standards (NAAQS), EPA has designated Montgomery and Chester Counties as unclassified or in attainment for carbon monoxide (CO), lead, sulfur dioxide (SO_2), and PM_{10} (particulate matter 10 microns or less in diameter) and nonattainment for ozone and $PM_{2.5}$ (particulate matter 2.5 microns or less in diameter) (40 CFR 81.339).

A new NGCC generating plant would qualify as a new major-emitting industrial facility and would be subject to Prevention of Significant Deterioration (PSD) under requirements of the Clean Air Act (CAA) (EPA 2012a). The Pennsylvania Department of Environmental Protection (PADEP) has adopted 25 Pa. Code Chapter 127, which implements the EPA's PSD review. The NGCC plant would need to comply with the standards of performance for stationary combustion turbines set forth in 40 CFR Part 60 Subpart KKKK.

Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including review of the new sources that may affect visibility in any Federal Class I area. If an NGCC alternative was located close to a mandatory Class I area, additional air pollution control requirements would be required. As noted in Section 2.2.2.1, there are no mandatory Class I Federal areas within 50 miles (80 km) of the LGS site. However, there are a total of 13 designated Class 1 Federal areas (40 CFR 81) located in the following PJM states: Kentucky, Michigan, New Jersey, North Carolina, Tennessee, Virginia, and West Virginia.

A new NGCC plant would have to comply with Title IV of the CAA (42 USC §7651) reduction requirements for sulfur dioxides (SO_2) and nitrogen oxides (NO_x), which are the main precursors of acid rain and the major causes of reduced visibility. Title IV establishes maximum SO_2 and NO_x emission rates from the existing plants and a system of SO_2 emission allowances that can be used, sold, or saved for future use by the new plants.

More recently, EPA has promulgated additional rules and requirements that apply to certain fossil-fuel-based power plants, such as NGCC generation. The Cross-State Air Pollution Rule (CSAPR) and the Prevention of Significant Deterioration and Title V Greenhouse Gas (GHG) Tailoring Rule impose several additional standards to limit ozone, particulate, and GHG emissions from fossil-fuel based power plants (EPA 2012c). A new NGCC plant would be subject to these additional rules and regulations.

The EPA has developed standard emission factors that relate the quantity of released air pollutants to a variety of regulated activities (EPA 2012b). Using these emission factors, the staff projects the following air emissions for the NGCC alternative:

- sulfur oxides (SO_x) – 167 tons (151 MT) per year,
- nitrogen oxides (NO_x) – 485 tons (440 MT) per year,
- carbon monoxide (CO) – 735 tons (667 MT) per year,

- PM_{10} and $PM_{2.5}$– 323 tons (293 MT) per year, and
- carbon dioxide (CO_2) – 5,390,097 tons (4,889,896 MT) per year.

Activities associated with the construction of the new NGCC plant on or off the LGS site would cause some additional temporary air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material-handling equipment. Emissions from workers' vehicles and motorized construction equipment exhaust would be temporary. The construction crews would use dust-control practices to control and reduce fugitive dust. The staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of the earth-moving and material-handling equipment would be SMALL.

8.1.1.1 Greenhouse Gas Emissions

Combustion of fossil fuels, including natural gas, is the greatest anthropogenic source of GHG emissions in the United States. Greenhouse gas emissions during construction of an NGCC alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. Analogous impacts would occur in association with offsite pipeline construction. All such impacts, however, would be temporary.

Although natural gas combustion in the combustion turbines (CTs) would be the primary source of GHGs during operations, other miscellaneous ancillary sources such as truck and rail deliveries of materials to the site and commuting of the workforce would make minor contributions.

The National Energy Technology Laboratory (NETL) estimates that carbon capture and storage (CCS) will capture and remove as much as 90 percent of the CO_2 from the exhausts of CTs, but it will result in a power production capacity decrease of approximately 14 percent, a reduction in net overall thermal efficiency of the CTs studied from 50.8 percent to 43.7 percent, and a potential increase in the levelized cost of electricity produced in NGCC units so equipped by as much as 30 percent (NETL 2007). Further, permanent sequestering of the CO_2 would involve removing impurities (including water) and pressurizing it to meet pipeline specifications and transferring the gas by pipeline to acceptable geologic formations. Even when opportunities exist to use the CO_2 for enhanced oil recovery (rather than simply disposing of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the NGCC units are far removed from acceptable geologic formations. With CCS in place, the NGCC alternative would release 539,000 tons per year (489,000 MT) of CO_2. Without CCS in place, the staff's projected CO_2 emissions for the NGCC alternative would be 5,390,097 tons (4,889,896 MT) per year.

Given the expected relatively small workforce, relatively short construction period for both the NGCC facility and the pipeline, and CO_2 emissions of operation for the NGCC alternative, the overall impact from the releases of GHGs of a natural gas-fired alternative would be SMALL to MODERATE.

8.1.1.2 Conclusion

Based on the above review, the overall air quality impacts of a new NGCC plant located at the LGS site are SMALL to MODERATE and based largely on operational impacts.

8.1.2 Groundwater Resources

Construction activities associated with the NGCC alternative could require groundwater dewatering of foundation excavations. This activity might require the use of cofferdams, sumps, wells, or other methods to address high water-table conditions. However, because of the relatively shallower depth of excavation for the NGCC plant as compared to other alternatives, any impacts would be expected to be minor at most sites; however, dewatering needs could be greater at some sites. Facility construction would increase the amount of impervious surface at the site location as well as alter the subsurface strata because of excavation work and the placement of backfill following facility completion. While an increase in impervious surface would reduce infiltration and reduce groundwater recharge, the effects on water-table elevations at most sites would likely be very small. Below-grade portions of the new NGCC plant could also alter the direction of groundwater flow beneath a site. Such effects would likely be very localized at most site locations and would not be expected to affect offsite wells. Application of best management practices (BMPs) in accordance with a state-issued NPDES general permit, including appropriate waste management, water discharge, and spill prevention practices, would prevent or minimize any groundwater quality impacts during construction.

For the construction period, the NRC has conservatively assumed that groundwater would be used. However, it is more likely that water would be supplied via a temporary utility connection, if available, or trucked to the point of use from offsite sources. Regardless, groundwater use for construction of a new NGCC plant would be substantially less than the volume required for the coal-fired or nuclear alternatives because of the smaller footprint involved for excavation, earthwork, and structural work. This would encompass such uses as potable and sanitary uses, concrete production, dust suppression, and soil compaction. The workforce at the NGCC would be slightly smaller than the existing LGS workforce, which uses substantially less than 100 gpm (380 L/min) for both potable water supply and fire suppression uses. The GEIS has found that pumping rates of less than 100 gpm (380 L/min) have not been shown to adversely affect groundwater availability (NRC 1996).

For NGCC plant operations, the NRC assumed that the NGCC alternative would entail the same relative ratio of groundwater use to surface water use as that used at LGS Units 1 and 2. This includes the use of groundwater for backup fire water supply and for potable and sanitary uses. Consequently, the staff expects that total groundwater usage and associated aquifer effects would be much less under this alternative than those under current LGS operations because of the smaller number of auxiliary systems requiring groundwater and the much smaller operational workforce under the NGCC alternative. Based on this assessment, the impacts on groundwater use and quality under the NGCC alternative would be SMALL.

8.1.3 Surface Water Resources

Construction activities associated with the NGCC alternative would be similar to construction activities for most large industrial facilities. A new NGCC plant would occupy a much smaller footprint (about 35 ac [14 ha]) than the current LGS or the proposed coal-fired or new nuclear alternatives. This would also result in less extensive excavation and earthwork than under either of the other conventional replacement power facility alternatives. The staff assumes that no surface water would be used during construction for the NGCC alternative because the staff assumed groundwater would be used or water would be supplied by a water utility or trucked in, as explained above in Section 8.1.2.

Some temporary impacts to surface water quality may result from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas and from dredging activities. During facility construction, runoff from disturbed areas in the plant footprint would be controlled under a state-issued NPDES general permit that would require implementation of a stormwater pollution prevention plan and associated BMPs to prevent or significantly mitigate soil erosion and contamination of stormwater runoff. Depending on the path of the gas pipeline to supply the NGCC plant, some creeks and streams would likely be crossed. However, because of the short-term nature of the dredging activities, the hydrologic alterations and sedimentation would be localized and temporary. In addition, modern pipeline construction techniques, such as horizontal directional drilling, would further minimize the potential for water quality impacts in the affected streams. Dredging would be conducted under a permit from the U.S. Army Corps of Engineers (COE) requiring the implementation of BMPs to minimize impacts.

For facility operations, the NGCC alternative would require much less cooling water than LGS Units 1 and 2, and consumptive water use would be much less. Assuming a typical ratio of 2 to 1 for electrical generation from gas turbine (Brayton cycle) to electrical generation from steam turbine (Rankine cycle) for a combined-cycle plant, the staff estimated that the consumptive water loss for an equivalent-sized combined-cycle plant would be about one-third the LGS water use. For the purposes of comparison, and as described in Section 2.2.4.1, the mean annual flow and 90 percent exceedance flows of the Schuylkill River are 1,935 cfs (54.8 m^3/s) and 482 cfs (13.6 m^3/s), respectively. At the mean annual flow and the 90 percent exceedance flow, the projected rate of consumptive water use for the NGCC plant (i.e., 22 cfs [0.62 m^3/s]) represents a 1 percent and a 4 percent reduction in the streamflow in the Schuylkill River downstream of the NGCC alternative location, if sited at or near the LGS site. This reduced demand for water would substantially reduce the need for low-flow augmentation from either the Delaware River or the Wadesville Mine Pool. Effects may vary at other sites, but the net consumption of water would be less than that associated with existing LGS operations.

The NRC assumed that water treatment additives for the NGCC alternative would be essentially identical to LGS because similar additives are required for water conditioning to operate NGCC and nuclear plants. The NRC also assumed that the proposed site's existing intake and discharge infrastructure would be used, as described above. While the quality would be chemically similar, the discharge volume would be about one-third less than current LGS operations. Surface water withdrawals would be subject to applicable water allocation requirements in Pennsylvania and other states, and effluent discharges and stormwater discharges associated with industrial activity would be subject to a state-issued NPDES permit under this alternative. The NRC also assumes that facility operations would be subject to and would be conducted in accordance with a spill prevention, control, and countermeasures (SPCC) plan, stormwater pollution prevention plan, or equivalent plans and associated BMPs and procedures to prevent and respond to accidental releases of non-nuclear fuels, chemicals, and other materials to soil, surface water, and groundwater.

Therefore, based on the above assessment, the impacts on surface water use and quality under the NGCC alternative would be SMALL.

8.1.4 Aquatic Resources

Construction activities for the NGCC alternative (such as construction of heavy-haul roads, a new pipeline, and the power block) could affect drainage areas or other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected because the plant operator would likely implement BMPs to minimize erosion and sedimentation. Stormwater control measures, which would be required to comply with Pennsylvania NPDES permitting, would minimize the flow of disturbed soils into aquatic features. Depending on the available infrastructure at the selected site, the NGCC alternative may require modification or expansion of the existing intake or discharge structures. Because of the relatively low withdrawal rates compared to the SCPC or new nuclear alternatives, it is unlikely that the operators would need to construct new intake and discharge structures for the NGCC alternative at an existing power plant site. Dredging activities that result from infrastructure construction would require BMPs for in-water work to minimize sedimentation and erosion. Because of the short-term nature of the dredging activities, the hydrological alterations to aquatic habitats likely would be localized and temporary.

During operations, the NGCC alternative would require approximately one-third less cooling water to be withdrawn from the Schuylkill River, or other similar water body, than required for LGS Units 1 and 2. Because of the lower withdrawal rates, the number of fish and other aquatic resources affected by cooling-water intake and discharge operations, such as entrainment, impingement, and thermal stress, would be less for an NGCC alternative than for those associated with license renewal. The cooling system for a new NGCC plant would have similar chemical discharges as LGS, but the air emissions from the NGCC plant would emit particulates that could settle onto the river surface and introduce a new source of pollutants as described in Section 8.1.1. However, the flow of the Schuylkill River (or other water source) would likely dissipate and dilute the concentration of pollutants, resulting in minimal exposure to aquatic biota.

The impacts on aquatic ecology would be minor because construction activities would require BMPs and stormwater management permits, and because surface water withdrawal and discharge for this alternative would be less than for LGS Units 1 and 2. Deposition of pollutants into aquatic habitats from the plant's air emissions would be minimal because the concentration of pollutants would be diluted with the river flow. Therefore, the staff concluded that impacts on aquatic ecology would be SMALL.

Consultation with National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (FWS) under the Endangered Species Act (ESA) would ensure that the construction and operation of an NGCC plant would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. Consultation with NMFS under the Magnuson-Stevens Act would require the NRC to evaluate impacts to essential fish habitat (EFH). NMFS would provide conservation recommendations if there would be adverse impacts to EFH. Coordination with state natural resource agencies would further ensure that the plant operator would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of an NGCC plant on protected species and habitats would be SMALL.

8.1.5 Terrestrial Resources

Construction of an NGCC plant would occur at the site of an existing power station other than LGS and would require about 35 ac (14 ha) of land for the plant itself and about 7,630 ac (3,090 ha) of additional land off site for wells, collection stations, and pipelines to bring the gas to the plant (see Section 8.1.7). Because the onsite land requirement is relatively small, Exelon would likely be able to site most of the construction footprint in previously disturbed, degraded habitat, which would minimize impacts to terrestrial habitats and species. Offsite construction would occur mostly on land where gas extraction is occurring already. To the extent practicable, Exelon would route gas pipelines along existing, previously disturbed utility corridors (Exelon 2011). Erosion and sedimentation, fugitive dust, and construction debris impacts would be minor with implementation of appropriate BMPs (Exelon 2011). Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance, and operation of the mechanical draft cooling towers would be similar in magnitude and intensity as those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 1996). Overall, the impacts of construction and operation of an NGCC plant to terrestrial habitats and species would be SMALL.

Consultation with FWS under the ESA would ensure that the construction and operation of an NGCC plant would not adversely affect any Federally listed terrestrial species or adversely modify or destroy designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of an NGCC plant on protected species and habitats would be SMALL.

8.1.6 Human Health

Impacts on human health from construction of the NGCC alternative would be similar to effects associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since crews would limit active construction area access to authorized individuals. Impacts on human health from the construction of the NGCC alternative would be SMALL.

Human health effects of gas-fired generation are generally low, although in Table 8–2 of the GEIS (NRC 1996), the staff identified cancer and emphysema as potential health risks from gas-fired plants. Nitrogen oxide emissions contribute to ozone formation, which in turn contributes to human health risks. Emission controls for the NGCC alternative can be expected to maintain NO_x emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NO_x releases in the region will not increase. Health risks for workers may also result from handling spent catalysts used for NO_x control that may contain heavy metals. Impacts on human health from the operation of the NGCC alternative would be SMALL.

8.1.7 Land Use

The GEIS generically evaluates the impacts of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a four-unit NGCC plant at the LGS site. Locating the new NGCC power plant near an existing power plant site would maximize the availability of support infrastructure and reduce the need for additional land.

Exelon estimated 35 ac (14 ha) for new unit construction (Exelon 2011). Based on GEIS estimates, approximately 243 ac (98.3 ha) of land would be needed to support an NGCC alternative to replace the LGS (NRC 1996). This amount of land use would include other plant structures and associated infrastructure and is unlikely to exceed the 243 ac (98.3 ha) estimate, excluding land for natural-gas wells and collection stations. Exelon's estimate appears reasonable and is a more site-specific estimate than the GEIS estimate. Depending on the site location and availability of existing natural gas pipelines, a 100-feet (ft)-wide (30.5-meter [m]-wide) right-of-way (ROW) would be needed for a new pipeline. Land-use impacts from NGCC construction would be SMALL to MODERATE depending on location.

In addition to onsite land requirements, land would be required off site for natural-gas wells and collection stations. Scaling from GEIS (NRC 1996) estimates, approximately 7,630 ac (3,090 ha) would be required for wells, collection stations, and pipelines to bring the gas to the plant. Most of this land requirement would occur on land where gas extraction already occurs. Some natural gas could come from within Pennsylvania or nearby states.

The elimination of uranium fuel for LGS could partially offset some, but not all, of the land requirements for the NGCC. Scaling from GEIS (NRC 1996) estimates, approximately 1,640 ac (664 ha) would no longer be needed for mining and processing uranium during the operating life of the plant. Operational land-use impacts from an NGCC power plant would be SMALL.

8.1.8 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a power plant could affect regional employment, income, and expenditures. Two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the NGCC alternative were evaluated to measure their possible effects on current socioeconomic conditions.

Scaling from GEIS estimates, the construction workforce would peak at 2,650 workers. Exelon estimated 800 workers at the peak of construction (Exelon 2011). Exelon's estimate appears to be reasonable and is consistent with trends toward lowering labor costs by reducing the size of plant workforces. Therefore, Exelon's estimate of 800 workers is used throughout this analysis. The relative economic impact of this many workers on the local economy and tax base would vary, with the greatest impacts occurring in the communities where the majority of construction workers would reside and spend their income. As a result, local communities could experience a short-term economic "boom" from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate in order to be closer to the construction work site. However, given the proximity of many existing power plants to metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

After completing the installation of the four-unit NGCC plant, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of construction workers, socioeconomic impacts during construction in communities near the new NGCC site could range from SMALL to MODERATE.

Scaling from GEIS estimates, the plant operations workforce would be 331 workers. Exelon estimated a plant operations workforce of approximately 45 workers (Exelon 2011). Exelon's estimate appears to be reasonable and is consistent with trends toward lowering labor costs by reducing the size of plant operations workforces. Therefore, Exelon's estimate of 45 workers is used throughout this analysis. The reduction in employment at LGS from operations to decommissioning and shut down could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the region. However, the amount of property taxes paid to local jurisdictions under the NGCC alternative may increase if additional land is required to support this alternative. Based on the above discussion, socioeconomic impacts during operations could range from SMALL to MODERATE.

8.1.9 Transportation

Transportation impacts associated with construction and operation of a four-unit NGCC power plant would consist of commuting workers and truck deliveries of construction materials to the power plant site. During periods of peak construction activity, up to 800 workers could be commuting daily to the site (Exelon 2011), as described in Section 8.1.8. Workers commuting to the construction site would arrive by site access roads, and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Pipeline construction and modification to existing natural gas pipeline systems could also have a temporary impact. Some power plant components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction could range from SMALL to MODERATE.

Traffic-related transportation impacts would be greatly reduced after completing the installation of the new NGCC units. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and the removal of commercial waste material to offsite disposal or recycling facilities by truck. The NGCC alternative is estimated to require an operational workforce of 45 (Exelon 2011), as described in Section 8.1.8. Since fuel is transported by pipeline, the transportation infrastructure would experience little to no increased traffic from plant operations. Overall, transportation impacts would be SMALL during power plant operations.

8.1.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between the NGCC alternative and the surrounding landscape and the visibility of the new NGCC plant at an existing power plant site. During construction, all of the clearing and excavation would occur on the existing power plant site. These activities could be visible from offsite roads. Since the existing power plant site would already appear industrial, construction of the NGCC power plant would appear similar to other ongoing onsite activities. The power block of the NGCC alternative could look similar to the existing power plant.

The four NGCC units could be approximately 100 ft (30 m) tall, with exhaust stacks up to 150 ft (46 m) tall. The facility would be visible off site during daylight hours, and some structures may require aircraft warning lights. The addition of mechanical draft cooling towers and associated condensate plumes could add to the visual impact. However, the new NGCC power plant would appear smaller and may be less noticeable than LGS, which has two cooling towers over 500 ft (152m) high (Exelon, 2011). Noise generated during NGCC power plant operations would be limited to routine industrial processes and communications. Pipelines delivering natural gas fuel could be audible off site near gas compressor stations.

In general, given the industrial appearance of the existing power plant site, the new NGCC power plant would blend in with the surroundings and the NGCC power plant could be similar in appearance to the existing power plant. Aesthetic changes therefore would be limited to the immediate vicinity of the existing power plant site, and any impacts would be SMALL depending on its location and surroundings.

8.1.11 Historic and Archaeological Resources

To consider effects on historic and archaeological resources, any areas potentially affected by the construction of the NGCC alternative would need to be surveyed to identify and record historic and archaeological resources. An inventory of a previously disturbed former plant (brownfield) site may still be necessary if the site has not been previously surveyed or to verify the level of disturbance and evaluate the potential for intact subsurface resources. Plant operators would need to survey all areas associated with operation of the alternative (e.g., a new pipeline, roads, transmission corridors, other ROWs). Any resources found in these surveys would need to be evaluated for eligibility on the National Register of Historic Properties (NRHP), and mitigation of adverse effects would need to be addressed if eligible resources were encountered. Areas with the greatest sensitivity should be avoided. Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the site—also should be assessed.

The potential for impacts on historic and archaeological resources from the NGCC alternative would vary greatly depending on the location of the proposed site. Given that the preference is to use a previously disturbed former plant site, avoidance of significant historic and archaeological resources should be possible and effectively managed under current laws and regulations. However, historic and archaeological resources could potentially be affected, depending on the resource richness of the land required for a new pipeline. Therefore, the impacts on historic and archaeological resources from the NGCC alternative would range from SMALL to MODERATE.

8.1.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of a new power plant. Minority and low-income populations are subsets of the general public living near the proposed power plant site.

Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceed the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. For example, increased demand for rental housing during replacement power plant construction could disproportionately affect low-income populations that rely on the previously inexpensive rental housing market.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be directly affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could cause rental costs to rise disproportionately affecting low-income populations living near the site who rely on inexpensive housing. However, given the proximity of some existing power plant sites to metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

Emissions from the operation of a NGCC plant could affect minority and low-income populations as well as the general population living in the vicinity of the new power plant. However, all would be exposed to the same potential effects from NGCC power plant operations, and any impacts would depend on the magnitude of the change in ambient air quality conditions. Permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new NGCC power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.1.13 Waste Management

During the construction stage of the NGCC generation alternative, land clearing and other construction activities would generate waste that could be recycled, disposed of on site, or shipped to an offsite waste disposal facility. Because the alternative would be constructed at power plant sites with existing infrastructure, the amount of wastes produced during land clearing would be reduced.

During the operational stage, spent selective catalytic reduction (SCR) catalysts, which are used to control NO_x emissions from natural gas−fired plants, would make up most of the waste generated by this alternative (see Air Quality, Section 8.1.1)

According to the GEIS (NRC 1996), a natural gas-fired plant would generate minimal waste. Waste impacts therefore would be SMALL for an NGCC alternative.

Table 8–2. Summary of Environmental Impacts of the NGCC Alternative Compared to Continued Operation of the Existing LGS

	New NGCC at an Existing Power Plant Site	Continued LGS Operation
Air Quality	SMALL to MODERATE	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic Resources	SMALL	SMALL
Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL to MODERATE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL to MODERATE	SMALL
Aesthetics	SMALL	SMALL
Historic and Archaeological	SMALL to MODERATE	SMALL
Waste Management	SMALL	SMALL[a]

[a] As described in Chapter 6, the issue, “offsite radiological impacts (spent fuel and high level waste disposal),” is not evaluated in this EIS.

8.2 Supercritical Pulverized Coal-Fired Alternative

In this section, the NRC evaluates the environmental impacts of a supercritical pulverized coal-fired (SCPC) alternative to the continued operation of LGS. In the Commonwealth of Pennsylvania, 48 percent of electricity was generated using coal-fired power plants in 2010 (EIA 2012). Throughout the PJM, coal-fired units provided 47 percent of electricity in 2011 (Monitoring Analytics 2012). As noted by EIA in its Annual Energy Outlook (EIA 2011b), coal-fired generation historically has been the largest source of electri city in the United States and is expected to remain so through 2035. Baseload coal units have proven their reliability and can routinely sustain capacity factors of 85 percent or greater. Among the various boiler designs available, pulverized coal boilers producing supercritical steam (SCPC boilers) are the most likely variant for a coal-fired alternative given their generally high thermal efficiencies and overall reliability.

While nuclear reactors, on average, operate with capacity factors above 90 percent, the new SCPC coal-fired power plant would operate with roughly an 85 percent capacity factor. Despite the slightly lower capacity factor, a SCPC plant would be capable of providing adequate replacement power for a nuclear plant for the purposes of this NEPA analysis.

A myriad of sizes of pulverized coal boilers and steam turbine generators (STGs) are available; however, the staff presumes that four equal-sized boiler/STG powertrains, operating independently and simultaneously, would likely be used to match the power output of LGS. To complete this analysis, the staff presumes that all powertrains would have the same features, operate at generally the same conditions, have similar impacts on the environment, and be equipped with the same pollution-control devices such that once all parasitic loads are overcome, the net power available would be equal to 2,120 MWe. The staff assumes that 6 percent of an SCPC boiler's gross capacity is needed to supply typical parasitic loads (plant operation plus control devices for criteria pollutants to meet New Source Performance Standards). Introducing controls for GHG emissions (i.e., CCS) would cause the parasitic load to increase to 27 percent of the boiler's gross rated capacity (NETL 2010). However, because of uncertainty regarding future GHG regulations and the limited real-world experience in CCS at utility-scale power plants, parasitic loads associated with CCS are not considered. Various bituminous coal sources are available to coal-fired power plants in Pennsylvania. EIA reports that, in 2008, Pennsylvania produced electricity from coal with heating values of 11,549 British thermal units per pound (Btu/lb), sulfur content of 2.07 percent, and ash of 16.29 percent (EIA 2010a). For the purpose of this evaluation, the NRC presumes that coal burned in 2008 will be representative of coal that would be burned in a coal-fired alternative regardless of where it was located. Approximately 74 percent of the coal burned in Pennsylvania in 2008 came from mines in Pennsylvania. West Virginia, Wyoming, and Ohio supplied most of the remaining coal (EIA 2010a). Bituminous coals from Appalachian mines have CO_2 emission factors ranging from 202.8 to 210.2 lb per million Btu of heat input (Hong and Slatick 1994).

Exelon determined that the current LGS site was not viable to accommodate a coal-fired alternative with net generating capacity sufficient to meet the power production of LGS because of limited space on the LGS site, as explained in Section 8.0 (Exelon 2011). The staff concurs with that assessment and the analysis of the impacts of the coal-fired alternative assumes that the SCPC coal-fired power plant would be sited at an existing power plant site to take advantage of existing infrastructure. The site could be located in Pennsylvania or elsewhere in the PJM.

It is reasonable to assume that a coal-fired alternative would use supercritical steam (see text box). Supercritical steam technologies are increasingly common in new coal-fired plants. They are commercially available and are feasible alternatives to LGS license renewal. Supercritical plants operate at higher temperatures and pressures than older subcritical coal-fired plants and, therefore, can attain higher thermal efficiencies. While supercritical facilities are more expensive to construct than subcritical facilities, they consume less fuel for a given output, reducing environmental impacts throughout the fuel life cycle. The staff expects that a new, supercritical coal-fired plant would operate at a heat rate of 8,844 Btu/kWh (EIA 2010b), or approximately 38 to 39 percent thermal efficiency. However, heat inputs could be less, depending on the coal source and whether fuel blending is practiced in order to remain compliant with emission limitations.

Supercritical Steam

"Supercritical" refers to the thermodynamic properties of the steam being produced. Steam whose temperature and pressure is below water's "critical point" (3,200 pounds per square inch absolute [psia; 221 bar] and 705 °F [374 °C]) is subcritical. Subcritical steam forms as water boils and both liquid and gas phases are observable in the steam. The majority of coal boilers currently operating in the United States produce subcritical steam with pressures around 2,400 psia (165 bar) and temperatures as high as 1,050 °F (566 °C). Above the critical point pressure, water expands rather than boils, and the liquid and gaseous phases of water are indistinguishable in the supercritical steam that results. More than 150 coal boilers currently operating in the United States produce supercritical steam with pressures between 3,300–3,500 psia (228 to 241 bar) and temperatures between 1,000–1,100 °F (538–593 °C). Ultrasupercritical boilers produce steam at pressures above 3,600 psia (248 bar) and temperatures exceeding 1,100 °F (593 °C). There are only a few of these boilers in operation worldwide, and none in the United States.

The overall environmental impacts of a supercritical coal-fired alternative, as well as the environmental impacts of proposed LGS license renewal, are shown in Table 8–3. Additional details of the impacts on individual resources of the supercritical coal-fired alternative are provided in subsequent sections.

8.2.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, which is part of the Metropolitan Philadelphia Interstate Air Quality Control Region AQCR (40 CFR 81.15). With regard to the National Ambient Air Quality Standards (NAAQS), EPA has designated Montgomery and Chester Counties as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

A new SCPC generating plant would qualify as a new major-emitting industrial facility and would be subject to PSD under requirements of the CAA (EPA 2012a). The PADEP has adopted 25 Pa. Code Chapter 127, which implements the EPA's PSD review. The SCPC plant would need to comply with the standards of performance for electric utility steam generating units set forth in 40 CFR Part 60 Subpart Da.

Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including the review of the new sources that may affect visibility in any Federal Class I area. If an SCPC alternative was located close to a mandatory Class I area, additional air pollution control requirements would be required. As noted in Section 2.2.2.1, there are no mandatory Class I Federal areas within 50 miles (80 km) of the LGS site. There are a total of 13 designated Class 1 Federal areas (40 CFR 81) located in the following PJM states: Kentucky, Michigan, New Jersey, North Carolina, Tennessee, Virginia, and West Virginia.

A new SCPC plant would have to comply with Title IV of the CAA (42 USC §7651) reduction requirements for SO_2 and NO_x, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NO_x emission rates from the existing plants and a system of SO_2 emission allowances that can be used, sold, or saved for future use by the new plants.

More recently, the EPA has promulgated additional rules and requirements for certain fossil-fuel based power plants, such as coal. The Cross-State Air Pollution Rule (CSAPR), the Prevention of Significant Deterioration and Title V Greenhouse Gas (GHG) Tailoring Rule, and the Mercury and Air Toxics Standards (MATS) for Power Plants impose several additional standards to limit ozone, particulate, mercury, and GHG emissions from fossil-fuel–based power plants (EPA 2012c). A new SCPC plant would be subject to these additional rules and regulations.

The EPA has developed standard emission factors that relate the quantity of released air pollutants to a variety of regulated activities (EPA 2012b). Using these emission factors, the staff projects the following air emissions for the SCPC alternative:

- sulfur oxides (SO_x) – 14,876 tons (13,495 MT) per year,
- nitrogen oxides (NO_x) – 1,891 tons (1,716 MT) per year,
- carbon monoxide (CO) – 1,891 tons (1,716 MT) per year,
- PM_{10} – 1,232 tons (1,118 MT) per year,
- $PM_{2.5}$ – 616 tons (559 MT) per year
- carbon dioxide (CO_2) – up to 18,363,843 tons (16,659,678 MT) per year, and
- mercury (Hg) – 0.31 tons (0.28 MT) per year.

The above emission estimates assume that the SCPC plant implements certain pollution control devices, including wet calcium carbonate scrubbers for SO_2 control (operating at 95 percent removal efficiency), low-NO_x burners with overfire air and selective catalytic reduction for nitrogen oxide controls capable of attaining a NO_x removal of 86 percent, and fabric particulate filters with 99.9 percent removal efficiency.

Activities associated with the construction of the new SCPC plant would cause some additional temporary air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material-handling equipment. Emissions from workers' vehicles and motorized construction equipment exhaust would be temporary. The construction crews would use dust-control practices to control and reduce fugitive dust. The staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of the earth-moving and material-handling equipment would be SMALL.

8.2.1.1 Greenhouse Gas Emissions

The largest anthropogenic source of CO_2 emissions is the combustion of fossil fuels, especially coal. After a thorough examination of the scientific evidence and careful consideration of public comments, the EPA announced on December 7, 2009, that GHGs threaten the public health and welfare of the American people and meet the CAA definition of air pollutants. The construction and operation of the coal-fired alternative would emit GHGs, which likely contribute to climate change.

Greenhouse gas emissions from the construction of a coal-fired alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. All such impacts would be temporary.

The staff estimates that uncontrolled emissions of CO_2-e (carbon dioxide equivalents) from operation of the coal-fired alternative would amount to 18.36 million tons per year (16.66 million metric tons per year). From a life-cycle perspective, Sovacool (2008) found that coal-burning plants can have GHG footprints as high as 1,050 grams of carbon dioxide equivalent per kWh. For comparison, nuclear facilities and NGCC facilities have life-cycle GHG footprints of 66 grams of CO_2-e/kWh and 443 grams of CO_2-e/kWh, respectively. Although coal combustion in the boilers would be the primary source, other miscellaneous ancillary sources, such as truck and rail deliveries of materials to the site, commuting of the workforce, and deliveries of wastes to offsite disposal or recycling facilities, would contribute to the CO_2-e emissions from continued operations.

NETL estimates that further development could yield technologies that could capture and remove as much as 90 percent of the CO_2 from the exhausts of SCPC boilers. However, NETL also estimates that such equipment imposes a significant parasitic load that would result in a power production capacity decrease of approximately 27 percent (NETL 2010). In addition, permanent sequestering of the CO_2 would involve removing impurities (including water) and pressurizing it to meet pipeline specifications to transfer the gas, by pipeline, to acceptable geologic formations. Even when opportunities exist to use the CO_2 for enhanced oil recovery (rather than simply disposing of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the SCPC units are far removed from acceptable geologic formations. With CCS in place, the coal-fired alternative would release 1.84 million tons of CO_2 per year (1.67 million metric tons per year). Without CCS in place, the staff's projected CO_2 emissions for the SCPC alternative would be 18,363,843 tons (16,659,678 MT) per year.

The overall impact from the releases of GHGs of a coal-fired alternative would be MODERATE. Construction impacts would be temporary, but GHG emissions during operation would be noticeable.

8.2.1.2 Conclusion

Based on the above discussion, the overall air emissions and associated quality impacts from a new SCPC plant located at the LGS site would be MODERATE, primarily because of the noticeable impact during operations.

8.2.2 Groundwater Resources

Construction activities associated with the SCPC alternative could require more extensive groundwater dewatering as compared to the NGCC alternative, depending on the hydrogeologic conditions of the selected site. This is because of the more extensive excavation that would be required for the SCPC power block and the onsite disposal facility. Nevertheless, engineering measures, as described in Section 8.1.2, can be used to minimize impacts to facilitate construction. Facility construction would increase the amount of impervious surface at the site location and alter the subsurface strata because of excavation work and the placement of backfill following facility completion. At some sites, this could cause a localized decline in water-table elevation in a surficial aquifer, if present. However, recharge basins incorporated into the stormwater management system design can make such alterations undetectable at the site boundary. Below-grade portions of a new SCPC plant also could alter the direction of groundwater flow beneath a site, although such effects would likely be very localized at most site locations. Finally, application of BMPs in accordance with a state-issued NPDES general permit, including appropriate waste management, water discharge, and spill prevention practices, would prevent or minimize any groundwater quality impacts during construction.

During the construction period, groundwater could be used to provide water for potable and sanitary uses, concrete production, dust suppression, and soil compaction. However, it is more likely that water would be supplied via a temporary utility connection, if available, or trucked to the point of use from offsite sources. The SPCP alternative would require a peak construction workforce of 2,500 (Exelon 2011), as described in Section 8.2.8. While the potential demands for groundwater based on this workforce combined with construction uses might result in water demands nearing 100 gpm (380 L/min) during the peak construction period, the staff determined that any impacts would be very temporary and localized.

For SCPC plant operations, the NRC assumed that the SCPC alternative would entail the same relative ratio of groundwater use to surface water use as that used at LGS Units 1 and 2. This includes the use of groundwater for backup fire water supply and for potable and sanitary uses. Consequently, it is expected that total groundwater usage and potential aquifer effects would be much less under this alternative than those under current LGS operations. This is because of the smaller number of auxiliary systems requiring groundwater and the much smaller workforce under this alternative. The only mechanism identified that could adversely affect groundwater quality under normal operations would be operation of the disposal facility. However, the leaching of contaminants from the fly ash and scrubber sludge and impacts to groundwater can be minimized in modern facilities with protective barriers, disposal cell liners, and leachate collection and treatment systems, along with groundwater monitoring systems. Therefore, based on the above assessment, the impacts on groundwater use and quality under this alternative would be SMALL.

8.2.3 Surface Water Resources

Impacts from construction activities associated with the SCPC alternative on surface water resources would be expected to be similar to but somewhat greater than those under the NGCC alternative. This is attributable to the additional land required for construction of the power block and for excavation and construction of an onsite disposal facility for coal ash and scrubber sludge. However, additional offsite impacts, including hydrologic changes in affected streams and contaminant runoff, would occur from coal mining (see Section 8.2.7). At the SCPC site, some temporary impacts to surface water quality may result from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas and from dredging activities. There also would be the potential for water quality effects to occur from the extension or refurbishment of a rail spur to transport coal to the site location. Nevertheless, as described in Section 8.1.3, water quality impacts would be minimized by the application of BMPs and compliance with state-issued NPDES permits. Any dredging would be conducted under a permit from the COE requiring the implementation of BMPs to minimize impacts.

During operations, the SCPC alternative would use slightly less water than LGS because of the greater generation-efficiency of the SCPC technology. Therefore, the water resources impact assessment presented in Section 4.3.2 of this SEIS generally applies to the SCPC alternative. The NRC assumed that water treatment additives for the SCPC alternative would be essentially identical to LGS. Existing intake and discharge infrastructure would be used at the selected power plant site but it could require refurbishment or expansion. Similar to LGS, surface water withdrawals would be subject to applicable state water allocation requirements, and effluent discharges and stormwater discharges associated with industrial activity would be subject to a state-issued NPDES permit under this alternative. The NRC further assumes that the SCPC plant and waste disposal facility would be operated in accordance with appropriate management plans with adherence to appropriate BMPs and procedures to minimize the release of non-nuclear fuels, chemicals, and other materials to soil, surface water, and groundwater (see Section 8.1.3). As a result, the overall impacts on surface water use and quality from construction and operations under the SCPC alternative would be SMALL.

8.2.4 Aquatic Resources

Construction activities for the SCPC alternative (such as construction of heavy-haul roads and the power block) could affect drainage areas or other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected because the plant operator would likely implement BMPs to minimize erosion and sedimentation. Stormwater control measures, which would be required to comply with Pennsylvania NPDES permitting, would minimize the flow of disturbed soils into aquatic features. Depending on the available infrastructure at the selected site, the SCPC alternative may require modification or expansion of the existing intake or discharge structures, or construction of new intake and discharge structures. Dredging activities that result from infrastructure construction would require BMPs for in-water work to minimize sedimentation and erosion. Because of the short-term nature of the dredging activities, the hydrological alterations to aquatic habitats likely would be localized and temporary.

During operations, the SCPC alternative would require slightly less cooling water to be withdrawn from the Schuylkill River or other similar water body than required for LGS Units 1 and 2. The number of fish and other aquatic resources affected by cooling water intake and discharge operations, such as entrainment, impingement, and thermal stress, would be equal or less for an SCPC alternative compared to LGS. The cooling system for a new SCPC plant would have similar chemical discharges as LGS, but the SCPC plant would emit small amounts of ash and particulates that would settle onto the river surface and introduce a new source of pollutants as described in Section 8.2.1.

The impacts on aquatic ecology would be minor because construction activities would require BMPs and stormwater management permits, and because the surface water withdrawal and discharge for this alternative would be slightly less compared to LGS Units 1 and 2. Therefore, impacts on aquatic ecology would be SMALL.

Consultation with NMFS and FWS under ESA would ensure that the construction and operation of an SCPC plant would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. Consultation with NMFS under the Magnuson-Stevens Act would require the NRC to evaluate impacts to EFH. NMFS would provide conservation recommendations if there would be adverse impacts to EFH. Coordination with state natural resource agencies would further ensure that the plant operator would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation on protected species and habitats would be SMALL.

8.2.5 Terrestrial Resources

Construction of an SCPC plant would require approximately 280 ac (113 ha), as described in Section 8.2.7. The SCPC alternative may require up to 46,600 ac (18,860 ha) of additional land for coal mining and processing (NRC 1996). Approximately 464 ac (188 ha) of land also would be required for disposal of ash and scrubber sludge (Exelon 2011). However, land for disposal would likely be located on site (see Section 8.2.7). Because of the relatively large land requirement for the site, a portion of the site would likely be land that had not been previously disturbed, which would directly affect terrestrial habitat by removing existing vegetative communities and displacing wildlife. The level of direct impacts would vary substantially based on site selection. Offsite construction would occur mostly on land where coal extraction is ongoing. To the extent practicable, Exelon would route the railroad spur along an existing, previously disturbed railroad corridor. Erosion and sedimentation, fugitive dust, and construction debris impacts would be minor with implementation of appropriate BMPs (Exelon 2011). Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance, and operation of the cooling system would be similar in magnitude and intensity as those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 1996). Because of the potentially large area of undisturbed habitat that could be affected from construction of an SCPC plant, the impacts of construction on terrestrial habitats and species could range from SMALL to MODERATE depending on the specific site location. The impacts of operation would be SMALL.

As with the NGCC alternative, consultation with FWS under the ESA would avoid potential adverse impacts to Federally listed species or adverse modification or destruction of designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of an SCPC plant on protected species and habitats would be SMALL.

8.2.6 Human Health

Impacts on human health from construction of the SCPC alternative would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Therefore, impacts on human health from the construction of the SCPC alternative would be SMALL.

Coal-fired power plants introduce worker risks from coal and limestone mining, coal and limestone transportation, and disposal of coal combustion residues and scrubber wastes. In addition, there are public risks from inhalation of stack emissions and the secondary effects of eating foods grown in areas subject to deposition from plant stacks.

Human health risks of coal-fired power plants are described, in general, in Table 8–2 of the GEIS (NRC 1996). Cancer and emphysema as a result of the inhalation of toxins and particulates are identified as potential health risks to occupational workers and members of the public (NRC 1996). The human health risks associated with coal-fired power plants, both for occupational workers and members of the public, are greater than those of the current LGS reactors because of exposures to chemicals such as mercury, SO_x, NO_x, radioactive elements such as uranium and thorium contained in coal and coal ash, and polycyclic aromatic hydrocarbon (PAH) compounds, including benzo(a)pyrene.

Regulations restricting emissions enforced by either EPA or delegated state agencies have reduced potential health effects, but have not entirely eliminated them. These agencies also impose site-specific emission limits as needed to protect human health. Even if the coal-fired alternative were located in a nonattainment area, emission controls and trading or offset mechanisms could prevent further regional degradation; however, local effects could be visible. Many of the byproducts of coal combustion responsible for health effects are largely controlled, captured, or converted in modern power plants, although some level of health effects may remain.

Aside from emissions impacts, the coal-fired alternative introduces the risk of coal pile fires and for those plants that manage coal combustion residue liquids and sludge in waste impoundments, the release of the waste may result because of a failure of the impoundment. Failures of these sludge impoundments, while uncommon, have occurred. One notable incident was the December 22, 2008 dike failure at the Tennessee Valley Authority's Kingston, Tennessee CCW impoundment that spilled of over 1 billion gallons of coal ash slurry, covering more than 300 acres. Information on CCW impoundments can be found on the EPA's website:

http://www.epa.gov/epawaste/nonhaz/industrial/special/fossil/coalashletter.htm. Good housekeeping practices to control coal dust greatly reduce the potential for coal dust explosions or coal pile fires. . Free water also could be recovered from such waste streams and recycled and the solid or semi-solid portions removed to permitted offsite disposal facilities.

Overall, given extensive health-based regulation and controls likely to be imposed as permit conditions applicable to waste handling and disposal, the staff expects human health impacts from operation of the coal-fired alternative at an alternate site to be SMALL.

8.2.7 Land Use

The GEIS generically evaluates the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land-use impacts focuses on the amount of land area that would be affected by the construction and operation of an SCPC power plant at an existing power plant site.

Based on scaled GEIS estimates, more than 3,800 ac (1,540 ha) of land could be needed to support a coal-fired alternative to replace the LGS. This amount of land use would include other plant structures and associated infrastructure and is unlikely to exceed the 3,800 ac (1,540 ha) estimate, excluding land needed for coal mining and processing. Exelon estimated 280 ac (113 ha) for new unit construction (Exelon 2011). The NRC determined that this estimate is reasonable because it is consistent with land requirements for modern coal-fired facilities. It is expected that the SCPC alternative would be located at an existing power plant site or otherwise disturbed industrial site, and thus the land-use impacts from construction would range from SMALL to MODERATE. Depending on existing power plant infrastructure, additional land may be needed for frequent coal and limestone deliveries by rail or barge.

Offsite land-use impacts would occur from coal mining, in addition to land-use impacts from the construction and operation of the new power plant. Using the GEIS figure, the SCPC alternative might require up to 49,600 ac (20,100 ha) of land for coal mining and waste disposal during power plant operations. However, much of the land in existing coal mining areas already has experienced some level of disturbance. An additional 464 ac (188 ha) of land would be required for disposal of ash and scrubber sludge (Exelon 2011). It is likely that most of the land needed for disposal would be found within the 22,000 ac (8,900 ha) requirement estimated in the GEIS.

The elimination of uranium fuel for the LGS could partially offset some, but not all, of the land requirements for the SCPC alternative. Scaling from GEIS estimates, approximately 1,640 ac (660 ha) no longer would be needed for mining and processing uranium during the operating life of the SCPC plant. Since a substantial amount of land could be converted for coal and limestone delivery and waste disposal, land-use impacts could range from SMALL to MODERATE.

8.2.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the SCPC alternative were evaluated to measure their possible effects on current socioeconomic conditions.

Scaling from GEIS estimates, the construction workforce would peak at 5,638 workers. Exelon estimated 2,500 workers at the peak of construction (Exelon 2011). This estimate appears to be reasonable and is consistent with trends toward lowering labor costs by reducing the size of plant workforces. Therefore, Exelon's estimate of 2,500 workers is used throughout this analysis. The relative economic impact of this many workers on the local economy and tax base would vary, with the greatest impacts occurring in communities where the majority of construction workers reside and spend their income. As a result, local communities could experience a short-term "boom" from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate in order to be closer to the construction work site. However, given the proximity of many existing power plants to metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing. After completing the installation of the subcritical coal-fired power plant, local communities could experience a return to pre-construction economic conditions. Based on this information and given the number of construction workers, socioeconomic impacts during construction in local communities could range from SMALL to MODERATE.

Scaling from GEIS estimates, the plant operations workforce would be 564 workers. Exelon estimated a plant operations workforce of approximately 141 workers (Exelon 2011). This estimate appears to be reasonable and is consistent with trends toward lowering labor costs by reducing the size of plant operations workforces. Therefore, Exelon's estimate of 141 workers is used throughout this analysis. This alternative would result in a loss of approximately 700 relatively high-paying jobs at LGS, with a corresponding reduction in purchasing activity and tax contributions to the regional economy. In addition, the permanent housing market also could experience increased vacancies and decreased prices if operations workers and their families move out of the region. However, a larger amount of property taxes may be paid to local jurisdictions under the SCPC alternative as more land may be required for coal-fired power plant operations than LGS. Therefore, socioeconomic impacts during operations could range from SMALL to MODERATE.

8.2.9 Transportation

Transportation impacts associated with construction and operation of a four-unit, SCPC power plant would consist of commuting workers and truck deliveries of construction materials to the power plant site. During periods of peak construction activity, up to 2,500 workers could be commuting daily to the site (Exelon 2011), as described in Section 8.2.8. Workers commuting to the construction site would arrive by site access roads and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Some power plant components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction could range from MODERATE to LARGE.

Traffic-related transportation impacts on local roads would be greatly reduced after the completion of the power plant. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and the removal of commercial waste material to offsite disposal or recycling facilities by truck. During operations, the estimated number of operations workers commuting to and from the power plant would be 141 workers (Exelon 2011), as described in Section 8.2.8. The increase in traffic on roadways would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Frequent deliveries of coal and limestone by rail would add to the overall transportation impact. Onsite coal storage would make it possible to receive several trains per day. Limestone delivered by rail could also add additional traffic (though considerably less traffic than that generated by coal deliveries). Coal and limestone delivery and ash removal by rail would cause levels of service impacts on certain roads because of delays at railroad crossings. Overall, transportation impacts would be SMALL to MODERATE during power plant operations.

8.2.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between the SCPC alternative and the surrounding landscape and the visibility of the new SCPC plant at an existing power plant site. During construction, all of the clearing and excavation would occur on the existing power plant site. These activities could be visible from offsite roads. The coal-fired power plant could be approximately 100 ft (30 m) tall, with two to four exhaust stacks several hundred feet tall with natural-draft cooling towers approximately 400 to 500 ft (122 to 152 m) in height. The facility would be visible off site during daylight hours, and some structures may require aircraft warning lights. The condensate plumes from the cooling towers could add to the visual impact. Noise generated during power plant operations would be limited to routine industrial processes and communications.

In general, given the industrial appearance of the existing power plant site on which it would be built, the new SCPC power plant would blend in with the surroundings. The power block of the SCPC alternative could look very similar to the existing power plant and construction would appear similar to other ongoing onsite activities. Aesthetic changes would therefore be limited to the immediate vicinity of the existing power plant site, and any impacts would be SMALL depending on its location and surroundings.

8.2.11 Historic and Archaeological Resources

The impacts of the construction of a new SCPC alternative on historic and archaeological resources are similar to those impacts associated with activities for constructing an NGCC facility. Any areas potentially affected by the construction of the SCPC alternative would need to be surveyed to identify and record historic and archaeological resources. An inventory of a previously disturbed former plant (brownfield) site may still be necessary if the site has not been previously surveyed or to verify the level of disturbance and evaluate the potential for intact subsurface resources. Plant operators would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). Any resources found in these surveys would need to be evaluated for eligibility on the NRHP and mitigation of adverse effects would need to be addressed if eligible resources were encountered. Areas with the greatest sensitivity should be avoided. Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the site—should also be assessed.

The potential for impacts on historic and archaeological resources from the SCPC alternative would vary greatly depending on the location of the proposed site. However, given that the preference is to use a previously disturbed former plant site, avoidance of significant historic and archaeological resources should be possible and effectively managed under current laws and regulations. Therefore, the impacts on historic and archaeological resources from the SCPC alternative would be SMALL.

8.2.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of a new power plant. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be directly affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could cause rental costs to rise disproportionately affecting low-income populations who rely on inexpensive housing. However, given the proximity of some existing power plant sites to metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

Emissions from the operation of a SCPC plant could affect minority and low-income populations as well as the general population living in the vicinity of the new power plant. However, all would be exposed to the same potential effects from SCPC power plant operations and any impacts would depend on the magnitude of the change in ambient air quality conditions. Permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new SCPC power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.2.13 Waste Management

Coal combustion generates several waste streams, including ash (a dry solid) and sludge (a semi-solid byproduct of emission control system operation). The staff estimates that a 2,120-MW(e) power plant would use approximately 7,340,000 tons (6,659,000 MT) of coal annually with an ash content of 16.29 percent. This would generate approximately 1,196,000 tons (1,085,000 MT) of ash and 559,000 tons (507,125 MT) of scrubber sludge each year. About 538,059 tons (488,119 MT) or 45 percent of the ash waste would be marketed for beneficial use (Exelon 2011). Therefore, approximately 559,000 tons (507,125 MT) of ash would be disposed of on site if space were available. According to Exelon (2011), disposal of the ash and sludge would require approximately 464 ac (187 ha) over 20 years. Disposal of the remaining waste could noticeably affect land use and ground water quality, but with proper siting and implementation of groundwater monitoring and management practices, in accordance with 25 Pa. Code 290, it would not destabilize important resources. After closure of the waste site and revegetation, the land could be available for other uses.

The impacts from waste generated during construction would be minor, although, as discussed in the preceding paragraph, the impacts of managing the substantial amounts of solid waste, especially fly ash and scrubber sludge generated during operation of this coal-fired alternative would be MODERATE(NRC 1996). The amount of the construction waste would be small compared to the amount of waste generated during the operational stage and much of it could be recycled (i.e, marketed for beneficial use). Therefore, the staff concludes that the overall waste management impacts from construction and operation of this alternative would be MODERATE.

Table 8–3. Summary of Environmental Impacts of the Supercritical Coal-Fired Alternative Compared to Continued Operation of LGS

	Supercritical Coal-Fired Generation	Continued LGS Operation
Air Quality	MODERATE	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic Resources	SMALL	SMALL
Terrestrial Resources	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL to MODERATE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL to LARGE	SMALL
Aesthetics	SMALL	SMALL
Historic and Archaeological	SMALL	SMALL
Waste Management	MODERATE	SMALL[a]

[a] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

8.3 New Nuclear

In this section, the NRC evaluates the environmental impacts of a new nuclear alternative to LGS. In the Commonwealth of Pennsylvania, 34 percent of electricity was generated using nuclear power plants in 2010 (EIA 2012). Throughout the PJM, nuclear units also provided 34 percent of electricity in 2011 (Monitoring Analytics 2012). As noted by EIA in its Annual Energy Outlook (EIA 2011b), nuclear generation is expected to account for 3 percent of capacity additions through 2035. A new nuclear power plant is likely to be similar to LGS in terms of capacity factor.

Several designs are possible for a new nuclear facility. However, a two-unit nuclear power plant similar to the existing LGS in output is most likely. While two Westinghouse AP1000 reactors would provide an approximately equivalent output, it is possible that other designs also would be available. The new nuclear alternative would rely on a closed-cycle cooling system, similar to the cooling system currently in place at LGS.

In its ER, Exelon determined that the current LGS site was not viable to accommodate a new nuclear alternative with net generating capacity sufficient to meet the power production of LGS because of insufficient space at the LGS site (ER 2011). Exelon also indicated that a new nuclear alternative was most likely to be constructed on a site that already hosts a nuclear power plant. This placement would allow the new nuclear alternative to take advantage of existing site infrastructure, including transmission lines and some support facilities. The staff concurs that a new nuclear facility is most likely to be sited at the location of an existing nuclear power plant. Utilities in the PJM have expressed interest in either early site permits or combined licenses for new nuclear facilities at several sites, including Calvert Cliffs (in

Maryland), Hope Creek (New Jersey), North Anna (Virginia), and Bell Bend (adjacent to the Susquehanna site in Pennsylvania).

New nuclear power plants are commercially available and feasible alternatives to LGS license renewal. The overall environmental impacts of a nuclear alternative, as well as the environmental impacts of proposed LGS license renewal, are shown in Table 8–4. Additional details of the impacts on individual resources of the new nuclear alternative are provided in subsequent sections.

8.3.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, which is part of the Metropolitan Philadelphia Interstate Air Quality Control Region AQCR (40 CFR 81.15). With regard to the National Ambient Air Quality Standards (NAAQS), EPA has designated Montgomery and Chester Counties as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

A new nuclear generating plant would have similar air emissions to those of the existing LGS site; air emissions would be primarily from backup diesel generators and boilers as well as particulates from the cooling towers. As noted in Section 2.2.2.1, Exelon maintains a Title V operating permit (TVOP-46-00038) for sources of air pollution at the LGS site (Exelon 2011). Because air emissions would be similar for a new nuclear plant, the staff expects similar air permitting conditions and regulatory requirements.

Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including the review of the new sources that may affect visibility in any Federal Class I area. If a new nuclear plant were located close to a mandatory Class I area, additional air pollution control requirements may be required. As noted in Section 2.2.2.1, there are no Mandatory Class I Federal areas within 50 miles (80 km) of the LGS site. There are a total of 13 designated Class 1 Federal areas (40 CFR 81) located in the following PJM states: Kentucky, Michigan, New Jersey, North Carolina, Tennessee, Virginia, and West Virginia. The following air emissions were reported by Exelon and are from the year 2011 for the existing LGS site (Exelon 2012).

- sulfur oxides (SO_x) – 7.8 T (7.1 MT) per year,
- nitrogen oxide (NO_x) – 32.8 T (29.8 MT) per year,
- carbon monoxide (CO) – 24.2 tons (21.9 MT) per year, and
- PM_{10} and $PM_{2.5}$ – 166.3 T (150.9 MT) per year.

The staff expects similar air emissions from a new nuclear plant because these emissions are primarily from backup diesel generators that would also be used at a new nuclear plant.

Activities associated with the construction of the new nuclear plant would cause some additional temporary air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material-handling equipment. Emissions from workers' vehicles and motorized construction equipment exhaust would be temporary. The construction crews could use dust-control practices to control and reduce fugitive dust. The staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of the earth-moving and material-handling equipment would be SMALL.

8.3.1.1 Greenhouse Gas Emissions

In Chapter 6, the staff discussed the relative GHG emissions of nuclear power compared to other electric generation technologies. This discussion, where applicable, addressed the nuclear lifecycle, including construction and operation. Impacts during construction of this alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. However, all such impacts would be temporary.

Greenhouse gas emissions from the new nuclear alternative during operation arise primarily from operation of onsite diesel generators and other auxiliary equipment. For additional discussion of GHG emissions from nuclear generation, see Chapter 6.

Given the expected workforces, relatively short construction period, and minor GHG emissions during operation, the overall impact from the releases of GHGs of the new nuclear alternative would be SMALL.

8.3.1.2 Conclusion

The overall air quality impacts of a new nuclear plant located at the LGS site would be designated as SMALL.

8.3.2 Groundwater Resources

Under this alternative, deep excavation work on the order of 70 ft (21 m) below ground surface for the nuclear island may require active dewatering during construction. Depending on the site and local hydrogeology, this dewatering could have localized drawdown effects on local wells and require the use of cofferdams, sumps, wells, or other methods to address high water-table conditions. However, grout injection and diaphragm walls can be installed to effectively eliminate offsite drawdown impacts and reduce the need for dewatering. Facility construction also would increase the amount of impervious surface at the site location and alter the subsurface strata because of excavation work and the placement of backfill following facility completion. This could cause a localized decline in water-table elevation in the surficial aquifer, but the incorporation of recharge basins into the stormwater management system design can make such alterations undetectable at the site boundary. Below-grade portions of a new nuclear power plant also could alter the direction of groundwater flow beneath a site. Such effects would likely be localized at most site locations, encompassing the area around the nuclear island, and would not be expected to affect offsite wells at most sites. In addition, application of BMPs in accordance with a state-issued NPDES general permit, including appropriate waste management, water discharge, and spill prevention practices, would prevent or minimize any groundwater quality impacts during construction.

During the construction period, groundwater could be used to provide potable water for potable and sanitary uses, concrete production, dust suppression, and soil compaction. However, it is more likely that water would be supplied via a temporary utility connection, if available, or trucked to the point of use from offsite sources. Exelon (2011) estimated a peak construction workforce of 3,650. While the potential demands for groundwater based on this workforce combined with construction uses might result in water demands nearing 100 gpm (380 L/min) during the peak construction period, the staff determined that any effects would be temporary and localized. To support operations of a new nuclear power plant, the NRC assumed that this alternative would entail the same relative ratio of groundwater use to surface water use as that at LGS Units 1 and 2, along with a similar-sized workforce and operational activities. This includes the use of groundwater for backup fire water supply and for potable and sanitary uses. Therefore, the groundwater resources impact assessment presented in Section 4.4 of this SEIS generally applies to the new nuclear alternative. Based on this assessment, impacts on groundwater use and quality under this alternative would be SMALL.

8.3.3 Surface Water Resources

Surface water resources impacts from construction activities associated with the new nuclear alternative at an alternative site would be similar to but somewhat greater in scale than those described for the SCPC alternative (see Section 8.2.3). While no ash and sludge disposal facility would be required as under the SCPC alternative, deep excavation work for the nuclear island and more extensive site clearing and larger laydown area for facility construction would have potentially greater impacts to water resources from water use and stormwater runoff. Thus, temporary impacts to surface water quality may result from increased sediment loading and from any pollutants in stormwater runoff from disturbed areas and from any required dredging activities. Nevertheless, as described in Section 8.1.3, water quality impacts would be minimized by the application of BMPs and compliance with state-issued NPDES permits. Any dredging would be conducted under a permit from the COE requiring the implementation of BMPs to minimize impacts. To support operations of a new nuclear power plant, the NRC has assumed that the new facility would consumptively use and discharge the same amount of water as LGS. Therefore, the water resources impact assessment presented in Section 4.3.2 of this SEIS applies to the new nuclear alternative. In Section 4.3.2, the NRC determined that the impacts of LGS operations on surface water resources are SMALL. The NRC assumed that water treatment additives for this alternative would be essentially identical to LGS. Existing intake and discharge infrastructure would be used at the selected power plant site, but it could require refurbishment or expansion. Similar to LGS, surface water withdrawals would be subject to applicable state water allocation requirements, and effluent discharges and stormwater discharges associated with industrial activity would be subject to a state-issued NPDES permit. The NRC further assumes that the new nuclear plant would be operated in accordance with appropriate management plans with adherence to appropriate BMPs and procedures to minimize the release of non-nuclear fuels, chemicals, and other materials to soil, surface water, and groundwater (see Section 8.1.3). Therefore, based on this assessment, the overall impacts on surface water use and quality from construction and operations under the new nuclear alternative would be SMALL.

8.3.4 Aquatic Resources

Construction activities for the new nuclear alternative (such as construction of heavy-haul roads and the power block) could affect drainage areas or other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected because the plant operator would likely implement BMPs to minimize erosion and sedimentation. Stormwater control measures, which would be required to comply with state NPDES permitting, would minimize the flow of disturbed soils into aquatic features. Depending on the available infrastructure at the selected site, the new nuclear alternative may require modification or expansion of the existing intake or discharge structures, or construction of new intake and discharge structures. Dredging activities that result from infrastructure construction would require BMPs for in-water work to minimize sedimentation and erosion. Because of the short-term nature of the dredging activities, the hydrological alterations to aquatic habitats would likely be localized and temporary.

During operations, the new nuclear alternative would require a similar amount of water from the Schuylkill River, or other similar water body, as is required for LGS Units 1 and 2. The number of fish and other aquatic resources affected by cooling water intake and discharge operations, such as entrainment, impingement, and thermal stress, would be similar for a new nuclear alternative as for those associated with LGS Units 1 and 2, provided the cooling-water intake and blowdown operations involve a water body similar in species composition and populations to the Schuylkill River.

The impacts on aquatic ecology would be minor because construction activities would require BMPs and stormwater management permits, and because the surface water withdrawal and discharge for this alternative would be similar to LGS Units 1 and 2 (as discussed in Section 4.5). Therefore, the staff concluded that impacts on aquatic ecology would be SMALL.

Consultation with NMFS and FWS under ESA would ensure that the construction and operation of a new nuclear plant would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. Consultation with NMFS under the Magnuson-Stevens Act would require the NRC to evaluate impacts to EFH. NMFS would provide conservation recommendations if there would be adverse impacts to EFH. Coordination with state natural resource agencies would further ensure that the plant operator would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation on protected species and habitats would be SMALL.

8.3.5 Terrestrial Resources

The new nuclear alternative, including the new reactor units and auxiliary facilities, would affect 630 ac to 1,260 ac (255 ha to 510 ha) of land at the site of an existing power station other than LGS (Exelon 2011), as described in Section 8.3.7. Because of the significant land requirement for the site, impacts to terrestrial species and habitats would vary depending on the amount of previously undisturbed land that would be cleared for the new nuclear alternative. By siting the new nuclear alternative at an existing nuclear site or adjacent to an existing site, the majority of land that would be affected by construction would be developed or previously disturbed. However, as with the SCPC alternative, the level of direct impacts would vary based on site selection. Erosion and sedimentation, fugitive dust, and construction debris impacts would be minor with implementation of appropriate BMPs (Exelon 2011). Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance, and operation of the cooling system would be similar in magnitude and intensity to those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 1996). The offsite land requirement (1,000 ac (400 ha)) (NRC 1996) and impacts associated with uranium mining and fuel fabrication to support the new nuclear alternative would be no different from those occurring in support of LGS (see Section 8.3.7). Overall, the impacts of construction of a new nuclear facility on terrestrial species and habitats would be SMALL to MODERATE, and the impacts of operation would be SMALL.

As with the previously discussed alternatives, consultation with FWS under the ESA would avoid potential adverse impacts to Federally listed species or adverse modification or destruction of designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of new nuclear generation on protected species and habitats would be SMALL.

8.3.6 Human Health

Impacts on human health from construction of two new nuclear units would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of two new nuclear units would be SMALL.

The human health effects from the operation of two new nuclear power plants would be similar to those of the existing LGS Units 1 and 2. Most other noises during power plant operations would be limited to industrial processes and communications. Impacts on human health from the operation of two new nuclear units would be SMALL.

8.3.7 Land Use

As discussed in Section 8.1.7, the GEIS generically evaluates the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each plant site. The analysis of land-use impacts focuses on the amount of land area that would be affected by the construction and operation of a new two-unit nuclear power plant at or adjacent to an existing nuclear power plant site.

Based on GEIS estimates, approximately 1,000 ac (400 ha) of land would be needed for the new nuclear alternative. Exelon estimated 630 ac to 1,260 ac (255 ha to 510 ha) of land would be needed to construct and operate a new two-unit nuclear power plant (Exelon 2011). The NRC determined that Exelon's estimate is reasonable because it is consistent with land requirements for proposed new nuclear plants.

Locating the new units at or adjacent to an existing nuclear power plant would mean that the majority of the affected land area would already be zoned for industrial use. Making use of the existing infrastructure would reduce the amount of land needed to support the new units. Local residents are already accustomed to living near a nuclear power plant. Land-use impacts from constructing two new units at an existing nuclear power plant site would be SMALL.

The amount of land required to mine uranium and fabricate nuclear fuel during rector operations would be similar to the amount of land required to support LGS, although an additional amount of land would be required during the license renewal term. According to GEIS estimates, an additional 1,000 ac (400 ha) of land would be affected by uranium mining and processing during the life of the new nuclear power plant. Impacts associated with uranium mining and fuel fabrication to support the new nuclear alternative would generally be no different from those occurring in support of the existing LGS reactors. Overall land-use impacts from nuclear power plant operations would range from SMALL to MODERATE depending on whether the nuclear plant is sited entirely contained within an existing nuclear power plant site or if it located on open land.

8.3.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) power plant operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of a new nuclear power plant were evaluated in order to measure their possible effects on current socioeconomic conditions.

Exelon estimated 3,650 workers at the peak of construction (Exelon 2011). The relative economic impact of this many workers on the local economy and tax base would vary, with the greatest impacts occurring in communities where the majority of construction workers reside and spend their income. As a result, local communities could experience a short-term economic "boom" from increased tax revenue and income generated by construction expenditures and the increased demand for temporary (rental) housing and business services. Some construction workers could relocate in order to be closer to the construction work site. However, given the proximity of many existing power plants to metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

After completing the installation of the two new reactor units, local communities could experience a return to preconstruction economic conditions. Based on this information and given the number of construction workers, socioeconomic impacts during construction in local communities could range from SMALL to LARGE.

Exelon estimated that the number of operations workers at the new nuclear power plant would be similar to the number of operations workers at LGS (Exelon 2011). The amount of property taxes paid under the new nuclear alternative may increase if additional land is required to support this alternative. However, the reduction in employment at LGS from operations to decommissioning and shutdown could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the region. Therefore, socioeconomic impacts during operations could range from SMALL to MODERATE.

8.3.9 Transportation

Transportation impacts associated with construction and operation of a new nuclear power plant would consist of commuting workers and truck deliveries of construction materials to the power plant site. During periods of peak construction activity, up to 3,650 workers could be commuting daily to the site (Exelon 2011). Workers commuting to the construction site would arrive by site access roads and the volume of traffic on nearby roads could increase substantially during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads.
The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Some power plant components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction could range from MODERATE to LARGE.

Traffic-related transportation impacts on local roads would be greatly reduced after the completion of the power plant. Transportation impacts would include daily commuting by the operating workforce, equipment and materials deliveries, and the removal of commercial waste material to offsite disposal or recycling facilities by truck. During operations, the estimated number of operations workers commuting to and from the power plant would be 820 workers (Exelon 2011). Traffic-related transportation impacts would be similar to current operations at LGS, because the new units would employ the same number of workers as currently employed at LGS. Overall, transportation impacts would be SMALL to MODERATE during power operations.

8.3.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between the new nuclear power plant and the surrounding landscape and the visibility of the new units at an existing nuclear power plant site. The power block of the two new units would look very similar to the power block(s) at the existing nuclear power plant.

During construction, all of the clearing and excavation would occur on site. These activities may be visible from offsite roads. Since the existing power plant site already appears industrial, construction of the new nuclear power plant would appear similar to other ongoing onsite activities.

Located near an existing power plant, the tallest power plant structures, the natural draft cooling towers could be 400 to 500 ft (122 to 152 m) tall. Visible off site during daylight hours, they may require aircraft warning lights. Associated condensate plumes could add to the visual impact. Noise generated during power plant operations would mostly be limited to routine industrial processes and communications. Natural draft cooling towers would also generate noise.

In general, given the industrial appearance of an existing power plant site, the new nuclear power plant would blend in with the surroundings. Aesthetic changes would therefore be limited to the immediate vicinity of the existing power plant site, and any impacts would be SMALL to MODERATE, depending on its location and surroundings.

8.3.11 Historic and Archaeological Resources

The impacts of constructing the new nuclear alternative on historic and archaeological resources are similar to those impacts associated with activities for constructing an NGCC facility. Any areas potentially affected by the construction of the SCPC alternative would need to be surveyed to identify and record historic and archaeological resources. An inventory of a previously disturbed former plant (brownfield) site may still be necessary if the site has not been previously surveyed or to verify the level of disturbance and evaluate the potential for intact subsurface resources. Plant operators would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). Any resources found in these surveys would need to be evaluated for eligibility on the NRHP, and mitigation of adverse effects would need to be addressed if eligible resources were encountered. Areas with the greatest sensitivity should be avoided. Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the site—should also be assessed.

The potential for impacts on historic and archaeological resources from the new nuclear alternative would vary greatly depending on the location of the proposed site. However, given that the preference is to use a previously disturbed former plant site, avoidance of significant historic and archaeological resources should be possible and effectively managed under current laws and regulations. Therefore, the impacts on historic and archaeological resources from the new nuclear alternative would be SMALL.

8.3.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of a new power plant. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short-term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be directly affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day.

During construction, increased demand for rental housing in the vicinity of the site could affect low-income populations living near the plant site. However, given the proximity of some existing nuclear power plant sites to metropolitan areas, workers could commute to the construction site, thereby reducing the need for rental housing.

Potential impacts to minority and low-income populations from new nuclear power plant operations would mostly consist of radiological effects; however, radiation doses are expected to be well below regulatory limits. All people living near the nuclear power plant would be exposed to the same potential effects from power plant operations, and any impacts would depend on the magnitude of the change in ambient air quality conditions. Permitted air emissions are expected to remain within regulatory standards.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of a new nuclear power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.3.13 Waste Management

During the construction stage of the new nuclear alternative, land clearing and other construction activities would generate waste that could be recycled, disposed of on site, or shipped to the offsite waste disposal facility. Because the new nuclear plants would be constructed at a location on and adjacent to an existing nuclear power plant (although not at LGS because of space limitations), the amount of wastes produced during land clearing would be reduced.

During the operational stage, normal plant operations, routine plant maintenance, and cleaning activities would generate nonradioactive waste as well as mixed waste, low-level waste, and high-level waste. Quantities of nonradioactive waste (discussed in Section 2.3.1 of this SEIS) and radioactive waste (discussed in Section 6.1 of this SEIS) generated by Units 1 and 2 would be comparable to that generated by the new nuclear plants.

According to the GEIS (NRC 1996), the generation and management of solid nonradioactive waste during the terms of an extended license are not expected to result in significant environmental impacts. Two new nuclear plants would generate waste streams similar to those at nuclear plants that have undergone license renewal. Based on this information, the waste impacts would be SMALL for the new nuclear alternative.

Table 8–4. Summary of Environmental Impacts of the New Nuclear Alternative Compared to Continued Operation of the Existing LGS

	New Nuclear Alternative	Continued LGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic Resources	SMALL	SMALL
Terrestrial Resources	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL to MODERATE	SMALL
Socioeconomics	SMALL to LARGE	SMALL
Transportation	SMALL to LARGE	SMALL
Aesthetics	SMALL to MODERATE	SMALL
Historic and Archaeological	SMALL	SMALL
Waste Management	SMALL[(a)]	SMALL[(a)]

[(a)] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

8.4 Wind Alternative

The feasibility of wind as a baseload power source depends on the availability, accessibility, and constancy of the wind resource within the region of interest. Wind, in general, cannot be stored without first being converted to electrical energy.

Wind installations, which may consist of several hundred turbines, produce variable amounts of electricity. LGS, however, produces electricity almost constantly. Because wind installations deliver variable output when wind conditions change, wind cannot substitute for existing baseload generation on a one-to-one basis. In its ER, Exelon discusses the need for "firming capacity" to provide support to the variable wind resource and provide consistent baseload power. Firming capacity could come from other generators, from compressed air energy storage (CAES), from pumped hydroelectric storage, or from interconnected wind installations. Archer and Jacobsen (2007), indicates that an array of interconnected wind sites (19 in their study), spread across significant distances (with approximately 850 km (530 mi) distance from north to south and east to west) could provide 21 percent of installed capacity 79 percent of the time. While the sites in Archer and Jacobsen's study, in most cases, accessed higher power-class wind resources than are readily available onshore in PJM, the approach suggests that approximately 20 percent of the installed capacity in a series of interconnected wind installations could provide baseload power. Therefore, this study indicates that interconnecting windfarms, as assumed in this alternative, may provide a source of consistent, baseload power. In this alternative, the staff considers a wind alternative that relies on numerous, interconnected wind installations scattered across PJM. This arrangement ensures that generators are sufficiently dispersed so that low-wind or no-wind conditions are unlikely to occur at all or most locations at any given time.

Wind farms currently operate at much lower capacity factors than nuclear power. For example, LGS Unit 1 has operated at a 97 percent capacity factor over the years 2003 to 2010, while LGS Unit 2 has operated at a 96 percent capacity factor over the same period (NRC 2011). Currently, Department of Energy (DOE) estimates that wind turbine installations operate at 39 percent or lower capacity factors because of the variability of wind resources. As Exelon indicated in its ER, this capacity factor is likely to increase as wind turbine technology advances and as operators become more experienced in maximizing output. DOE indicates that, by 2020, onshore wind turbines may reach a 52 percent capacity factor, while offshore units may reach a 55 percent capacity factor (DOE 2008). As described in more detail below, the staff finds it likely that all wind turbines in this alternative will be land-based and, therefore, used the 52 percent capacity factor as an upper range of the capacity factor for this analysis.

For a lower range of the capacity factor used in this analysis, the staff reviewed PJM's 13 percent capacity factor to wind. (PJM 2010) Assuming a 13 percent capacity factor for wind, 18,000 MW(e) of wind would be necessary to replace 2,340 MW(e) of LGS because of the intermittency of wind.

Wind is a commercially available and feasible means of generating electricity. Assuming a range of 13 to 52 percent capacity factor, the staff, in this alternative, evaluates a wind-powered alternatives that contains between 4,500 MW(e) and 18,000 MW(e) of installed capacity. Relying on commonly available 2-MW(e) turbines, 2,250 to 9,000 turbines would be required to replace LGS. The NRC staff determined this was a reasonable alternative because wind is currently a source of energy generation within PJM. As of October 2012, approximately 6,000 MW of installed wind capacity exists within PJM (PJM 2012a). The installed wind capacity within Pennsylvania, Delaware, Maryland, New Jersey, Ohio, and West Virginia has grown on average 50 percent per year from 2000 through 2011 (DOE 2012). Similar growth is likely within the next several years. For example, as of January 2012, a total of 37,792 MW of wind energy generation is proposed within PJM (PJM 2012b). Similarly, in a recent update of PJM's renewable portfolio standards, PJM (2012a) estimated that 35,600 MW of wind energy would be installed by 2027.

As described above, this alternative assumes all wind would be generated onshore because it is currently commercially available and a feasible means of generating electricity. While some offshore wind development is possible by 2024, no commercial offshore wind installations currently operate in the United States, despite more than a decade of development efforts. In the Atlantic Ocean, several commercial wind-power projects have been proposed, but none have yet received final approvals or begun construction. The most prominent of these projects, Cape Wind would consist of 130 turbines with a maximum installed capacity of 468 MW. The project was initially proposed in 2001; however, because of significant delays related to permitting and the NEPA process, the project is currently scheduled to begin construction as soon as it completes its project financing phase (Cape Wind 2014). Cape Wind is the first and only U.S. offshore wind farm to have received all required Federal and State approvals, a commercial lease, and an approved construction and operations plan (BOEMRE, 2012b). Other projects offshore of Rhode Island and New Jersey are smaller than Cape Wind (Wald 2011), and another organization has proposed—though not yet constructed—a high-voltage direct-current powerline on the seafloor to connect offshore projects (Atlantic Wind Connection undated, Wald 2011). Additionally, a group working near Long Island proposed an installation of 700 MW(e) of wind capacity (Con Edison 2009). Finally, in October 2012, the Bureau of Ocean Energy Management reached an agreement with Bluewater Wind Delaware, LLC for a 96,430 ac (39,024 ha) commercial offshore wind energy lease off the coast of Delaware. (BOEM 2014). While wind data suggest there is potential for offshore wind farms along the coast of the mid-Atlantic and in the Great Lakes, project costs likely limit the future potential of large-scale projects (NREL 2010). NREL (2010) estimated that offshore project costs would run approximately 200 to 300 percent higher than land-based systems. Also, based on current prices for wind turbines, the 20-year levelized cost of electricity produced from an offshore wind farm would be above the current production costs from existing power generation facilities. In addition to cost, other barriers include the immature status of the technology, limited resource area, and high risks and uncertainty (NREL 2010).

Environmental impacts from the wind alternative are summarized in Table 8–5.

8.4.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, which is part of the Metropolitan Philadelphia Interstate Air Quality Control Region AQCR (40 CFR 81.15). With regard to the National Ambient Air Quality Standards (NAAQS), EPA has designated Montgomery and Chester Counties as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

Beyond maintenance of the wind turbines, there would be no routine air emissions associated with operations from wind generation. Activities associated with the construction and installation of the wind turbines would cause some temporary air pollutant emissions. However, emissions from workers' vehicles and construction equipment exhaust would be temporary. The staff concludes that the air quality impact from construction would be SMALL.

8.4.1.1 Greenhouse Gas Emissions

Wind releases no GHGs during operation, although some GHG emissions occur during component manufacturing, transportation, and installation, as well as during site preparation. Impacts from the construction of components of this alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. However, all such impacts would be temporary.

In general, wind is one of the least carbon-intensive electric generation options available. For a comparison to other means of electric generation, see the discussion in Chapter 6.

Given the expected relatively small workforces, short construction period, and GHG emissions resulting from site preparation and installation, the overall impact from the release of GHGs of the wind alternative would be SMALL.

8.4.1.2 Conclusions

Based on the above discussion, the overall air emissions and air quality impacts from the wind alternative would be designated as SMALL.

8.4.2 Groundwater Resources

Groundwater dewatering, where required for installation of wind turbines on land, would be minimal because of the small footprint of foundation structures and piling emplacements. For all construction activities, appropriate BMPs, including spill prevention practices, would be used during wind turbine construction to prevent or minimize impacts on groundwater quality.

Little or no groundwater use would be expected for operation of wind turbines, and no impacts on groundwater quality would be expected from routine operations. Consequently, the impacts on groundwater use and quality under this alternative would be SMALL.

8.4.3 Surface Water Resources

Small amounts of water would be required during the construction phase for each of the 2,250 wind turbines, including for dust suppression and soil compaction during site clearing and for concrete production for pad and piling construction, as appropriate. Although surface water from nearby water bodies may be used for pad site construction at some locations, it is likely that water would be procured from offsite sources and trucked to the point of use on an as needed basis. Use of ready-mix concrete also would reduce the need for onsite use of nearby water sources.

Further, the installation of land-based wind turbines would require installation of access roads and possibly transmission lines (especially for turbine sites not already proximal to transmission line corridors). Access road construction also would require some water for dust suppression and roadbed compaction and would have the potential to result in soil erosion and stormwater runoff from cleared areas. Water would likely be trucked to the point of use from offsite locations along with road construction materials. Construction activities would be conducted in accordance with state-issued NPDES or equivalent permits for stormwater discharges associated with construction activity, which would require the implementation of appropriate BMPs to prevent or mitigate water quality impacts.

To support operations of individual wind turbine installations, only very small amounts of water would be needed to periodically clean turbine blades and motors as part of routine servicing. It would be expected that water would be trucked to the point of use and procured from nearby sources. Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing would minimize the risks to soils and surface water resources from spills of petroleum, oil, and lubricant products and runoff associated with the turbine installations. Therefore, the impacts on surface water use and quality under the wind alternative would be SMALL.

8.4.4 Aquatic Resources

Construction activities for the land-based wind alternative (such as construction of heavy-haul roads and the wind turbines) could affect drainage areas and other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected because the plant operator would likely implement BMPs to minimize erosion and sedimentation. Stormwater control measures, which would be required if an NPDES permit was necessary, would minimize the flow of disturbed soils into aquatic features. During operations, the land-based wind alternative would not require consumptive water use.

The impacts on aquatic ecology would be minor because construction activities would likely require BMPs and stormwater management permits. During operations, the land-based wind alternative would not require consumptive water use. Therefore, impacts on aquatic ecology from the land-based wind alternative would be SMALL.

Consultation with NMFS and FWS under ESA would ensure that the construction and operation of wind farms would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. If wind farms were located near EFH, consultation with NMFS under the Magnuson-Stevens Act would require the NRC to evaluate impacts to EFH. NMFS would provide conservation recommendations if there would be adverse impacts to EFH. Coordination with state natural resource agencies would further ensure that the wind farm operators would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation on protected species and habitats would be SMALL.

8.4.5 Terrestrial Resources

The wind alternative would contain between 2,250 and 9,000 wind turbines requiring approximately 3,200 to 13,300 ac (1,300 to 5,400 ha) of land. This land estimate includes only the area directly affected by placement of turbines, and about two-thirds of this land area would only experience temporary disturbance during construction. The logistics of delivering heavy or oversized components to ideal locations such as hilltops or ridgelines would be challenging and might require extensive modifications to existing road infrastructures and construction of access roads that take circuitous routes to their destination to avoid unacceptable grades. However, once construction was completed, many access roads could be reclaimed and replaced with more-direct access to the wind farm for maintenance purposes. Likewise, land used for equipment laydown and turbine component assembly and erection could be returned to its original state. BMPs following construction that include plans to restore disturbed land would also reduce the impact of construction on terrestrial habitats. Because wind turbines require ample spacing between one another to avoid inter-turbine air turbulence, the footprint of utility-scale wind farms could be quite large. The turbines would be spread across a total area of 200 to 830 mi^2 (520 to 2,150 km^2), and most of this area will remain in compatible land uses, such as agriculture and forests (Exelon, 2011). During operations, only 5 to 10 percent of the total acreage within the footprint of wind installations would actually be occupied by turbines, access roads, support buildings, and associated infrastructure while the remaining land areas could be put to other compatible uses, including agriculture. Habitat loss and some habitat fragmentation may occur as a result, especially for wind turbines installed in forested areas. Overall, construction impacts on terrestrial species and habitats could range from SMALL to MODERATE.

Operation of wind turbines could uniquely affect terrestrial species through noise, collision with turbines and meteorological towers, site maintenance activities, disturbance associated with activities of the project workforce, and interference with migratory behavior. Bat and bird mortality from turbine collisions is a concern for operating wind farms; however, recent developments in turbine design have reduced the potential for bird and bat strikes. Additionally, impacts to those bird and bat species protected by the ESA, the Migratory Bird Treaty Act, or the Bald and Golden Eagle Protection Act would be mitigated through consultation with the appropriate agencies as discussed below. Impacts to terrestrial habitats and species from transmission line operation and corridor vegetation maintenance would be similar in magnitude and intensity to those resulting from operating nuclear reactors and would, therefore, be SMALL (NRC 1996). Overall, operation impacts to terrestrial species and habitats could range from SMALL to MODERATE.

As with the previously discussed alternatives, consultation with FWS under the ESA would avoid potential adverse impacts to Federally listed species or adverse modification or destruction of designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of a wind alternative on protected species and habitats would be SMALL.

8.4.6 Human Health

Impacts on human health from construction of the wind alternative would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of the wind alternative would be SMALL.

The Massachusetts Department of Environmental Protection (MassDEP), in collaboration with the Massachusetts Department of Public Health (MDPH), convened a panel of independent experts to identify any documented or potential health impacts of risks that may be associated with exposure to wind turbines (MassDEP and MDPH 2012). The panel conducted an extensive literature review of scientific literature, as well as other reports, popular media, and the public comments received by MassDEP, to write its report. Based on its review, the panel presented findings relative to three factors associated with the operation of wind turbines: noise and vibration, shadow flicker, and ice throw.

8.4.6.1 Noise and Vibration

Noise produced by wind turbines during operation depends on the design of the wind turbine. Propagation of the sound is primarily a function of distance from the wind turbine, but can also be affected by placement of the wind turbine, surrounding terrain, and atmospheric conditions. Infrasound refers to vibrations with frequencies below 20 Hertz (Hz). Infrasound at amplitudes over 100–110 decibels (dB) can be heard and felt. Research has shown that vibrations below these amplitudes are not felt. Through its research, the panel found that the highest infrasound levels measured near turbines are under 90 dB at 5 Hz and lower at higher frequencies for locations as close as 100 meters (m). The panel found that there was not sufficient evidence to conclude that noise and vibration from wind turbines cause negative impacts on human health (MassDEP and MDPH 2012).

8.4.6.2 Shadow Flicker

Shadow flicker results from the passage of the blades of a rotating wind turbine between the sun and the observer. The occurrence of shadow flicker depends on the location of the observer relative to the turbine and the time of day and year, and is found to be present only at distances of less than 1,400 m (4,600 ft) from the turbine. The panel found through its research that there was not sufficient evidence to conclude that shadow flicker causes negative impacts (such as seizures from photic stimulation) on human health (MassDEP and MDPH 2012).

8.4.6.3 Ice Throw

Ice can fall or be thrown from a wind turbine during or after an event when ice forms or accumulates on the blades. The distance that a piece of ice may travel from the turbine is a function of the wind speed, the operating conditions, and the shape of the ice. The panel found that in most documented cases of ice throw, the ice falls within a distance from the turbine equal to the tower height, and very seldom does the distance exceed twice the total height of the turbine (tower height plus blade length). The panel found that there is sufficient evidence that falling ice is a human health impact, and measures should be taken to ensure proper hazard minimization. Proper siting of the wind turbines, limitation of access by members of the public, and adequate training of persons in charge of maintenance of the facility will help to minimize the danger of ice throw (MassDEP and MDPH 2012).

Overall, given proper health-based regulation through procedures and access limitations, the staff expects human health impacts from operation of the wind alternative at an alternate site to be SMALL.

8.4.7 Land Use

As discussed in Section 8.1.7, the GEIS generically evaluates the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land-use impacts focuses on the amount of land area that would be affected by the construction and operation of new land-based wind farms in the PJM territory. Most of the wind farms would likely be located on open agricultural cropland, which would remain largely unaffected by the wind turbines.

Since wind turbines require ample spacing between one another to avoid air turbulence, the footprint of a utility scale wind farm could be quite large. Under the wind alternative, land-based turbines would be located on multiple wind farms spread across approximately 130,000 to 534,000 ac (53,000 to 216,000 ha or 200 to 830 mi^2 [520 to 2,150 km^2]) of land. A small portion of this land, approximately 3,200 to 13,300 ac (1,300 to 5,400 ha), would be directly affected by the placement of the wind turbines (Exelon 2011). This land would be temporarily affected during the installation of the turbines and the construction of support facilities, and about one-third of the land across a very wide area would be permanently impacted during the operation. Land in between the turbines can be used for farming or grazing.

Delivering heavy and oversized wind turbine components would also require the construction of temporary site access roads, some of which may require a circuitous route to their destination. However, once construction is completed, many temporary access roads can be reclaimed and replaced with more direct access to the wind turbines for maintenance purposes. Likewise, land used for equipment and material lay down areas, turbine assembly, and installation could be returned to its original state. During operations, however, only 5–10 percent of the total acreage within the wind farm is actually occupied by turbines, access roads, support buildings, and associated infrastructure while the remaining land area can be returned to its original condition or some other compatible use, such as farming or grazing.

The elimination of uranium fuel for LGS could partially offset some, but not all, of the land requirements for the wind farms. Scaling from GEIS estimates, approximately 1,640 ac (660 ha) would no longer be needed for mining and processing uranium during the operating life of the wind farms.

The wind farms would require a substantial amount of open land, although only a small portion would be used for wind turbines, access roads, and infrastructure. Therefore, land use impacts from the wind alternative would range from MODERATE to LARGE.

8.4.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the wind alternative were evaluated in order to measure their possible effects on current socioeconomic conditions.

Exelon estimated 200 construction and 50 operations workers would be required for this alternative (Exelon 2011). These numbers appear reasonable and in line with current construction and operational trends. Because of the relatively small number of construction workers and the large area covered by the wind farms (i.e., 200 to 830 mi^2 [520 to 2,160 km^2]), the relative economic impact of this many workers on local communities and the tax base would be SMALL. Given the small number of operations workers, socioeconomic impacts associated with operation of the wind farms would also be SMALL.

The reduction in employment at LGS could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the LGS region. However, the increased property taxes paid by wind farms may offset lost tax revenues in local jurisdictions. Based on this information, socioeconomic impacts during wind farm operations could range from SMALL to MODERATE.

8.4.9 Transportation

Transportation impacts during the construction and operation of the wind alternative would be less than the impacts for the NGCC, SCPC, and new nuclear alternatives, discussed in the previous sections, because of a smaller construction workforce and smaller volume of materials and equipment needed to be transported to the construction site.

As described in 8.4.8, up to 200 workers could be commuting daily to the site during periods of peak construction activity (Exelon 2011). Workers commuting to the construction site would arrive by site access roads and the volume of traffic on nearby roads could increase during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Transporting heavy and oversized wind turbine components on local roads could have a noticeable impact over a large area. Some components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction could range from SMALL to MODERATE depending on the location of the wind farm site, road capacities, and traffic volumes.

During plant operations, transportation impacts would not be noticeable. Exelon estimated an operational workforce of 50 workers (Exelon 2011). Given the small number of operations workers, transportation impacts on local roads would be SMALL.

8.4.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between the wind farms and the surrounding landscape and the visibility of wind turbines. In general, aesthetic changes would be limited to the immediate vicinity of the wind farms. However, wind turbines would have the greatest visual impact. At 400 ft (122 m) tall (Exelon 2011) and spread across multiple sites, wind turbines would dominate the view and would likely become the major focus of attention. Because wind farms are generally located in rural or remote areas, the introduction of wind turbines would be in sharp contrast to the visual appearance of the surrounding environment. Placing turbines along ridgelines would maximize their visibility. Wind turbines also generate noise. Most other noises would be limited to industrial processes and communications. Based on this information, aesthetic impacts from the construction and operation of a land-based wind alternative would range from MODERATE to LARGE depending on location and surroundings.

8.4.11 Historic and Archaeological Resources

To consider effects on historic and archaeological resources, any areas potentially affected by the construction of a wind alternative would need to be surveyed to identify and record historic and archaeological resources. Any resources found in these surveys would need to be evaluated for eligibility on the NRHP, and mitigation of adverse effects would need to be addressed if eligible resources were encountered. The owner of the wind farms would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). Areas with the greatest sensitivity should be avoided. Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the sites—also should be assessed.

The potential for impacts on historic and archaeological resources from the wind alternative would vary greatly, depending on the location of the proposed sites. Areas with the greatest sensitivity could be avoided or effectively managed under current laws and regulations. However, construction of wind farms and their support infrastructure have the potential to notably impact historic and archaeological resources because of earthmoving activities (e.g., grading and digging) and the aesthetic changes they may bring to the viewshed of historic properties located nearby. Therefore, depending on the resource richness of the site chosen for the wind farms and associated infrastructure, the impacts could range from SMALL to LARGE.

8.4.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of new wind farms. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could affect low-income populations. However, given the small number of construction workers and the possibility that workers could commute to the construction site, the need for rental housing would not be significant. Minority and low-income populations living in close proximity to the wind farms could be disproportionately affected by wind farm operations. However, operational impacts would mostly be limited to noise and aesthetic effects. The general public living near the wind farms would also be exposed to the same effects.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of new wind farms would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.4.13 Waste Management

During the construction stage of the wind alternative facility, land clearing and other construction activities would produce minor quantities of waste. Only small quantities of waste, such as dielectric fluids used during maintenance activities, would be produced during operation (Exelon 2011). In addition, Table 8–2 of the GEIS (NRC 1996), the staff identified very minor amounts of waste from maintenance of equipment and potentially removing vegetation. Based on this information, waste impacts would be SMALL for a wind turbine site.

Table 8–5. Summary of Environmental Impacts of the Wind Alternative Compared to Continued Operation of the Existing LGS

	Wind	Continued LGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic Resources	SMALL	SMALL
Terrestrial Resources	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Land Use	MODERATE to LARGE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL to MODERATE	SMALL
Aesthetics	MODERATE to LARGE	SMALL
Historic and Archaeological	SMALL to LARGE	SMALL
Waste Management	SMALL	SMALL[a]

[a] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

8.5 Purchased Power

The impacts from purchased power would depend substantially on the generation technologies used to supply the purchased power. Given PJM's market-based system operations, replacement power could come from different generators at different times of the year, so impacts are not necessarily predictable. Impacts from operation of other generators would likely occur in Pennsylvania or elsewhere in PJM.

Exelon assumed that purchased power would be available as a reasonable alternative for meeting load obligations if the LGS licenses are not renewed (Exelon 2011). The NRC staff finds this assessment reasonable given the large size of the PJM service area and wide range of existing and potential energy-producing facilities available to purchase power. Purchased power would likely come from one or more of the other types of alternatives considered in this chapter. As a result, operational impacts would be similar to the operational impacts of the alternatives considered in this chapter. Unlike the alternatives considered in this chapter, however, facilities from which power would be purchased would not likely be constructed solely to replace LGS. Purchased power may, however, require new transmission lines (which may require new construction), and may also rely on slightly older and less efficient power plants' operating at higher capacities than they currently operate. Exelon, in the ER, states that impacts would be "incremental and reflective of the increased amount of power being produced," and may vary based on fuels used, waste management practices, and facility locations (Exelon 2011). The NRC staff finds that assessment reasonable given the various parameters that influence the purchase of replacement power.

At some times, some portion of replacement power needs may be addressed by PJM's demand-response program, which the staff discusses in Section 8.6.14. As noted in

Section 8.6.14, impacts from DSM programs are generally small, although backup generators could impact air quality.

During operations, impacts from new nuclear, coal-fired, and natural gas–fired plants and wind energy projects would be similar to those described under the new nuclear, coal, natural gas, and wind alternatives in the previous sections. Impacts from the operations of existing coal and natural gas–fired plants would likely be greater than the operations of new plants because older plants are more likely to be less efficient and without modern emissions controls. Air quality impacts from the combination of all sources would likely be greater than license renewal because a large portion of the purchased power would likely be from coal- and natural gas–fired plants.

While purchased power is a reasonable alternative, the potential impacts of constructing and operating new power generating facilities are addressed elsewhere in this chapter. In general, the impacts would likely be greater than license renewal because of potential new construction and because continued operation of older plants could result in higher emissions. A brief summary of the impacts for each resource area is provided below.

8.5.1 Air Quality

New and continued nuclear and wind energy generation would not have noticeable impacts on air quality. New and continued natural gas- and coal-fired plants would have noticeable impacts on air quality; both natural gas- and coal-fired plants emit higher amounts of NO_x, SO_x, PM, PAHs, CO, CO_2, and mercury as compared to LGS Units 1 and 2, and would have noticeable impacts. Based on this information, air quality impacts would be SMALL to MODERATE for the purchase power alternative.

8.5.2 Groundwater and Surface Water

New and continued operation of nuclear, coal-fired, and natural gas–fired plants and wind energy projects would not have noticeable impacts on water resources assuming all energy generating facilities operate within their associated water quality and water use permits. Based on this information, groundwater and surface water impacts would be SMALL for the purchase power alternative.

8.5.3 Terrestrial and Aquatic

New and continued operation of existing natural gas–fired and nuclear plants would not have noticeable impacts on aquatic and terrestrial resources assuming plants are built in areas that avoid sensitive species and habitats. New land-based wind energy projects would not have noticeable impacts on aquatic resources assuming projects are built in areas that avoid sensitive species and habitats. New wind energy projects would have noticeable impacts on avian and bat communities. Any new transmission lines would likely be collocated with existing right-of-way, which would minimize impacts to ecological resources. New and continued operation of coal-fired plants would have noticeable impacts, primarily because of the deposition of ash and other pollutants and because of the extent of terrestrial habitat disturbance associated with coal mining. Based on this information, terrestrial and aquatic impacts would be SMALL to MODERATE for the purchase power alternative.

8.5.4 Human Health

New and continued operation of existing nuclear, coal-fired, and natural gas–fired plants and wind energy projects would not have noticeable impacts on human health because of the extent of regulations to protect public health. Based on this information, human health impacts would be SMALL for the purchase power alternative.

8.5.5 Land Use

Purchased power from existing nuclear power plants would not cause any land use changes. However, new power plants could be constructed to provide power, if necessary. Purchased power from coal- and natural gas-fired plants could have a noticeable impact on land use because of the amount of land required for coal mining and gas drilling. Wind energy projects would have a noticeable land-use impact because of the large amount of land required for wind farms. Any new transmission lines would likely be collocated with existing right-of-way, which would minimize any land use impacts. Based on this information, land use impacts would be SMALL ot LARGE for the purchase power alternative.

8.5.6 Socioeconomics, Transportation, and Aesthetics

Purchased power from existing power plants would not have any socioeconomic, transportation, or aesthetic impact, because there would be no change in power plant operations or workforce. If the amount of purchased power exceeds the available supply, new electrical power generating facilities would be needed. Construction and operation of a new electrical power generating facility to supply purchased power could cause noticeable socioeconomic, transportation, and aesthetic impacts in the communities located near the new facility. The intensity of the socioeconomic impact would depend on the number of workers required to build and operate the new electrical power generating facility and the amount of increased demand for housing and public services. Construction and operation of a new electrical power generating facility would also cause noticeable transportation impacts depending on the number of workers and truck deliveries required to build and operate the new electrical power generating facility. Traffic volumes would increase noticeably on local roads during shift changes.

Wind energy projects would have the greatest visual impact; wind turbines would dominate the view and would likely become the major focus of attention.

Whether or not there would be any socioeconomic, transportation, or aesthetic impacts would depend on whether a new electrical power generating facility was needed to supply purchased power. If a new power generating facility is needed, socioeconomic, transportation, and aesthetic impacts would range anywhere from SMALL to LARGE.

8.5.7 Historic and Archaeological Resources

No direct impacts on historic and archaeological resources are expected from purchased power. If new transmission lines were needed to convey power to the PJM area, surveys similar to those discussed in Section 8.1.11 would need to be performed. However, transmission lines would likely be collocated with existing right-of-ways minimizing any impacts to historic and archaeological resources.

Indirectly, construction of new nuclear, coal-fired, and natural gas–fired plants, wind energy projects and any new transmission lines to support the purchased power alternative could affect archaeological and historic resources. Any areas potentially affected by the construction would need to be surveyed to identify and record historic and archaeological resources. Resources found in these surveys would need to be evaluated for eligibility on the NRHP and mitigation of adverse effects would need to be addressed if eligible resources were encountered. Plant operators would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). The potential for impacts on historic and archaeological resources would vary greatly depending on the location of the proposed sites; however, using previously disturbed sites could greatly minimize impacts to historic and archaeological resources. Areas with the greatest sensitivity could be avoided or effectively managed under current laws and regulations. Therefore, depending on the resource richness of the sites chosen, the impacts could range from SMALL to LARGE.

8.5.8 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low income populations that could result from the construction and operation of new wind farms. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Purchased power from existing power plants would not have any environmental justice impact, because there would be no change in power plant operations or workforce. However, low-income populations could be disproportionately affected by increased utility bills because of the cost of purchased power. However, programs, such as the low income home energy assistance program in Pennsylvania, are available to assist low-income families in paying for increased electrical costs.

Construction of new electrical power generating facilities could have a noticeable impact. Potential impacts to minority and low income populations would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low income populations residing along site access roads would be affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could affect low income populations. However, many construction workers could commute to the construction site. Minority and low income populations living in close proximity to the new power generating facilities could be disproportionately affected by power plant operations. However, operational impacts would mostly be limited to noise and aesthetic effects.

Whether or not there would be disproportionately high and adverse impacts to minority and low income populations resulting from construction and operation of new electrical power generating facilities would depend upon the designs, sites chosen, and nearby population demographics and distribution.

8.5.9 Waste Management

New and continued operations of existing nuclear and natural gas–fired plants and wind energy projects would not have noticeable impacts. However, new and continued generation of coal-fired plants would have noticeable impacts because of the accumulation of ash and scrubber sludge.

The impacts presented in Table 8–6 represent the potential range of impacts from relying on purchased power to replace LGS. Impacts from operation of other generators would likely occur elsewhere in the PJM service area. The overall impacts would range from SMALL to MODERATE.

Table 8–6. Summary of Environmental Impacts of Purchased Power Compared to Continued Operation of the Existing LGS

	Purchased Power Alternative	Continued Operation of LGS
Air Quality	SMALL to MODERATE	SMALL
Groundwater Resources	SMALL	SMALL
Surface Water Resources	SMALL	SMALL
Aquatic & Terrestrial Resources	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL to LARGE	SMALL
Socioeconomics (including transportation and aesthetics)	SMALL to LARGE	SMALL
Historic and Archaeological	SMALL to LARGE	SMALL
Waste Management	SMALL to MODERATE	SMALL[a]

[a] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

8.6 Alternatives Considered but Dismissed

Alternatives to LGS license renewal that were considered and eliminated from detailed study are presented in this section. These alternatives were eliminated because of technical, resource availability, or current commercial limitations. Many of these limitations would continue to exist when the current LGS licenses expire.

8.6.1 Solar Power

Solar technologies, including photovoltaic (PV) and solar thermal (also known as concentrated solar power (CSP)), use the sun's energy to produce electricity at a utility scale. In PV systems, special PV materials convert the energy contained in photons of sunlight incident to direct current electricity that can be aggregated, converted to alternating current, and connected to the high-voltage transmission grid. Some PV installations, especially those located on existing buildings, provide power directly to consumers without first going onto the grid. CSP technologies produce electricity by capturing the sun's heat energy. CSP facilities are typically grid connected, and owing to their size and operational characteristics, are not located atop existing structures. Although some aspects of solar generation result in few environmental impacts, solar technology requires substantial land areas, and CSP technologies require roughly the same amount of water for cooling of the steam cycle as most other thermoelectric technologies.

The potential for solar technologies to serve as reliable baseload power alternative to LGS depends on the value, constancy, and accessibility of the solar resource. Both PV and CSP are enjoying explosive growth worldwide, especially for various off-grid applications or to augment grid-provided power at the point of consumption; however, discrete baseload applications still have technological limitations. As Exelon indicates in the ER, solar power generation typically requires backup generation or other means of balancing its variable output. Further, PV installations have no ability to provide power at night, and they provide reduced levels of power on overcast days, during fog events, and when snow accumulates. While their generation during summer months is high when electricity consumption is high, their capacity to generate electricity in winter declines before the evening electricity demand peaks.

EIA reports the total solar generating capacity (CSP and solar PV) in the United States in 2009 was 619 MW, 0.005 percent of the total nationwide generating capacity. Solar power produced 891,000 MWh of power in 2009, 0.02 percent of the nationwide production (EIA 2011a). The staff is not aware of any CSP facilities in the United States that are not located in the southwest, while many PV installations occur throughout the country. As a result, the staff determined that a solar-powered alternative in PJM would rely on solar PV technology rather than CSP technology.

Because PV does not produce electricity at night and produces diminished amounts of power during particular weather conditions, the staff does not consider solar PV to provide a viable, standalone alternative to license renewal. The staff considers a standalone PV alternative here, however, because Exelon includes solar PV in its range of alternatives to LGS license renewal in the ER, and because solar PV comprises a portion of the combination alternative in Section 8.6.2.

This section addresses only the solar PV impacts, and does not address impacts from load balancing or firming methods, which would be necessary for solar to serve as a standalone alternative to LGS. Technology to achieve load balancing or firming methods is not yet feasible or commercially available, which is part of the reason why the staff's determined that this alternative is not reasonable. As a result, this analysis likely understates potential impacts from a solar PV alternative because technology to achieve load balancing or firming methods would also result in environmental impacts. As discussed in the wind section, pumped hydroelectric storage, compressed air energy storage, and backup generating capacity could all conceivably offset the variable power output of solar PV facilities. Unlike wind, however, interconnected solar installations cannot span a sufficient area to provide consistent output at night.

Within the PJM, solar PV installations receive a 38 percent capacity credit (PJM 2010). On this basis, approximately 6,160 MW(e) of solar capacity would be necessary to replace LGS. Exelon indicates that a utility-scale solar PV facility located in PJM receives 2.8 to 3.9 kWh of solar radiation per square meter per day (2011). (These estimates take into account average weather conditions, and they also account for solar unavailability at night. The estimate thus also accounts for solar capacity factors.) As a result, Exelon estimated that a solar PV facility would require approximately 6.5 ha (16 ac) per MW(e) of capacity (Exelon 2011). The total area necessary for solar PV installations, then, is approximately 40,000 ha (98,900 ac).

The staff notes that much of the solar capacity installed in the PJM is likely to be in the form of rooftop installations. This type of installation minimizes land disturbance, can provide electricity directly to end-users, and minimizes the modifications necessary to the transmission system. Some land-based installations are also likely to occur. They would likely be larger than rooftop installations, and they would require some degree of land disturbance for installation purposes.

Environmental impacts from the solar PV alternative are summarized in Table 8–7.

8.6.1.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, and is part of the Metropolitan Philadelphia Interstate Air Quality Control Region AQCR (40 CFR 81.15). With regard to the National Ambient Air Quality Standards (NAAQS), EPA has designated Montgomery and Chester Counties as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

Beyond maintenance activities (e.g., serving equipment or repairs), there would be no routine air emissions associated with operations from solar PV. Activities associated with the construction and installation would cause some temporary air pollutant emissions. Emissions from workers' vehicles and construction equipment exhaust would be temporary. The staff concludes that the air quality impact from construction would be SMALL.

Greenhouse Gas Emissions

Solar PV installations release no GHGs during operation, although some GHG emissions occur during component manufacturing, transportation, and installation, as well as during site preparation. Greenhouse gas emissions during construction of this alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. However, all such impacts would be temporary. In general, solar PV installations are among the least carbon-intensive electric generation options available. For a comparison to other means of electric generation, see the discussion in Chapter 6.

Given the expected small workforces and GHGs emitted during construction, site preparation and installation, the overall impact from the release of GHGs of the solar PV alternative would be SMALL.

Conclusion

Based on the above analysis, the impact would be SMALL.

8.6.1.2 Groundwater Resources

For construction of solar PV installations, the need for groundwater dewatering likely would be minimal because of the small footprint and shallow depth of excavation for PV installations. For all construction activities, appropriate BMPs, including spill prevention practices, would be used during construction to prevent or minimize impacts on groundwater quality. Operation of PV units would not be expected to have any appreciable effect on groundwater resources. Based on the foregoing, the impacts on groundwater use and quality associated with the solar PV alternative would be SMALL.

8.6.1.3 Surface Water Resources

Siting and construction of solar PV installations would require relatively small amounts of water for dust suppression and soil compaction during site clearing and for concrete production. The NRC assumes that required water would be procured from offsite sources and trucked to the point of use on an as needed basis. Use of ready-mix concrete also would reduce the need for onsite use of nearby water sources. To support operations, water additionally would be required to clean PV panels. The staff expects that water would be trucked to the point of use and procured from nearby sources or could be supplied from a municipal water source. Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing of PV installations would minimize the risks to soils and surface water resources from spills of petroleum, oil, and lubricant products and runoff. As a result, the impacts on surface water use and quality under this alternative would be SMALL.

8.6.1.4 Aquatic Resources

Construction activities for the solar PV alternative (such as construction of heavy-haul roads and the solar panels) could affect drainage areas or other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected because BMPs would likely be used to minimize erosion and sedimentation at large facilities. Stormwater control measures, which would be required if an NPDES permit was necessary, would minimize the flow of disturbed soils into aquatic features. Many of the solar panels would be installed on rooftops. Because construction would occur within an existing structure, impacts to aquatic resources would be minimal. During operations, the solar PV alternative would not require consumptive water use.

For installations that do not occur on top of existing buildings, operators of the solar PV alternative would need to assess the occurrence and potential impacts to protected aquatic species within surface waters potentially affected during construction. In compliance with the ESA, FWCA, and the Magnuson-Stevens Act, the solar PV operators would need to consult with state officials, NMFS, and FWS to determine whether any avoidance or mitigation measures would be required and to ensure that construction and operation do not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat.

The impacts on aquatic ecology would be minor because construction activities would likely require BMPs and stormwater management permits. During operations, the solar PV alternative would not require consumptive water use. Therefore, impacts on aquatic ecology from the solar PV alternative would be SMALL.

8.6.1.5 Terrestrial Resources

Up to 155 mi^2 (420 km^2) of land would be needed to support a solar PV alternative to replace LGS if all installations were located at standalone solar sites (see Section 8.6.1.7). Because the solar PV alternative would include many relatively small installations on building roofs or existing residential, commercial, or industrial sites, impacts to terrestrial species and habitats would be minimal. Some installations may be built on standalone solar sites, and impacts to terrestrial species and habitats on these sites would vary greatly depending on site selection and the allocation of installations on buildings versus standalone sites. Because many of the installations would likely be installed in developed areas that are already connected to the regional electric grid, construction of additional transmission lines or access roads to solar PV installation sites would likely be unnecessary. The impacts of construction to terrestrial habitats and species could range from SMALL to MODERATE, and the impacts of operation to terrestrial habitats and species would be SMALL.

Impacts to protected species and habitats would only occur in locations where solar PV installations are constructed on standalone solar sites. However, as with the previously discussed alternatives, consultation with FWS under the ESA would avoid any potential adverse impacts to Federally listed species or adverse modification or destruction of designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of the solar PV alternative on protected species and habitats would be SMALL.

8.6.1.6 Human Health

The manufacture of solar cells involves the use of many hazardous chemicals, including toxic gases (e.g., arsine, phosphine, silane, sulfur hexafluoride, molybdenum hexafluoride, tungsten hexafluoride, hydrogen selenide, hydrochloric, and hydrofluoric acids), toxic metals (e.g., arsenic, cadmium, selenium, and various other heavy metals), and numerous flammable, corrosive, or highly reactive chemicals. In addition, the photocells contain cadmium, selenium, and other heavy metals. However, worker exposure to these hazards often are minimized. For example, a 2003 study conducted jointly by the Electric Power Research Institute (EPRI) and the California Energy Commission (CEC) concluded that the manufacture and use of photocells presented no significant health or environmental risk (EPRI and CEC 2003). In the study, EPRI and CEC (2003) state that the greatest possibility of human health risks comes from the manufacturing of the solar PV cells. The study states that, because of these health risks, extensive work has been done to reduce those hazards to plant workers. It also states that OSHA and similar state agencies set standards for allowable exposure limits to the various toxic chemicals used in the manufacturing process.

Impacts on human health from construction of the solar PV alternative would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of the solar PV alternative would be SMALL.

Solar PV panels are encased in heavy-duty glass or plastic. As a result, there is little risk that the small amounts of hazardous semiconductor material they contain will be released into the environment.

In the event of a fire, hazardous particulate matter could be released to the atmosphere. Given the short duration of fires and the high melting points of the materials found in the solar photovoltaic panels, the impacts from inhalation are minimal. Also, the risk of fire at ground-mounted solar installations is minimal because of precautions taken during site preparation, such as the removal of fuels and the lack of burnable materials contained in the solar photovoltaic panels. Another potential risk associated with photovoltaic systems and fire is the potential for shock or electrocution if a person would come in contact with a high-voltage conductor. Proper procedures and clear marking of system components should be used to provide emergency responders with appropriate warnings to diminish risk of shock or electrocution (OIPP 2010).

Photovoltaic solar panels do not produce electromagnetic fields at levels considered harmful to human health established by the International Commission on Non-Ionizing Radiation Protection. These small electromagnetic fields diminish significantly with distance and are indistinguishable from normal background levels within several yards (OIPP 2010).

Overall, given proper health-based regulation through procedures and access limitations, the staff expects human health impacts from operation of the Solar PV alternative at an alternate site to be SMALL.

8.6.1.7 Land Use

As discussed in Section 8.1.7, the GEIS generically evaluates the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land-use impacts focuses on the amount of land area that would be affected by the installation and operation of solar PV technologies. PV technologies would generally be installed on building roofs at existing residential, commercial, or industrial sites. Some solar installations may also be built at standalone solar sites. Land use impacts may vary depending on the amount of additional land required and the actual allocation of solar installations.

The footprint of a utility scale standalone PV solar installation would be quite large. Based on Exelon's local PJM territory estimates, approximately 98,900 ac (40,000 ha or 155 mi^2 [400 km^2]) of land would be needed to support a solar PV alternative to replace the LGS (Exelon 2011). Land required for a standalone PV solar installation would alter the existing land to energy production, and would preclude most other land uses from coexisting. Land would also be needed for transmission lines to connect PV solar installations to the electrical power grid and site access roads for maintenance purposes. Installing PV solar technologies on building rooftops would reduce the amount of land required for standalone solar.

The elimination of uranium fuel for the LGS would partially offset some, but not all, of the land requirements for standalone PV solar sites. Scaling from GEIS estimates, approximately 1,640 ac (660 ha) (NRC 1996) would no longer be needed for mining and processing uranium during the operating life of the plant. Based on this information, overall land-use impacts from the construction and operation of a PV solar alternative could range from SMALL to LARGE, depending in part on the extent to which PV installations occur on existing buildings rather than standalone sites.

8.6.1.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the PV alternative were evaluated in order to measure their possible effects on current socioeconomic conditions.

Exelon estimated 200 construction and 50 operations workers would be required for this alternative (Exelon 2011). These estimates appear reasonable and in line with current construction and operational trends. Because of the relatively small number of construction workers and the potentially large area covered by the PV solar installations at standalone sites and other locations, the relative economic impact of this many workers on local communities and the tax base would be SMALL. Given the small number of operations workers, socioeconomic impacts associated with operation of the PV solar installations would also be SMALL.

The reduction in employment at LGS could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the LGS region. However, the amount of property taxes paid for a utility-scale standalone PV solar installation may offset lost tax revenues in the socioeconomic region around local jurisdictions if more land is required for solar installations. Based on this information, socioeconomic impacts during PV solar power generating operations could range from SMALL to MODERATE.

8.6.1.9 Transportation

Transportation impacts during the construction and operation of the PV alternative would be similar to the wind alternative, discussed in Section 8.4.10, as a smaller construction workforce and smaller volume of materials and equipment would be needed to be transported to the construction site.

During periods of peak construction activity, up to 200 workers could be commuting daily to the sites (Exelon 2011). Workers commuting to the construction sites would arrive by site access roads and the volume of traffic on nearby roads could increase during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksites, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Delays may not be noticeable because the solar alternative may be spread across multiple sites. Some components and materials could also be delivered by train or barge, depending on the locations. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic related transportation impacts during construction could range from SMALL to MODERATE depending on the location of the standalone site, road capacities, and traffic volumes.

During plant operations transportation impacts would not be noticeable because of the small estimated operational workforce spread across multiple sites. Exelon estimated an operational workforce of 50 workers (Exelon 2011), which appears reasonable. Given the small numbers of operations workers, the traffic impacts on local roads from PV solar installation operations would be SMALL.

8.6.1.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between PV solar installations and the surrounding landscape and the visibility of PV installed technologies. In general, aesthetic changes would be limited to the immediate vicinity of PV solar installations.

As previously discussed, the footprint of a utility scale standalone PV solar installation would be quite large, and could create a noticeable visual impact. Spread across a large site, the utility scale standalone PV solar installation could dominate the view and would likely become the major focus of attention. The introduction of a utility scale standalone PV solar installation would be in sharp contrast to the visual appearance of the surrounding environment. Installing PV solar technologies on building rooftops, although noticeable to a lesser degree in urban settings, would reduce the amount of land required for standalone solar sites. Any noise at utility scale standalone PV solar installation would be limited to industrial processes and communications. Based on this information, aesthetic impacts from the construction and operation of a PV alternative could range from MODERATE to LARGE depending on the type of solar technology installed and its location and surroundings.

8.6.1.11 Historic and Archaeological Resources

Any areas potentially affected by the construction of the solar alternative would need to be surveyed to identify and record historic and archaeological resources. Resources found in these surveys would need to be evaluated for eligibility on the NRHP and mitigation of adverse effects would need to be addressed if eligible resources were encountered. Plant operators would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the sites—should also be assessed.

The impacts of the construction of a new solar PV alternative on historic and archaeological resources will vary depending on the form of the solar capacity installed in PJM. Rooftop installations minimize land disturbance and the modifications necessary to the transmission system, thereby minimizing impacts to historic and archaeological resources. Land-based installations are larger than rooftop installations and will require some degree of land disturbance for installation purposes, potentially causing greater impacts to historic and archaeological resources. Aesthetic changes caused by the installation of both forms could have a noticeable effect on the viewshed of nearby historic properties. Using previously disturbed sites for land-based installations and collocating any new transmission lines with existing right-of-ways could minimize impacts to historic and archaeological resources. Areas with the greatest sensitivity could be avoided or effectively managed under current laws and regulations. Therefore, depending on the resource richness of the sites chosen and the type of solar technology installed, the impacts could range from SMALL to LARGE.

8.6.1.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of PV solar installations. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects would only occur during certain hours of the day and not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. Increased demand for rental housing during construction could affect low-income populations. However, given the small number of construction workers and the possibility that workers could commute to the construction site, the need for rental housing would not be significant.

Minority and low-income populations living in close proximity to the PV solar installations could be disproportionately affected by operations. However, operational impacts would mostly be limited to aesthetic effects. The general public living near the PV solar installation would also be exposed to the same effects.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of PV solar installations would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.6.1.13 Waste Management

During the construction stage of a solar PV facility, land clearing and other construction activities would produce minor quantities of waste. During operation, very small quantities of waste might be produced when operators perform maintenance activities. Based on this information, waste impacts would be SMALL for the solar PV alternative.

Table 8–7. Summary of Environmental Impacts of the Solar PV Alternative Compared to Continued Operation of the Existing LGS

	Solar PV Alternative	Continued LGS Operation
Air Quality	SMALL	SMALL
Groundwater Resources	SMALL	SMALL
Surface Water Resources	SMALL	SMALL
Aquatic Ecology	SMALL	SMALL
Terrestrial Ecology	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL to LARGE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL to MODERATE	SMALL
Aesthetics	MODERATE to LARGE	SMALL
Historic and Archaeological	SMALL to LARGE	SMALL
Waste Management	SMALL	SMALL[a]

[a] As described in Chapter 6, the issue, “offsite radiological impacts (spent fuel and high level waste disposal),” is not evaluated in this EIS

8.6.2 Combination Alternative: Wind, Solar, and NGCC

The combination alternative consists of 2,300 MW(e) of installed wind capacity, 3,000 MW(e) of solar PV capacity, and 400 MW(e) of NGCC capacity to provide the balance needed to replace LGS. The impacts of this alternative are similar to the combined and scaled impacts of the NGCC, wind, and solar PV alternatives considered in Sections 8.1, 8.4, and 8.6.1, respectively. The staff assumes that sufficient rooftop space exists throughout the PJM to support installation of the solar-PV portion of this alternative solely on existing structures, thus minimizing potential for land-use and terrestrial ecology impacts from solar PV installations. The staff applied a capacity-factor-based approach to determining the relative amount of wind (much as it did in Section 8.4), and applied a capacity-credit approach to solar-PV capacity (using PJM's 38 percent capacity credit) in this alternative. The NGCC capacity considered here provides backup and firming capacity to the variable wind and solar PV resources, though it may not be adequate to provide full firming capacity at all times (e.g., on nights with little wind across PJM). At the same time, this alternative may produce markedly more power than LGS on days that are both sunny and windy.

Because this alternative may not be able to generate 2,340 MW(e) because of the variable wind and solar PV resources, the staff does not consider the wind, solar, and NGCC combination alternative to provide a viable, standalone alternative to license renewal. The staff considers a standalone alternative here, however, because Exelon includes a wind, solar, and NGCC combination alternative in its range of alternatives to LGS license renewal in the ER.

Table 8–8 summarizes the environmental impacts of the combination alternative compared to the continued operation of LGS.

8.6.2.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, and is part of the Metropolitan Philadelphia Interstate Air Quality Control Region AQCR (40 CFR 81.15). With regard to the National Ambient Air Quality Standards (NAAQS), EPA has designated Montgomery and Chester Counties as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

This alternative includes a combination of generation from wind, solar, and NGCC capacity. Operational air emissions would only be associated with the NGCC portion (400 MW[e]) of this alternative. The NGCC component would qualify as a new major-emitting industrial facility and would be subject to PSD under CAA requirements (EPA 2012a). The Pennsylvania Department of Environmental Protection (PADEP) has adopted 25 Pa. Code Chapter 127, which implements the EPA's PSD review. The NGCC plant would need to comply with the standards of performance for stationary combustion turbines set forth in 40 CFR Part 60 Subpart KKKK.

Subpart P of 40 CFR Part 51.307 contains the visibility protection regulatory requirements, including the review of the new sources that may affect visibility in any Federal Class I area. If the NGCC component of this combination alternative were located close to a mandatory Class I area, additional air pollution control requirements would be required. As noted in Section 2.2.2.1, there are no Mandatory Class I Federal areas within 50 miles (80 km) of the LGS site. There are a total of 13 designated Class 1 Federal areas (40 CFR 81) located in the following PJM states: Kentucky, Michigan, New Jersey, North Carolina, Tennessee, Virginia, and West Virginia.

A new NGCC plant would have to comply with Title IV of the CAA (42 USC § 7651) reduction requirements for SO_2 and NOx, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NOx emission rates from the existing plants and a system of SO_2 emission allowances that can be used, sold, or saved for future use by the new plants.

More recently, EPA has promulgated additional rules and requirements that apply to certain fossil-fueled power plants, such as NGCC generation. The Cross-State Air Pollution Rule (CSAPR) and the Prevention of Significant Deterioration and Title V Greenhouse Gas (GHG) Tailoring Rule impose several additional standards to limit ozone, particulate, and GHG emissions from fossil-fuel–based power plants (EPA 2012c). A new NGCC plant would be subject to these additional rules and regulations.

The EPA has developed standard emission factors that relate the quantity of released air pollutants to a variety of regulated activities (EPA 2012b). Using these emission factors, the staff projects the following air emissions for the NGCC portion of this alternative:

- sulfur oxides (SO_x) – 31.4 tons (28.5 MT) per year,
- nitrogen oxides (NO_x) – 91.5 tons (83.0 MT) per year,
- carbon monoxide (CO) – 138.7 tons (125.8 MT) per year,
- PM_{10} and $PM_{2.5}$ – 61.0 tons (55.4 MT) per year, and
- carbon dioxide (CO_2) – 1,016,100 tons (922,622 MT) per year.

Activities associated with the construction of the combination alternative, which include wind, solar, and NGCC, would cause some additional temporary air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material-handling equipment. Emissions from workers' vehicles and motorized construction equipment exhaust would be temporary. Construction crews would use dust-control practices to control and reduce fugitive dust. The staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of the earth-moving and material-handling equipment would be SMALL.

<u>Greenhouse Gas Emissions</u>

As discussed in Sections 8.1.1 and 8.2.1, combustion of fossil fuels, including natural gas, is the greatest anthropogenic source of GHG emissions in the United States. As noted in Sections 8.4.1 and 8.6.1.1—and discussed in Section 6.2—wind and solar PV generation are among the least GHG-intensive generation options available.

Greenhouse gas emissions during construction of this alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. However, all such impacts would be temporary.

Only the NGCC portion of this alternative would emit GHGs during operations, and it would emit approximately 25 percent of the emissions of the full NGCC alternative that the staff evaluated in Section 8.1.1. As discussed in Section 8.1.1, NETL estimates that CCS will capture and remove as much as 90 percent of the CO_2 from the exhausts of combustion turbines but will result in a power production capacity decrease of approximately 14 percent, a reduction in net overall thermal efficiency of the CTs studied from 50.8 percent to 43.7 percent, and a potential increase in the levelized cost of electricity produced in NGCC units so equipped by as much as 30 percent (NETL 2007). Further, permanent sequestering of the CO_2 would involve removing impurities (including water) and pressurizing it to meet pipeline specifications and transferring the gas by pipeline to acceptable geologic formations. Even when opportunities exist to use the

CO_2 for enhanced oil recovery (rather than simply disposing of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the NGCC unit is far removed from acceptable geologic formations. With CCS in place, the NGCC portion of this alternative would release 92,262 MT per year (0.102 million tons) of CO_2. Without CCS in place, the staff's projected CO_2 emissions for the NGCC portion would be 922,622 MT (1,016,100 tons) per year.

Given the expected relatively small workforces, relatively short period for constructing the alternatives' components, and GHG emissions resulting from operations of the NGCC portion, the overall impact from the release of GHGs of the combination alternative would be SMALL to MODERATE.

Conclusion

There would be no routine air emissions associated with the wind and solar component of this alternative. However, the NGCC component of this alternative would result in routine air emissions. Therefore, the overall air-quality impact from this combination alternative would be SMALL to MODERATE.

8.6.2.2 Groundwater Resources

Impacts on groundwater resources from constructing and operating a new NGCC plant under this alternative would be a fraction of those described in Section 8.1.2. For construction of wind turbine and solar PV installations, the need for groundwater dewatering likely would be minimal. For all construction activities, appropriate BMPs, including spill prevention practices, would be used during wind turbine construction to prevent or minimize impacts on groundwater quality. Operation of the wind turbine and PV components of this alternative would not be expected to have any appreciable effect on groundwater resources. Based on the above, the impacts on groundwater use and quality under this alternative would be SMALL.

8.6.2.3 Surface Water Resources

Impacts on surface water resources from constructing and operating a new NGCC plant under this alternative would be a fraction of those described in Section 8.1.3 because the NGCC component has been scaled back to 400 MW(e). Construction of the wind turbine and solar PV installations would each require relatively small amounts of water for dust suppression and soil compaction during site clearing and for concrete production. The NRC assumes that required water would be procured from offsite sources and trucked to the point of use on an as needed basis. Use of ready-mix concrete would also reduce the need for onsite use of nearby water sources.

To support operation of individual wind turbine installations, only very small amounts of water would be needed to periodically clean turbine blades and motors as part of routine servicing. Water also would be required to clean PV panels. The staff expects that water would be trucked to the point of use and procured from nearby sources. Adherence to appropriate waste management and minimization plans, spill prevention practices, and pollution prevention plans during servicing of turbine and PV installations would minimize the risks to soils and surface water resources from spills of petroleum, oil, and lubricant products and runoff. As a result, the impacts on surface water use and quality under the combination alternative would be SMALL.

8.6.2.4 Aquatic Resources

Construction activities for the wind, solar, and NGCC combination alternative (such as construction of heavy-haul roads, the NGCC power block, wind turbines, and solar panels) could affect drainage areas or other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected because BMPs would likely be used to minimize erosion and sedimentation. Stormwater control measures, which would be required to comply with Pennsylvania NPDES permitting, would minimize the flow of disturbed soils into aquatic features. Depending on the available infrastructure at the selected site, the NGCC plant may require modification or expansion of the existing intake or discharge structures. Because of the relatively low withdrawal rates compared to the NGCC, SCPC, or new nuclear alternatives, it is unlikely that the operators would need to construct new intake and discharge structures for the combination alternative. Dredging activities that result from infrastructure construction would require BMPs for in-water work to minimize sedimentation and erosion. Because of the short-term nature of the dredging activities, the hydrological alterations to aquatic habitats would likely be localized and temporary.

Similar to the NGCC alternative described in Section 8.1.4, during operations, the NGCC component of the combination alternative would require cooling water to be withdrawn from the Schuylkill River or other similar water body, would have chemical discharges, and would emit some pollutants that could settle onto the river surface. However, these impacts would be less than that described in Section 8.1.4 because NGCC would be a smaller portion of this alternative. During operations, the solar PV and wind components of the combination alternative would not require consumptive water use.

The impacts on aquatic ecology would be minor because construction activities would require BMPs and stormwater management permits, and because the surface water withdrawal and discharge for this alternative would be less than for LGS Units 1 and 2. Therefore, the staff concluded that impacts on aquatic ecology would be SMALL.

Consultation with NMFS and FWS under ESA would ensure that the construction and operation of wind, solar, NGCC plants would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. If new infrastructure were located near EFH, consultation with NMFS under the Magnuson-Stevens Act would require NRC to evaluate impacts to EFH and NMFS would provide conservation recommendations if there would be adverse impacts to EFH. Coordination with state natural resource agencies would further ensure that the plant and wind farm operators would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation on protected species and habitats would be SMALL.

8.6.2.5 Terrestrial Resources

Impacts to terrestrial species and habitats from construction and operation of this combined alternative would be similar to those described under each individual alternative in Sections 8.1.5, 8.4.5, and 8.6.1.5. The same is true of mitigation measures. The primary difference in this alternative is that each portion of this alternative is smaller than the full-replacement alternatives considered in Sections 8.1, 8.4, and 8.8.1. Also, solar PV capacity would be installed almost entirely at already-developed sites on building rooftops. The wind-power portion of this alternative would require approximately half of the area required for the standalone wind alternative in Section 8.4. The development of the solar component on land already in use for other purposes, combined with the reduced size of the wind-power component, would likely result in minimal additional impacts to terrestrial species and habitats during construction and operation. The NGCC component of this alternative would be smaller and require less land than the NGCC plant described in Section 8.1.5. This alternative still assumes that the NGCC plant would be sited on an already existing power station other than LGS, and predominantly previously developed or pre-disturbed land would be affected. The impacts of construction and operation of this alternative on terrestrial species and habitats would be SMALL because of this alternative's extensive use of developed or previously disturbed land.

Because the solar PV installations would be sited on buildings and other already-developed sites, impacts to protected species and habitats would be most likely to occur as a result of the wind or NGCC component of this alternative. As with the previously discussed alternatives, consultation with FWS under the ESA would avoid potential adverse impacts to Federally listed species or adverse modification or destruction of designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation of this alternative on protected species and habitats would be SMALL.

8.6.2.6 Human Health

Impacts on human health from construction of the wind alternative, the NGCC alternative, and the solar PV portion of this alternative would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of the wind alternative would be SMALL.

Given proper health-based regulation through procedures and access limitations, the staff expects human health impacts from operation of the solar PV and the wind portions of this alternative at an alternate site to be SMALL.

The staff notes that human health effects of gas-fired generation are generally low, although in Table 8–2 of the GEIS (NRC 1996), the staff identified cancer and emphysema as potential health risks from gas-fired plants. NO_x emissions contribute to ozone formation, which in turn contributes to human health risks. Emission controls on the NGCC alternative can be expected to maintain NO_x emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NO_x releases in the region will not increase. Health risks for workers may also result from handling spent catalysts used for NO_x control that may contain heavy metals. Impacts on human health from the operation of the NGCC alternative would be SMALL.

8.6.2.7 Land Use

As discussed in Section 8.1.7, the GEIS (NRC 1996) generically discusses the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land-use impacts here focuses on the amount of land area that would be affected by the construction and operation of a combination of wind turbines, PV solar installations, and a NGCC power plant in the PJM territory.

Land-use impacts from this alternative would be similar those described for each of the alternatives described in Sections 8.1.7, 8.4.7, and 8.6.1.7. Because each component of this alternative would individually be generating less electricity, the magnitude of the impacts from each individual component would be less than those previously described. For example, under this combination alternative, solar PV technology would be installed on existing building rooftops, and approximately half the number of wind turbines would be installed as would be installed in the standalone wind alternative (Section 8.4). In addition, the NGCC component would be constructed at an existing power plant site.

The elimination of uranium fuel for the LGS would partially offset some, but not all, new land requirements. Scaling from GEIS estimates, approximately 1,640 ac (660 ha) would no longer be needed for mining and processing uranium during the operating life of the plant. Based on this information, overall land-use impacts from the construction and operation of a combination of wind, solar, and NGCC alternatives would range from SMALL to MODERATE.

8.6.2.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of a combination of wind turbines, PV solar installations, and a NGCC power plant were evaluated in order to measure their possible effects on current socioeconomic conditions.

Approximately 200 construction and 50 operations workers would be required for the utility scale wind alternative and 200 construction and 50 operations workers would be required for the solar alternative (see Sections 8.4.8, and 8.6.1.8) (Exelon 2011). These estimates appear reasonable and in line with current construction and operational trends. The construction and operation workforce requirements for these two components of this combination alternative would be much less. The NGCC component scaled down to 400 MW(e) would require 150 (Exelon 2011) to 500 (NRC 1996) construction workers during peak construction and 8 to 60 operations workers. Socioeconomic impacts would be similar to those described for NGCC, wind, and solar alternatives discussed in Sections 8.1.8, 8.4.8, and 8.6.1.8, but on a smaller scale than each of the full alternatives. Because of the relatively small number of construction workers scattered over a large area at various locations, the relative economic impact of this many workers on local communities and the tax base would be SMALL. Given the small number of operations workers, socioeconomic impacts associated with operation of the NGCC, wind, and solar components of this combination alternative would also be SMALL.

The net reduction in employment at LGS could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the region. Nevertheless, the amount of property taxes paid under the combination alternative may offset lost tax revenues in the socioeconomic region around LGS. Based on this information, socioeconomic impacts during operations could range from SMALL to MODERATE.

8.6.2.9 Transportation

Transportation impacts during the construction and operation of the NGCC, wind, and solar components of this combination alternative would be less than the impacts for the NGCC, wind, and PV solar alternatives, discussed in Sections 8.1.7, 8.4.7, and 8.6.1.7. This is because the construction workforce for each component and the volume of materials and equipment needing to be transported to each respective construction site would be smaller than each of the individual alternatives. In other words, the transportation impacts would not be as concentrated as in the other alternatives, but spread out over a wider area.

As previously described for each alternative, workers commuting to the construction site would arrive by site access roads and the volume of traffic on nearby roads could increase during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary levels of service impacts and delays at intersections. Transporting heavy and oversized wind turbine components on local roads could have a noticeable impact over a large area. Some components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction could range from SMALL to MODERATE depending on the location of the NGCC power plant, wind farm, and PV solar installation; road capacities; and traffic volumes.

During operations, transportation impacts would be less noticeable during shift changes and maintenance activities. Given the small number of operations workers, the levels of service traffic impacts on local roads from NGCC power plant, wind farm, and PV solar installation operations would be SMALL.

8.6.2.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between the wind, solar, and NGCC alternative and surrounding landscapes and the visibility of new wind turbines at existing wind farms, PV solar technologies on existing buildings, and the new NGCC plant at an existing power plant site. In general, aesthetic changes would be limited to the immediate vicinity of the wind farms, PV solar installations, and NGCC power plant.

Wind turbines would have the greatest potential visual impact. At 400 ft (122 m) tall (Exelon 2011) and spread across multiple sites, wind turbines often dominate the view and become the major focus of attention. However, adding additional wind turbines to existing wind farms at multiple sites is not likely to increase the visible impact of the wind farm unless it significantly increases the number of wind turbines at the wind farm. PV solar technologies located on building rooftops, depending on the angle of the roof, may or may not be seen offsite, and would be less noticeable in urban settings.

Located near an existing power plant site, the NGCC power plant could be approximately 100 ft (30 m) tall, with an exhaust stack up to 150 ft (46 m) tall and have two cooling towers over 500 ft (152 m) high (Exelon 2011). The facility would be visible off site during daylight hours, and some structures may require aircraft warning lights. The power block of the new NGCC power plant unit could look very similar to the existing power plant at the site where it would be constructed. The addition of mechanical draft cooling towers and associated condensate plumes could add to the NGCC power plant visual impact. Mechanical draft cooling towers also generate noise. Most other noises during power NGCC plant operations would be limited to industrial processes and communications. Pipelines delivering natural gas fuel could be audible off site near gas compressor stations.

Based on this information, aesthetic changes caused by this combination alternative would be limited to the immediate vicinity of the existing facilities and would therefore be SMALL to MODERATE depending on location and surroundings.

8.6.2.11 Historic and Archaeological Resources

Areas potentially affected by the construction of the NGCC, wind, and solar PV alternative would need to be surveyed to identify and record historic and archaeological resources. Any resources found in these surveys would need to be evaluated for eligibility on the NRHP and mitigation of adverse effects would need to be addressed if eligible resources were encountered. An inventory of a previously disturbed former plant (brownfield) site may still be necessary if the site has not been previously surveyed or to verify the level of disturbance and evaluate the potential for intact subsurface resources. Plant operators would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). Areas with the greatest sensitivity should be avoided. Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the sites—should also be assessed.

The impacts of this alternative are similar to the combined and scaled impacts of the NGCC, wind, and solar PV alternatives considered in Sections 8.1, 8.4, and 8.6.1, respectively. The potential for impacts would vary greatly depending on the location of the proposed sites. Use of a previously disturbed site for the NGCC alternative and rooftop PV technology could minimize affects to historic and archaeological resources. Wind turbines could be installed in pre-established wind farms. Areas with the greatest sensitivity could be avoided or effectively managed under current laws and regulations. However, construction of wind farms sites and their support infrastructure on developed sites, agricultural areas, or previously undisturbed have the potential to notably impact historic and archaeological resources because of earthmoving activities (e.g., grading and digging). Aesthetic changes from wind farms and solar technology may also impact the viewshed of historic properties located nearby. Therefore, depending on the resource richness of the site chosen for the NGCC, wind, and solar PV alternative, the impacts could range from SMALL to MODERATE.

8.6.2.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the construction and operation of a combination of wind turbines, PV solar installations, and a NGCC power plant. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. During construction, increased demand for rental housing in the vicinity of the site could affect low-income populations living near the plant site. However, given the small number of construction workers and the possibility that workers could commute to the construction site, the need for rental housing would not be significant.

Minority and low-income populations living in close proximity to the power generating facilities could be disproportionately affected by wind farm, PV solar, and NGCC power plant operations. However, all would be exposed to the same potential effects from operations, and any effects would depend on the magnitude of the change in ambient conditions. Operational impacts from the wind turbines and PV solar installations would mostly be limited to noise and aesthetic effects. The general public living near the wind farms and PV solar installations would be exposed to the same effects.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of new wind turbines, PV solar installations, and a NGCC power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.6.2.13 Waste Management

During the construction stage of this combination of alternatives (wind, solar, and NGCC), land clearing and other construction activities would generate wastes that could be recycled, disposed of on site, or shipped to the offsite waste disposal facility. During the operational stage, spent SCR catalysts, which control NO_x emissions from the NGCC plant, would make up the majority of the waste generated by this alternative, along with some wastes generated during maintenance for the wind and solar operations.

The staff concludes that overall waste impacts from the combination of the NGCC unit constructed on an existing site, and renewable energy components such as wind and solar, would be SMALL.

Table 8–8. Summary of Environmental Impacts of the Combination Alternative Compared to Continued Operation of the Existing LGS

	Combination Alternative	Continued Operation of LGS
Air Quality	SMALL to MODERATE	SMALL
Groundwater Resources	SMALL	SMALL
Surface Water Resources	SMALL	SMALL
Aquatic Ecology	SMALL	SMALL
Terrestrial Ecology	SMALL	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL to MODERATE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL to MODERATE	SMALL
Aesthetics	SMALL to MODERATE	SMALL
Historic and Archaeological	SMALL to MODERATE	SMALL
Waste Management	SMALL	SMALL[a]

[a] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

8.6.3 Combination Alternative: Wind and Compressed Air Energy Storage

In compressed air energy storage (CAES), an electric motor uses electricity to pump air into an underground, pressurized cavity, and when electricity is needed, the operator releases the compressed air through a gas turbine generator. The compressed air provides some power to the generator (essentially, reducing the need for compression by the turbine), and burning natural gas provides heat to increase pressure and to power the turbine. Thus, CAES is not solely an energy storage technology, but also relies on additional fossil fuel.

CAES is a commercially viable technology for energy storage, though it is seldom-used on a utility scale. It is in use at one site in the United States and one site in Germany (with capacities of 110 MW[e] and 290 MW[e], respectively) (NETL 2011).

Currently, no state or utility in the United States is operating wind in combination with compressed air energy storage, let alone doing so to offset baseload power supplies. A group of utilities had proposed a 270-MW(e) project of that type in Iowa but have since terminated the project because of geologic unsuitability of the proposed site (ISEPA 2011). The McIntosh facility in Alabama is the only existing U.S. compressed air energy storage installation; it provides peaking capacity to existing non-wind generation, and it is relatively small. It provides

110 MW(e) of power for up to 26 hours. The McIntosh facility and Germany's Huntorf facility are both based in salt domes.

Currently, no compressed air energy storage facilities exist in the PJM service area. In Ohio, the First Energy Nuclear Operating Company (FENOC) has acquired the Norton Energy Storage project, a proposed CAES facility that could be constructed in a retired limestone mine. FENOC indicates that the Norton Energy Storage facility could have a maximum of 536 MW(e) of capacity available by 2017 (though it has not committed to install this capacity in that time period) and that it has an air permit for up to 804 MW(e) of capacity at the site (FENOC 2011). FENOC indicates that the maximum potential storage capacity at the Norton Energy Storage project is 2,700 MW(e) (FENOC 2011). However, the NRC is not aware of a CAES project coupled with wind generation that is providing baseload power. Therefore, the NRC concludes that the use of CAES in combination with wind turbines to generate 2,340 MW(e) in the PMJ service area is unlikely.

Because the use of CAES in combination with wind turbines to generate 2,340 MW(e) in the PJM service area is unlikely, the staff does not consider CAES in combination with wind to provide a viable, standalone alternative to license renewal. The staff considers a standalone alternative here, however, because Exelon includes a CAES and wind combination alternative in its range of alternatives to LGS license renewal in the ER.

This section analyzes the potential impacts from a CAES and wind combination alternative. NREL (2006) suggests that 2,000 MW(e) of wind together with 900 MW(e) of CAES can provide a near-constant 900 MW(e) of output. Using the high capacity factors the staff applied to the windpower alternative in Section 8.4 (which exceeds current wind capacity factors), this alternative relies on 2,000 MW(e) of CAES capacity from a facility similar in operation to the Norton project and 4,500 MW(e) of onshore wind capacity. While the approach in NREL (2006) suggests that 2,340 MW(e) of CAES may be necessary to provide firming capacity that would provide similar baseload potential as that provided by LGS, this alternative underestimates the amount of CAES capacity necessary to provide for technological advances and avoid overstating the potential impacts from relying on a combination of wind and CAES. In general, the staff relies on information from the Norton project to describe the potential impacts of a CAES project, though the staff notes that projects at different sites may incur varying levels of environmental impacts. Where appropriate, the staff scales impacts from the Norton project to account for the size of the CAES project considered here.

Table 8–9 summarizes the environmental impacts of the wind and CAES alternative compared to the continued operation of LGS.

8.6.3.1 Air Quality

As discussed in Section 2.2.2.1, the LGS site is located in Montgomery and Chester Counties, Pennsylvania, and is part of the Metropolitan Philadelphia Interstate Air Quality Control Region AQCR (40 CFR 81.15). With regard to the NAAQS, EPA has designated Montgomery and Chester Counties as unclassified or in attainment with respect to carbon monoxide, lead, sulfur dioxide, and PM_{10}; and nonattainment with respect to ozone and $PM_{2.5}$ (40 CFR 81.339).

This alternative relies on CAES to store electricity produced by wind turbines, which is then released during periods of low wind production. CAES facilities burn natural gas to heat the compressed air; therefore, they produce air emissions. The CAES facility would qualify as a new major-emitting industrial facility and would be subject to PSD under CAA requirements (EPA 2012). The PADEP has adopted 25 Pa. Code Chapter 127, which implements the EPA's PSD review. The CAES plant would need to comply with the standards of performance for stationary combustion turbines set forth in 40 CFR Part 60 Subpart KKKK.

Subpart P of 40 CFR Part 51.307 contains visibility protection regulatory requirements, including the review of the new sources that may affect visibility in any Federal Class I area. If the CAES component of this combination alternative were located close to a mandatory Class I area, additional air pollution control requirements would be required. As noted in Section 2.2.2.1, there are no Mandatory Class I Federal areas within 50 miles of the LGS site. There are a total of 13 designated Class 1 Federal areas (40 CFR 81) located in the following PJM states: Kentucky, Michigan, New Jersey, North Carolina, Tennessee, Virginia, and West Virginia. A new CAES facility would have to comply with Title IV of the CAA (42 USC §7651) reduction requirements for SO_2 and NO_x, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NO_x emission rates from the existing plants and a system of SO_2 emission allowances that can be used, sold, or saved for future use by the new plants.

More recently, the EPA has promulgated additional rules and requirements that apply to certain fossil-fuel–based power plants, such as the CAES portion of this alternative. The CSAPR and the Prevention of Significant Deterioration and Title V GHG Tailoring Rule impose several additional standards to limit ozone, particulate, and GHG emissions from fossil-fuel–based power plants (EPA 2012c). A new CAES plant would be subject to these additional rules and regulations.

Air emission permits from the Norton CAES Project in Norton, Ohio, were used as a basis for estimating emissions for this alternative. The current Norton air emissions permit allows 804 MW(e), so the staff scales the values from the Norton CAES project to 2,000 MW(e) to determine air quality impacts associated with this alternative. The staff projects the following air emissions for the CAES alternative:

- sulfur oxides (SO_x) – 105.5 tons (96.2 MT) per year,
- nitrogen oxides (NO_x) – 233.0 tons (212.4 MT) per year,
- carbon monoxide (CO) – 224.8 tons (204.9 MT) per year,
- PM_{10} and $PM_{2.5}$ – 116.0 tons (105.8 MT) per year, and
- carbon dioxide (CO_2) – 1,694,279 tons (1,544,735 MT) per year.

Activities associated with the construction of the CAES alternative would cause some additional temporary air effects as a result of equipment emissions and fugitive dust from operation of the earth-moving and material-handling equipment. Emissions from workers' vehicles and motorized construction equipment exhaust would be temporary. Construction crews could use dust-control practices to control and reduce fugitive dust. The staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of the earth-moving and material-handling equipment would be SMALL.

<u>Greenhouse Gas Emissions</u>

Greenhouse gas emissions during construction of this alternative would result primarily from the consumption of fossil fuels in the engines of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. However, all such impacts would be temporary.

Greenhouse gas emissions during operation would primarily be from natural gas combustion in the combustion turbines (at both the NGCC facility and the CAES facility). However, other miscellaneous ancillary sources such as truck and rail deliveries of materials to the site and commuting of the workforce would make minor contributions.

NETL estimates that CCS will capture and remove as much as 90 percent of the CO_2 from the exhausts of combustion turbines, but will result in a power production capacity decrease of approximately 14 percent, a reduction in net overall thermal efficiency of the CTs studied from 50.8 percent to 43.7 percent, and a potential increase in the levelized cost of electricity produced in NGCC units so equipped by as much as 30 percent (NETL 2007). Further, permanent sequestering of the CO_2 would involve removing impurities (including water) and pressurizing it to meet pipeline specifications and transferring the gas by pipeline to acceptable geologic formations. Even when opportunities exist to use the CO_2 for enhanced oil recovery (rather than simply disposing of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the combustion turbines are far removed from acceptable geologic formations. With CCS in place, the CAES alternative would release 0.154 million MT per year (0.169 million tons) of CO_2. Without CCS in place, the CAES alternative would release 1.54 million MT (1.69 million tons) of CO_2 per year

Given the temporary impacts during the construction period and GHG emissions resulting from operations, the overall impact from the release of GHGs of the CAES alternative would be SMALL to MODERATE.

Conclusion

The overall air quality impacts from CAES alternative would be similar to those of an NGCC facility and would be designated as SMALL to MODERATE.

8.6.3.2 Groundwater Resources

Impacts on groundwater resources of constructing and operating wind turbine installations under this alternative would be similar to those described in Section 8.4.2. Similarly, for construction and operation of the CAES facility, it is expected that overall impacts would be similar to and would be bounded by those described for the NGCC alternative (see Section 8.1.2) because construction and operations of the two facilities would be relatively similar, although the NGCC plant would be larger than the CAES facility. As an additional impact, pressurization of an underground cavity associated with CAES operations could affect groundwater flow on a localized basis. However, overall impacts on groundwater use and quality under this alternative would be SMALL.

8.6.3.3 Surface Water Resources

Impacts on surface water resources of constructing and operating wind turbine installations under this alternative would be similar to those described in Section 8.4.3. For construction and operation of the CAES facility, it is expected that overall impacts on surface water would be similar to and would be bounded by those described for the NGCC alternative (see Section 8.1.3). The nature of potential surface water impacts of CAES would depend on the type of CAES reservoir. For CAES using hard rock caverns, makeup water would be required because of evaporation from the surface reservoir and some potential for leakage. With these systems, as well as with porous rock reservoirs, there is generally a provision for pumping of water into the caprock or zones above the caprock to ensure hydraulic overpressure that would counter the potential for air leakage. In general, however, the potential for effects from caprock overpressure requirements would be smaller than the makeup water required for cooling. As a result, the projected cooling water demands would be smaller than the requirement presented in Section 8.1.3 for the NGCC alternative; the demands would relate primarily to removing waste heat from compression of the stored air. In conclusion, the overall impacts on surface water use and quality under this alternative would be SMALL.

8.6.3.4 Aquatic Resources

Construction activities for the wind and CAES alternative (such as construction of heavy-haul roads, the wind turbines, and CAES facility) could affect drainage areas and other onsite aquatic features. Minimal impacts on aquatic ecology resources are expected as the plant operator would likely implement BMPs to minimize erosion and sedimentation elsewhere on the site. Stormwater control measures, which would be required to comply with Pennsylvania NPDES permitting, would minimize the flow of disturbed soils into aquatic features. Depending on the available infrastructure at the selected site, the CAES facility may require modification or expansion of the existing intake or discharge structures. Because of the relatively low withdrawal rates compared to the NGCC, SCPC, or new nuclear alternatives, it is unlikely that the operators would need to construct new intake and discharge structures. Dredging activities that result from infrastructure construction would require BMPs for in-water work to minimize sedimentation and erosion. Because of the short-term nature of the dredging activities, the hydrological alterations to aquatic habitats would likely be localized and temporary.

During operations, the CAES alternative would require less cooling water to be withdrawn from the Schuylkill River, or other similar water body, than required for LGS Units 1 and 2. In addition, the cooling system for a CAES plant would have similar chemical discharges as LGS. The flow of the Schuylkill River, or other similar waterbody, would likely dissipate and dilute the concentration of pollutants resulting in minimal exposure to aquatic biota.

The impacts on aquatic ecology would be minor because construction activities would require BMPs and stormwater management permits, and because the surface water withdrawal and discharge for this alternative would be less than for LGS Units 1 and 2. Therefore, the staff concluded that impacts on aquatic ecology would be SMALL.

Consultation with NMFS and FWS under ESA would ensure that the construction and operation of wind farms and CAES facility would not adversely affect any Federally listed species or adversely modify or destroy designated critical habitat. If new infrastructure were located near EFH, consultation with NMFS under the Magnuson-Stevens Act would require NRC to evaluate impacts to EFH and NMFS would provide conservation recommendations if there would be adverse impacts to EFH. Coordination with state natural resource agencies would further ensure that the CAES and wind farm operators would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats. Consequently, the impacts of construction and operation on protected species and habitats would be SMALL.

8.6.3.5 Terrestrial Resources

Impacts to terrestrial species and habitats from construction and operation of this combined alternative would be similar in type, magnitude, and intensity as those described in Section 8.4.5 for the wind alternative. The primary difference in impact would result from the additional 92 ac (37 ha) required for the CAES facility. Impacts resulting from the CAES facility would vary depending on the site of the facility, but would generally not contribute considerably more impacts than the wind component because of the wind component's large land area requirements. Consequently, the impacts of construction and operation of this alternative to terrestrial habitats and species could range from SMALL to MODERATE.

As with the previously discussed alternatives, consultation with FWS under the ESA would avoid potential adverse impacts to Federally listed species or adverse modification or destruction of designated critical habitat. Coordination with state natural resource agencies would further ensure that Exelon would take appropriate steps to avoid or mitigate impacts to state-listed species, habitats of conservation concern, and other protected species and habitats.

Consequently, the impacts of construction and operation of a wind and CAES alternative on protected species and habitats would be SMALL.

8.6.3.6 Human Health

CAES is a process by which air is compressed and forced into a holding area (like a large underground cavern) for later use in powering a gas turbine. Construction impacts of a CAES facility would be similar to impacts associated with the construction of any major industrial facility. Although constructing an energy facility with and near a suitable holding area (like a large underground cavern) would pose some unique challenges, proper regulation through state and Federal agencies would ensure that human health impacts are minimized.

Impacts on human health from construction of the wind alternative would be similar to impacts associated with the construction of any major industrial facility. Compliance with worker protection rules would control those impacts on workers at acceptable levels. Impacts from construction on the general public would be minimal since limiting active construction area access to authorized individuals is expected. Impacts on human health from the construction of the wind alternative would be SMALL.

Given proper health-based regulation through procedures and access limitations, the staff expects human health impacts from operation of the CAES and the wind alternative at an alternate site to be SMALL.

8.6.3.7 Land Use

As discussed in Section 8.1.7, the GEIS generically discusses the impact of constructing and operating various replacement power plant alternatives on land use, both on and off each power plant site. The analysis of land-use impacts focuses on the amount of land area that would be affected by the construction and operation of new wind turbines and CAES.

Land-use impacts from the wind turbines would be similar to the impacts described for the wind alternative (see Section 8.4.7). Most of the wind farms would be located on open agricultural cropland, which would remain largely unaffected by the presence of the wind turbines. Since wind turbines require ample spacing between one another to avoid air turbulence, the footprint of a utility scale wind farm could be quite large. Exelon estimates 3,200 ac (1,300 ha) of land would be directly affected by the placement of the wind turbines (Exelon 2011). These estimates appear reasonable based upon the size of current and proposed wind farms. Nevertheless, wind turbines would be located on multiple wind farms spread across approximately 130,000 ac (53,000 ha or 200 mi^2 [520 km^2]) of land. Most of this land would be temporarily affected during the installation of the turbines and the construction of support facilities, and about one-third of the land would be permanently impacted. Based on Exelon's estimates, approximately 3,200 ac (1,300 ha) of land would be needed to support the wind portion of the alternative to replace the LGS. This amount of land use would include the area directly affected by the placement of turbines. Turbines would be spread across about 200 mi^2 (520 km^2). Additional land would be needed for any new transmission lines to connect wind farms to the grid and for any needed access roads.

Delivering heavy and oversized wind turbine components would also require the construction of temporary site access roads, some of which may require a circuitous route to their destination. However, once construction is completed, many temporary access roads can be reclaimed and replaced with more direct access to the wind turbines for maintenance purposes. Likewise, land used for equipment and material lay down areas, turbine assembly, and installation could be returned to its original state. During operations, only 5–10 percent of the total acreage within the wind farm is actually occupied by turbines, access roads, support buildings, and associated infrastructure while the remaining land area can be returned to its original condition or some other compatible use, such as farming or grazing.

Land-use impacts from the gas-fired portion of the energy recovery process associated with the CAES portion of this alternative would be similar to the impacts described for a NGCC power plant (see Section 8.1.7). Only a minor amount of land would be needed above the geologic storage formation. As a whole, construction and operation of a wind generation facility combined with the construction and operation of a CAES facility would have relatively greater impacts than the wind generation facilities alone.

The elimination of uranium fuel for LGS would partially offset some, but not all, of the land requirements for the wind farms. Scaling from GEIS estimates, approximately 1,640 ac (660 ha) would no longer be needed during the operating life of the wind farms and the CAES facility. Overall land-use impacts from the construction and operation of new wind farms and a CAES facility would range from MODERATE to LARGE.

8.6.3.8 Socioeconomics

As previously explained in Section 8.1.8, two types of jobs would be created by this alternative: (1) construction jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operations jobs, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of a combination of wind turbines and a CAES facility were evaluated in order to measure their possible effects on current socioeconomic conditions.

Socioeconomic impacts from the wind turbine component would be similar to the impacts described for the wind alternative (see Section 8.4.8). Exelon estimated the wind alternative would require 200 construction and 50 operations workers (Exelon 2011). These estimates appear reasonable and in line with current construction and operational trends. Impacts from the construction and operation of the gas-fired portion of the energy recovery process associated with the CAES component would be similar to the impacts described for a NGCC power plant (see Section 8.1.8). Because of the relatively small number of construction workers at wind farms scattered over a large area at various locations, the relative economic impact of this many workers on local communities and the tax base would be SMALL. Given the small number of operations workers, socioeconomic impacts associated with operation of the wind and CAES components of this combination alternative would also be SMALL.

The reduction in employment at LGS could affect property tax revenue and income in local communities and businesses. In addition, the permanent housing market could also experience increased vacancies and decreased prices if operations workers and their families move out of the LGS region. However, the amount of property taxes paid by wind farms and CAES may offset lost tax revenues in the socioeconomic region around local jurisdictions if additional land is required to support this alternative. Based on this information, socioeconomic impacts during wind farm operations and CAES could range from SMALL to MODERATE.

8.6.3.9 Transportation

Transportation impacts during the construction and operation of the wind and CAES components of this combination alternative would be similar to the impacts for the NGCC and wind alternatives, discussed in Sections 8.1.7 and 8.4.7. This is because the construction workforce for each component and the volume of materials and equipment needing to be transported to each respective construction site would be the same.

As previously described for the NGCC and wind alternatives, workers commuting to the construction site would arrive by site access roads and the volume of traffic on nearby roads could increase during shift changes. In addition to commuting workers, trucks would be transporting construction materials and equipment to the worksite, thus increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes, resulting in temporary traffic volume impacts and delays at intersections. Transporting heavy and oversized wind turbine components on local roads could have a noticeable impact over a large area. Some components and materials could also be delivered by train or barge, depending on location. Train deliveries could cause additional traffic delays at railroad crossings. Based on this information, traffic-related transportation impacts during construction could range from SMALL to MODERATE depending on the location of the wind farm and CAES facility; road capacities; and traffic volumes.

During operations, transportation impacts would be less noticeable during shift changes and maintenance activities. Given the small numbers of operations workers, traffic impacts on local roads from wind turbine and CAES facility operations would be SMALL.

8.6.3.10 Aesthetics

The analysis of aesthetic impacts focuses on the degree of contrast between the wind and CAES alternative and surrounding landscapes and the visibility of new wind turbines at existing wind farms and the new CAES facility. In general, aesthetic changes would be limited to the immediate vicinity of the wind farms and CAES facility.

Aesthetic impacts during the construction and operation of the wind and CAES components of this combination alternative would be similar to the impacts for the NGCC and wind alternatives, discussed in Sections 8.1.10 and 8.4.10. Wind turbines would have the greatest potential visual impact. At 400 ft (122 m) tall (Exelon 2011) and spread across multiple sites, wind turbines often dominate the view and become the major focus of attention. Because wind farms are generally located in rural or remote areas, the introduction of wind turbines will be in sharp contrast to the visual appearance of the surrounding environment. Placing turbines along ridgelines would maximize their visibility. Wind turbines also generate noise.

The new CAES facility could be sited at a previously undisturbed location. The mechanical draft cooling towers and associated condensate plumes along with the CAES facility surface structures would be the only significant visual for this part of the alternative. Mechanical draft cooling towers also generate noise. Most other noises during facility operations would be limited to industrial processes and communications. Based on this information, aesthetic impacts from the construction and operation of new wind farms and CAES facility would range from MODERATE to LARGE depending on location and surroundings.

8.6.3.11 Historic and Archaeological Resources

Any areas potentially affected by the construction of a wind and CAES alternative should be surveyed to identify and record historic and archaeological resources. Resources found in these surveys would need to be evaluated for eligibility on the NRHP and mitigation of adverse effects would need to be addressed if eligible resources were encountered. Plant operators would need to survey all areas associated with operation of the alternative (e.g., roads, transmission corridors, other ROWs). Visual impacts on significant cultural resources—such as the viewsheds of historic properties near the sites—should also be assessed.

The potential for impacts on historic and archaeological resources from the wind and CAES alternative would vary greatly depending on the location of the proposed sites. Areas with the greatest sensitivity could be avoided or effectively managed under current laws and regulations. However, construction of wind farms and CAES could have the potential to notably impact historic and archaeological resources because of ground disturbing-activities (e.g., grading, digging an underground geologic repository). Aesthetic changes caused by the installation of wind turbines could also have a noticeable effect on the viewshed of nearby historic properties. Therefore, depending on the resource richness of the site chosen for the wind farm and CAES alternative, the impacts could range from SMALL to LARGE.

8.6.3.12 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health, environmental, and socioeconomic effects on minority and low-income populations that could result from the installation and operation of wind turbines and a CAES facility. As previously discussed in Section 8.1.12, such effects may include human health, biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this SEIS.

Potential impacts to minority and low-income populations would mostly consist of environmental and socioeconomic effects during construction (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts during construction would be short term and primarily limited to onsite activities. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle and truck traffic. However, because of the temporary nature of construction, these effects would only occur during certain hours of the day and are not likely to be high and adverse and would be contained to a limited time period during certain hours of the day. During construction, increased demand for rental housing in the vicinity of the site could affect low-income populations living near the alternatives. However, given the small number of construction workers and the possibility that workers could commute to the construction site, the need for rental housing would not be significant.

Minority and low-income populations living in close proximity to the wind farms and CAES facility could be disproportionately affected by operations. However, operational impacts would mostly be limited to noise and aesthetic effects. The general public living near the wind farms and CAES facility would also be exposed to the same effects.

Based on this information and the analysis of human health and environmental impacts presented in this SEIS, the construction and operation of new wind turbines and a CAES facility would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations.

8.6.3.13 Waste Management

During the construction stage of the combination of wind and CAES alternative, land clearing and excavation, and other construction activities would generate wastes that could be recycled, disposed of on site, or shipped to the offsite waste disposal facility. During the operational stage, the wind and CAES alternative might generate minor amounts of waste.

The staff concludes that overall waste impacts from the combination of the wind and CAES alternative would be SMALL.

Table 8–9. Summary of Environmental Impacts of the Wind and CAES Alternative Compared to Continued Operation of the Existing LGS

	Wind and CAES Alternative	Continued Operation of LGS
Air Quality	SMALL to MODERATE	SMALL
Groundwater Resources	SMALL	SMALL
Surface Water Resources	SMALL	SMALL
Aquatic Ecology	SMALL	SMALL
Terrestrial Ecology	SMALL to MODERATE	SMALL
Human Health	SMALL	SMALL
Land Use	MODERATE to LARGE	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL to MODERATE	SMALL
Aesthetics	MODERATE to LARGE	SMALL
Historic and Archaeological	SMALL TO LARGE	SMALL
Waste Management	SMALL	SMALL[(a)]

[(a)] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

8.6.4 Wood Waste

As noted in the GEIS (NRC 1996,), the use of wood waste to generate utility-scale baseload power is limited to those locations where wood waste is plentiful. Wastes from pulp, paper, and paperboard industries and from forest management activities can be expected to provide sufficient, reliable supplies of wood waste as feedstocks to external combustion sources for energy generation. Beside the fuel source, the technological aspects of a wood-fired generation facility are virtually identical to those of a coal-fired alternative—combustion in an external combustion unit such as a boiler to produce steam to drive a conventional STG. Given constancy of the fuel source, wood waste facilities can be expected to operate at equivalent efficiencies and reliabilities. Costs of operation would depend significantly on processing and delivery costs. Wood waste combustors would be sources of criteria pollutants and GHGs, and pollution control requirements would be similar to those for coal plants. Unlike coal plants, there is no potential for the release of HAPs such as mercury. Co-firing of wood waste with coal is also technically feasible. Processing the wood waste into pellets can improve the overall efficiency of such co-fired units.

Although co-fired units can have capacity factors similar to baseload coal-fired units, such levels of performance are dependent on the continuous availability of the wood fuel. In the Commonwealth of Pennsylvania, 2010 electricity generating capacity from wood waste was 108 MW(e) and produced 675,000 MWh (EIA 2011c). Given the limited capacity and modest actual electricity production, the staff has determined that production of electricity from wood waste at levels equivalent to LGS would not be a feasible alternative to LGS license renewal.

8.6.5 Conventional Hydroelectric Power

Three technology variants of hydroelectric power exist: dam and release (also known as impoundment), run-of-the-river (also known as diversion), and pumped storage. In each variant, flowing water spins turbines of different designs to drive a generator to produce electricity. Dam and release facilities affect large amounts of land behind the dam to create reservoirs but can provide substantial amounts of power at capacity factors greater than 90 percent. Power generating capacities of run-of-the-river dams fluctuate with the flow of water in the river, and the operation of such dams is typically constrained (and stopped entirely during certain periods) so as not to create undue stress on the aquatic ecosystems present. Pumped storage facilities use electricity from other power sources to pump water from lower impoundments or flowing watercourses to higher elevations during off-peak load periods. Water is then released during peak load periods through turbines to generate electricity. Capacities of pumped storage facilities are dependent on the configuration and capacity of the elevated storage facility.

A comprehensive survey of hydropower resources in Pennsylvania was completed in 1997 by DOE's Idaho National Environmental Engineering Laboratory (now known as the Idaho National Laboratory). In the study, generating potential was defined by a model that considered the existing hydroelectric technology at developed sites or applied the most appropriate technology to undeveloped sites and introduced site-specific environmental considerations and limitations. Pennsylvania had modest hydroelectric potential, with a total generating potential of 703 MW(e) (INEEL 1997). This potential was spread across 104 sites, only one of which had the potential for more than 100 MW(e) of generation. Most other states in the PJM service area have very limited potential (INEEL 1998b), with the exception of West Virginia, which has 1,149 MW(e) spread across 37 sites (INEEL 1998a)

More recently, EIA reported that, in 2010, conventional hydroelectric power (excluding pumped storage) was the principal electricity generation source among renewable sources in Pennsylvania (EIA 2011c). Nevertheless, only 747 MW(e) of hydroelectric capacity was installed in the Commonwealth. Those installations provided 2,332 gigawatt-hours of electricity (EIA 2011a). Although hydroelectric facilities can demonstrate relatively high capacity factors, the small potential capacities and actual recent power generation of hydroelectric facilities in Pennsylvania, combined with the diminishing public support for large hydroelectric facilities because of their potential for adverse environmental impacts, supports the staff's conclusion that hydroelectric is not a feasible alternative to LGS.

8.6.6 Ocean Wave and Current Energy

Ocean waves, currents, and tides represent kinetic and potential energies. The total annual average wave energy off the U.S. coastlines at a water depth of 60 m (197 ft) is estimated at 2,100 terawatt-hours (TWh) (MMS 2006). Waves, currents, and tides are often predictable and reliable; ocean currents flow consistently, while tides can be predicted months and years in advance with well-known behavior in most coastal areas. Four principal wave energy conversion (WEC) technologies have been developed to date to capture the potential or kinetic energy of waves: point absorbers, attenuators, overtopping devices, and terminators. All have similar approaches to electricity generation but differ in size, anchoring method, spacing, interconnection, array patterns, and water depth limitations. Point absorbers and attenuators both allow waves to interact with a floating buoy, subsequently converting its motion into mechanical energy to drive a generator. Overtopping devices and terminators are also similar in their function. Overtopping devices trap some portion of the incident wave at a higher elevation than the average height of the surrounding sea surface, thus giving it higher potential energy, which is then transferred to power generators. Terminators allow waves to enter a tube, compressing air trapped at the top of the tube, which is then used to drive a generator.

Capacities of point absorbers range from 80–250 kW, with capacity factors as high as 40 percent; attenuator facilities have capacities of as high as 750 kW. Overtopping devices have design capacities as high as 4 MW, while terminators have design capacities ranging from 500 kW–2 MW and capacity factors as high as 50 percent (MMS 2007).

The most advanced technology for capturing tidal and ocean current energy is the submerged turbine. Underwater turbines share many design features and functions with wind turbines, but because of the greater density of water compared to air, they have substantially greater power-generating potential than wind turbines with comparably sized blades. Only a small number of prototypes and demonstration units have been deployed to date, however. Underwater turbine "farms" are projected to have capacities of 2–3 MW, with capacity factors directly related to the constancy of the current with which they interact.

The staff is not currently aware of any plans to develop or deploy ocean wave and ocean current generation technologies on a scale similar to that of LGS. Consequently, the relatively modest power capacities, relatively high costs, and limited planned implementation support the staff's conclusion that water energy current technologies are not feasible substitutes for LGS.

8.6.7 Geothermal Power

Geothermal technologies extract the heat contained in geologic formations to produce steam to drive a conventional steam-turbine generator. The following variants of the heat exchanging mechanism have been developed:

- Hot geothermal fluids contained under pressure in a geological formation are brought to the surface where the release of pressure allows them to flash into steam (the most common of geothermal technologies applied to electricity production).
- Hot geothermal fluids are brought to the surface in a closed loop system and directed to a heat exchanger where they convert water in a secondary loop into steam.
- Hot dry rock technologies involve fracturing a rock formation and extracting heat through injection of a heat transfer fluid.

Facilities producing electricity from geothermal energy can routinely demonstrate capacity factors of 95 percent or greater, making geothermal energy clearly eligible as a source of baseload electric power. However, as with other renewable energy technologies, the ultimate feasibility of geothermal energy serving as a baseload power replacement for LGS depends on the quality and accessibility of geothermal resources within or proximate to the region of interest—in this case, Pennsylvania or PJM. As of April 2010, the United States had a total installed geothermal electricity production capacity of 3,087 MW(e) originating from geothermal facilities in nine states—Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming. Additional geothermal facilities are being considered for Colorado, Florida, Louisiana, Mississippi, and Oregon. Neither Pennsylvania nor the remaining PJM service area has adequate geothermal resources to support utility-scale electricity production (GEA 2010). NRC concludes, therefore, that geothermal energy does not represent a feasible alternative to LGS.

8.6.8 Municipal Solid Waste

Municipal solid waste (MSW) combustors use three types of technologies—mass burn, modular, and refuse-derived fuel. Mass burning is currently the method used most frequently in the United States and involves no (or little) sorting, shredding, or separation. Consequently, toxic or hazardous components present in the waste stream are combusted, and toxic constituents are exhausted to the air or become part of the resulting solid wastes. Currently, approximately 86 waste-to-energy plants operate in 24 states, processing 97,000 tons (88,000 MT) of municipal solid waste per day. Approximately 26 million tons (24 million MT) of trash were processed in 2008 by waste-to-energy facilities. With a reliable supply of waste fuel, waste-to-energy plants have a nationwide aggregate capacity of 2,572 MW(e) (compared to 2,340 MW[e] capacity at LGS) and can operate at capacity factors greater than 90 percent (ERC 2010). The EPA estimates that, on average, air impacts from MSW-to-energy plants are as follows:

- carbon dioxide (CO_2) –3,685 lb (1,672 kg)/MWh,
- sulfur dioxide (SO_X) –1.2 lb (0.54 kg)/MWh, and
- nitrogen oxide (NO_x) – 6.7 lb (3.0 kg)/MWh.

Depending on the composition of the municipal waste stream, air emissions can vary greatly, and the ash produced may exhibit hazardous characteristics that require special treatment and handling (EPA 2010).

Estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant would be approximately the same as that for a coal-fired power plant. Additionally, waste-fired plants have the same or greater operational impacts as coal-fired technologies (including impacts on the aquatic environment, air, and waste disposal). The initial capital costs for municipal solid-waste plants are greater than those for comparable steam-turbine technology at coal-fired facilities or at wood-waste facilities because of the need for specialized waste separation and handling equipment (NRC 1996).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills, rather than energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term as energy prices increase (and especially since such landfills, of sufficient size and maturity, can be sources of easily recoverable methane fuel); however, it is possible that municipal waste combustion facilities may become attractive again.

Regulatory structures that once supported municipal solid waste incineration no longer exist. For example, the Tax Reform Act of 1986 made capital-intensive projects, such as municipal waste combustion facilities, more expensive relative to less capital-intensive waste disposal alternatives such as landfills. Additionally, the 1994 Supreme Court decision C&A Carbone, Inc. *v.* Town of Clarkstown, New York, struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than landfills that may have had lower fees. In addition, environmental regulations have increased the capital cost necessary to construct and maintain municipal waste combustion facilities.

Given the limited nationwide implementation of MSW-based generation to date (only 10 percent greater than the capacity of LGS), small average installed size of municipal solid waste plants, the likelihood that additional stable streams of MSW are not likely to be available to support numerous new facilities, and the increasingly unfavorable regulatory environment, the staff does not consider municipal solid waste combustion to be a reasonable alternative to LGS license renewal.

8.6.9 Biomass Fuels

When used here, “biomass fuels” include crop residues, switchgrass grown specifically for electricity production, forest residues, methane from landfills, methane from animal manure management, primary wood mill residues, secondary wood mill residues, urban wood wastes, and methane from domestic wastewater treatment. The feasibility of using biomass fuels for baseload power depends on its geographic distribution, available quantities, constancy of supply, and energy content. A variety of technical approaches has been developed for biomass-fired electric generators, including direct burning, conversion to liquid biofuels, and biomass gasification. In a study completed in December 2005, Milbrandt of NREL documented the geographic distribution of biomass fuels within the United States, reporting the results in metric tons available (dry basis) per year (NREL 2005). Most counties in Pennsylvania have limited potential biomass fuels, with the exception of Philadelphia and Bucks County. Use of biomass fuels in Pennsylvania is also limited. Beyond the wood and wood waste considered in Section 8.6.4, generators in the Commonwealth used biomass fuels to produce merely 3,000 MWh of electricity in 2010 (EIA 2011c).

After reviewing existing statewide capacities and the extent to which biomass is currently being used to produce electricity, the staff finds biomass-fueled alternatives are still unable to replace the LGS capacity and are not considered feasible alternatives to LGS license renewal.

8.6.10 Oil-Fired Power

Although oil has historically been used extensively in the Northeast for comfort heating, EIA projects that oil-fired plants will account for very little of the new generation capacity constructed in the United States during the 2008 to 2030 time period. In 2010, Pennsylvania generated 0.2 percent of its total electricity from oil (EIA 2012). Further, EIA does not project that oil-fired power will account for any significant additions to capacity (EIA 2011b).

The variable costs of oil-fired generation tend to be greater than those of nuclear or coal-fired operations, and oil-fired generation tends to have greater environmental impacts than natural gas-fired generation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly expensive (EIA 2011b). The high cost of oil has prompted a steady decline in its use for electricity generation. Thus, the staff does not consider oil-fired generation as a reasonable alternative to LGS license renewal.

8.6.11 Delayed Retirement

Exelon currently plans to retire three coal-fired units and one oil-fired unit (Exelon 2011). These units total 946 MW(e) of capacity, far less than the 2,340 MW(e) LGS currently provides. In PJM, however, Exelon indicates that generators have retired 5,945 MW(e) from 2003 to 2009 (Exelon 2011).

Most retired units are dirtier and less efficient than new units. Often, units are retired because operation is no longer economical. In some cases, the cost of environmental compliance or necessary repairs and upgrades are too high to justify continued operation. As a result, the staff does not consider delayed retirement a reasonable alternative to license renewal. It is possible, however, that a site where a unit has been retired could play host to a new generation facility, like the NGCC and SCPC alternatives considered in Sections 8.1 and 8.2, and the NGCC portion of the combination alternative considered in Section 8.6.2.

8.6.12 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air (or oxygen) over a cathode and separating the two by an electrolyte. The only byproducts (depending on fuel characteristics) are heat, water, and CO_2. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam reforming under pressure. Natural gas is typically used as the source of hydrogen.

Currently, fuel cells are not economically or technologically competitive with other alternatives for electricity generation. EIA projects that fuel cells may cost $5,478 per installed kW (total overnight costs, 2008 dollars) (EIA 2010c). This amount is substantially greater than coal ($2,223), advanced (natural gas) combustion turbines ($648), onshore wind ($1,966), or offshore wind ($3,937), but it is cost-competitive with solar PV ($6,171) or CSP solar ($5,132). Installed costs provided for PV and CSP solar are before application of Investment Tax Credits provided in Federal statutes. More importantly, fuel cell units are likely to be small in size (the EIA reference plant is 10 MWe). While it may be possible to use a distributed array of fuel cells to provide an alternative to LGS, it would be extremely costly to do so and would require many units and wholesale modifications to the existing transmission system. Accordingly, the staff does not consider fuel cell technology to be a reasonable alternative to LGS license renewal.

8.6.13 Coal-Fired Integrated Gasification Combined-Cycle

Integrated gasification combined-cycle (IGCC) is a technology for generating electricity with coal that combines modern coal gasification technology with both gas turbine and steam turbine power generation. Gasifiers, similar to those used in oil refineries, use heat pressure and steam to pyrolyze (thermally reform complex organic molecules without oxidation) coal to produce synthesis gases (generically referred to as syngas) typically composed of carbon monoxide, hydrogen, and other flammable constituents. After processing to remove contaminants and produce various liquid chemicals, the syngas is combusted in a combustion turbine to produce electric power. Separating the CO_2 from the syngas before combustion is also possible. Latent heat is recovered both from the syngas as it exits the gasifier and from the combustion gases exiting the combustion turbine and directed to a heat recovery steam generator feeding a conventional Rankine cycle STG to produce additional amounts of electricity. Emissions of criteria pollutants would likely be slightly higher than those from an NGCC alternative but significantly lower than those from the supercritical coal-fired alternative. Depending on the gasification technology employed, IGCC would use less water than SCPC units but slightly more than NGCC (NETL 2007). Long-term maintenance costs of this relatively complex technology would likely be greater than those for a similarly sized SCPC or NGCC plant.

Operating at higher thermal efficiencies than supercritical coal-fired boilers, IGCC plants can produce electrical power with fewer air pollutants and solid wastes than coal-fired boilers. Currently, there is an operating IGCC plant at Edwardsport, Indiana and another one being constructed in Mississippi (Duke 2013 and DOE 2010a). IGCC technology may become more commonplace in the future due to potential environmental requlations mandating carbon capture and storage (CCS) system as the best method of emission reduction.[2] CCS is less expensive

[2] On January 8, 2014, the Environmental Protection Agency (EPA) issued a proposed rule for carbon pollution that would apply to new fossil fuel-fired power plants. The action proposes performance standards for utility boilers and IGCC units based on partial implementation of a carbon capture and storage (CCS) system as the best method of emission reduction. The proposed emission limit for these sources is 1,100 lb CO_2/MWh. The proposed rule cites a number of IGCC projects and concludes that the projects are "consistent with the EIA modeling which projects that few, if any, new coal-fired units would be built in this decade and that those that are built would include CCS" (EPA 2014). If this rule becomes final, any new coal-fired power plants would likely require CCS in order to achieve the 1,100 lb CO_2/MWh emission limit.

to operate with IGCC than SCPC primarily because the carbon dioxide is separated from the syngas before combustion whereas with SCPC, the carbon dioxide is separated after combustion (CEUS 2014).

8.6.14 Demand-Side Management

In its ER, Exelon indicates that DSM does not fulfill the stated purpose of license renewal because it does not provide power generation capacity (Exelon 2011). Exelon also notes that the purpose of LGS license renewal is to “allow Exelon to sell wholesale power generated by LGS to meet future demand.” The ER continues to note that, because “Exelon 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.” While the staff finds this position reasonable for purposes of this analysis, it notes that DSM is an option for energy planners and decisionmakers—and it may be a potential consequence of no action—and so will discuss it in brief in this section.

DSM measures—unlike the energy supply alternatives discussed in previous sections—address energy end uses. DSM can include measures that do the following:

- reduce energy consumption;
- shift energy consumption to different times of the day to reduce peak loads;
- interrupt certain large customers during periods of high demand;
- interrupt certain appliances during high demand periods; and
- encourage customers to switch from gas to electricity for water heating and other similar measures that utilities use to boost sales.

In terms of overall ability to offset or replace an existing baseload power plant, DSM measures that reduce energy consumption, typically referred to as energy conservation and energy efficiency, are the most useful. Though often used interchangeably, energy conservation and energy efficiency are different concepts. Energy efficiency typically means deriving a similar level of service by using less energy, while energy conservation simply indicates a reduction in energy consumption. The GEIS directly addressed energy conservation, and noted that it is not a discrete power-generating source; it represents an option that states and utilities may use to reduce their need for power generation capability (NRC 1996). Conservation measures may include incentives to reduce overall energy consumption, while efficiency measures may include incentives to replace older, less efficient appliances, lighting, or heating and cooling systems. A variety of conservation or energy efficiency measures would likely be necessary to replace the capacity currently provided by LGS.

Another DMS approach is called demand-response. PJM currently has a robust demand-response program, which, unlike energy efficiency and energy conservation measures, generally aims to reduce consumption during times of high demand. This program also reduces stresses on the PJM transmission system.

PJM’s demand-response program provides payments to participants who reduce demand (PJM 2012c, PJM undated). The payments increase as the price of electricity increases, so that participants are most likely to reduce consumption when electricity is most expensive, which usually (though not always) occurs during times of high demand (this may also occur during certain emergencies). This type of approach usually offsets intermediate and peaking generation rather than baseload generation. Exelon notes, in the ER, that it is unlikely that demand reductions in PJM could be sufficiently increased to replace the LGS baseload capacity

(Exelon 2011). The NRC staff determined that this conclusion is reasonable because a considerable amount of demand reduction efforts are currently in place and it is unlikely that additional programs could reduce use by another 2,340 MW(e).

As Exelon noted in its ER, the impacts of DSM at most sites are generally SMALL. The staff has considered energy efficiency or energy conservation in several SEISs (see, e.g., NUREG-1437, Supplements 33, 37, and 38) and in each case has found the impacts to be SMALL, except when conservation or efficiency measures are unlikely to offset socioeconomic impacts of plant shutdown. For LGS, the conservation or efficiency measures may not offset the socioeconomic plant shutdown because the measures could occur across the entire PJM territory, which includes several states. The GEIS also indicates that impacts from energy conservation are likely to be SMALL. The staff notes, however, that some generation owners recently expressed concern that in cases where demand-response programs trigger increased reliance on backup diesel generators, air-quality impacts may occur, particularly in PJM (see, e.g., Beattie 2012). The EPA has provided clean-air waivers for the use of these generators for a limited number of hours throughout the year. Emergency use of these generators is likely to occur during the hottest days of the summer, when impaired air quality often also occurs (Beattie 2012). Some air quality effects from some DSM measures are possible, but they would depend on the specific DSM measures employed. Because it is unlikely that demand reductions in PJM could be sufficiently increased to replace the LGS baseload capacity, the NRC did not consider DSM to be a reasonable alternative.

8.7 No-Action Alternative

This section examines the environmental effects that occur if NRC takes no action. No action, in this case, means that NRC denies the renewed operating licenses for LGS and the licenses expire at the end of the current license terms, in 2024 and 2029. If the NRC denies the renewed operating licenses, the plant will shut down at or before the end of the current licenses. After shutdown, plant operators will initiate decommissioning in accordance with 10 CFR 50.82.

No action does not satisfy the purpose and need for this SEIS, as it neither provides power-generation capacity nor meets the needs currently met by LGS or that the alternatives evaluated in Sections 8.1–8.5 would satisfy. Assuming that a need currently exists for the power generated by LGS, the no-action alternative would require the appropriate energy planning decision-makers (not NRC) to rely on an alternative to replace the capacity of LGS, rely on energy conservation or power purchases to offset parts of the LGS capacity, or rely on some combination of measures to offset and replace the generation provided by the facility.

This section addresses only those impacts that arise directly as a result of plant shutdown. The environmental impacts from decommissioning and related activities have already been addressed in several other documents, including the "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," NUREG-0586, Supplement 1 (NRC 2002); the license renewal GEIS, Chapter 7 (NRC 1996); and Chapter 7 of this SEIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever Exelon ceases to operate LGS.

Even with a renewed operating license, LGS will eventually shut down, and the environmental effects we address in this section will occur at that time. Because these effects have not otherwise been addressed in this SEIS, the impacts are addressed in this section. As with decommissioning effects, shutdown effects are expected to be similar whether they occur at the end of the current license or at the end of a renewed license. Table 8–10 provides a summary of the environmental impacts of the no-action alternative.

8.7.1 Air Quality

When the plant stops operating, there will be a reduction in emissions from activities related to plant operation, such as use of diesel generators and employee vehicles. In Chapter 4, the staff determined that these emissions would have a SMALL impact on air quality during the renewal term; therefore, if emissions decrease, the impact on air quality would also decrease and would be SMALL.

8.7.2 Groundwater Resources

Impacts to groundwater resources would decrease, as the plant would withdraw less water than it does during operations. Therefore, shutdown would reduce the impacts to groundwater resources, which would remain SMALL.

8.7.3 Surface Water Resources

Impacts to surface water resources would decrease, as the plant would withdraw and discharge less water than it does during operations. Therefore, shutdown would reduce the impacts to surface water resources, which would remain SMALL.

8.7.4 Aquatic and Terrestrial Resources

Impacts to aquatic ecology would decrease, as the plant would withdraw and discharge less water than it does during operations. Therefore, fewer organisms would be subject to impingement, entrainment, and heat shock. Shutdown would reduce the impacts to aquatic ecology, which would remain SMALL.

Terrestrial ecology impacts would remain SMALL. No additional land disturbances on or offsite would occur.

8.7.5 Human Health

In Chapter 4 of this SEIS, the staff concluded that the impacts of continued plant operation on human health would be SMALL. After cessation of plant operations, the amounts of radioactive material released to the environment in gaseous and liquid forms, all of which are currently within respective regulatory limits, would be reduced or eliminated. Therefore, the staff concludes that the impact of plant shutdown on human health would also be SMALL. In addition, the potential for a variety of accidents would also be reduced to only those associated specifically with shutdown activities and fuel handling. In Chapter 5 of this SEIS, the staff concluded that impacts of accidents during operation would be SMALL. It follows, therefore, that impacts on human health from a reduced suite of potential accidents after reactor operation ceases would also be SMALL. Therefore, the staff concludes that impacts on human health from the no-action alternative would be SMALL.

8.7.6 Land Use

Plant shutdown would not affect onsite land use. Plant structures and other facilities would remain in place until decommissioning. Most transmission lines connected to the LGS would remain in service after the plant stops operating. Maintenance of most existing transmission lines would continue as before. Impacts on land use from plant shutdown would be SMALL.

8.7.7 Socioeconomics

Plant shutdown would have a noticeable impact on socioeconomic conditions in the communities located in the immediate vicinity of LGS. Should LGS shut down, there would be immediate socioeconomic impact from the loss of jobs (some, though not all, of the 820 employees would begin to leave), and tax payments may be reduced. As the majority of LGS employees reside in Montgomery, Berks, and Chester Counties, socioeconomic impacts from plant shutdown would be concentrated in these counties, with a corresponding reduction in purchasing activity and tax contributions to the regional economy. Revenue losses from LGS operations would directly affect Montgomery County and other local taxing districts and communities closest to, and most reliant on, the nuclear plant's tax revenue. The impact of the job loss, however, may not be as noticeable given the amount of time required to decontaminate and decommission existing facilities and the proximity of LGS to the Philadelphia metropolitan area. The socioeconomic impacts of plant shutdown (which may not entirely cease until after decommissioning) could, depending on the jurisdiction, range from SMALL to MODERATE.

8.7.8 Transportation

Traffic volumes on the roads in the vicinity of LGS would be reduced after plant shutdown. Most of the reduction in traffic volume would be associated with the loss of jobs at the nuclear power plant. The number of deliveries to the power plant would be reduced until decommissioning. Transportation impacts would be SMALL as a result of plant shutdown.

8.7.9 Aesthetics

Plant structures and other facilities would remain in place until decommissioning. Most sources of operational noise would cease. Therefore, aesthetic impacts of plant closure would be SMALL.

8.7.10 Historic and Archaeological Resources

Impacts from the no-action alternative on historic and archaeological resources would be SMALL. A separate environmental review addressing the protection of historic and archaeological resources would be conducted for decommissioning.

8.7.11 Environmental Justice

Impacts to minority and low-income populations would depend on the number of jobs and the amount of tax revenues lost by communities in the immediate vicinity of the power plant after LGS ceases operations. Closure of LGS would reduce the overall number of jobs (there are currently 820 employed at the facility) and tax revenue for social services attributed to nuclear plant operations. Minority and low-income populations in the vicinity of LGS could experience some socioeconomic effects from plant shutdown, but these effects would not likely be high and adverse.

8.7.12 Waste Management

If the no-action alternative were implemented, the generation of high-level waste would stop, and generation of low-level and mixed waste would decrease. Impacts from implementation of the no-action alternative are expected to be SMALL.

Table 8–10. Environmental Impacts of No-Action Alternative

	No-Action Alternative	Continued Operation of LGS
Air Quality	SMALL	SMALL
Groundwater Resources	SMALL	SMALL
Surface Water Resources	SMALL	SMALL
Aquatic Ecology	SMALL	SMALL
Terrestrial Ecology	SMALL	SMALL
Human Health	SMALL	SMALL
Land Use	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Transportation	SMALL	SMALL
Aesthetics	SMALL	SMALL
Historic and Archaeological	SMALL	SMALL
Waste Management	SMALL[(a)]	SMALL[(a)]

[(a)] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS

8.8 Alternatives Summary

In this SEIS, the staff has considered alternative actions to license renewal of LGS, including in-depth evaluations of new generation alternatives (Sections 8.1–8.4), a purchased power alternative (Section 8.5), alternatives that the staff dismissed from detailed evaluation as infeasible or inappropriate (Section 8.6; including in-depth consideration of solar PV generation and two combination alternatives), and the no-action alternative in which the operating license is not renewed (Section 8.7). Impacts of all alternatives considered in detail are summarized in Table 8-11.

Based on the above evaluations, the staff concludes that the environmental impacts of renewal of the operating license for LGS would be smaller than those of feasible and commercially viable alternatives studied in this SEIS that satisfy the purpose and need of license renewal (providing 2,340 MWe of baseload power to the grid). Impacts on air quality are less from continued operation of LGS than from any of the alternatives involving fossil fuels, though they are likely to be greater than wind and solar PV alone. Finally, the staff concluded that under the no-action alternative, the act of shutting down LGS on or before its license expiration would have mostly SMALL impacts, although socioeconomic impacts would be SMALL to MODERATE. Depending on how the power lost to the region from reactor shutdown was replaced (decisions outside of the NRC's authority and made instead by Exelon, other power producers, PJM operators, and state or non-NRC Federal authorities), the net environmental impact of the no-action alternative could be greater than continued reactor operation, especially when fossil energy power plants provide replacement generation capacity.

Table 8–11. Summary of Environmental Impacts of Proposed Action and Alternatives

Alternative	Impact Area							
	Air Quality	Groundwater and Surface Water Resources	Aquatic and Terrestrial Resources	Human Health	Land Use	Socioeconomics (including Transportation and Aesthetics)	Historic and Archaeological Resources	Waste Management
License Renewal	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL[a]
NGCC at an Existing Site	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALLto MODERATE	SMALL
SCPC at an Alternate Site	MODERATE	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL to LARGE	SMALL	MODERATE
New Nuclear at an Alternate Site	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL to LARGE	SMALL	SMALL[a]
Wind	SMALL	SMALL	SMALL to MODERATE	SMALL	MODERATE to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL
Purchased Power	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL	SMALL to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL to MODERATE
Solar PV (dismissed in Section 8.6.1)	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL
Wind, Solar, and NGCC (dismissed in Section 8.6.2)	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL
Wind and CAES (dismissed in Section 8.6.3)	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL	MODERATE to LARGE	SMALL to LARGE	SMALL to LARGE	SMALL
No-Action Alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL[a]

[a] As described in Chapter 6, the issue, "offsite radiological impacts (spent fuel and high level waste disposal)," is not evaluated in this EIS.

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9.0 CONCLUSION

This supplemental environmental impact statement (SEIS) contains the environmental review of Exelon's application for renewed operating licenses for Limerick Generating Station, Units 1 and 2 (LGS), as required by Title 10 of the *Code of Federal Regulations* (10 CFR), Part 51 (10 CFR Part 51), the U.S. Nuclear Regulatory Commission's (NRC's) regulations that implement the National Environmental Policy Act (NEPA). This chapter presents conclusions and recommendations from the site-specific environmental review of LGS and summarizes site-specific environmental issues of license renewal that the NRC staff (staff) noted during the review. Section 9.1 summarizes the environmental impacts of license renewal; Section 9.2 presents a comparison of the environmental impacts of license renewal and energy alternatives; Section 9.3 discusses unavoidable impacts of license renewal, energy alternatives, and resource commitments; and Section 9.4 presents conclusions and staff recommendations.

9.1 Environmental Impacts of License Renewal

Based on its review of site-specific environmental issues in this SEIS, the staff concludes that issuing renewed licenses for LGS would have SMALL impacts with respect to the Category 2 issues applicable to license renewal at LGS, as well as with respect to environmental justice and the chronic effects of electromagnetic fields.

The staff considered mitigation measures for each Category 2 issue, as applicable. For surface water use, current measures to mitigate the environmental impacts of plant operations were found to be adequate. The Delaware River Basin Commission (DRBC) requires LGS to shift to an alternative water source when the flow of the Schuylkill River falls to 560 cubic feet per second (cfs) (15.9 cubic meters per second [m^3/s]) to ensure that LGS cooling water withdrawals and associated consumptive use will not reduce flow by more than 12 percent during low-flow periods.

The staff also considered cumulative impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes them. The staff concluded in Section 4.11 that the cumulative impacts of LGS's license renewal would be SMALL for all areas except aquatic ecology and terrestrial ecology. For aquatic ecology, the staff concluded that the cumulative impacts would be SMALL to MODERATE. For terrestrial ecology, the staff concluded that the cumulative impacts would be MODERATE.

9.2 Comparison of Alternatives

In the conclusion to Chapter 8, the staff considered in detail the following alternatives to LGS license renewal:

- natural-gas-fired combined-cycle (NGCC),
- supercritical pulverized coal,
- new nuclear,
- wind power,
- purchased power, and
- no action.

The staff concluded that the environmental impacts of the renewal of the operating license for LGS would be smaller than those of feasible and commercially viable alternatives. The no-action alternative—the act of shutting down LGS on or before its license expiration date—would have SMALL environmental impacts in most areas with the exception of socioeconomic impacts which would be SMALL to MODERATE. Continued operation of LGS would have SMALL environmental impacts in all areas. Therefore, the staff concluded that continued operation of the existing LGS is the environmentally preferred alternative.

9.3 Resource Commitments

9.3.1 Unavoidable Adverse Environmental Impacts

Unavoidable adverse environmental impacts are impacts that would occur after implementation of all workable mitigation measures. Carrying out any of the energy alternatives considered in this SEIS, including the proposed action, would result in some unavoidable adverse environmental impacts.

Minor unavoidable adverse impacts on air quality would occur due to emission and release of various chemical and radiological constituents from power plant operations. Nonradiological emissions resulting from power plant operations are expected to comply with U.S. Environmental Protection Agency (EPA) emissions standards, although the alternative of operating a fossil-fueled power plant in some areas may worsen existing attainment issues. Chemical and radiological emissions would not exceed the National Emission Standards for hazardous air pollutants.

During nuclear power plant operations, workers and members of the public would face unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be exposed to radiation and chemicals associated with routine plant operations and the handling of nuclear fuel and waste material. Workers would have higher levels of exposure than members of the public, but doses would be administratively controlled and would not exceed standards or administrative control limits. In comparison, the alternatives involving the construction and operation of a non-nuclear power generating facility would also result in unavoidable exposure to hazardous and toxic chemicals to workers and the public.

The generation of spent nuclear fuel and waste material, including low-level radioactive waste, hazardous waste, and nonhazardous waste would also be unavoidable. In comparison, hazardous and nonhazardous wastes would also be generated at non-nuclear power generating facilities. Wastes generated during plant operations would be collected, stored, and shipped for suitable treatment, recycling, or disposal in accordance with applicable Federal and State regulations. Due to the costs of handling these materials, power plant operators would be expected to carry out all activities and optimize all operations in a way that generates the smallest amount of waste possible.

9.3.2 Short-Term Versus Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment, as described in Chapters 4, 5, 6, 7, and 8. "Short-term" is the period of time that continued power generating activities take place.

Power plant operations require short-term use of the environment and commitment of resources and commit certain resources (e.g., land and energy), indefinitely or permanently. Certain short-term resource commitments are substantially greater under most energy alternatives, including license renewal, than under the no-action alternative because of the continued generation of electrical power and the continued use of generating sites and associated infrastructure. During operations, all energy alternatives require similar relationships between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Air emissions from power plant operations introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but they are not expected to impact air quality or radiation exposure to the extent that public health and long-term productivity of the environment would be impaired.

Continued employment, expenditures, and tax revenues generated during power plant operations directly benefit local, regional, and State economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term.

The management and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste requires an increase in energy and consumes space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long-term productivity of the land.

Power plant facilities are committed to electricity production over the short term. After decommissioning these facilities and restoring the area, the land could be available for other future productive uses.

9.3.3 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitment of resources that have been noted in this SEIS. Resources are irreversible when primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitments of resources for electrical power generation include the commitment of land, water, energy, raw materials, and other natural and man-made resources required for power plant operations. In general, the commitment of capital, energy, labor, and material resources are also irreversible.

The implementation of any of the energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitment of energy, water, chemicals, and in some cases, fossil fuels. These resources would be committed during the license renewal term and over the entire life cycle of the power plant, and they would be unrecoverable.

Energy expended would be in the form of fuel for equipment, vehicles, and power plant operations and electricity for equipment and facility operations. Electricity and fuel would be purchased from offsite commercial sources. Water would be obtained from existing water supply systems. These resources are readily available, and the amounts required are not expected to deplete available supplies or exceed available system capacities.

9.4 Recommendations

The NRC's recommendation is that the adverse environmental impacts of license renewal for LGS are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on the following:

- the analyses and findings in NUREG-1437, Volumes 1 and 2, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*;

- the environmental report submitted by Exelon;
- the NRC's consultation with Federal, state, and local agencies;
- the NRC's independent environmental review;
- the NRC's consideration of public comments received during the scoping process;
- the NRC's consideration of public comments received on the draft SEIS; and
- the NRC's consideration of the information presented in the Natural Resources Defense Council's SAMA-related waiver petition.

10.0 LIST OF PREPARERS

Members of the U.S. Nuclear Regulatory Commission's (NRC's) Office of Nuclear Reactor Regulation (NRR) prepared this supplemental environmental impact statement (SEIS) with assistance from other NRC organizations and contract support from Pacific Northwest National Laboratory (PNNL). Table 10–1 lists each contributor's name, affiliation, and function or expertise.

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[(a)] PNNL is operated by Battelle for the U.S. Department of Energy.

11.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THIS SEIS ARE SENT

Table 11–1. List of Agencies, Organizations, and Persons to Whom Copies of This SEIS Are Sent

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12.0 INDEX

NRC FORM 335 (12-2010) NRCMD 3.7 U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG-1437, Supplement 49, Volume 1 Final Report
2. TITLE AND SUBTITLE Generic Environmental Impact Statement for License Renewal of Nuclear Plants Supplement 49 Regarding Limerick Generating Station, Units 1 and 2, Volume 1 Final Report	3. DATE REPORT PUBLISHED MONTH: August YEAR: 2014 4. FIN OR GRANT NUMBER
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Office of Nuclear Reactor Regulation
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Washington, DC 20555-0001

9. SPONSORING ORGANIZATION - NAME AND ADDRESS (If NRC, type "Same as above", if contractor, provide NRC Division, Office or Region, U. S. Nuclear Regulatory Commission, and mailing address.)

Same as above

10. SUPPLEMENTARY NOTES

Docket Nos. 50-352, 50-353

11. ABSTRACT (200 words or less)

This draft supplemental environmental impact statement has been prepared in response to an application submitted by Exelon Generation Company, LLC (Exelon) to renew the operating license for Limerick Generating Station, Units 1 and 2 (LGS) for an additional 20 years. This draft supplemental environmental impact statement includes the preliminary analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include natural gas combined-cycle (NGCC); supercritical pulverized coal; new nuclear; wind power; purchased power; and not renewing the license (the no action alternative). The U.S. Nuclear Regulatory Commission's preliminary recommendation is that the adverse environmental impacts of license renewal for LGS are not great enough to deny the option of license renewal for energy planning decisionmakers. This recommendation is based on the following: (1) the analysis and findings in NUREG 1437, Volumes 1 and 2, Generic Environmental Impact Statement for License Renewal of Nuclear Plants; (2) the environmental report submitted by Exelon; (3) consultation with Federal, state, and local agencies; (4) the NRC's environmental review; (5) consideration of public comments received during the scoping process; (6) consideration of public comments received on the draft supplemental environmental impact statement; and (7) consideration of the information presented in the Natural Resources Defense Council's severe accident mitigation alternatives-related waiver petition.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)	
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Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding Limerick Generating Station, Units 1 and 2

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