Applicant's Environmental Report – Operating License Renewal Stage Byron Station

Unit 1
License No. NPF-37

Unit 2
License No. NPF-66

Exelon Generation Company, LLC

May 2013

Byron & Braidwood Stations, Units 1 & 2
License Renewal Application
Appendix E, Item E-1

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Acronyms and Abbreviations

AADT	Annual Average Daily Traffic
ac	acre
AIU	Ameren Illinois Utilities
ALARA	as low as reasonably achievable
ARES	alternative retail electric suppliers
BP	before present
BPA	Bonneville Power Authority
Btu	British Thermal Units
c-14	carbon-14 isotope
CAA	Clean Air Act
CAES	compressed air energy storage
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
cm	centimeter
CO	carbon monoxide
CO_2	carbon dioxide
COL	Combined Construction and Operation License
ComEd	Commonwealth Edison Company
CPUE	catch per unit effort
CROP	Construction Run-off Pond
CSA	Combined Statistical Area
CSAPR	Cross-State Air Pollution Rule
CSP	concentrating solar power
CWA	Clean Water Act
CWS	circulating water system
DNR	[Illinois] Department of Natural Resources
DO	dissolved oxygen
DOE	U.S. Department of Energy
DSM	demand side management
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act
ERCOT	Electric Reliability Council of Texas

EU	electric utilities
FAA	Federal Aviation Administration
FES	Final Environmental Statement
FESOP	Federally Enforceable State Operating Permit
ft, ft^3	feet, cubic feet
gal	gallon
GEIS	Generic Environmental Impact Statement
GHG	greenhouse gases
GL	generic letter
gpd	gallons per day
gpm	gallons per minute
GW	gigawatt
GWPS	gaseous waste processing system
ha	hectare
HDPE	high density polyethylene
HFC	hydrofluorocarbon
HIC	high integrity container
HRSG	Heat Recovery Steam Generator
HTGR	high-temperature gas-cooled reactor
IAC	Illinois Administrative Code
IBI	Index of Biological Integrity
IDCEO	Illinois Department of Commerce and Economic Opportunity
IDOT	Illinois Department of Transportation
IEPA	Illinois Environmental Protection Agency
ILCS	Illinois Compiled Statutes
in	inch
IPA	Integrated Plant Assessment
IPE	internally initiated events
IPEEE	individual plant examination for externally-initiated events
IRSF	Interim radioactive storage facility
ISFSI	Independent Spent Fuel Storage Installation
ISGS	Illinois State Geological Survey
ISO	Independent [Transmission] System Operator Independent Standards Organization
kg	kilogram
km	kilometer
kWh	kilowatt hour
kV	kilovolt
L	liter

lb	pound
LCCP	Lee County Comprehensive Plan
LERF	Large Early Release Frequency
LRMP	land resource management plan
LLD	lower limit of detection
LLC	Limited Liability Company
LLRW	Low-level radioactive waste
LLRWPAA	Low-level Radioactive Waste Policy Amendments Act of 1985
L/day	liters per day
L/sec	liters per second
LOS	level of service
MACCS2	MELCOR Accident Consequences Code System, ver. 2
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NEAC	[DOE] Nuclear Energy Advisory Committee
NEI	Nuclear Energy Institute
NGNP	Next Generation Nuclear Plant
NOAA	National Oceanic and Atmospheric Administration
NO_X	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NSPS	New source performance standards
m, m^3	meter, cubic meter
mi	mile
MATS	Mercury and Air Toxic Standards
MGD	million gallons per day
mg/L	milligrams per liter
mi	mile
MM	million
MUR	measurement uncertainty recapture
MWe	megawatts electric
MWt	megawatts thermal
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NERI	Nuclear Energy Research Institute
NESC	National Electric Safety Code

NEI	Nuclear Energy Institute
NH_3	ammonia
NHS	Natural History Survey
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NRIS	National Register Information System
NSPS	New Source Performance Standard
OTEC	Ocean thermal energy conversion
PCB	polychlorinated byphenols
pCi/L	picocuries/liter
PECO	PECO Energy Company
PFC	perfluorocarbons
PHS	pumped hydro storage
PIAT	payment in addition to taxes
PIMW	potentially infectious medical waste
PJM	regional electric distribution network
$PM_{2.5}$	particulate matter with aerodynamic diameters of 2.5 microns or less
PM_{10}	particulate matter with aerodynamic diameters of 10 microns or less
PRA	probabilistic risk assessment
PSD	Prevention of Significant Deterioration
psi	pounds per square inch
PV	photovoltaic
PWR	pressurized water reactor
PWSCC	primary water stress corrosion cracking
REMP	Radiological Environmental Monitoring Program
RGPP	Radiological Groundwater Protection Program
ROI	region of interest
ROW	right-of-way
RPS	Renewable Portfolio Standards
RVH	reactor vessel head
SAMA	severe accident mitigation alternative
SCR	selective catalytic reduction
SF_6	sulfur hexafluoride

SGR	steam generator replacement
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMITTR	surveillance, monitoring, inspection, testing, trending and recordkeeping
SO_2	sulfur dioxide
Sr-90	Strontium-90
TES	thermal energy storage
tpy	tons per year
TSP	total suspended particulates
TSS	transmission substation
T&E	threatened and endangered
UFSAR	Updated Final Safety Analysis Report
USC	United States Code
USCB	U.S. Census Bureau
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
URL	Uniform Resource Locator
UWM	University of Wisconsin - Milwaukee
VOC	volatile organic compound
WCD	Waste Confidence Decision
yr	year

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Chapter 1

Purpose of and Need for Action

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1.1 Purpose of and Need for Action

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants in accordance with the Atomic Energy Act of 1954, as amended, and NRC implementing regulations. Exelon Generation Company, LLC (Exelon Generation) operates the Byron Station Units 1 and 2 (Byron), pursuant to NRC Operating Licenses NPF-37 (Unit 1) and NPF-66 (Unit 2), respectively. The existing license for Unit 1 will expire on October 31, 2024. The existing license for Unit 2 will expire on November 6, 2026.

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

> Title 10, Energy, Code of Federal Regulations (CFR), Part 54, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, Section 54.23, Contents of Application-Environmental Information (10 CFR 54.23) and

> Title 10, Energy, CFR, Part 51, Environmental Protection Requirements for Domestic Licensing and Related Regulatory Functions, Section 51.53, Post-construction Environmental Reports, Subsection 51.53(c), Operating License Renewal Stage [10 CFR 51.53(c)] (49 FR 9381, March 12, 1984) and proposed revisions to the rule (NRC 2012a).

NRC has clarified the purpose and need for the proposed action, renewal of the operating license for nuclear power plants such as Byron, as follows:

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

The renewed operating licenses would allow an additional 20 years of operation for the Byron units beyond their current licensed operating period. The renewed license for Byron Unit 1 would expire on October 31, 2044, and the renewed license for Byron Unit 2 would expire on November 6, 2046.

1.2 Environmental Report Scope and Methodology

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

- Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996b and NRC 1999a) and the Draft Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Rev. 1 (NRC 2009a)

- NRC supplemental information in the Federal Register (NRC 1996a; NRC 1996c; NRC 1996d; and NRC 1999b)

- Regulatory Analysis for Amendments to Regulations for the Environmental Review for Renewal of Nuclear Power Plant Operating Licenses (NRC 1996e)

- Public Comments on the Proposed 10 CFR Part 51 Rule for Renewal of Nuclear Power Plant Operating Licenses and Supporting Documents: Review of Concerns and NRC Staff Response (NRC 1996f)

- Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Report for Applications to Renew Nuclear Power Plant Operating Licenses (NRC 2000), and the proposed Revision 1 of Regulatory Guide 4.2, Supplement 1, Preparation of Environmental Reports for Nuclear Power Plant License Renewal Applications (NRC 2009b).

Exelon Generation has prepared Table 1.2-1 to verify conformance with regulatory requirements. Table 1.2-1 indicates the sections in the Byron License Renewal Environmental Report that respond to each requirement of 10 CFR 51.53(c). In addition, each responsive section is prefaced by a boxed quote of the regulatory language and applicable supporting document language.

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

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(1)		Entire Document
10 CFR 51.53(c)(2), Sentences 1 and 2	3.0	Proposed Action
10 CFR 51.53(c)(2), Sentence 3	7.2.2	Environmental Impacts of Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(1)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(2)	6.3	Unavoidable Adverse Impacts
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	7.0	Alternatives to the Proposed Action
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	8.0	Comparison of Environmental Impacts of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(4)	6.5	Short-Term Use Versus Long-Term Productivity of the Environment
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(5)	6.4	Irreversible and Irretrievable Resource Commitments
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	6.2	Mitigation
	7.2.2	Environmental Impacts of Alternatives
	8.0	Comparison of Environmental Impacts of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(d)	9.0	Status of Compliance
10 CFR 51.53(c)(2) and 10 CFR 51.45(e)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(3)(ii)(A)	4.1	Water Use Conflicts (Plants with Cooling Ponds or Cooling Towers Using Makeup Water from a Small River with Low Flow)
10 CFR 51.53(c)(3)(ii)(A)	4.6	Groundwater Use Conflicts (Plants Using Cooling Water Towers Withdrawing Makeup Water from a Small River)
10 CFR 51.53(c)(3)(ii)(B)	4.2	Entrainment of Fish and Shellfish in Early Life Stages
10 CFR 51.53(c)(3)(ii)(B)	4.3	Impingement of Fish and Shellfish
10 CFR 51.53(c)(3)(ii)(B)	4.4	Heat Shock
10 CFR 51.53(c)(3)(ii)(C)	4.5	Groundwater Use Conflicts (Plants Using > 100 gpm of Groundwater)
10 CFR 51.53(c)(3)(ii)(C)	4.7	Groundwater Use Conflicts (Plants Using Ranney Wells)
10 CFR 51.53(c)(3)(ii)(D)	4.8	Degradation of Groundwater Quality

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

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(3)(ii)(E)	4.9	Impacts of Refurbishment on Terrestrial Resources
	4.10	Threatened and Endangered Species
10 CFR 51.53(c)(3)(ii)(F)	4.11	Air Quality During Refurbishment (Non-Attainment or Maintenance Areas)
10 CFR 51.53(c)(3)(ii)(G)	4.12	Microbiological Organisms
10 CFR 51.53(c)(3)(ii)(H)	4.13	Electric Shock from Transmission-Line-Induced Currents
10 CFR 51.53(c)(3)(ii)(I)	4.14	Housing Impacts
10 CFR 51.53(c)(3)(ii)(I)	4.15	Public Water Supply
10 CFR 51.53(c)(3)(ii)(I)	4.16	Education Impacts from Refurbishment
10 CFR 51.53(c)(3)(ii)(I)	4.17	Offsite Land Use
10 CFR 51.53(c)(3)(ii)(J)	4.18	Transportation
10 CFR 51.53(c)(3)(ii)(K)	4.19	Historic and Archaeological Resources
10 CFR 51.53(c)(3)(ii)(L)	4.20	Severe Accident Mitigation Alternatives (SAMA)
10 CFR 51.53(c)(3)(iii)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(3)(iii)	6.2	Mitigation
10 CFR 51.53(c)(3)(iv)	5.0	Assessment of New and Significant Information
10 CFR Part 51, Appendix B, Table B-1, Footnote 6	2.6.2	Minority and Low-Income Populations

1.3 Byron Station Licensee and Ownership

Byron is 100 percent owned and operated by Exelon Generation Company, LLC (Exelon Generation), the applicant and licensee. Exelon Generation is wholly owned by Exelon Corporation.

Exelon Corporation delivers energy via its energy delivery subsidiaries, Commonwealth Edison Company (ComEd), serving retail customers in northern Illinois; PECO Energy Company (PECO), serving retail customers in southeastern Pennsylvania; and Baltimore Gas and Electric Company (BGE), serving retail customers in central Maryland. The transmission lines that connect Byron to the regional electricity grid are owned and operated by ComEd.

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Chapter 2

Site and Environmental Interfaces

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2.1 Location and Features

Byron Station (Byron) is in northern Illinois near the center of Ogle County, approximately 145 kilometers (km) (90 miles [mi]) west-northwest of Chicago, 27 km (17 mi) southwest of Rockford, and 6 km (3.7 mi) south-southwest of the City of Byron (Figure 2.1-1). The site is located on a topographic high in the Rock River Hill Country physiographic province (Exelon Nuclear 2006) in an agricultural area. The Rock River is approximately 3.2 km (2 mi) west of the western site boundary; and that river location is 185 km (115 river mi) upstream from the Rock River's confluence with the Mississippi River (Exelon Nuclear 2006).

The Byron site is located on approximately 721 hectares (ha) (1,782 acres [ac]), and consists of the main site area and a right-of-way (ROW) to the Rock River for the circulating water makeup intake and blowdown discharge pipelines (Figures 2.1-2 and 2.1-3). The main site area occupies approximately 566 ha (1,398 ac), while the water pipelines' ROW occupies the remaining 155 ha (384 ac) (Exelon Nuclear 2010a). The nuclear generating facilities are sited in the approximate center of the main site area and include the two reactor containment structures and related facilities, two circulating water natural draft cooling towers, two essential service water mechanical draft cooling towers, a switchyard, administration buildings, warehouses, and other features. The water intake and discharge pipelines' ROW runs from the northwest site boundary approximately 3.2 km (2 mi) west to the Rock River. The Rock River is the source of makeup water for the circulating water system and the receiving body for the circulating water blowdown discharge, which is subject to limitations established by National Pollutant Discharge Elimination System (NPDES) Permit IL0048313.

The Byron Salvage Yard Superfund Site bounds the north portion of the west side of the Byron site. It consists of two separate parcels: the Byron Salvage Yard and Dirk's Farm. Section 2.3.4.2 provides more information about these parcels.

Three ROWs leaving the Byron site for transmission lines that were constructed at the time of initial plant construction to connect Byron to the regional electrical grid are shown on Figure 2.1-3. One ROW runs north and then east from Byron approximately 30 miles to the Wempletown Transmission Substation, located approximately 7 miles northwest of Rockford, IL. A second ROW runs northeast from Byron for approximately 21 miles, to the Cherry Valley Transmission Substation. The third ROW goes directly south for a total length of 8.5 miles to its intersection with the Nelson to Cherry Valley transmission line ROW, which existed before Byron was constructed. These ROWs, which total approximately 1,210 acres, are owned and maintained by Commonwealth Edison Company (ComEd). Figure 3.1-3 depicts the full ROW routings, and Section 3.1.6 provides more information about the transmission line ROWs.

Interstate 39 is approximately 19 km (12 mi) east of the site and provides access to the site vicinity, including Rockford, from the north via State Route 72 and from the south via State Route 64. County Route 2 (German Church Road) provides direct access to the site from State Routes 72 and 64. The Canadian Pacific Railroad provides a spur to the site (DM&E 2009).

Figure 2.1-1. Byron 50-Mile Radius Map

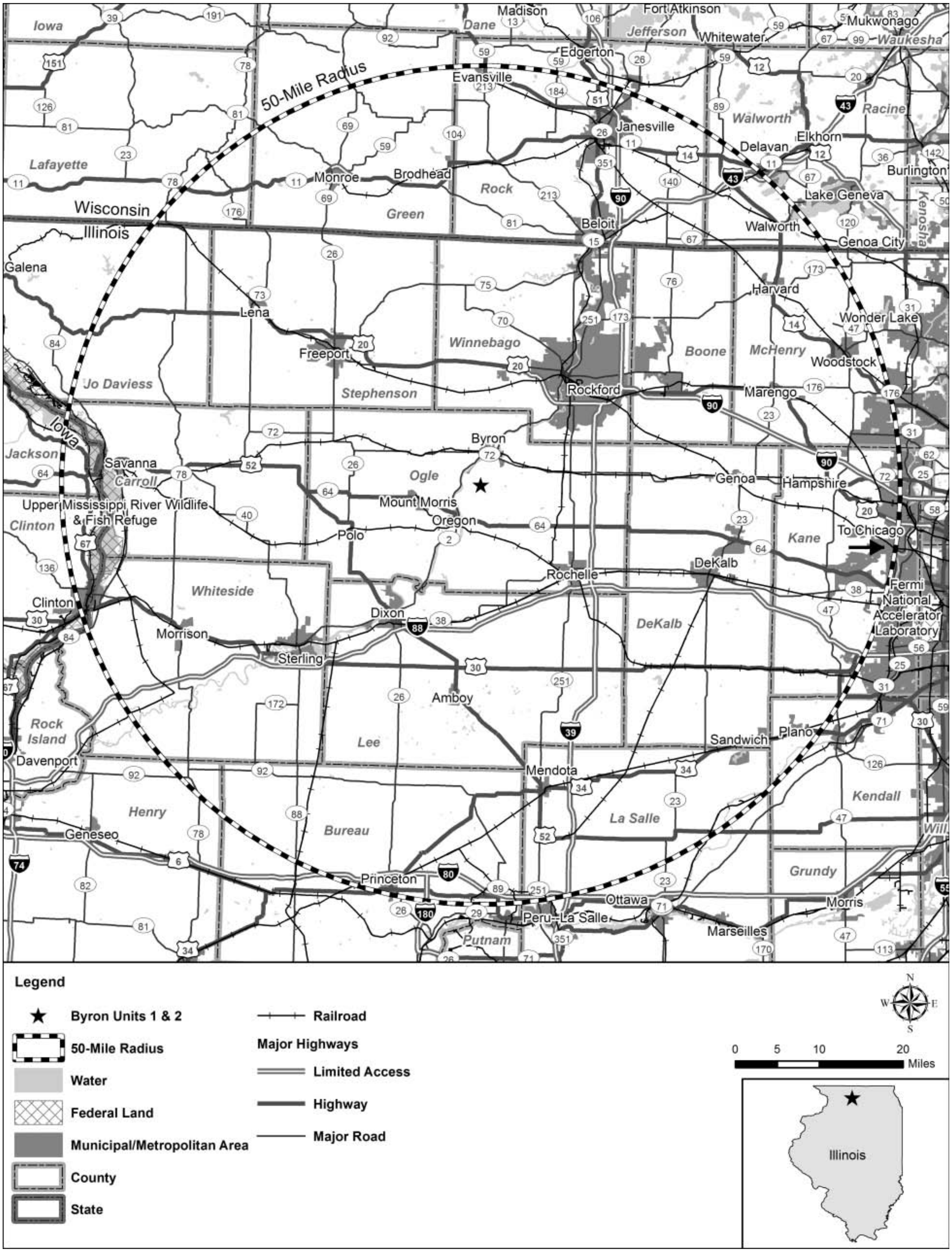


Figure 2.1-2. Byron 6-Mile Radius Map

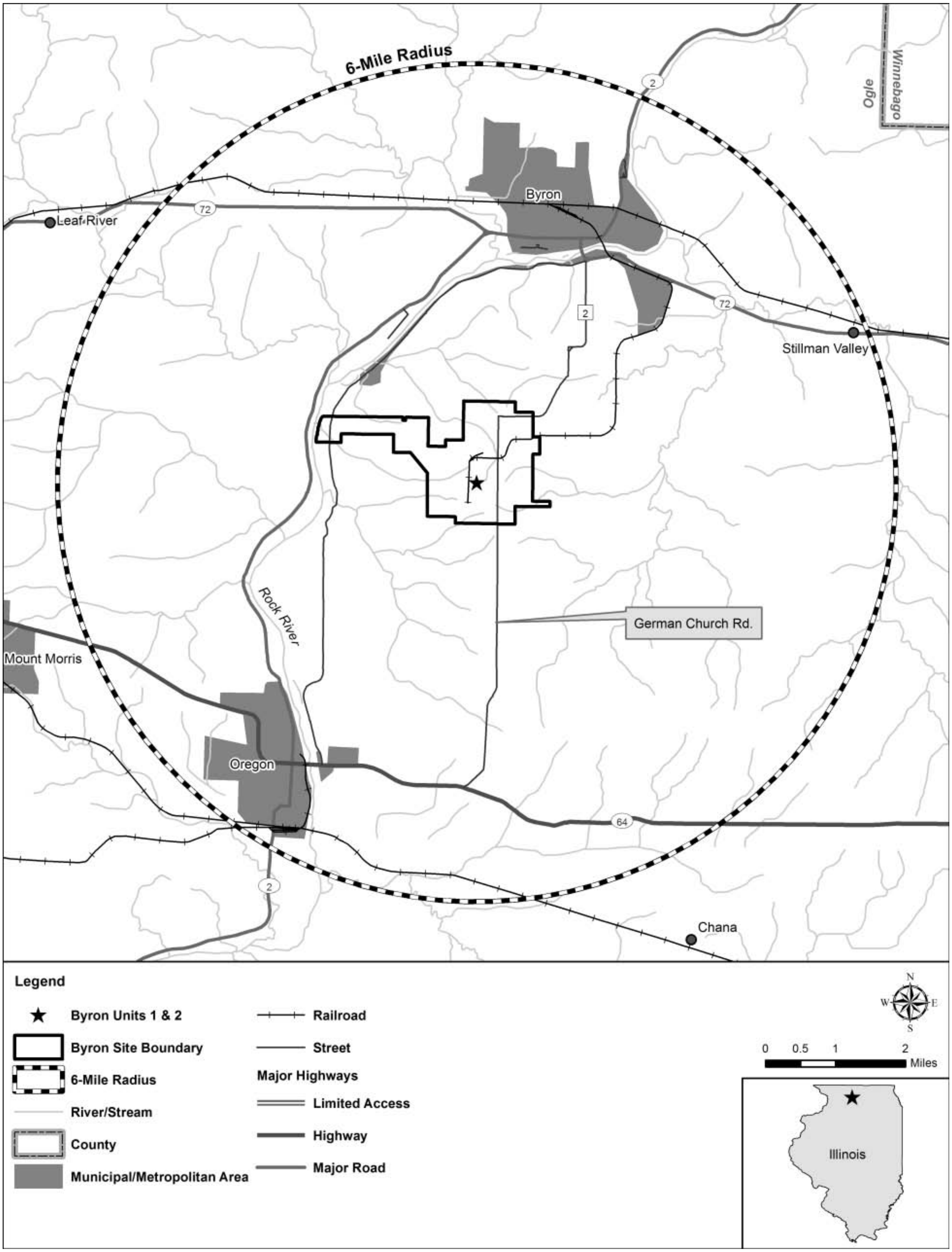
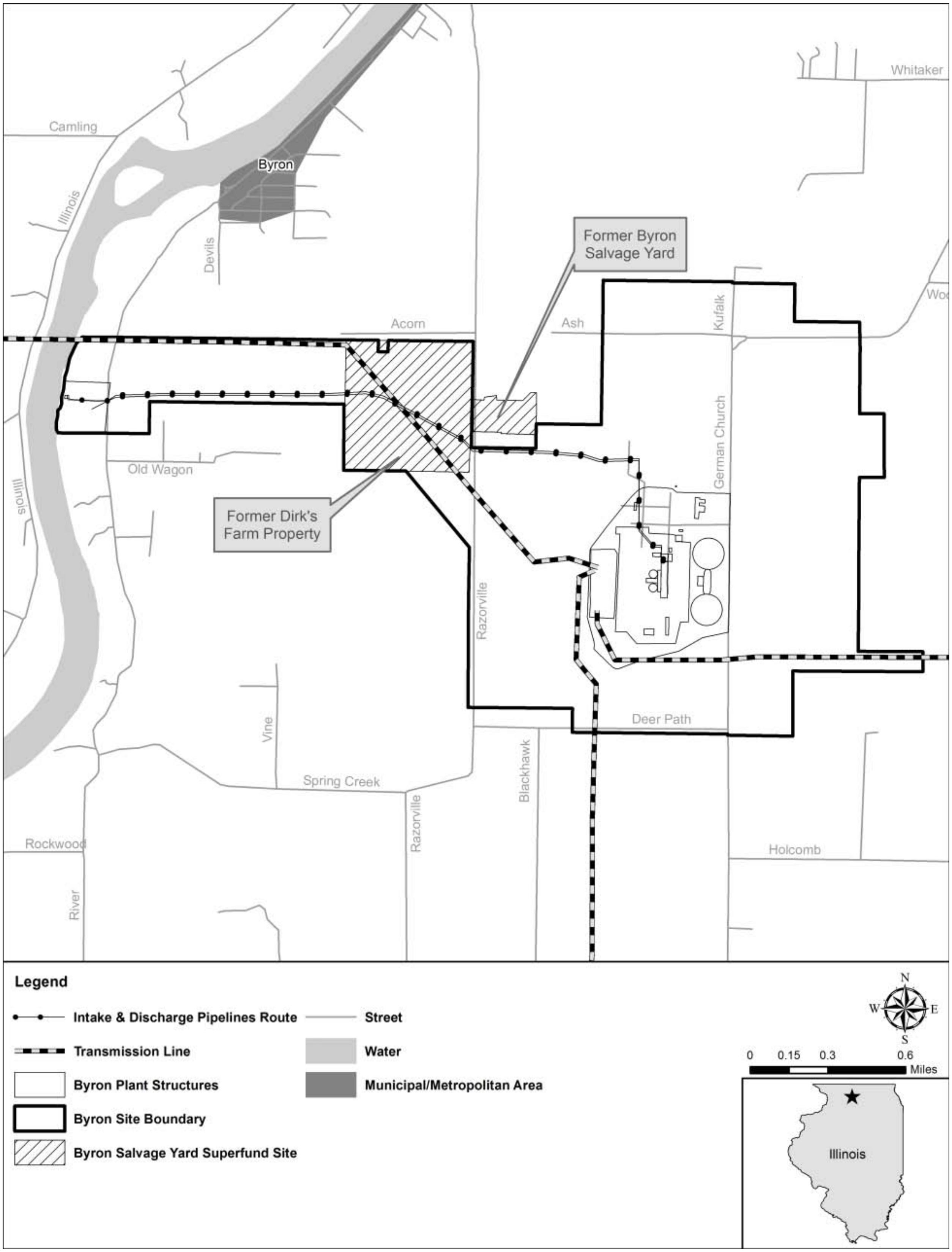


Figure 2.1-3. Byron Site Boundary



2.2 Aquatic and Riparian Communities

2.2.1 Introduction

The Rock River originates in the Horicon Marsh in Dodge County, Wisconsin, from which it meanders south, entering Illinois just south of Beloit, Wisconsin. From the Wisconsin-Illinois state line, the Rock River flows south, then southwest, to its confluence with the Mississippi River at Rock Island, Illinois. The river is some 512 km (318 mi) long, approximately 262 km (163 mi) of which are in Illinois (Sinclair 1996). The Rock River watershed totals approximately 28,270 square km (10,915 square mi), of which 14,633 square km (5,650 square mi) are in the state of Illinois (Sinclair 1996).

The three largest tributaries of the Rock River are the Pecatonica River (Wisconsin-Illinois), the Kishwaukee River (Illinois), and the Green River (Illinois), with drainage areas of 6,840, 3,256, and 2,929 square km (2,641, 1,257, and 1,131 square mi), respectively (Sinclair 1996). Land use in the Rock River basin is primarily agricultural, but there are several small cities on the river's main stem, including Rockford, Sterling/Rock Falls, and Rock Island-Moline (Sinclair 1996; USACE 2001). Another population center, DeKalb (Illinois), is on the Kishwaukee River, a major tributary of the Rock River. Agricultural runoff and urban storm water runoff in the basin have degraded the Rock River's water quality (USACE 2001).

Hydrologic modifications, including the installation of dams and levees, stream channelization, and drainage of wetlands have reduced the quantity and quality of aquatic habitat in the basin (USACE 2001). There are low-head dams on the main stem of the river at Rockton, Rockford, Oregon, Dixon, Sterling/Rock Falls (two, "upper" and "lower"), and Milan (Milan Steel Dam, which blocks one of the two main channels) (IDNR 2010). The dam at Oregon, which is approximately 8.0 km (5.0 mi) downstream of the Byron discharge, creates the pool from which Byron draws circulating water makeup and to which it discharges blowdown.

2.2.2 Hydrology

Byron's circulating water makeup intake structure stands on the east bank of the Rock River at (approximately) River Mile 115. Blowdown is discharged to the Rock River about 61 m (200 ft) downstream of the intake structure. The U.S. Geological Survey (USGS) maintains gaging stations at Byron, Illinois, approximately 8 km (5 mi) upstream of the Byron intake at River Mile 120.3 (in operation since 2000), and Como, Illinois, approximately 74 km (46 mi) downstream of the Byron blowdown discharge at River Mile 69.2 (in operation since 1935 and used in Section 4.1 to establish that the Rock River is a low-flow river) (USGS 2011). For water years 2000 to 2010, annual mean flow at the Byron gaging station ranged from 93,000 to 342,351 liters/second (L/sec) (3,256 to 12,090 cubic feet per second [cfs]) and averaged 204,023 L/sec (7,205 cfs) (USGS 2011). Daily mean flows over the same period ranged from 34,263 to 1,016,575 L/sec (1,210 to 35,900 cfs).

At the Como gaging station, from 1935 to 2010, annual mean flows ranged from 61,929 to 373,499 L/sec (2,187 to 13,190 cfs) and averaged 170,241 L/sec (6,012 cfs) (USGS 2011). Daily mean flows ranged from 14,838 to 1,279,499 L/sec (524 to 45,200 cfs).

Flows at both Byron and Como gaging stations are highest in spring and early summer (March-June) and lowest in late-summer and fall (August-November).

2.2.3 Water Quality

In addition to river flow, the USGS monitors water quality at both the Byron and Como gaging stations. Water temperatures at the Byron gaging station ranged from 0.1°C (32.2°F) to 23.4°C (74.1°F) over the October 2009 through September 2010 period, while dissolved oxygen (DO) concentrations over the same period ranged from 7.0 to 14.8 milligrams per liter (mg/L) (USGS 2011). Specific conductance ranged from 503 to 745 micro-Siemens/cm over the same monitoring period. At Como, Illinois, water temperatures ranged from 0 to 24.8°C (32°F to 76.6°F) in water year 2010, while DO ranged from 7.9 to 16.9 mg/L. Specific conductance at the Como gaging station ranged from 542 to 739 micro-Siemens/cm (USGS 2011).

The Rock River is classified by the Illinois Pollution Control Board as General Use water (Section 303.201 of Title 35, Part 303, Subpart B of the Illinois Administrative Code). General Use waters are subject to the water quality standards in Subpart B of Part 302 of the regulation, which include standards for DO, temperature, nutrients (e.g., phosphorus), a range of chemical constituents, and radioactivity. The Rock River at this location is listed in Appendix D to Part 302 as one of the stream segments that are afforded “enhanced dissolved oxygen protection.” DO concentrations in these streams/stream segments must be not less than 5.0 mg/L at any time during the period of March through July and not less than 4.0 mg/L at any time during the period of August through February.

The stream segment (IL_P-20) receiving the discharge from Byron NPDES-permitted Outfall 001 is identified in the December 2012 *Illinois Integrated Water Quality Report and Section 303(d) List* as “impaired waters,” not fully supporting Aquatic Life and Fish Consumption designated uses (IEPA 2012). Ethanol is the listed cause of impairment for Aquatic Life. Mercury and polychlorinated biphenyls (PCBs) are the listed causes of impairment for Fish Consumption. Releases of PCBs and mercury are prohibited by NPDES Permit IL0048313.

In its 2012 Rock River Illinois Fish Advisory, the Illinois Department of Public Health recommended that anglers taking fish from the Rockford Dam to Milan Steel Dam reach of the Rock River (the portion of the river that encompasses the Byron intake and discharge) consume no more than one meal per month of carp, channel catfish larger than 41 centimeters (cm) (16 inches [in]), or flathead catfish larger than 51 cm (20 in) (IDPH 2012a). The advisory notes that PCBs are the contaminant(s) of primary concern in this reach of the river. There is also a statewide mercury advisory (all waters) that cautions against sensitive populations (young children and women of childbearing age) eating more than one meal per week of “predator fish” (e.g., black bass, striped bass, white bass, pike, walleye), as these piscivorous species tend to bioconcentrate mercury (IDPH 2012b).

Based on the Illinois Department of Natural Resources (DNR) Biological Stream Rating mapping tool, the Rock River is not a biologically significant stream at the Byron blowdown discharge location. The Rock River has not been assigned a biological diversity rating or integrity rating at this location due to insufficient data/information (IDNR 2012).

2.2.4 Aquatic Communities

2.2.4.1 Pre-operational Monitoring

Information on the status of the aquatic communities of the Rock River prior to operation of Byron can be found in the Final Environmental Statement (FES) related to the proposed Byron

Station Units 1 and 2 (AEC 1974), the Byron Station Environmental Report - Operating License Stage (ComEd 1981a), and the Final Environmental Statement related to the operation of Byron Station Units 1 and 2 (NRC 1982). These documents summarize results of pre-construction and pre-operational monitoring of phytoplankton, zooplankton, benthic macroinvertebrate, and fish communities in the Rock River (1972-1980). However, the discussion that follows emphasizes benthic macroinvertebrate and fish communities, consistent with the focus of the NRC's regulation at 10 CFR 51.53 and the findings of the GEIS (NRC 1996b), which asserts (Section 4.3.3) that:

> "The relatively small volumes of makeup and blowdown water needed for closed-cycle cooling systems result in concomitantly low entrainment, impingement, and discharge effects. Studies of intake and discharge effects of closed-cycle cooling systems have generally judged the impacts to be insignificant. None of the resource agencies consulted for this GEIS expressed concerns about the impacts of closed-cycle cooling towers on aquatic resources."

The GEIS (Section 4.3.3) states that impacts of closed-cycle cooling systems on aquatic communities are only a concern when an "unusually important resource" is at risk, and cites two examples of such unusually important resources: threatened and endangered aquatic species and anadromous fish populations. No federally listed endangered or threatened aquatic species has been recorded from the Rock River in the vicinity of the Byron plant (see Section 2.5), and there are no runs of true anadromous fish in the Rock River (white bass and yellow bass are considered "semi-anadromous" species). However, in light of the importance of the Rock River's recreational fish populations to Illinois anglers, Exelon Generation has chosen to include information in this Environmental Report on fish populations and the benthic macroinvertebrate populations on which these fish populations rely. The health of these fish and benthic organisms is tied inextricably to the health of the river. Exelon Generation has also provided detailed information on mussel communities in the Rock River because (1) mussels are regarded as "sentinel" species (sensitive to changes in water quality) and (2) several rare (state-listed) Unionid species have been collected in the area of the Byron intake and discharge in the past.

<u>Benthic Macroinvertebrates/Mussels (1972-1985)</u>

During sampling performed in 1972-1973 to support the 1974 FES, Rock River benthos samples were dominated by four groups: oligochaetes of the family Tubificidae (9 taxa), mayfly larvae (Ephemeroptera; 5 taxa), caddisfly larvae (Trichoptera; 2 taxa), and midges (Chironomidae; 21 taxa) (AEC 1974). Average density was 147.3 organisms/square meter (m^2) (13.7 organisms/square foot [ft^2]) for oligochaetes, 9.6 organisms/m^2 (0.9 organism/ft^2) for mayflies, 15.7 organisms/m^2 (1.5 organisms/ft^2) for caddisflies, and 20.1 organisms/m^2 (1.9 organisms/ft^2) for chironomids. The (1974) FES does not comment on the relative pollution tolerance of these groups, but tubificid worms and oligochaetes are widely considered to be pollution tolerant groups, whereas mayflies and caddisflies are generally considered less tolerant of chemical and thermal pollution (EPA 1999).

Benthos samples were collected from five Rock River transects on six occasions between September 5, 1973 and October 28, 1974 using a Ponar dredge (Commonwealth Edison 1981a). Representatives of more than 100 invertebrate taxa were collected over the 15-month period. A wide variety of benthic organisms was collected (including dipterans, mayflies, caddisflies, snails, clams, and flatworms), but collections were dominated by pollution-tolerant tubificids (ComEd 1981a). A variety of mollusks were collected, including six gastropods (snails) and four pelecypods (bivalves) (ComEd 1981a). Two unionids, *Quadrula* sp. (almost certainly *Q. pustulosa*, the pimpleback mussel) and *Lasmigona compressa* (creek heelsplitter), were collected. The creek heelsplitter is widely distributed across the midwestern U.S. but is uncommon throughout its range (Cummings and Mayer 1992). This species is typically found in headwater streams rather than large streams and rivers.

Fish (1973-1985)

Thirty-two species of fish were collected over the 1973-1974 sampling period from the Rock River and its tributaries, as compared to 42 species in the baseline study (first year of monitoring). Samples were dominated by bottom-oriented species, including river carpsucker (*Carpiodes carpio*; 25 percent of all fish collected), channel catfish (*Ictalurus punctatus*; 19.1 percent), quillback carpsucker (*Carpiodes cyprinus*; 15.3 percent), and common carp (*Cyrprinus carpio*; 13.0 percent) (ComEd 1981a). The river carpsucker is found throughout the Mississippi River basin, where it is common-to-abundant in slow-moving rivers and impoundments (Lee, et al. 1980). Channel catfish are native to the central drainages of the U.S., including the Mississippi River, and have been introduced into virtually every state in the continental U.S. (Lee, et al. 1980). They are typically associated with medium-to-large rivers with substantial current. The quillback is found in both Mississippi River and Atlantic Slope drainages in silty rivers and impoundments (Lee, et al. 1980). The common carp was introduced to the U.S. in the 19th century from Europe and is now well established from coast to coast, flourishing in a range of aquatic habitats, from clear streams to muddy bayous to large impoundments (Lee, et al. 1980). Barbour et al. (EPA 1999) classify the river carpsucker, channel catfish, and quillback as “intermediate” in terms of pollution tolerance and sensitivity to habitat degradation. They classify the common carp as “tolerant” of pollution and habitat degradation.

Centrarchids (sunfish) were not as common as suckers, carp, and catfish in the 1973-1974 collection, but were also well represented in samples. They included black crappie (*Pomoxis nigromaculatus*; 4.3 percent of all fish collected), white crappie (*Pomoxis annularis*; 3.2 percent), bluegill (*Lepomis macrochirus*; 1.5 percent), largemouth bass (*Micropterus salmoides*; less than 1 percent), and smallmouth bass (*Micropterus dolomieui;* less than 1 percent (ComEd 1981a).

Channel catfish made up 62 percent of the game fish collected in the 1974-1975 monitoring year, followed by crappies (24 percent), and bluegills (5 percent) (NRC 1982). Channel catfish was the game species most often collected in pre-operational studies in 1975-76 and 1976-77; bluegill was the game fish most often collected in the 1977-78 study year; and black crappie was the game fish most often collected in 1978-79 and 1979-80 collections (NRC 1982). Rough fish dominated the fish community in both numbers and biomass over the five (1975-1980) years of pre-operational monitoring.

2.2.4.2 Operational Monitoring

Mussels/Benthic Macroinvertebrates (1986-Present)

Commonwealth Edison commissioned a mussel survey in the Rock River up- and downstream of the Byron intake/discharge in 1993, when the utility was considering installing sediment control structures in the river. Exelon Generation repeated the survey in 2011 (see Figure 2.2-1), in support of license renewal (ESI 2011). In 1993, 235 live mussels representing 11 species were collected. Three common, widely-distributed mussel species dominated collections in 1993: pimpleback (*Quadrula pustulosa*; 35.7 percent of all mussels collected), white heelsplitter (*Lasmigona complanata*; 28.9 percent), and fragile papershell (*Leptodea fragilis*; 17.4 percent) (ESI 2011). Two live specimens of a special-status species, the black sandshell mussel (*Ligumia recta*; listed as Threatened by the State of Illinois), were collected in 1993. Section 2.5 contains a more detailed discussion of special-status mussels in the Rock River in the Byron vicinity.

Representatives of 21 freshwater mussel species were collected in 2011, but live specimens of only 8 species were collected (ESI 2011). The large number of weathered and subfossil shells and the number of species these shells represented provided evidence that the area once supported a more species-rich Unionid community. The vast majority (93.1 percent) of the 389 live Unionids collected in 2011 were a single species, the pimpleback (*Quadrula pustulosa*). The plain pocketbook (*Lampsilis cardium*) was next most abundant, making up 4.1 percent of all mussels collected. The Wabash pigtoe (*Fusconaia flava*) was third in abundance, but only 1.0 percent of mussels collected. The pimpleback, plain pocketbook, and Wabash pigtoe are "widespread and common" in the midwestern U.S. and are found in streams and rivers across Illinois (Cummings and Mayer 1992). The other five species were all present in very small numbers, less than 1.0 percent each. No special-status mussel species was collected alive.

Although species richness was lower in 2011, mussel densities appeared to be higher, and the mix of young and old individuals present was indicative of a healthy, self-sustaining mussel community. The survey suggested that Unionids are more abundant upstream of the Byron intake/discharge than downstream, but the difference appears to be habitat-related rather than power plant (discharge)-related (ESI 2011).

Exelon Generation also commissioned benthic macroinvertebrate surveys in 2011 to assess the status of the benthic community in the Rock River in the vicinity of the Byron intake and discharge and allow comparisons with earlier studies (EA Engineering 2012). Any such comparisons should be made with caution, taking into account the fact that (1) gear design (Hester-Dendy samplers) changed between sampling periods and (2) the precise locations of pre-operational sampling locations were unknown, thus could not be re-surveyed. Some patterns did emerge, however. Chironomids dominated Hester-Dendy samples from both pre-operational and operational periods with respect to taxa richness and abundance (EA Engineering 2012). *Glyptotendipes*, a pollution-tolerant (chironomid) midge, was the most abundant organism in both 2011 and 1977-1978 Hester-Dendy surveys. Tubificids and chironomids (especially the genus *Chironomus,* sometimes referred to as a "bloodworm") were the two dominant taxa in 1977-1978 Ponar samples from all sampling locations. In 2011, tubificids were again numerically dominant in Ponar samples (four of four stations sampled), but *Cryptochironomus* (a genus closely related to *Chironomus*) was the next most abundant (EA Engineering 2012). The EA Engineering (2012) report concludes that "…overall, the 2011 benthic community in the Rock River near the Byron Station was rather similar to the pre-operational benthic community…(with)…community structure…generally consistent as evidenced by the dominant taxa…"

Fish (1986-Present)

Byron Unit 1 began operating commercially in September 1985, with Unit 2 coming on line in August 1987. Biologists from the Illinois Natural History Survey (NHS) conducted surveys of fish in the Rock River adjacent to Castle Rock State Park (approximately 16 km [10 mi] downstream of the Byron discharge structure) in 1986 as part of an assessment of potential impacts of a highway improvement project (Wetzel, et al. 1988). Figure 2.2-1 shows the river reach surveyed by NHS. Three tributary streams in the area were also surveyed in 1986 and 1987. During the surveys, 37 species of fish representing 8 families and 24 genera were collected. Twenty-five species (seven families) were collected from two sampling transects in the Rock River.

Rock River collections in 1986 were dominated numerically by cyprinids (minnows), which comprised 88.4 percent of all fish collected (Wetzel, et al. 1988). One minnow species, the spotfin shiner (*Notropis spilopterus*), was particularly abundant, making up 67.1 percent of all fish collected. Three other minnow species were relatively common: bullhead minnow (*Pimephales vigilax*; 7 percent of all fish collected), bluntnose minnow (*Pimephales notatus*; 6.9 percent), and striped shiner (*Notropis* [*Luxilus*] *chrysocephalus*; 5.8 percent).

The spotfin shiner is found in creeks and small rivers across the midwestern U.S., where it is often associated with clean sand and gravel substrates and moderate currents (Pflieger 1975, Smith 2002). Once found across Illinois, it is now restricted to northern and eastern parts of the state (Smith 2002). Habitat alteration and competition with the red shiner, a hardier and more pollution-tolerant species, are the apparent causes of the species' decline in Illinois. Barbour et al (EPA 1999) classify the spotfin shiner as an insectivore and rate its pollution tolerance as "intermediate." Grabarkiewicz and Davis (EPA 2008a) call the spotfin shiner a "geographically ubiquitous" species that has shown tolerance to turbidity, development, and pollution.

The bullhead minnow is found from Illinois and Ohio south to the Gulf Coastal Plain of Texas (Pflieger 1975). In Illinois, this species is generally found in larger rivers, but may also occur in smaller streams and impoundments. It is most abundant in clear streams with sand-mud-gravel substrates. Barbour et al. (EPA 1999). classify the species as an omnivore and rate its pollution tolerance as "intermediate."

The bluntnose minnow is found across the Midwest and as far south as the Gulf Coast (Pflieger 1975). The most common and widespread fish species in Illinois, it is found in a variety of habitats but is most abundant in streams and rivers with clear, warm water and at least some aquatic vegetation (Smith 2002). Barbour et al (EPA 1999) classify the species as an omnivore and rate it as a pollution-tolerant species. Grabarkiewicz and Davis (EPA 2008a) call the bluntnose minnow a "geographically ubiquitous" species that has shown tolerance to turbidity, development, and pollution.

The striped shiner is found across the Great Lakes region, from Wisconsin to New York, and in the Mississippi River drainage south to the Gulf of Mexico. Smith's *The Fishes of Illinois* (Smith 2002) notes that this species is found in clear, gravel-bottomed creeks in eastern and central Illinois but is not found in northwest Illinois. Range maps in Smith (Smith 2002) show no striped shiner collecting sites on the Rock River, but numerous common shiner collecting sites. Given the fact that this species is "exceedingly similar" to the common shiner (*Notropis cornutus*) and the two species are known to hybridize, it is difficult to determine if the Illinois NHS biologists collected striped shiners, common shiners, or *N. luxilus* X *N. cornutus* hybrids in 1986. Interestingly, Smith (Smith 2002) reports that the striped shiner is more tolerant of warmer, turbid water than the common shiner and has supplanted the common shiner in streams in northern Illinois that have been degraded by agricultural practices.

Game fish species such as largemouth bass and black crappie were collected less frequently in the 1986 study, but the sampling methods and gear employed (minnow seines and bag seines) almost certainly yielded biased samples. Most state and federal agencies that have published standard methods or protocols for conducting bio-assessments have recommended electrofishing for these kinds of assessments or a mix of sampling gear designed to sample all micro-habitats present. Seines can only be used effectively in shallow areas with relatively flat, snag-free bottoms. The areas sampled by the Illinois NHS in September 1986 were characterized by hard-packed sand and gravel bottoms and water less than 1.5 m (5 ft) deep (Wetzel, et al. 1988).

Exelon commissioned a survey of fish in the Rock River in 2011 to determine the status of local fish populations and compare with results of previous pre-operational and operational studies (EA Engineering 2012). Fish were collected in August 2011 at transects in the mainstem of the Rock River upstream and downstream of the Byron intake and discharge (blowdown) and at a transect at the confluence of the Rock River and Spring Creek, approximately 1.0 mi downstream of the Byron discharge.

Fish were collected by electrofishing and seining. Electrofishing samples appeared to be more representative of the fish community than seine samples. More fish were collected with seines (1,794), than electrofishing gear (783) but fish in seine samples were predominately cyprinids (minnows) from the shallow littoral zone, whereas electrofishing samples included a broad mix of species that occupy a range of habitats (EA Engineering 2012). Although 14 species were collected with seines, more than 95 percent of fish collected in this manner were cyprinid minnows. By contrast, 27 species were collected with electrofishing gear, with numbers more evenly distributed among species. All fish sampling gear are selective to some degree; however, electrofishing has proven to be the least selective and most effective single method for collecting stream fishes (EPA 1999).

Spotfin shiner (1,037 fish; 40.2 percent of total), bullhead minnow (643 fish; 25.0 percent), sand shiner (*Notropis stramineus*; 213 fish; 8.3 percent), gizzard shad (*Dorosama cepedianum*; 125 fish; 4.9 percent), and bluntnose minnow (109 fish; 4.2 percent) were the fish species most often collected in 2011. Smallmouth bass, highly regarded by anglers, were also relatively common, making up 4 percent of all fish collected. Other popular sport fish routinely collected in 2011 included channel catfish (37 fish; 1.4 percent) and largemouth bass (21 fish; 0.8 percent) (EA Engineering 2012).

Electrofishing CPUE, a metric that takes into account sampling effort and yields "normalized" data, was 224 fish per hour (fish/hr) for the four Rock River transects (EA Engineering 2012). This fell within the historical (1988-2002) range of 65.3 to 406.5 fish/hr. It also fell within the range of values (81.4 to 281.3 fish/hr) for 1990-2002 which are assumed to be more representative of typical conditions: 1988 and 1989 data were atypical, skewed by large numbers of minnows and young-of-the-year catastomids.

Twenty-eight species were collected in 2011, as compared to 34-43 species over the 1988-2002 period. Differences between years in measures of species diversity were attributed to the "incidental" capture of uncommon or secretive species in some years rather than actual changes in community structure. More significant changes over the operating period included (1) increased abundance of walleye as a result of a state stocking program, (2) the appearance, circa 1990, of gizzard shad, presumably fish that had escaped from private impoundments in the drainage, (3) the appearance, around 1990, of goldfish, individuals almost certainly released or discarded by home aquarists, and (4) the appearance of sauger in 1992, following the species' introduction in the Rock River upstream in Wisconsin (EA Engineering 2012).

Pre-operational and operational fish assemblages were similar (EA Engineering 2012). Collections from both periods were dominated by common Midwestern forage fish (e.g., spotfin shiner, bullhead minnow, gizzard shad), rough fish (e.g., common carp, quillback, freshwater drum), and game fish (e.g., channel catfish, smallmouth bass, and largemouth bass). Noteworthy differences between pre-operational and operational periods included (1) higher relative abundance of catfish and suckers in pre-operational samples, which the authors attributed to differences in gear (used hoop nets in 1970s) and (2) the appearance of four "new" species in collections, gizzard shad being the most important in terms of biomass and trophic dynamics. Gizzard shad are an important food source for species such as walleye and smallmouth bass when young, but grow quickly and are too large as adults to be taken by these species. No special-status fish species were collected in 2011 (EA Engineering 2012).

June 21-23, 2009 Fish Kill in Rock River

Between June 21 and 23, 2009, a large fish kill occurred along nearly 87 km (54 mi) of the Rock River. The fish kill followed the derailment of a Canadian National freight train on June 19, in which 14 tanker cars were either damaged or caught fire and up to 283,906 liters (75,000 gallons) of ethanol leaked into a tributary of the Rock River (Cummings and Mayer 1992). The upstream limit of the kill was 3 km (2 mi) upstream of the State Route 2 bridge at Grand Detour (over 16 km [10 mi] downstream from the Byron plant site), and the downstream limit of the kill was 8 km (5 mi) below Prophetstown (Figure 2.2-1). Most of the fish killed were catfish, suckers, and carp. An estimated 72,372 fish were killed, including 36,339 channel catfish and flathead catfish (IDNR 2010).

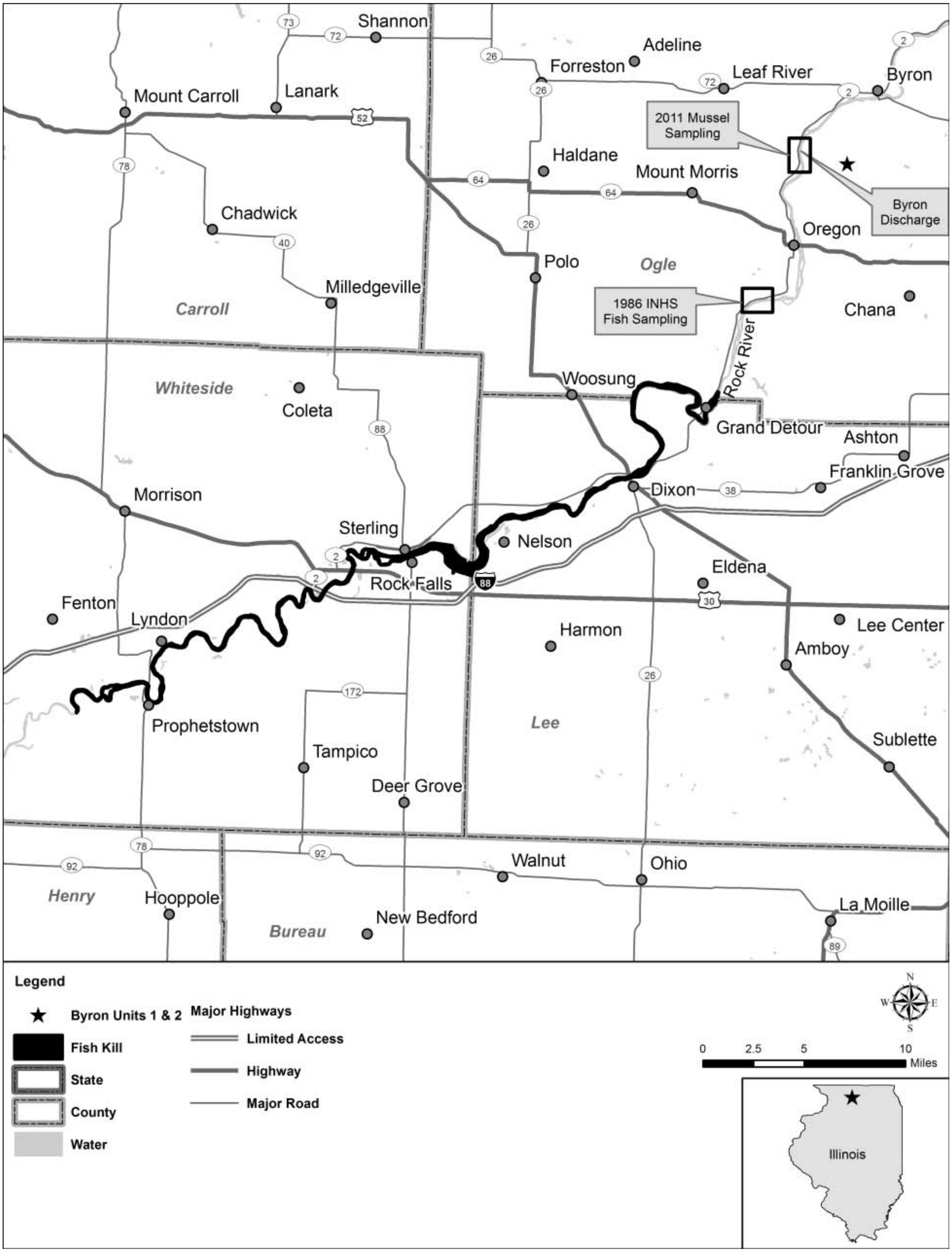
Illinois DNR biologists surveyed Rock River fish in September 2010 to determine the degree to which fish populations had recovered from the kill. The 2010 survey replicated, to the extent practicable, a survey conducted in late August 2008. Sites inside (Dixon, Sterling, and Prophetstown) and outside (Oregon and Erie) of the 87-km (54-mi)-long kill zone were sampled, using a boat-mounted electrofishing unit. In addition, targeted surveys of two important game fish species, smallmouth bass and walleye, were conducted (IDNR 2010).

When 2010 results were compared to 2008 results, Illinois DNR found little or no change in either species composition or measures of Index of Biotic Integrity (IBI) between sampling periods. The small differences observed at stations within the kill zone were attributed to sample variability or sample bias rather than pollution (i.e., the fish kill). Four of the five stations evaluated scored within the "B" range of Index of Biotic Integrity (IBI) Integrity Classes, scores indicative of a "highly valued aquatic resource" (IDNR 2010).

With respect to smallmouth bass, numbers and CPUE at all stations (regardless of whether they were affected by the fish kill) were much lower in 2010 than 2008. The author of the report speculates that prolonged flooding in 2010 may have driven smallmouth bass downstream, outside of the study area, basing this on the fact that a commercial fisherman netting downstream of Erie caught "huge" numbers of smallmouth bass in 2010. Walleye sampling produced mostly small fish, probably because electrofishing was ineffective in deeper-water areas preferred by adults (IDNR 2010).

The report concludes that "the fish kill of 2009 appears to have done little damage to the overall fishery of the Rock River" with the exception of one species: the flathead catfish. A (post-fish-kill) survey of flathead catfish in 2009 within the kill zone revealed a marked decline in the total number of flathead catfish, especially from Dixon to Como. However there was a marked increase in the total number of flathead catfish outside the kill zone at Erie, IL, indicating that some of the larger fish may have moved downstream of the kill zone to avoid injury (IDNR 2010).

Figure 2.2-1. Rock River Below Byron Discharge Structure



2.3 Groundwater Resources

In response to the 1987 Illinois Groundwater Protection Act (Public Act 85-863), the Illinois Environmental Protection Agency (IEPA) established a regional groundwater protection planning program for the state. Since 1991, the IEPA, in cooperation with the Illinois Department of Natural Resources (DNR), has designated four Priority Groundwater Protection Planning Regions in Illinois. Byron is not located within any of the four existing Priority Groundwater Protection Planning Regions.

Groundwater resources in the region are developed mainly from three aquifer systems, listed below in descending order (Exelon Nuclear 2006; Exelon Nuclear 2010a):

- The Quaternary Alluvial Aquifer System
- The Quaternary Glacial Drift Aquifer System
- The Cambrian-Ordovician Aquifer System

The plant is located on a bedrock high area where post-glacial erosion has removed all but a thin veneer of the Quaternary glacial drift sediments. The Quaternary alluvial sediments occur along the Rock River valley and overlie the Cambrian-Ordovician bedrock (Exelon Nuclear 2010a).

2.3.1 Groundwater Supply and Sources

2.3.1.1 Quaternary Alluvial Aquifer System

Groundwater in the shallow alluvial aquifer occurs under unconfined (water table) conditions along the narrow Rock River valley. The alluvial aquifer along the Rock River adjacent to the site ranges from 0.8 to 1.6 kilometer (km) (0.5 to 1.0 mile) wide and consists of approximately 34 meters (m) (113 feet [ft]) of highly permeable gravelly sand and cobbles. The depth to shallow groundwater in the alluvial aquifer near the site is approximately 1.2 m (4 ft) (Exelon Nuclear 2010a), but the water level in the alluvial aquifer changes in response to the water level in the river. Figure 2.3-1 provides a schematic of the geologic units beneath Byron.

2.3.1.2 Quaternary Glacial Drift Aquifer System

The site is covered with a mantle of glacial drift consisting mainly of glacial till covered by a few feet of loess (windblown silt). Drilling logs from the site indicate that the thickness of the drift at the site averages about 4.9 m (16 feet). Groundwater may occur in the drift perched on the underlying bedrock. Limestone fragments in the drift result in hardness and high alkalinity in the shallow groundwater. The generally low permeability and thinness of the glacial drift precludes development of wells in the thin glacial drift (Exelon Nuclear 2010a).

2.3.1.3 Cambrian-Ordovician Aquifer System

The most important aquifer in the region is the Cambrian-Ordovician Aquifer System, which comprises the following aquifers (Figure 2.3-1):

- Ordovician-aged Galena-Platteville Group (Galena-Platteville dolomites), and the Ancell Group (Glenwood – St. Peter Sandstone)

- Cambrian-aged Ironton-Galesville Sandstone Aquifer and the Mt. Simons Aquifer.

The Cambrian-Ordovician Aquifer system averages approximately 300 m (1,000 ft) thick. Although numerous alternating layers of sandstones, limestones, and dolomites impart a heterogeneous character to them, these units are hydraulically connected and behave as a single aquifer (Visocky, et al. 1985; Exelon Nuclear 2010a).

The general regional groundwater flow direction in the Galena-Platteville and Ancell Aquifers is to the west toward the Rock River. Local groundwater flow conditions are typically influenced by surface topography and aquifer thickness. Groundwater flow patterns vary under the site. Since the plant sits on a bedrock high, groundwater directly beneath the plant flows radially outward in all directions (Exelon Nuclear 2006).

2.3.2 Off-site Groundwater Usage

Most of the water for domestic, municipal, and industrial use in the region is obtained from groundwater sources. The major unit is the Cambrian-Ordovician St. Peter Sandstone aquifer, although minor supplies are obtained from the glacial drift aquifer.

There are 99 private water supply wells within a 3.2 km (2 mi) radius of the plant (ISGS 2012). Many of the wells are completed in the St. Peter Sandstone; however, the well completion records were not available for all the wells listed in the Illinois State Geological Survey (ISGS) well database.

There are seven public water supply systems within 16 km (10 mi) of the plant. All use groundwater from the Cambrian-Ordovician Aquifer, which is dependable and capable of high yields. The closest public water system to the Byron site belongs to the Northern Illinois University Lorado Taft field campus, located 5.6 km (3.5 mi) southwest of the site. The Northern Illinois University public water system consists of two wells installed in the St. Peter Sandstone at depths of 133 m (435 ft) and 178 m (580 ft) (Exelon Nuclear 2010a).

Byron uses groundwater from two wells that are completed in the Cambrian-Ordovician Ironton-Galesville and Mt. Simon aquifers (ComEd 1980; Exelon Nuclear 2010a), which are deeper and more productive than the St. Peter Sandstone. The nearest public water system that withdraws water from the deeper aquifer is the City of Byron, which is approximately 6.4 km (4 mi) northwest of the Byron site and has one well installed in the Mt. Simon aquifer at a depth of 610 m (2,000 ft).

2.3.3 Plant Groundwater Usage

As discussed earlier, Byron uses groundwater from two wells (W-1 and W-2). On-site groundwater uses include potable water, demineralizer water, and backup makeup water for the essential service water cooling towers. The wells are pumped on rotation, and are piped to a common manifold (Exelon Nuclear 2006).

In 1974, W-1 and W-2 were installed to depths of 254 m (834 ft) and 260 m (853 ft), respectively. In 1980, both wells were extended to a depth of 457 m (1,500 ft) because of caving in the St. Peter Sandstone (ComEd 1980). The wells now produce largely from Cambrian-Ordovician and Mt. Simon aquifers (see Figure 2.3-1)(ComEd 1980; Exelon Nuclear 2010a). The well casings in both wells are open from the lower reaches of the Prairie du Chien Formation through the Ironton and Galesville Sandstones, and into the Mt. Simon Sandstone (Exelon Nuclear 2010a). The locations of the wells are shown in Figure 3.1-1.

The average annual groundwater requirement for the plant's potable water supply is approximately 0.6 liter per second (L/sec) (10 gallons per minute [gpm]), and 1.3 L/sec (20 gpm) during peak demand, usually associated with refueling and maintenance outages. Groundwater for the demineralizer is required at an average rate of 28 L/sec (450 gpm). The total peak groundwater demand for potable water and the demineralizer is approximately 30 L/sec (470 gpm) Exelon Nuclear 2010a) or 9.3 x 10^8 liters per year (2.5 x 10^8 gallons per year).

Groundwater use records for Byron indicate that in 2009, W-1 pumped 2. 9 x 10^6 liters (L) (7.7 x 10^5 gal) and W-2 pumped 4.5 x 10^7 L (1.2 x 10^7 gal) of groundwater (Exelon Nuclear 2010b) for a total groundwater use of 4.8 x 10^7 liters per year (1.3 x 10^7 gal per year).

In the event that makeup water to the essential service water cooling towers is not available from the Rock River, the two groundwater wells, which are capable of pumping at a maximum rate of 101 L/sec (1,600 gpm), could be used to maintain adequate essential service water cooling tower basin inventory during a 30-day safe shutdown period (Exelon Nuclear 2010a).

In Illinois, there is no general permitting system for groundwater withdrawals. However, wells located on a parcel of property where the total rate of withdrawal of all wells on the parcel exceeds approximately 263 liters per minute or 378,541 liters per day (70 gpm or 100,000 gal per day) are defined as high-capacity wells and must file annual reports of their withdrawals to the Illinois State Water Survey. Since January 1, 2010, an entity installing any high-capacity well has been required to notify the Illinois Department of Agriculture's designated Soil and Water Conservation District before construction of the well begins [525 ILCS 45/, Water Use Act of 1983, as amended by Public Act 096-0222; effective 1/1/2010], Based on the total Byron site groundwater pumping rate, Wells W-1 and W-2 at Byron are high-capacity wells installed prior to January 1, 2010. (IGA 2010).

2.3.4 Plant Groundwater Quality

2.3.4.1 Radionuclides in Groundwater

Radionuclides are produced in the reactor coolant system and released to the Rock River via the discharge or "blowdown" pipeline. Radioactive liquid effluent discharges are by batch. Prior to discharge, each batch is sampled, analyzed and processed to ensure compliance with NRC regulations (see Section 3.1.4). Also, all radioactive liquid effluents are mixed with blowdown water from the cooling towers prior to discharge.

2.3.4.1.1 Annual Radiological Environmental Monitoring Program (REMP)

Since 1985, Exelon Generation has been monitoring for tritium, iodine-131, strontium, and certain specified beta- and gamma-emitting radionuclides in off-site water wells located near Byron Station through Byron's REMP. Six wells within a 3.2 km (2-mi) radius of the site are part of the REMP (Exelon Nuclear 2011a). During 2006 through 2010, no water well samples exceeded the lower limit of detection for tritium or any other monitored radionuclide (Exelon

Nuclear 2007a; Exelon Nuclear 2008a; Exelon Nuclear 2009a; Exelon Nuclear 2010c; Exelon Nuclear 2011a).

2.3.4.1.2 Blowdown Discharge Pipeline

In 2006, Exelon Generation initiated two separate investigations related to radionuclides in groundwater at Byron. The first, specific to Byron, is described in this section. The second, part of a fleetwide program to determine whether groundwaters at and in the vicinity of Exelon's nuclear power generating facilities were adversely affected by releases of radionuclides, is described in Section 2.3.4.1.3.

Exelon Generation investigated potential groundwater impacts at the Byron site as a result of tritiated water released to groundwater beneath the vacuum breaker vaults installed along the circulating water blowdown pipeline to the Rock River. During the blowdown pipeline investigation, 12 temporary and 17 permanent monitoring wells were installed and developed at the Byron site. Four of 39 groundwater samples collected in monitoring wells near the blowdown line had detectable tritium concentrations. No samples exceeded the U.S. Environmental Protection Agency's (EPA's) safe level for public drinking water (20,000 pCi/L). During this study, samples also were collected from the vacuum breaker vaults, from nearby residential wells, from the blowdown line itself, from holding ponds, and from pre-existing monitoring wells. Split samples were provided to the NRC and Illinois Emergency Management Agency (IEMA). None of the residential wells had detectable tritium concentrations.

During the investigation, Exelon Generation identified elevated tritium concentrations in groundwater beneath the blowdown line and in water from some vacuum breaker vaults. The highest on-site tritium concentration (82,000 pCi/L) was measured in standing water collected from a vacuum breaker vault (Circuit Court 2010).

Byron has cooperated with the IEPA, the Illinois Attorney General's Office, and the NRC to investigate and assess the need to remediate tritium from the circulating water blowdown pipeline. In March 2010, the Circuit Court for the Fifteenth Judicial Circuit, Ogle County, Illinois Chancery Division approved a Consent Order under which Byron agreed to perform the following actions to assure future compliance with applicable Illinois statutes and regulations (Circuit Court 2010).

- Prevent further releases of regulated wastewater to soil, surface or groundwater;
- Operate continuous monitoring systems in vacuum breaker vaults along the blowdown pipeline;
- Provide funding for implementation of supplemental environmental projects, including:
    - Provide funding for materials to be used by two specified environmental education programs; and
    - Provide funding to restore 23 acres to prairie.

According to its terms, the Consent Order was terminated in March 2011 following 12 months of continuous compliance. Monitoring continues at two wells along the blowdown pipeline, with a decreasing trend in tritium concentrations.

2.3.4.1.3 Hydrogeologic Investigation

In May 2006, as part of a fleetwide program to determine whether groundwater at and in the vicinity of its nuclear power generating facilities was adversely affected by releases of radionuclides, Exelon Generation conducted a hydrogeologic investigation at Byron in accordance with the Nuclear Energy Institute (NEI) Industry Groundwater Protection Initiative - Final Guidance Document (NEI 2007). During the Byron hydrogeologic investigation, which was initiated independently of, but in parallel with, the blowdown discharge line investigation also performed in 2006 (described in Section 2.3.4.1.2), groundwater samples were collected from 41 monitoring wells and water levels were measured in 63 monitoring wells. The groundwater samples were analyzed for tritium, certain specified gamma-emitting radionuclides, and strontium (Sr-90) (Exelon Nuclear 2006).

The investigation did not detect tritium in groundwater at concentrations greater than the EPA drinking water limit of 20,000 pCi/L, and concluded that tritium was not migrating off the Byron property at detectable concentrations. Continued monitoring assures that tritium and other radionuclides are not migrating off the Byron property at detectable levels. (Exelon Nuclear 2006; Exelon Nuclear 2011b).

2.3.4.1.4 Radiological Groundwater Protection Program (RGPP)

In 2006, Exelon Generation implemented a program to proactively review the environmental status of its nuclear power generating stations, specifically to identify the potential for releases of tritium, Sr-90, or station-related gamma-emitting radionuclides from all systems, structures, and components at the stations that are not designed for such a release. The investigation was part of an Exelon Generation fleetwide program involving all Exelon Generation-owned nuclear generating stations, including Byron. The Exelon Generation program was designed as part of an industry-wide initiative, consistent with the guidance provided by the Nuclear Energy Institute NEI 2007). The groundwater component of the investigation is described in Section 2.3.4.1.3.

To thoroughly quantify the potential for unmonitored releases of tritium, Sr-90, or other radionuclides to the environment from various systems, engineers performed an internal review of systems, structures, and components, and work practices, to determine which have the greatest potential for impacting shallow groundwater quality, should a release of radionuclides occur. These data were used in conjunction with information from past REMPs and other Byron-related groundwater information to develop a groundwater monitoring well network designed to include wells: (1) in the vicinity and downgradient of Byron systems that "screened in" as a result of the engineering review; (2) at downgradient locations around the perimeter of Byron; and, (3) at upgradient locations, to determine if radionuclides that may be found in groundwater downgradient of the plant are from plant sources or are migrating from off-site.

Monitoring under the RGPP was initiated in 2006 in parallel with the blowdown pipeline investigation. Under the continuing RGPP, sampling is performed at least semi-annually on each RGPP monitoring well. Monitoring includes sampling and analyses for tritium on each sample and once each calendar year for Sr-90 and gamma-emitting radionuclides. The initial monitoring data, including hydrological characterizations, were reported along with data from the blowdown line investigation in the Hydrogeologic Investigation Report completed for Byron (Exelon Nuclear 2006).

In 2007, 22 RGPP monitoring wells were sampled and 4 (AR-2 [383-548 pCi/L], AR-3 [327-965 pCi/L], AR-4 [2890-3050 pCi/L] and AR-11 [1300-1820 pCi/L]) had concentrations above the lower limit of detection (LLD) and below the EPA safe drinking water limit (Exelon Nuclear 2007b).

In 2008, 22 RGPP monitoring wells were sampled and 3 (AR-4 [1910-2150 pCi/L], AR-7 [207 pCi/L] and AR-11 [1220-1280 pCi/L]) had concentrations above the LLD and below the EPA safe drinking water limit (Exelon Nuclear 2008b).

In 2009, the number of RGPP monitoring wells sampled was reduced from 22 to 13 because none of the 9 wells removed from the program had ever had tritium concentrations above the LLD. Of the 13 RGPP monitoring wells sampled, 2 (AR-4 [1350-1360 pCi/L] and AR-11 [1010-1110 pCi/L]) had tritium in concentrations above the LLD and below the EPA safe drinking water limit (Exelon Nuclear 2009b).

In 2010, 13 RGPP monitoring wells were sampled. Two (AR-4 [1170-1250 pCi/L] and AR-11 [947-1120 pCi/L] had tritium in concentrations above the LLD and below the EPA safe drinking water limit (Exelon Nuclear 2010d).

In 2011, 10 RGPP monitoring wells were sampled (AMOED 2011). Two of the 10 wells (AR-4 [777-818 pCi/L] and AR-11 [231-919 pCi/L]) had concentrations of tritium above the 200 pCi/L LLD. Since 2009, these are the only two wells with elevated tritium concentrations. Both wells are adjacent to the blowdown pipeline, where historical leakage through vacuum breakers occurred. Well AR-4 is installed in the Upper Galena-Platteville aquifer and Well AR-11 is installed in the Lower Galena-Platteville aquifer. The U. S. Environmental Protection Agency (EPA) drinking water concentration limit for tritium is 20,000 pCi/L. The highest tritium levels observed during 2011 in Wells AR-4 and AR-11 were a small fraction of this safe level for drinking. As demonstrated by the information presented here, Well AR-4 has shown an overall steady decrease in tritium concentration since first sampled in 2006. Well AR-11 has also shown an overall decrease in tritium since 2006.

2.3.4.2 Byron Salvage Yard Superfund Site

The Byron Salvage Yard Superfund Site (Byron Salvage Site; not contaminated by activities at the Byron Station) bounds the north portion of the west side of the Byron site. The Byron Salvage Site is administered by EPA Region 5. It was proposed for listing on the Superfund National Priorities List (NPL) in 1982 and consists of two separate parcels: the Byron Salvage Yard and Dirk's Farm. The Dirk's Farm property is a former farm west of the Byron Salvage Yard that was purchased by Exelon Generation as part of the original Byron circulating water makeup and blowdown pipelines' ROW (see Figure 2.1-3; Exelon Nuclear 2006). The Byron Salvage Yard property is not owned by Exelon Generation.

Non-radioactive waste was discarded on both parcels. From the mid-1960's to 1972, approximately 4 ha (10 ac) of the Byron Salvage Site were used as an automotive salvage yard and dump, and miscellaneous waste and debris consisting of drums of electroplating wastes and other materials, including oil sludges, cutting wheels, solvents, scrap metal, and industrial wastes were discarded. Plating waste containing cyanide was sprayed on roads as dust control at the Byron Salvage Site (Exelon Nuclear 2006).

In 1975, Commonwealth Edison Company (ComEd), as land owner, began investigating contamination on the Dirk's Farm property after cattle were determined to have died from drinking cyanide-contaminated water on the property (EPA 2008b). Based on the investigation results, ComEd initiated cleanup measures at the Dirk's Farm property, including drum removal, removal of contaminated soils, and treatment of cyanide-contaminated soils (EPA 2008b). After the broader Byron Salvage Site was nominated for listing on the Superfund NPL, EPA performed a Remedial Investigation/Feasibility Study and initiated action under Superfund (EPA 2008b). In 2000, a Consent Decree was entered for remedial work on the Dirk's Farm property. The final remedial action for soils on the Dirk's Farm property was completed by Exelon Generation in 2003, ending its responsibilities under the Consent Decree. A long term groundwater monitoring plan for the Byron Salvage Site, including some wells on Dirk's Farm property, was approved by EPA in 2003 (EPA 2008b).

EPA's third 5-year review of the Byron Salvage Yard Superfund Site was completed in 2008 (EPA 2008b). Based on this review EPA concluded that the remedial actions implemented continue to remain protective of human health and the environment. All soil and groundwater remedial actions are complete. Institutional controls in the form of groundwater use restrictions remain in place. Groundwater is sampled routinely to monitor natural attenuation of any residual contaminants in the groundwater (EPA 2008b).

Figure 2.3-1 Schematic of Geologic Units

System	Group or Formation	Hydrogeologic (Aquifer) Unit		Description	Hydrogeologic Characteristics
Quaternary	Undifferentiated sand & gravel channel deposits Peoria Loess (undifferentiated)	Alluvial Aquifer		Silt, locally clayey, gravelly and sandy, with interbedded lenses of sand and gravel	Ground water occurs predominantly in thin sand and gravel pockets within the glacial drift. Yields are quite variable and typically low, suitable only for domestic and farm purposes. Wells or cisterns that intersect the more permeable zones may exhibit high, short-term yields.
	Wedron Formation (Esmond Till Member)	Glacial Drift Aquitard			
	Morton Loess				
	Winnebago Formation (Argyle Till Member)				
	Glasford Formation (Ogel Till Member)				
Ordovician	Galena Group	Galena-Platteville dolomites	Cambrian-Ordovician Aquifer	Dolomite and limestone, locally cherty, sandy at base, shale partings	Ground water occurs under leaky artesian conditions in the sandstone and in joints in the dolomites. In the Galena-Plattsville dolomites ground water also occurs under water table conditions where the overlying Maquoketa Group is absent. Yields are variable and depend upon which units are open to the well. In terms of the total yield of a well penetrating the entire thickness of the Cambrian-Ordovician Aquifer, the Glendwood-St. Peter snadstone supplies about 15 percent, the Prairie du Chien, Eminence, Potosi, and Franconia dolomites collectively supply about 35 percent, and the Ironton-Galesville sandstone supplies about 50 percent.
	Platteville Group				
	Ancell Group	Glenwood-St. Peter Sandstone		Sandstone, shale at top, little dolomite, locally cherty at base	
	Prairie du Chien Group	Prairie du Chien, Eminence, Potosi, and Franconia dolomites		Sandy dolomite, dolomitic sandstone, cherty at top, interbedded shale in lower part	
Cambrian	Eminence Formation				
	Potosi Dolomite				
	Franconia Formation				
	Frantor Sandstone	Ironton-Galesville Sandstone		Sandstone, upper part dolomite	
	Galesville Sandstone				
	Eau Claire Formation	Eau Claire Aquitard (upper and middle beds)		Shales, dolomites, and shaly dolomitic sandstone	Insignificant amounts of groundwater may occur in joints. These beds act as a confining layer between the Cambrian-Ordovician Aquifer and the Mt. Simon Aquifer.
	Mt. Simon Sandstone	Mt. Simon Aquifer		Sandstone	Ground water occurs under leaky artesian conditions. Adequate supplies for municipal and industrial use are more easily obtained from shallower aquifers.

Source: Exelon Nuclear 2010a.

2.4 Critical and Important Terrestrial Habitats

Byron occupies about 721 ha (1,782 ac) and consists of the main site area and ROW to the Rock River for the circulating water makeup and blowdown pipelines (Figure 2.1-3). The main site is approximately 566 ha (1398 ac), and the ROW to the river is about 155 ha (384 ac) (Exelon Nuclear 2010a).

According to the land classification system used by the U.S. Forest Service, which is based on climate, geology, topography, and vegetation, Byron is located within the Central Loess Plains Section of the Prairie Parkland Province of the Humid Temperate Domain. Climatic conditions in the Humid Temperate Domain are generally classified as humid continental, with hot and humid summers and often severely cold winters. The Central Loess Plains Section is characterized as having both irregular and smooth rolling plains that are naturally covered by bluestem prairie grasses, and floodplain forests along the drainages (Exelon Nuclear 2011c).

Some ecologists classify the region within which Byron is located as the Central Forest-Grassland Transition Zone (Exelon Nuclear 2011c). This transition zone separates the forested regions of the east from the tallgrass, mixed prairies of the plains, and therefore exhibits characteristics of both forest and grassland. Habitats within this transition zone display a higher density of trees and shrubs than the prairies and savannahs to the west, and a more diverse mosaic of savannah and prairie habitats than the hardwood forested zone to the east. The mix of native grassland, forestland, and wetland habitats was historically maintained by regular disturbances from periodic droughts and fires (Exelon Nuclear 2011c).

The area surrounding Byron is primarily agricultural, but includes some areas of rural residential development. Agricultural land in the area is dominated by corn and soybeans (Exelon Nuclear 2010a).

Approximately 300 ha (750 ac) of the Byron site are leased to local farmers for agriculture. The rest of the site is a mixture of wooded areas, meadows, and grassland (Exelon Nuclear 2011c). The southern portion of the site consists mostly of croplands and the northern portion of the site and utility corridor support a mixture of woodlands and agricultural lands, which include croplands, pastures, and old (fallow) fields (ComEd 1981b).

Woodlands on the Byron site are dominated by oak (*Quercus* spp.) and hickory (*Carya* spp.). Other trees commonly found in the wooded areas include elm (*Ulmus* sp.), black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), and cottonwood (*Populous deltoides*). Typical understory plants in woodlands include round-leaf dogwood (*Cornus rugosa*), blackberry (*Rubus allegheniensis*), greenbriar (*Smilax hispida*), hawthorn (*Crataegus* spp.), prickly ash (*Zanthoxylum americanum*), and wild grape (*Vitis* spp.) (ComEd 1981a). The meadows, grasslands, and old fields are characterized by Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*Poa compressa*), alfalfa (*Medicago sativa*), red clover (*Trifolium pretense*), timothy (*Phleum pratense*), ragweed (*Ambrosia artemisiifolia*), dandelion (*Taraxacum officinale*), foxtail (*Setaria* sp.), aster (*Aster* sp.), plantain (*Plantago* sp.), cinquefoil (*Potentilla* sp.), and a mixture of other less common perennial and annual plants (ComEd 1981a; AEC 1974).

Bird and mammal species on the Byron site are those typical of northwestern Illinois. During baseline surveys conducted in the 1970s, 103 bird species representing a variety of migratory and resident species were recorded ComEd 1981a). Observations since the 1970s have resulted in a total of 107 bird species being identified on the Byron site (Exelon Nuclear 2011c).

Common migrants include the slate-colored junco (*Junco hyemalis*), white-throated sparrow (*Zonotrichia albicollis*), fox sparrow (*Passerella iliaca*), and golden-crowned kinglet (*Regulus calendula*). Common resident species include the cedar waxwing (*Bombycilla cedrorum*), robin (*Turdus migratorius*), common crow (*Corvus brachyrhynchos*), and American goldfinch (*Spinus tristis*) (ComEd 1981b). Upland game birds on the site include the bobwhite quail (*Colinus virginianus*), ring-necked pheasant (*Phasianus colchicus*), mourning dove (*Zenaidura macroura*), American woodcock (*Philohela minor*) and gray partridge (*Perdix perdix*) (ComEd 1981a).

Fourteen mammal species were recorded on the Byron site during the baseline surveys (ComEd 1981a), with meadow voles (*Microtus pennsylvanicus*), wood mice (*Peromyscus leucopus*), and deer mice (*P. maniculatus*) being the small mammal species most often trapped during the surveys (ComEd 1981a). Data from the baseline surveys indicated that raccoon (*Procyon lotor*) and common opossum (*Didelphis marsupialis*) populations were relatively high on site (ComEd 1981a). Observations since the 1970s have added seven mammal species to the list (Exelon Nuclear 2011c).

Only three reptile or amphibian species were recorded on the site during the baseline surveys (ComEd 1981a). Numerous bullfrogs (*Rana catesbeiana*) were seen along Woodland Creek in the northeastern portion of the site, but other reptiles and amphibians were limited to one American toad (*Bufo americanus*) and one Eastern hognose snake (*Heterodon platyrhinos*) (ComEd 1981a). Observations since the 1970s have resulted in seven more reptile or amphibian species identified on the Byron site: the alligator snapping turtle (*Macroclemys temminckii*), Western chorus frog (*Pseudacris triseriata*), smooth softshell turtle (*Apalone mutica*), spring peeper (*Hyla crucifer*), garter snake (*Thamnophis sirtalis*), red milk snake (*Lampropeltis triangulum syspila*), and bull snake (*Pituophis melanoleucus*) (Exelon Nuclear 2011c).

Byron was recognized in November 2011 by the Wildlife Habitat Council as having a certified Wildlife at Work program. The Wildlife Habitat Council is a nonprofit group of corporations, conservation organizations, and individuals dedicated to restoring and enhancing wildlife habitat. The certification was awarded as a result of wildlife habitat enhancement and conservation education activities undertaken by personnel at Byron Generating Station. For example, bat houses have been erected and are monitored, and nest boxes for Eastern bluebirds (*Sialia sialis*) and wood ducks (*Aix sponsa*) have been placed in appropriate habitats at the site and are monitored for nesting success. A butterfly garden has also been established (Exelon Nuclear 2011c).

Section 3.1.6 describes the transmission lines built to deliver electricity generated at Byron to the transmission grid. The 97 km (60 mi) of transmission rights-of-way (ROW) within the scope of this assessment are associated with the Byron-to-Wempletown transmission line, two Byron-to-Cherry Valley transmission lines (in a common ROW), and the Byron to Lee County Station transmission line. The ROWs pass through land that is primarily agricultural, with isolated patches of forest. They do not cross any federal, state, or county parks or nature preserves. Lowden State Park, located along the Rock River, is 4 km (2.5 mi) west of the south right-of-way. The ROWs are maintained by ComEd. ComEd periodically performs ground inspections and aerial inspections, and maintains vegetation (primarily the removal of fast-growing trees, trimming, and application of herbicides or mechanical cutting if herbicides are prohibited) as needed to ensure continued safe distribution of electricity throughout the system.

2.5 Endangered and Threatened Species

Byron Station is in Ogle County, Illinois. The Byron-to-Wempletown and Byron-to-Cherry Valley transmission lines and ROWs cross portions of Winnebago County. The south running ROW extends to Lee County Station in Lee County, but the portion that is within the scope of this assessment (see Section 3.1.6), is wholly within Ogle County. Table 2.5-1 lists special-status plant and animal species recorded in Ogle and Winnebago counties. Species listed in Table 2.5-1 are those that are state- or federally listed as Threatened or Endangered (T&E). The county occurrences indicated in the table were based on records maintained by the U.S. Fish and Wildlife Service (USFWS) (USFWS 2012) and Illinois DNR (IDNR 2011). According to the USFWS database (USFWS 2012) there are no records of species that are candidates for federal listing or that are proposed for federal listing in Ogle or Winnebago counties.

The only species listed in Table 2.5-1 that Exelon Generation is aware of being observed or recorded on the Byron site or along the associated ROWs is the common tern (*Sterna hirundo*). At least one common tern was observed in the area during 1979-1980 (NRC 1982), but Byron personnel are not aware of any sightings of common terns since then. The common tern is state-listed as Endangered (IDNR 2011).

Federally listed species recorded in Ogle and Winnebago counties are discussed below.

The Indiana bat (*Myotis sodalis*) is federally listed as Endangered. Indiana bats hibernate during winter in caves or man-made hibernacula. During the summer, they migrate to wooded areas where they usually roost under loose tree bark on dead or dying trees. Indiana bats mate during the fall, and females store the sperm through winter and become pregnant in spring soon after they emerge from hibernation. They feed on flying insects found along rivers or lakes and in uplands (USFWS 2012). The nearest federally designated critical habitat for the Indiana bat is in La Salle County, well to the south of Ogle and Winnebago counties.

The Eastern prairie fringed orchid (*Platanthera leucophaea*), federally listed as Threatened, occurs in a wide variety of habitats, including mesic prairie, wetlands such as sedge meadows, marsh edges, and bogs. It requires full sun for optimum growth and flowering and a grassy habitat with little or no woody encroachment. Night-flying hawkmoths pollinate the nocturnally fragrant white flowers of this orchid (USFWS 2012). Federally designated critical habitat has not been established for this species.

Prairie bush clover (*Lespedeza leptostachya*) is a federally Threatened plant found only in the tallgrass prairie region of the upper Mississippi River Valley. It favors open, prairie-like areas with moderately damp to dry soils. Many existing prairie bush clover populations occur in sites that escaped agricultural plowing because they were too steep or rocky (USFWS 2012). Federally designated critical habitat has not been established for this species.

Bald eagles (*Haliaeetus leucocephalus*) are sometimes seen along the Rock River near the site. The USFWS removed the bald eagle from the federal list of Threatened and Endangered (T&E) species in 2007. The bald eagle is still protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. The bald eagle is not state-listed as threatened or state-endangered in Illinois.

No federally-listed fish or mussel species is believed to occur in the Rock River in the vicinity of the Byron site. In more than seven years of baseline (1972-1974), construction, and pre-operational monitoring (1975-1980), no listed aquatic species was identified in field collections made by biologists and consultants employed by ComEd (NRC 1982). In more recent years, ComEd and Exelon Generation have commissioned surveys of freshwater mussels in the Rock River to provide a baseline for impact assessments and to rule out the presence of any federally listed mussel species.

ComEd or Exelon Generation conducted mussel surveys in the Rock River up- and downstream of the Byron intake/discharge in 1993, when ComEd was considering installing sediment control structures in the river, and again in 2011, in support of the Exelon Generation license renewal effort (2011). In 1993, 235 live mussels representing 11 species were collected. Two live specimens of one special-status species, the black sandshell mussel (*Ligumia recta*; listed as threatened by the State of Illinois), were collected. Old, weathered shells of four more special-status species were collected: purple wartyback mussel (*Cyclonaias tuberculata*; state threatened), spike mussel (*Elliptio dilatata*; state threatened), sheepnose mussel (*Plethobasus cyphyus*; federal and state endangered), and kidneyshell mussel (*Ptychobranchus fasciolaris*; state Endangered). The sheepnose and kidneyshell mussels do not appear on Illinois DNR's lists of T&E species for either Ogle or Winnebago County, presumably because no live specimens have been collected in decades, thus do not appear in Table 2.5-1.

Rock River mussel collections in 2011 were characterized by higher numbers (389) of live mussels and a lower measure of species richness (8 species) (ESI 2011). No special-status mussels were collected alive. Old, weathered shells of five special-status species were found: sheepnose mussel, purple wartyback mussel, spike mussel, butterfly mussel (*Ellipsaria lineolata*; state Threatened), and black sandshell. The butterfly mussel does not appear on Illinois DNR's lists of T&E species for either Ogle or Winnebago County, presumably because no live specimens have been collected in decades, and thus does not appear in Table 2.5-1.

Three common, widely-distributed mussel species dominated collections in 1993: pimpleback (*Quadrula pustulosa*; 35.7 percent of all mussels collected), white heelsplitter (*Lasmigona complanata*; 28.9 percent), and fragile papershell (*Leptodea fragilis*; 17.4 percent) (ESI 2011). A single species, the pimpleback, "overwhelmingly" dominated collections in 2011, comprising more than 93 percent of all mussels collected. Although species richness was lower in 2011, mussel densities appeared to be higher, and the mix of young and old individuals present was indicative of a healthy, self-sustaining mussel community.

Table 2.5-1 Endangered and Threatened Species Recorded in Ogle and Winnebago Counties

Scientific Name	Common Name	Status[a]		County[b]
		Federal	State	
Mammals				
Myotis sodalis	Indiana Bat	E	E	Ogle, Winnebago
Spermophilus franklinii	Franklin's Ground Squirrel	-	T	Winnebago
Birds				
Bartramia longicauda	Upland Sandpiper	-	E	Ogle, Winnebago
Circus cyaneus	Northern Harrier	-	E	Winnebago
Dendroica cerulea	Cerulean Warbler	-	T	Winnebago
Ictinia mississippiensis	Mississippi Kite	-	T	Winnebago
Lanius ludovicianus	Loggerhead Shrike	-	E	Ogle, Winnebago
Nycticorax nycticorax	Black-crowned Night-Heron	-	E	Winnebago
Rallus elegans	King Rail	-	E	Winnebago
Reptiles				
Emydoidea blandingii	Blanding's Turtle	-	E	Ogle, Winnebago
Heterodon nasicus	Plains Hog-nosed Snake	-	T	Ogle
Terrapene ornata	Ornate Box Turtle	-	T	Ogle, Winnebago
Amphibians				
Hemidactylium scutatum	Four-toed Salamander	-	T	Ogle
Fish				
Ammocrypta clarum	Western Sand Darter	-	E	Winnebago
Erimystax x-punctatus	Gravel Chub	-	T	Ogle, Winnebago
Etheostoma exile	Iowa Darter		T	Winnebago
Fundulus dispar	Starhead topminnow	-	T	Winnebago
Notropis texanus	Weed Shiner	-	E	Winnebago
Mussels				
Alasmidonta viridis	Slippershell	-	T	Winnebago
Cyclonaias tuberculata	Purple Wartyback	-	T	Ogle, Winnebago
Elliptio dilatata	Spike	-	T	Winnebago
Ligumia recta	Black Sandshell	-	T	Ogle, Winnebago
Insects				
Hesperia Ottoe	Ottoe Skipper	-	E	Winnebago
Speyeria idalia	Regal Fritillary	-	T	Ogle
Plants				
Alnus incana rugosa	Speckled Alder	-	E	Winnebago
Amelanchier interior[c]	Shadbush	-	T	Winnebago
Amelanchier sanguinea[c]	Shadbush	-	E	Ogle
Arctostaphylos uva-ursi	Bearberry	-	E	Ogle, Winnebago

Table 2.5-1 Endangered and Threatened Species Recorded in Ogle and Winnebago Counties (Continued)

Scientific Name	Common Name	Status[a]		County[b]
		Federal	State	
Artemisia dracunculus	Dragon Wormwood	-	E	Winnebago
Asclepias lanuginosa	Wooly Milkweed	-	E	Ogle, Winnebago
Aster furcatus	Forked Aster	-	T	Ogle, Winnebago
Besseya bullii	Kittentails	-	T	Ogle, Winnebago
Betula alleghaniensis	Yellow Birch	-	E	Ogle
Botrychium matricariifolium	Daisyleaf Grape Fern	-	E	Winnebago
Botrychium multifidum	Northern Grape Fern	-	E	Winnebago
Botrychium simplex	Dwarf Grape Fern	-	E	Winnebago
Calopogon tuberosus	Grass Pink Orchid	-	E	Winnebago
Carex cryptolepis	Sedge	-	E	Ogle
Carex echinata	Sedge	-	E	Ogle, Winnebago
Carex inops heliophila	Sedge	-	E	Winnebago
Carex woodii	Pretty Sedge	-	T	Ogle
Castilleja sessiliflora	Downy Yellow Painted Cup	-	E	Ogle, Winnebago
Ceanothus herbaceus	Redroot	-	E	Ogle, Winnebago
Chimaphila umbellata	Pipsissewa	-	E	Winnebago
Comptonia peregrina	Sweetfern	-	E	Winnebago
Corallorhiza maculata	Spotted Coral-root Orchid	-	T	Winnebago
Cornus canadensis	Bunchberry	-	E	Ogle
Corydalis sempervirens	Pink Corydalis	-	E	Ogle
Cypripedium acaule	Moccasin Flower	-	E	Ogle
Cypripedium candidum	White Lady's Slipper	-	T	Winnebago
Dichanthelium boreale	Northern Panic Grass	-	E	Ogle
Elymus trachycaulus	Bearded Wheat Grass	-	T	Winnebago
Equisetum pratense	Meadow Horsetail	-	T	Ogle
Equisetum sylvaticum	Horsetail	-	E	Ogle
Filipendula rubra	Queen-of-the-prairie	-	E	Ogle
Gymnocarpium dryopteris	Oak Fern	-	E	Ogle
Helianthus giganteus	Tall Sunflower	-	E	Ogle, Winnebago
Juncus vaseyi	Vasey's Rush	-	E	Winnebago
Juniperus communis	Ground Juniper	-	T	Winnebago
Juniperus horizontalis	Trailing Juniper	-	E	Winnebago
Lathyrus ochroleucus	Pale Vetchling	-	T	Ogle
Lechea intermedia	Pinweed	-	T	Winnebago
Lespedeza leptostachya	Prairie Bush Clover	T	E	Ogle, Winnebago
Luzula acuminata	Hairy Woodrush	-	E	Ogle
Lycopodium clavatum	Running Pine	-	E	Ogle

Table 2.5-1 Endangered and Threatened Species Recorded in Ogle and Winnebago Counties (Continued)

Scientific Name	Common Name	Status[a]		County[b]
		Federal	State	
Lycopodium dendroideum	Ground Pine	-	E	Ogle
Nothocalais cuspidata	Prairie Dandelion	-	E	Ogle
Oenothera perennis	Small Sundrops	-	T	Winnebago
Penstemon grandiflorus	Large-flowered Beard Tongue	-	E	Winnebago
Phegopteris connectilis	Long Beech Fern	-	E	Ogle
Platanthera leucophaea	Eastern Prairie Fringed Orchid	T	E	Ogle, Winnebago
Ranunculus rhomboideus	Prairie Buttercup	-	T	Winnebago
Sambucus racemosa pubens	Red-berried Elder	-	E	Winnebago
Sorbus americana	American Mountain Ash	-	E	Ogle
Sparganium americanum	American Burreed	-	E	Winnebago
Sullivantia sullivantii	Sullivantia	-	T	Ogle
Tomanthera auriculata	Ear-leafed Foxglove	-	T	Ogle
Trientalis borealis	Star-flower	-	E	Ogle
Ulmus thomasii	Rock Elm	-	E	Winnebago
Vaccinium corymbosum	Highbush Blueberry	-	E	Winnebago
Woodsia ilvensis	Rusty Woodsia	-	E	Ogle

a. E = Endangered; T = Threatened; - = Not listed.
b. Source of county occurrence: USFWS 2012; IDNR 2011.
c. Two species of *Amelanchier* are known by the same common name (shadbush).

2.6 Demography

2.6.1 Regional Demography

The 1996 GEIS presents a population characterization method that is based on two factors: “sparseness” and “proximity” (NRC 1996b). “Sparseness” characterizes population density and city size within 20 miles (32 kilometers [km]) of a site and categorizes the demographic information as follows:

Demographic Categories Based on Sparseness

		Category
Most sparse	1.	Less than 40 persons per square mi (15 persons per square km) and no community with 25,000 or more persons within 32 km (20 mi)
	2.	40 to 60 persons per square mi (15 to 23 persons per square km) and no community with 25,000 or more persons within 32 km (20 mil)
	3.	60 to 120 persons per square mi (23 to 46 persons per square km) or less than 60 persons per square mi with at least one community with 25,000 or more persons within 32 km (20 mi)
Least sparse	4.	Greater than or equal to 120 persons per square mi (46 persons per square km) within 32 km (20 mi)
Source: NRC 1996b		

“Proximity” characterizes population density and city size within 50 miles (80 km) and categorizes the demographic information as follows:

Demographic Categories Based on Proximity

		Category
Not in close proximity	1.	No city with 100,000 or more persons and less than 50 persons per square mi (19 persons per square km) within 80 km (50 mi)
	2.	No city with 100,000 or more persons and between 50 and 190 persons per square mi (19 and 73 persons per square km) within 80 km (50 mi)
	3.	One or more cities with 100,000 or more persons and less than 190 persons per square mi (73 persons per square km) within 80 km (50 miles)
In close proximity	4.	Greater than or equal to 190 persons per square mi (73 persons per square km) within 80 km (50 mi)
Source: NRC 1996b		

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

GEIS Sparseness and Proximity Matrix

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

Low Population Area — Medium Population Area — High Population Area

Source: NRC 1996b

Exelon Generation used 2010 census data from the U.S. Census Bureau (Tetra Tech 2012a) with geographic information system software (ArcGIS®) to determine most demographic characteristics in the Byron vicinity. The calculations (Tetra Tech 2012a) determined that 248,387 people live within 32 km (20 miles) of Byron, or a population density of 76 persons per square km (198 persons per square mi). Applying the GEIS sparseness criteria, the 32-km (20-mi) population falls into the least sparse category, Category 4 (greater than or equal to 120 persons per square mile within 20 miles [32 km]).

To calculate the proximity measure, Exelon Generation determined that 1,247,087 people live within 80 km (50 mi) of Byron, which equates to a population density of 159 persons per square mile (61 persons per square km) (Tetra Tech 2012a). Applying the GEIS proximity measures, the 80 km (50-mi) radius around Byron is classified as Category 3 (one or more cities with 100,000 or more persons and less than 190 persons per square mile (73 persons per square km) within 50 miles [80 km]). Therefore, according to the GEIS sparseness and proximity matrix, Byron, with a sparseness rank of 4 and a proximity rank of 3 (a score of 4.3), is located in a high population area.

The nearest city with a population greater than 100,000 is Rockford, Illinois (27 km [17 mi] northeast), with a 2010 population of 152,871 (USCB 2012). Rockford is the seat of Winnebago County. The population distribution within the 80-km (50-mi) radius of Byron is generally considered rural, with the exception of those areas closer to the city of Rockford and the Chicago metropolitan areas, to the east. The municipality nearest the Byron site is the City of Byron (6 to 8 km [4 to 5 mi] northeast) with a 2010 population of 3,753 (USCB 2010a).

All or parts of 21 counties fall within 80 km (50 mi) of the Byron site (Figure 2.1-1). The Byron site is within the Rockford-Freeport-Rochelle Combined Statistical Area (CSA). The 2010 population of the Rockford-Freeport-Rochelle CSA was 450,639 (USCB 2010a).

Because approximately 80 percent of Byron employees reside in Ogle, Lee, or Winnebago Counties, they are the counties with the greatest potential to be socioeconomically affected by license renewal at Byron (see Section 3.4). Table 2.6-1 shows historical populations, population projections, and decennial growth rates for Ogle, Lee, and Winnebago Counties. Data for the State of Illinois are provided for comparison.

Winnebago County has, by far, the largest population of the three counties. Through 2020, Winnebago County has had, and is projected to have, the largest rates of population growth, when compared with Ogle and Lee Counties and the state of Illinois. Lee County, with the smallest population of the three, showed a slight decline in population between 2000 and 2010, and is projected to grow the least.

2.6.2 Minority and Low-Income Populations

NRC has concluded that, for environmental justice analyses, an 80-km (50-mi) radius could reasonably be expected to experience potential environmental impacts from license renewal activities, and that the state or states which have land within the 80-km (50-mi) radius of the nuclear plant seeking license renewal would be appropriate as the geographic area(s) for comparative analysis. Exelon Generation has used this approach for identifying the minority and low-income populations that could be affected by Byron operations.

Exelon Generation used ArcGIS® geographic information system software to determine the minority/low-income characteristics by block group. Exelon Generation included in the analysis any block group if any part of its area lay within 80 km (50 mi) of Byron. The 80-km (50-mi) radius includes 971 block groups (Table 2.6-2) (Tetra Tech 2012b).

2.6.2.1 Minority Populations

The NRC Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues defines a “minority” population as: American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black Races, and Hispanic Ethnicity (NRC 2009c). Additionally, NRC’s guidance requires that (1) all other single minorities are to be treated as one population and analyzed, (2) multi-racial populations are to be analyzed, and (3) the aggregate of all minority populations are to be treated as one population and analyzed. The guidance indicates that a minority population exists if either of the following two criteria is met:

- The minority population in a census block group or environmental impact site exceeds 50 percent.
- The minority population percentage of the block group or environmental impact area is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for comparative analysis.

For each of the 971 block groups within the 80-km (50-mi) radius, Exelon Generation calculated each minority’s percent of the block group’s population. If any minority percentage exceeded 50 percent of the block group population, then the block group was identified as having a minority population. Exelon Generation used the entire states of Illinois, Iowa, and Wisconsin as the geographic areas for comparative analysis, and calculated the percentages of each minority category in those states. If any block group percentage exceeded the corresponding state percentage by more than 20 percent, then a minority population was determined to exist (Tetra Tech 2012b).

Census data for Illinois (Tetra Tech 2012b) characterizes 0.34 percent of the state's population as American Indian or Alaskan Native; 4.57 percent Asian; 0.03 percent Native Hawaiian or other Pacific Islander; 14.55 percent Black races; 6.71 percent all other single minorities; 2.26 percent multi-racial; 28.47 percent aggregate of minority races; and 15.80 percent Hispanic ethnicity.

Census data for Iowa (Tetra Tech 2012b) characterizes 0.36 percent of the state's population as American Indian or Alaskan Native; 1.74 percent Asian; 0.07 percent Native Hawaiian or other Pacific Islander; 2.93 percent Black races; 1.84 percent all other single minorities; 1.75 percent multi-racial; 8.69 percent aggregate of minority races; and 4.97 percent Hispanic ethnicity.

Census data for Wisconsin (Tetra Tech 2012b) characterizes 0.96 percent of the state's population as American Indian or Alaskan Native; 2.27 percent Asian; 0.03 percent Native Hawaiian or other Pacific Islander; 6.32 percent Black races; 2.39 percent all other single minorities; 1.83 percent multi-racial; 13.80 percent aggregate of minority races; and 5.91 percent Hispanic ethnicity.

Table 2.6-2 presents the numbers of block groups, by county, within the 80-km (50-mi) radius that exceed either, or both, of the threshold for minority populations. Figures 2.6.2-1 through 2.6.2-4 locate the minority block groups within the 80-km (50-mi) radius. Within the 80-km (50-mi) radius, the numbers of census block groups meeting one or both criteria for populations of concern were as follows:

- 40 (4 percent of total census block groups in the 80-km [50-mi] radius) for Black races minority populations;
- 11 (1 percent) for All Other Single Minority populations;
- 52 (5 percent) for Aggregate Minority populations; and
- 34 (4 percent) for Hispanic Ethnicity populations.

2.6.2.2 Low-Income Populations

NRC guidance defines low-income population based on statistical poverty thresholds (NRC 2009c) if either of the following two criteria is met:

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

Exelon Generation divided USCB low-income households in each census block group by the total households for that block group to obtain the percentage of low-income households per block group. Illinois, Iowa, and Wisconsin have 11.92 percent, 11.34 percent, and 11.17 percent, respectively, of households as low-income households (Tetra Tech 2012b). Table 2.6-2 identifies the low-income block groups with the 80-km (50-mi) radius of Byron. Figure 2.6.2-5 locates the low-income block groups.

Within the 80-km (50-mi) radius, 67 census block groups meet one or both criteria for low-income households.

Table 2.6-1. Historical and Projected Population Data

Year	Ogle County	% Change	Lee County	% Change	Winnebago County	% Change	State of Illinois	% Change
2000	51,032	NA	36,062	NA	278,418	NA	12,419,293	NA
2010	53,497	4.8	36,031	-0.1	295,266	6.1	12,830,632	3.3
2020	59,230	10.7	37,939	5.3	337,049	14.2	14,316,487	11.6
2030	63,765	7.7	38,923	2.6	359,900	6.8	15,138,849	5.7

Sources: USCB 2012; IDCEO 2011

Note: Year 2000 and 2010 data are provided by the USCB and are from the 2000 and 2010 decennial censuses. Year 2020 and 2030 data are projections developed by the Illinois Department of Commerce and Economic Opportunity (IDCEO) and are based on the 2000 decennial census. Therefore, 2020 and 2030 data may be slightly overstated, as actual 2010 data from the 2010 decennial census are lower than the 2010 data projected by the IDCEO (which were based on the 2000 decennial census). See IDCEO 2011 for the projected 2010 population data, as they are not presented in this table.

Table 2.6-2. Minority and Low-Income Population Block Groups within 80 km (50 mi) of Byron Station

State	County	County Number	Number of Block Groups within 50-Miles[a]	Black[a]	American Indian or Alaskan Native[a]	Asian[a]	Native Hawaiian or Other Pacific Islander[a]	Some Other Race[a]	Multi-Racial[a]	Aggregate[a]	Hispanic[a]	Low-Income Households[a]
Illinois	Boone	7	27	0	0	0	0	2	0	0	2	0
	Bureau	11	26	0	0	0	0	0	0	0	0	0
	Carroll	15	18	0	0	0	0	0	0	0	0	0
	DeKalb	37	60	1	0	0	0	0	0	1	1	8
	Henry	73	2	0	0	0	0	0	0	0	0	0
	Jo Daviess	85	12	0	0	0	0	0	0	0	0	0
	Kane	89	76	0	0	0	0	1	0	1	7	0
	Kendall	93	8	0	0	0	0	0	0	0	1	0
	La Salle	99	27	1	0	0	0	0	0	0	1	0
	Lee	103	38	0	0	0	0	0	0	0	0	1
	McHenry	111	80	0	0	0	0	1	0	0	6	0
	Ogle	141	44	0	0	0	0	0	0	0	2	2
	Stephenson	177	49	5	0	0	0	0	0	2	0	5
	Whiteside	195	62	0	0	0	0	0	0	0	3	2
	Winnebago	201	263	29	0	0	0	6	0	40	7	38
Iowa	Clinton	45	18	0	0	0	0	0	0	0	0	2
	Jackson	97	2	0	0	0	0	0	0	0	0	0
Wisconsin	Green	45	29	0	0	0	0	0	0	0	0	0
	Lafayette	65	3	0	0	0	0	0	0	0	0	0
	Rock	105	108	4	0	0	0	1	0	8	3	9
	Walworth	127	19	0	0	0	0	0	0	0	1	0
		Totals	**971**	**40**	**0**	**0**	**0**	**11**	**0**	**52**	**34**	**67**
Illinois State Percentages[b]				14.55	0.34	4.57	0.03	6.71	2.26	28.47	15.80	11.92
Iowa State Percentages[b]				2.93	0.36	1.74	0.07	1.84	1.75	8.69	4.97	11.34
Wisconsin State Percentages[b]				6.32	0.96	2.27	0.03	2.39	1.83	13.80	5.91	11.17

Note: Highlighted counties are completely within the 80-km (50-mi) radius.

People living in the following types of institutions/facilities on the date of the Census are counted as living at the institution/facility of residence rather than at any other former residence (USCB 2010b):
• Correctional facilities (e.g., federal/state/local prisons, confinement/detention centers);
• Non-correctional facilities (e.g., adult/juvenile group homes, residential treatment centers, shelters);
• Long term medical facilities (e.g., psychiatric care facilities, nursing facilities); and
• Housing for students living away from their parental home (on- or off-campus).
[a]Entries denote numbers of census block groups.
[b]Entries denote state percentages of race, ethnicity, and low-income households.
Source: Tetra Tech 2012b

Figure 2.6.2-1. Black Races Minority Map

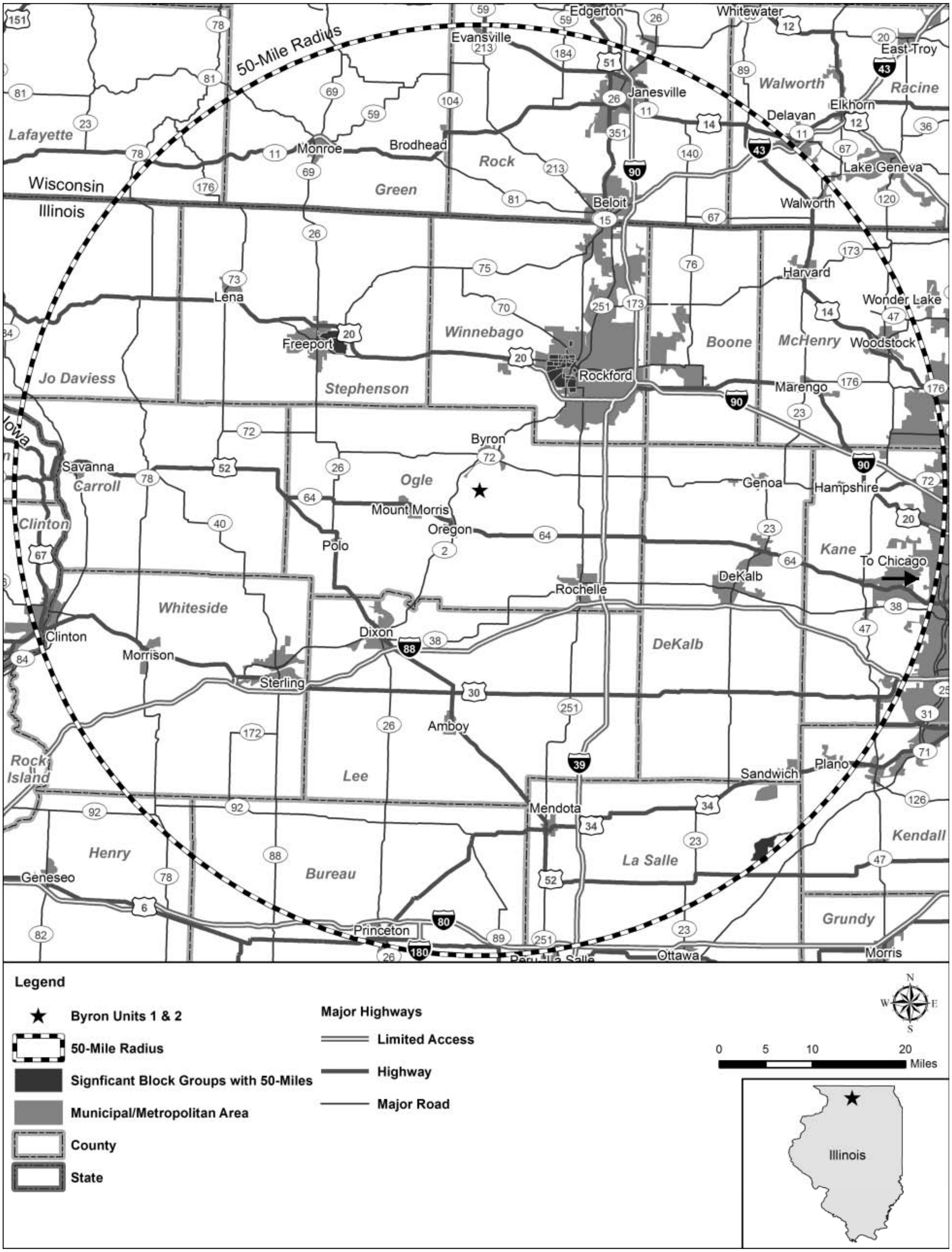


Figure 2.6.2-2. Other Races Minority Map

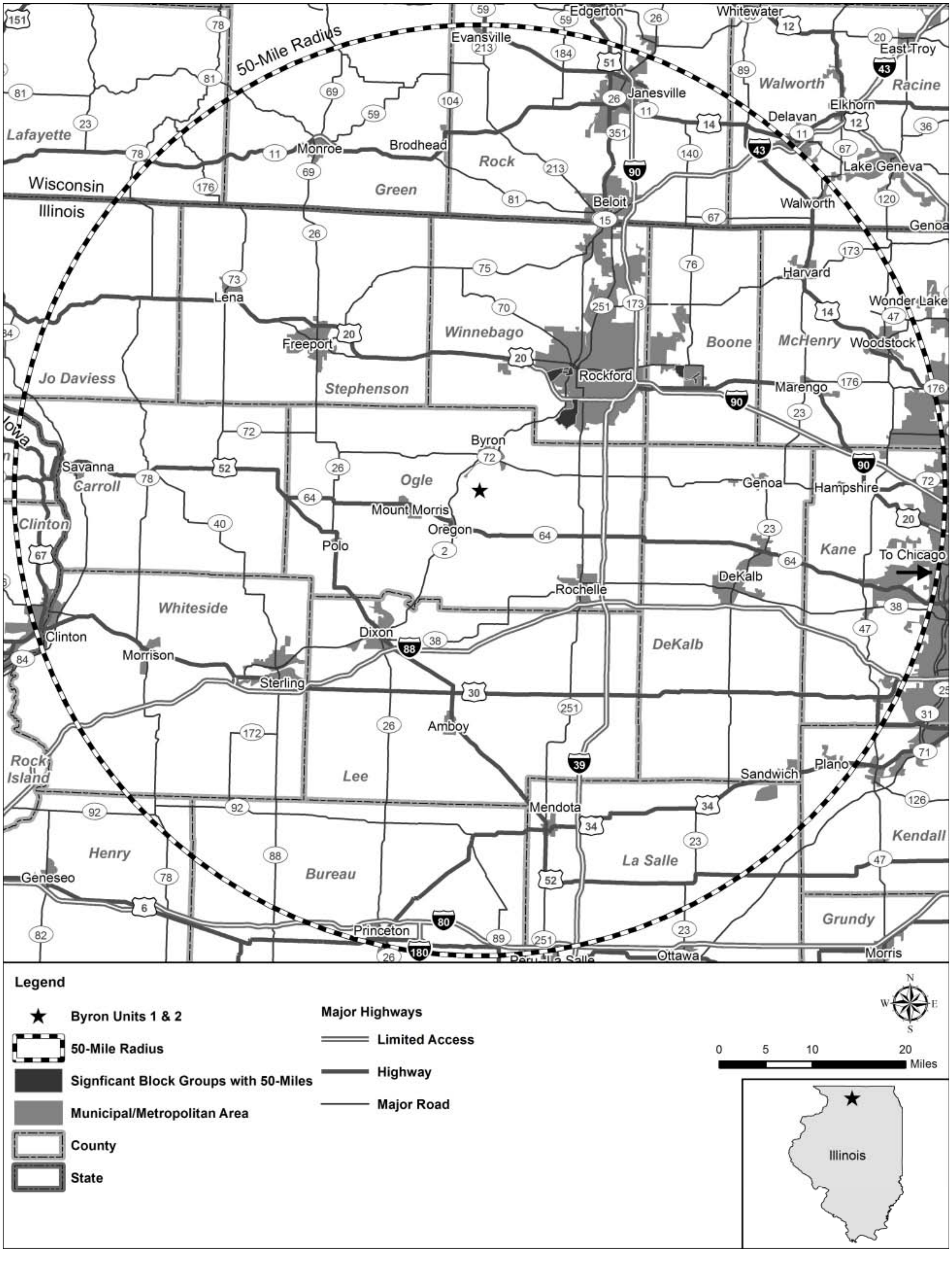


Figure 2.6.2-3. Aggregate of Races Minority Map

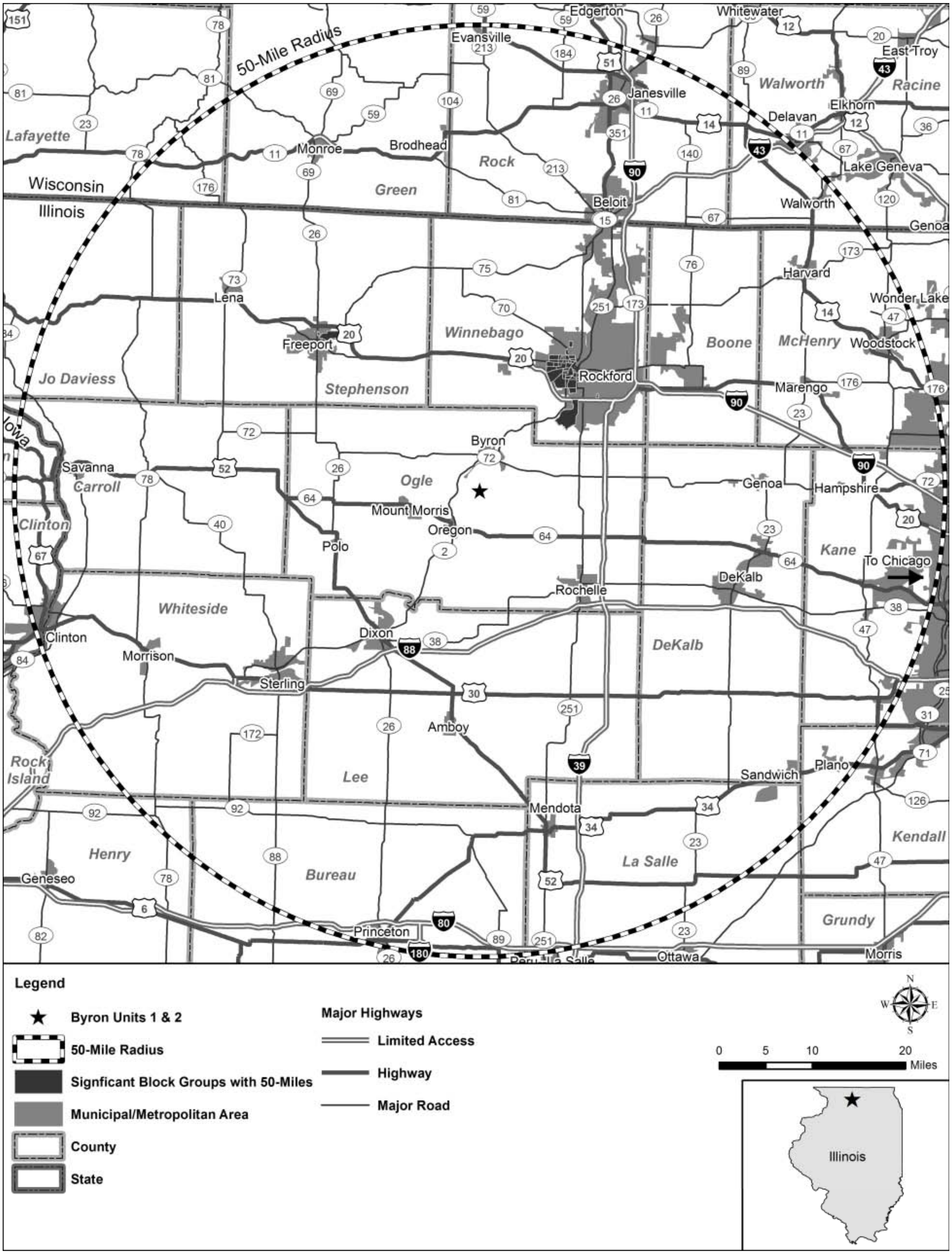


Figure 2.6.2-4. Hispanic Ethnicity Map

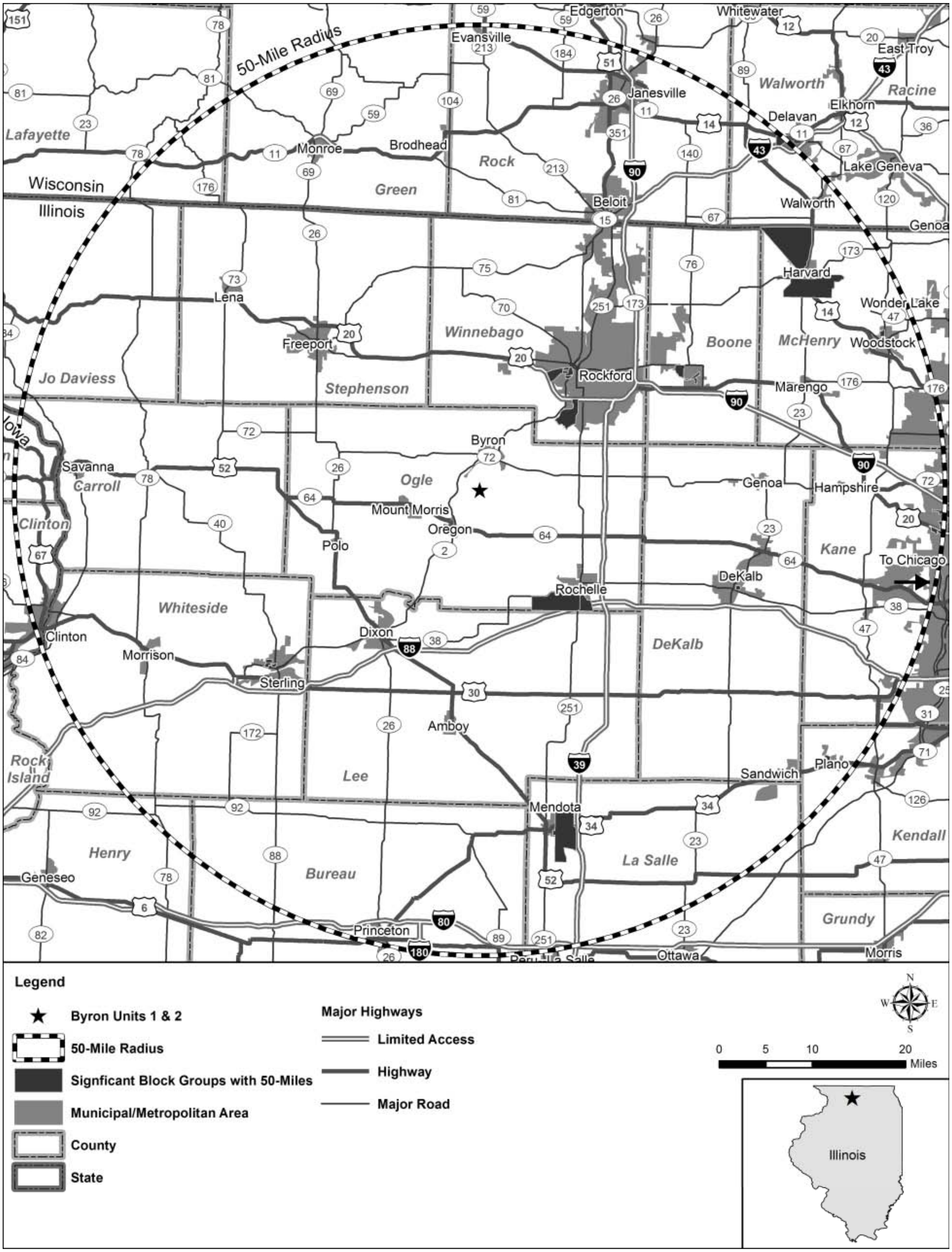
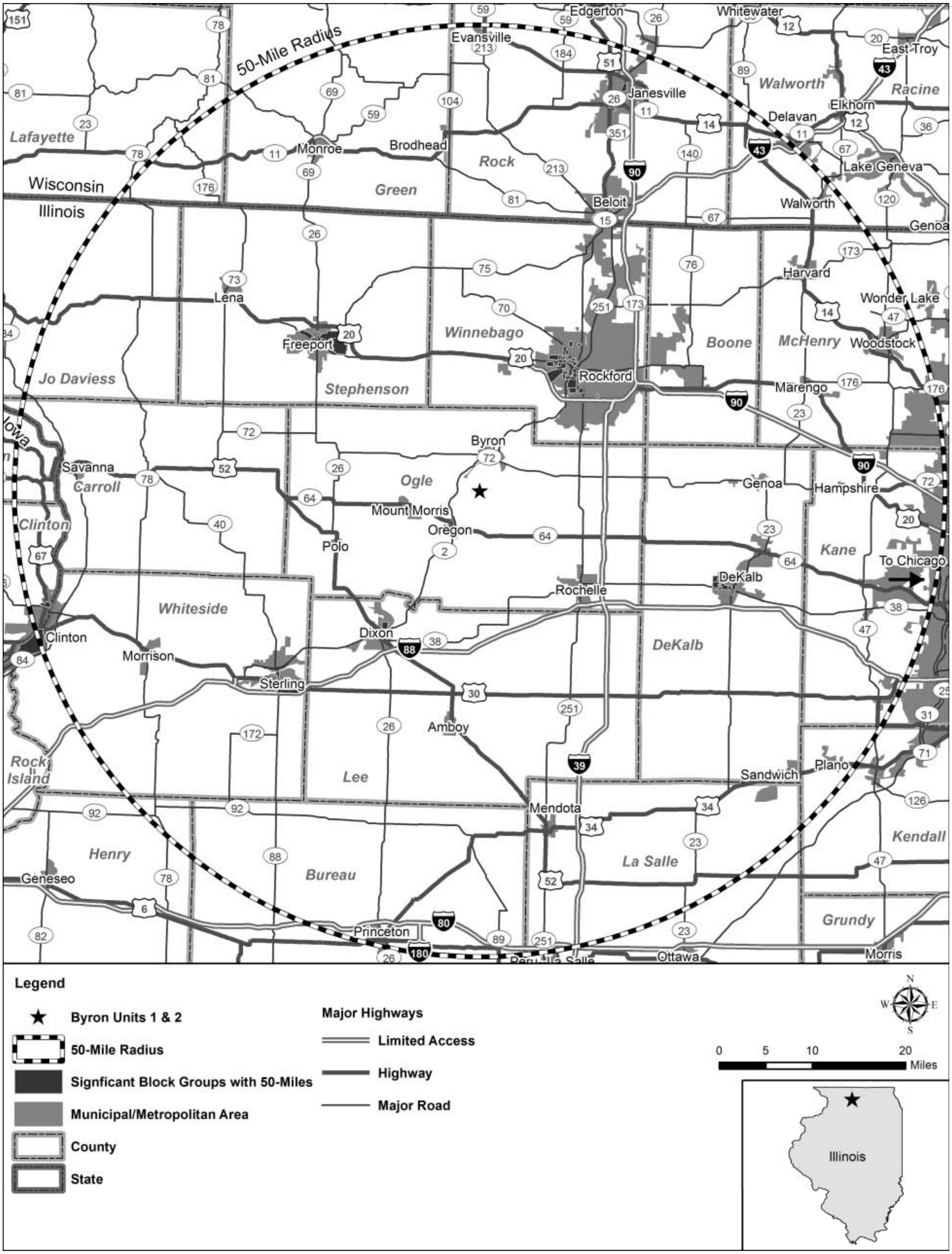


Figure 2.6.2-5. Low-Income Household Map



2.7 Property Taxes

The property taxes paid by Byron are generally determined using the equalized assessed value (EAV) set by the county assessor, and the tax levy and rates set by each of the taxing districts in which Byron is located. Periodically, Exelon Generation enters into negotiations (which may result in a “settlement agreement”) with Ogle County and the other relevant taxing districts to set the EAV of Byron Station. Negotiations can consider, but are not limited to, property valuation approaches, tax “triggers” (or limits), and payments in addition to taxes (PIATs). Byron’s last settlement agreement was signed on November 8, 2008 and covered tax years 2005 through 2011. Exelon Generation negotiated tax triggers that could not be exceeded by Byron’s taxing entities. If the levies exceeded these negotiated triggers, Exelon Generation could reduce Byron’s tax obligation by the amounts in excess of the triggers. Exelon Generation also agreed to make PIATs (additional payments) to specific tax recipients. These payments are not considered tax payments in the traditional sense. They have fewer limitations for use and provide additional benefits for recipients. In accordance with the 2008 settlement agreement, Exelon Generation made two PIAT payments of $2,302,000 each; one in 2008 and the other, in 2010. Table 2.7-1 lists the PIATs and their recipients.

For Byron Station, Exelon Generation pays annual property taxes to a number of taxing entities within, and including, Ogle County. The Ogle County Treasurer collects Byron’s property tax payment and disperses it to the various taxing entities to partially fund their respective operating budgets. The taxing entities to which Byron pays taxes include, but are not limited to, the Byron Forest Preserve, the Oregon Park District, the Rock Valley Community College 511, the Byron Unit 226 School District, the Byron Fire District, the Byron Library District, Ogle County, and Rockvale Township. From 2008 through 2010, Ogle County’s total adjusted property tax levies ranged from approximately $99.3 to $114.5 million annually (see Table 2.7-2). From 2008 through 2010, Byron’s total property tax payments (after tax triggers and not including PIAT payments) represented 26.0 to 26.4 percent of Ogle County’s total adjusted property tax levy (see Table 2.7-2).

The recipient of the largest percentage of Byron’s property tax payment is the Byron Unit 226 School District (Coffman 2012). Table 2.7-3 compares Byron’s property tax payments (after tax triggers and not including PIAT payments) to the Byron Unit 226 School District’s adjusted total property tax levies. From 2008 through 2010, Byron’s property tax payments to the school district represented 72.9 to 73.5 percent of the school district’s total adjusted property tax levies (Table 2.7-3).

Although variations in tax levies are not completely under its control, Exelon Generation expects that Byron’s annual property tax payments will remain relatively constant through the license renewal period.

In 1998, Byron Station replaced the Unit 1 steam generators. Because the replacement was considered one-for-one, the Station’s assessed value was unaffected. Exelon Generation expects that any future one-for-one replacement projects will also not affect the station’s assessed value.

Table 2.7-1. PIAT Payments and Recipients, 2008 and 2010

Ogle County	$270,863
Byron Fire Protection District	$166,564
Byron Library District	$56,659
Byron Museum District	$6,256
Byron Forest Preserve District	$127,339
Oregon Park District	$147,137
Rockvale Township	$12,888
Rockvale Township Road District	$30,192
Rock Valley College	$90,874
Byron Community Unit School District No. 226	$1,346,079
Kishwaukee College	$4,926
Oregon Community Unit School District No. 220	$42,223
Total	**$2,302,000**

Table 2.7-2. Property Tax Payment Comparison, All Taxing Districts Combined

Year	Total Combined Taxing District Levy – Ogle County (after adjustments) ($)	Byron Station Property Tax Payment (after tax triggers have been applied and not including PIAT payments) ($)	Byron Station Payment as Percent of Total District Levy (%)
2008	111,337,743	29,053,546.54	26.1
2009	113,841,479	29,553,842.06	26.0
2010	114,458,142	30,173,147.74	26.4

Source: Coffman 2012

Note: Table 2.7-2 includes all taxing districts, including the Byron Unit 226 School District property tax revenues and payments.

Table 2.7-3. Property Tax Payment Comparison, Byron Unit 226 School District

Year	Total Byron Unit 226 School District Levy (after adjustments) ($)	Byron Unit 226 School District Portion of Byron Station Property Tax Payment (after tax triggers have been applied and not including PIAT payments) ($)	Byron Station Payment as Percent of Byron Unit 226 School District Levy (%)
2008	22,394,644	16,334,177.57	72.9
2009	22,727,906	16,650,104.82	73.3
2010	23,091,850	16,976,716.16	73.5

Source: Coffman 2012

Note: Table 2.7-3 includes Byron Unit 226 School District property tax revenues and payments, only. They have been extracted from Table 2.7-2 and highlighted here in Table 2.7-3.

2.8 Off-Site Land Use

This section provides baseline data that are used in the land use and housing analyses in Chapter 4 of this document. This section focuses on Ogle, Lee, and Winnebago Counties because the majority of the permanent Byron workforce lives in these counties (see Section 3.4) and because Byron pays property taxes in Ogle County.

All three counties have experienced some growth over the last several decades (see Table 2.6-1) and their comprehensive land use plans account for this growth in the planning process. The three plans share the goals of encouraging growth and development in areas where public facilities, such as water and sewer systems, are planned and discouraging strip development along county roads and highways. They also promote the preservation of the counties' natural features and prime undeveloped areas.(Ogle County 2012; Lee County 2010; Winnebago County 2009)

Much of the growth in this region has been influenced by the continued expansion of the Chicago region. For example, in an effort to facilitate and streamline this expansion, the Midwest Regional Rail Initiative was created. The Initiative is a cooperative effort between Amtrak; the Federal Railroad Administration; and the states of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, and Wisconsin to develop an improved and expanded passenger rail system in the Midwest. As part of this initiative, a rail system is proposed to provide a high-speed connection between Chicago and many of the major cities throughout the entire region (Lee County 2010). Some of the proposed rail lines and stations are located in or adjacent to the three counties (MHSRA 2012). Therefore, should the Midwest Regional Rail Initiative be completed, local planners expect Chicago-influenced developmental pressures in the region to continue.

<u>Ogle County</u>

Ogle County is in north-central Illinois, 37 km (23 mi) south of the Illinois-Wisconsin border. It is bordered by DeKalb, Winnebago, Stephenson, Carroll, Whiteside, and Lee Counties. Ogle County is the 17th largest county in Illinois, comprising 24 townships (Ogle County 2012) totaling 197,613 ha (488,313 ac) (Ogle County 2012).

The Ogle County line is within 8 km (5 mi) of the city of Rockford. Ogle County lies adjacent to the Chicago-Joliet-Naperville and Rockford Metropolitan Statistical Areas (MSAs). The growth of both MSAs has exerted some developmental pressures on Ogle County.

Ogle County's primary comprehensive land use planning document is the *Ogle County, Illinois, Amendatory Comprehensive Plan* for which a draft was published in 2012(Ogle County 2012).

Existing Land Use

Ogle County's current land use is primarily agriculture (about 90 percent) and includes 'farmsteads" and farm buildings, pasture and grazing land, timberlands, grasslands, and other rural open space uses. The County's most intensive development is in the municipalities, which collectively account for only 4.5 percent of the land area, but 57 percent of the population (Ogle County 2012). The three largest municipalities are Rochelle, Oregon, and Byron, with 2010 populations of 9,574, 3,721, and 3,753, respectively (Ogle County 2012). Between 2000 and 2010, municipalities in western Ogle County decreased in population and municipalities in eastern Ogle County increased in population (Ogle County 2012). Existing land use in Ogle County is provided in Table 2.8-1.

Future Land Use

Ogle County's primary planning goal is to preserve its rural and agricultural character, while accommodating economic and developmental expansion. New growth is expected and encouraged within and adjacent to the existing municipalities in the County (Ogle County 2012).

Other Planning Instruments

In addition to the Comprehensive Plan, Ogle County planners use several other instruments to guide development within the County. They include, but are not limited to, the following:

1. Ogle County Zoning Ordinance
2. Ogle County Subdivision Ordinance
3. Ogle County Greenways and Trails Plan
4. Special Flood Hazard Areas Ordinance
5. Comprehensive Stormwater Management Ordinance
6. Local municipality comprehensive land use plans

The County has no formal growth control measures.

Lee County

Lee County is in northwestern Illinois, about 161 km (100 mi) west of Chicago, 64 km (40 mi) southwest of Rockford, and 105 km (65 mi) northeast of the Quad Cities (Lee County 2010, pg.1-3). It is bordered by Ogle, Dekalb, LaSalle, Bureau, and Whiteside Counties. Lee County contains two cities (Dixon and Amboy), 10 villages, and 22 townships. The County comprises 188,720 ha (466,338 ac) (Lee County 2010).

The economy of the Upper Midwest has historically been linked to agriculture. However, with the continued expansion of the Chicago region, there has been an increase in developmental pressure on the surrounding region. Proposed transportation enhancements, like the Midwest Regional Rail Initiative, are expected to facilitate this expansion and increase the development pressure. Lee County's planners want to address this expansion through the use of planning documents and ordinances (Lee County 2010).

Existing Land Use

Lee County's primary comprehensive land use planning document is the *Lee County Comprehensive Plan* (LCCP) (Lee County 2010). According to the LCCP, Lee County's existing land use pattern is primarily rural, with large areas of contiguous farmland dominating the County's landscape. Table 2.8-2 provides a breakdown of Lee County's existing land uses. Agriculture comprises 92 percent of the total land area and can be found throughout the county. Recreational land uses, including the Green River State Wildlife Area and Richardson Wildlife

Foundation, are concentrated in the southern portion of the County. Large extraction operations are located primarily in Dixon, South Dixon, Palmyra, and Amboy Townships. The County's population is concentrated in city, villages, historic rural settlements, and waterfront areas. There are pockets of single-family residential development located in most townships, usually along roads or in unincorporated hamlets (Lee County 2010).

Historically, Lee County has experienced only modest increases in population, development, and traffic.

Future Land Use

Like Ogle County, Lee County's primary planning goal is to preserve its rural and agricultural character, while accommodating economic and developmental expansion. New growth is encouraged within and adjacent to the existing municipalities in the County (Lee County 2010).

In addition to the LCCP, Lee County uses local municipality comprehensive land use plans, the Lee County Greenways and Trails Plan, and zoning and subdivision ordinances to guide development. The County does not employ growth control measures.

Winnebago County

Winnebago County is in north-central Illinois, and abuts Wisconsin. It is bordered by Boone, DeKalb, Ogle, and Stephenson Counties in Illinois, and Green and Rock Counties in Wisconsin. Winnebago County has 14 townships and 8 villages and comprises 134,420 ha (332,160 acres) (Winnebago County 2009).

Existing Land Use

Land development in Winnebago County is guided by the county's comprehensive land management plan, *2030 Land Resource Management Plan for Winnebago County, Illinois* (LRMP) (Winnebago County 2009). According to the plan, the highest land use in the county is agriculture, at 63 percent, followed by incorporated areas, at 22 percent. Residential land in unincorporated areas totals 10 percent and is followed by open space/forest preserves, at 3 percent. There is little commercial or industrial land use. Urban development is concentrated along the eastern boundary of the county and includes the municipalities of Rockford, Roscoe, Rockton, Loves Park, and Machesney Park. The western half of the county is more rural (Winnebago County 2009). Existing land use in Winnebago County is provided in Table 2.8-3.

Future Land Use

With respect to future development, local planners indicate that Winnebago County will preserve prime agricultural land and encourage new residential development in areas where infrastructure and services already exist. Infill development and expansion of existing municipalities is encouraged. Expansion of forest preserve lands and open space is also encouraged (Winnebago County 2009).

In addition to the LRMP, Winnebago County uses local comprehensive land use plans, and zoning and subdivision ordinances to guide development. The County does not employ growth control measures.

Table 2.8-1. Ogle County Land Use

Land Use	Hectares (Acres)	Percent
Agriculture and Rural Lands	176,318 (435,692)	89.2
Incorporated Cities/Villages	8,852 (21,873)	4.5
Rural Settlement	2,897 (7,158)	1.5
Residential	2,043 (5,048)	1.0
State Parks/Forest	2,000 (4,943)	1.0
Private Camp/Recreation Area	1,513 (3,739)	0.8
Industrial	1,404 (3,469)	0.7
Private Conservation Land	946 (2,338)	0.5
Other Public Park/Open Space	722 (1,785)	0.4
Commercial	647 (1,598)	0.3
Public/Governmental	138 (341)	0.1
Church/Cemetery	133 (329)	0.1
TOTAL	197,613 (488,313)	100.0

Source: Ogle County 2012

Table 2.8-2 Lee County Land Use

Land Use	Hectares (Acres)	Percent
Agriculture	173,873 (429,650)	92.1
Rural Residential	2,778 (6,865)	1.5
Single-Family Residential	265. (654)	0.1
Mixed Residential	30 (73)	<0.1
Multi-Family Residential	18 (45)	<0.1
General Office/Business	280 (693)	0.1
General Industrial	748 (1,849)	0.4
Heavy Industrial	121 (298)	0.1
Extraction	947 (2,341)	0.5
Institutional	118 (292)	0.1
Active and Passive Recreation	1,393 (3,442)	0.7
Special Recreation	969 (2,395)	0.5
Surface Water	1,020 (2,520)	0.5
Right-of-Way	1,395 (3,446)	0.7
Land in Cities and Villages	4,765 (11,774)	2.5
TOTAL	188,720 (466,338)	100.0

Source: Lee County 2010

Table 2.8-3. Winnebago County Land Use

Land Use	Percent
Agriculture	63.33
Agriculture – Rural Residential	3.54
Residential – Low Density	2.82
Residential – Medium Density	3.56
Residential – High Density	0.05
Residential – Manufactured Housing	0.05
Commercial	0.33
Industrial	0.78
Open Space and Forest Preserves	3.23
Public Facilities	0.12
Places of Worship	0.05
Incorporated Areas	22.14
TOTAL	100.00

Source: Winnebago County 2009

2.9 Social Services and Public Facilities

2.9.1 Public Water Systems

Because Byron is in Ogle County and most Byron employees reside in Ogle, Lee, or Winnebago Counties, the discussion of public water supply systems is limited to those three counties.

Most of the water for domestic, municipal, and industrial use in the region comes from groundwater. Groundwater resources are developed mainly from the Cambrian-Ordovician Aquifer System (Section 2.3.3).

Byron gets potable water from two 457 m (1,500 ft) on-site groundwater wells and is not connected to a public water system. During refueling and maintenance outages, the wells draw a peak of 30 L/sec (470 gpm) for potable water and demineralizer use from the Cambrian-Ordovician Ironton-Galesville and Mt. Simon aquifers (Section 2.3.3).

All major public water suppliers in Ogle, Lee, and Winnebago Counties obtain their supplies from groundwater. Table 2.9-1 lists the largest public water suppliers in Ogle, Lee, and Winnebago Counties and provides water use and supply information for those suppliers. Currently, there is excess capacity in every major public water system in the three counties.

2.9.2 Transportation

Ogle County covers a land area of approximately 197,613 ha (488,313 ac) (Ogle County 2012). It is primarily bordered by Stephenson and Winnebago Counties to the north, Dekalb County to the east, Lee County to the south, and Carroll County to the west.

Major freeways serving Ogle County include I-39 and I-88. Other routes serving the county are north/south state routes 2, 26, and 251, US Highway 52, and east/west state routes 38, 64, and 72 (Figure 2.9-1) (Ogle County 2008).

Road access to Byron is via German Church Road (also known as County Highway 2), which runs northeast-southwest. Byron has two access roads available to it (a northern entrance and a southern entrance) which intersect German Church Road approximately 5 to 6 km (3 to 4 mi) southwest of the City of Byron, however, only the northern access road is normally used (Figures 2.9-1 and 3.1-2). In the City of Byron, German Church Road intersects County Highway 33 and IL 72, at a single intersection. IL 72 travels east and north at that intersection. County Highway 33 travels west. German Church Road intersects IL 64 at a location 8 to 9.5 km (5 to 6 mi) south of the station entrance. Employees traveling from northwest, north, and northeast to Byron would use some combination of IL 2, IL 72, County Highway 33, and north German Church Road to reach the station. Employees traveling from the southwest, south, and southeast would likely use some combination of IL 2, IL 64, and south German Church Road to reach the station.

In determining the significance levels of transportation impacts for license renewal, the NRC uses the Transportation Research Board's level of service (LOS) definitions (NRC 1996b). The definitions range from LOS A least congested (i.e., no congestion), to LOS F, most congested. Illinois Department of Transportation (IDOT) traffic engineers state that the only locations at which increases in employment at Byron could cause noticeable changes in LOS are the intersections of German Church Road/IL 72/County Highway 33 and German Church

Road/IL64. The LOS value for both locations is LOS B (McCormick 2012). IDOT engineers predict that an additional 300 southbound vehicles per hour on German Church Road would change the LOS value of the intersection with IL 64 to LOS D and that an additional 225 vehicles per hour on German Church Road would change the LOS value of its intersection with IL 72 to LOS D (McCormick 2012).

Other roadways and intersections in the cities of Byron and Oregon either have signals and can accommodate additional traffic, or are far enough from the Byron site that there would be sufficient dispersion of the traffic streams (McCormick 2012). These roadways and intersections would not be significantly impacted.

The IDOT maintains Annual Average Daily Traffic (AADT) volumes for most roadways in the state. Figure 2.9-1 and Table 2.9-1 provide locations and AADTs, respectively, in the vicinity of Byron.

During normal operations, only the northern entrance to Byron is open. Byron employees report that there is no traffic congestion in the area during normal operations. During major outages, such as for refueling or major maintenance, Byron opens both entrances to alleviate potential congestion. During the first weeks of an outage, some congestion occurs at Byron's northern entrance because the back shifts have not yet started and most outage workers are on the first shift. Once the back shifts start, however, the congestion usually abates. Maintenance crews from Byron add signage warning of temporary congestion in the area. Byron employees do not recall any congestion issues during the 1998 steam generator replacement (SGR) project.

Table 2.9-1. Public Water Supply Data: Ogle, Lee, and Winnebago Counties, 2007-2010

Public Water Supplier	County	Source	Average Daily Use (MGD)	Maximum Pump Capacity (MGD)
Byron	Ogle	Groundwater	0.6	2.3
Oregon	Ogle	Groundwater	0.4	3.1
Rochelle	Ogle	Groundwater	2.7	7.2
Dixon	Lee	Groundwater	2.2	12.0
Woodhaven	Lee	Groundwater	0.4	2.1
Cherry Valley	Winnebago	Groundwater	0.6	6.2
Illinois American – South Beloit	Winnebago	Purchased Groundwater	0.7	not available
Loves Park	Winnebago	Groundwater	3.0	6.9
North Park Public Water District	Winnebago	Groundwater	3.5	18.1
Rockford	Winnebago	Groundwater	25.6	125.0
Rockton	Winnebago	Groundwater	0.8	6.2

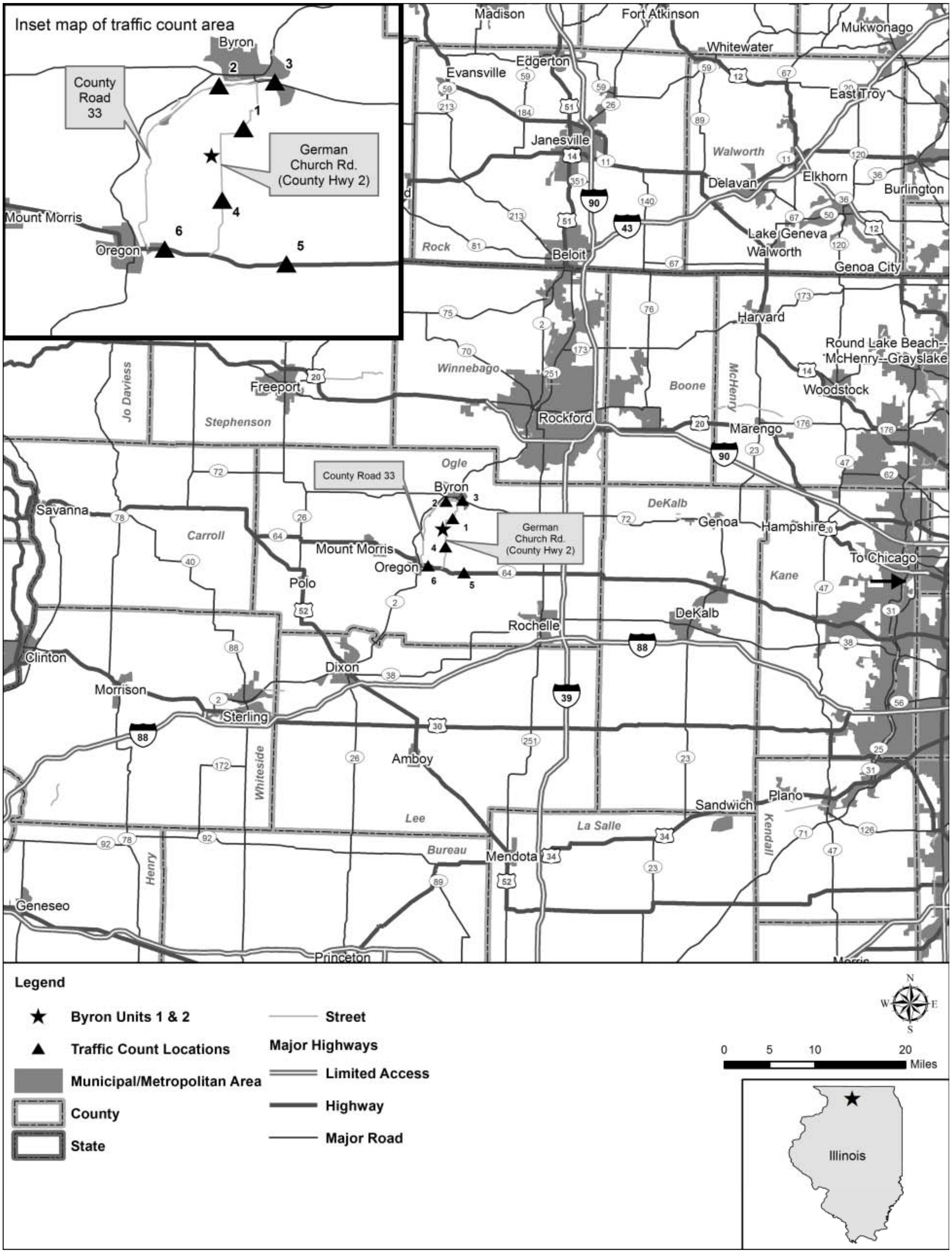
Sources: EPA 2012a; Nallatan 2012
MGD = million gallons per day

Table 2.9-2. AADT Volumes in the Vicinity of Byron

Map Location	Roadway Description	2009 AADT
1	The section of North German Church Road between the station entrance and IL 72	1,950
2	On County Highway 33, near its intersection with North German Church Road	3,200
3	On IL 72, just east of its intersection with North German Church Road	7,900
4	The section of South German Church Road between the station entrance and IL 64	750-1,150
5	On IL 64, just east of the intersection with South German Church Road	3,500
6	On IL 64, just west of the intersection with South German Church Road	4,350

Source: IDOT 2009
AADT = Annual Average Daily Traffic

Figure 2.9-1. Regional Transportation Network



2.10 Meteorology and Air Quality

Byron is in Ogle County, Illinois, approximately 27 km (17 mi) southwest of Rockford, Illinois and 145 km (90 mi) west-northwest of Chicago. The climate of northern Illinois is typically continental, with cold winters, warm summers, and frequent short-period fluctuations in temperature, humidity, cloudiness, and wind direction. The great variability in northern Illinois climate is due to its location, particularly during the cooler months, in a confluence zone between different air masses (ComEd 1981a). During the fall, winter, and spring months, the frequency and variation of weather types is determined by the movement of large-scale storm systems that commonly follow paths along the major confluence zone, which is usually oriented from southwest to northeast through the region (ComEd 1981a). Low-pressure systems are most frequent during winter and spring, making these seasons very cloudy. Winter is characterized by alternating periods of steady precipitation (rain, freezing rain, sleet, or snow) and periods of clear, crisp, and cold weather. Springtime precipitation is primarily showers with many thunderstorms due to the frequent passage of low-pressure systems. These thunderstorms occasionally produce hail, damaging winds, and tornadoes. In contrast, the region's weather during summer is influenced by weaker storm systems that tend to pass to the north of Illinois and is characterized by sunshine interspersed with some thunderstorms (ComEd 1981a).

Based on climatological data from the nearby Chicago Rockford International Airport (Rockford AP) weather station, 21 km (13 mi) northeast of Byron, the coldest weather in the area of Byron occurs in January (7.2°C [19.0°F] on average) and the warmest occurs in July (22.7°C [72.9°F] on average) (NOAA 2004). Average annual precipitation at the Rockford AP weather station for the 30-year period from 1971 to 2000 was 93.0 cm (36.6 in), with the least amount of rainfall recorded, on average in the month of February (3.4 cm [1.3 in]) and the most recorded in June (12.2 cm [4.8 in]) (NOAA 2004). Meteorological information, as it relates to the analysis of severe accidents, is included in Appendix F of this Environmental Report.

Under the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) that specify maximum concentrations for carbon monoxide (CO), particulate matter with aerodynamic diameters of 10 microns or less (PM_{10}), particulate matter with aerodynamic diameters of 2.5 microns or less ($PM_{2.5}$), ozone, sulfur dioxide (SO_2), lead, and nitrogen dioxide (NO_2). Areas of the U.S. with air quality as good as or better than the NAAQS are designated by the EPA as "attainment areas." Areas with air quality worse than the NAAQS are designated by the EPA as "non-attainment areas." Areas that were designated non-attainment and subsequently re-designated as attainment due to meeting the NAAQS are termed "maintenance areas." States with maintenance areas are required to develop an air quality maintenance plan as an element of the State Implementation Plan (SIP).

Ogle County is in the Rockford (Illinois)-Janesville-Beloit (Wisconsin) Interstate Air Quality Control Region (EPA 2011a) and is designated as either unclassifiable or attainment for all of the NAAQS. The EPA significantly tightened the NAAQS for SO_2 in 2010, and the CAA directed states to recommend non-attainment designations to the EPA by June 3, 2011 (EPA 2010a). The IEPA has noted that portions of five counties in Illinois are not meeting the air quality standard for SO_2 and recommends that they be designated as non-attainment. The IEPA also recommended that all other areas of the state be designated as unclassifiable (IEPA 2011a). No portion of Ogle County was included in the list as not meeting the standard; therefore, Ogle County is recommended as being designated as unclassifiable.

Byron has a number of stationary emission sources permitted through its Federally Enforceable State Operating Permit, including standby emergency diesel generators, auxiliary boilers, auxiliary feedwater pumps, essential service water makeup water pumps, a fire pump, and cooling towers. As reported and submitted to IEPA, actual total emissions from all sources at Byron from 2007 to 2011 are shown in Table 2.10-1. The highest emissions were reported in 2007.

In December 2011, the EPA finalized rules to reduce emissions of toxic air pollutants from power plants. Specifically, these Mercury and Air Toxics Standards (MATS) for power plants will reduce emissions from new and existing coal and oil-fired electric utility steam generating units. (The MATS rule was published in the Federal Register on February 16, 2012.) Once these standards are implemented, SO_2 emissions from the power sector are likely to be reduced even further as a co-benefit of the technology necessary to directly reduce emissions of mercury and other air toxics (EPA 2012b).

In October 2009, the EPA issued the Mandatory Reporting of Greenhouse Gases Rule (EPA 2009), which requires reporting of greenhouse gas (GHG) emissions data and other relevant information from large sources and suppliers of these gases in the United States. The rule was implemented as the Greenhouse Gas Reporting Program. Facilities that emit 25,000 metric tons or more per year of GHGs are required to submit annual reports to the EPA.

On May 13, 2010, the EPA issued a final rule that addressed GHG emissions from stationary sources under the CAA permitting programs. The Greenhouse Gas Tailoring Rule set thresholds for GHG emissions that define when permits under the Prevention of Significant Deterioration (PSD) and Title V Operating Permit programs are required for new and existing industrial facilities. This final rule “tailored” the requirements of these CAA permitting programs to limit which facilities are required to obtain PSD and Title V permits. The GHG Tailoring Rule addresses emissions of a group of six GHGs: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6) (EPA 2010b).

Operations at Byron release GHG emissions, including CO_2, CH_4 and N_2O (Exelon Nuclear 2009c). The volume of combustion-related GHG emissions at Byron is small, because Byron does not burn fossil fuels to generate electricity. GHG stationary emission sources at Byron include emergency diesel generators, auxiliary boilers, auxiliary feedwater pumps, essential service water makeup water pumps and a fire pump. These combustion sources are designed for efficiency and operated using good combustion practices on a limited basis throughout the year (e.g., often only for testing) (IEPA 2002).

The CAA, as amended, established Mandatory Class I Federal Areas where visibility is an important issue. The closest Class I areas to Byron are Mammoth Cave National Park, approximately 603 km (375 mi) to the south-southeast of Byron, in Kentucky, and the Mingo Wilderness Area, approximately 579 km (360 mi) to the south-southwest of Byron, in Missouri (EPA 2011b).

Table 2.10-1. 2006-2010 Byron Air Emissions

Pollutant	2007 Reported Emissions (metric tons [tons] per year)	2008 Reported Emissions (metric tons [tons] per year)	2009 Reported Emissions (metric tons [tons] per year)	2010 Reported Emissions (metric tons [tons] per year)	2011 Reported Emissions (metric tons [tons] per year)
CO	6.08 (6.70)	4.52 (4.98)	5.90 (6.50)	5.13 (5.66)	5.13 (5.65)
CO_2	2,688.80 (2,963.90)	875.61 (965.20)	1,140.43 (1,257.11)	997.13 (1099.15)	998.72 (1,100.9)
NH_3	0.07 (0.08)	0.03 (0.03)	0.04 (0.04)	0.04 (0.04)	0.04 (0.04)
NO_X	22.98 (25.33)	17.08 (18.83)	22.24 (24.51)	19.37 (21.35)	19.32 (21.30)
PM_{10}	23.22 (25.60)	18.43 (20.32)	18.90 (20.83)	18.52 (20.42)	19.17 (21.13)
$PM_{2.5}$	23.19 (25.56)	18.43 (20.32)	18.90 (20.83)	18.52 (20.42)	19.17 (21.13)
SO_2	0.26 (0.29)	0.05 (0.05)	0.04 (0.04)	0.02 (0.02)	0.02 (0.02)
VOC	0.71 (0.78)	0.57 (0.63)	0.65 (0.72)	0.64 (0.71)	0.61 (0.67)

Sources: Exelon Nuclear 2008c; Exelon Nuclear 2009c; Exelon Nuclear 2010e; Exelon Nuclear 2011d; Exelon Nuclear 2012.
CO = carbon monoxide
CO_2 = carbon dioxide
NH_3 = ammonia
NO_X = nitrogen oxides
PM_{10} = particulate matter with aerodynamic diameters of 10 microns or less
$PM_{2.5}$ = particulate matter with aerodynamic diameters of 2.5 microns or less
SO_2 = sulfur dioxide
VOC = volatile organic compound

2.11 Historic and Archaeological Resources

2.11.1 Regional History in Brief

The prehistory of Illinois can be broadly divided into five different periods, or cultural traditions: the Paleo-Indian period, the Archaic period, the Woodland period, the Mississippian period, and the Oneota and Protohistoric period. The Paleo-Indian period began with the migration of the earliest populations into North America. Evidence of Paleo-Indians found in Illinois includes distinct fluted projectile points and stone scrapers. Around 10,000 BP, the retreat of the continental ice sheets and changing environmental conditions marked the beginning of the Archaic period. Extending to approximately 3,000 years BP, the Archaic period is notable for an increase in the variety of natural resources incorporated in the prehistoric diet, a shift toward group subsistence strategies, and seasonal migration patterns. The Woodland period, extending from approximately 3,000 to 1,200 BP, provides evidence for the domestication of certain plants, and the development of ceramic technology. The Mississippian period, spanning approximately 1,200 to 700 BP, immediately follows the Woodland and is notable for dramatic political changes. During the Mississippian periods, large cities were created, centered around clusters of mounds that dot the Illinois landscape. Cahokia, in Collinsville, IL, held the largest Native American population in North America. It is believed these communities were controlled by a loosely organized group of chiefs, religious leaders, and powerful families. By 900 years BP, the large population centers had begun to shrink and archaeological evidence supports an outward migration of people. Evidence indicates that by 700 years BP, a small population of Native Americans unrelated to the Mississippians, known as the Oneota people, began to appear in Illinois. The Oneota consisted of small bands of hunter-farmers with distinct lithic and ceramic styles (IHPA 1993).

French explorers began traveling down the Mississippi River into Illinois as early as 1673. The French found the region populated by a confederation of tribes who called themselves "Hileni" or "Illiniwek" which means "men" (Blasingham 1956). The French translated this as “Illinois” Other inhabitants of the region included tribes with similar dialects known as the Miami family of tribes. French naturalists of the time believed that the Illini and Miami people shared a common ancestry (Hauser 1976). The Illini Confederation and Miami family of tribes were surrounded by other powerful groups that vied for land and resources such as the Fox, Winnebago, Sioux, Osage, Missouri, Chickasaw, and most notably the Iroquois Confederation (Jones and Voeglin 1974). Competition for resources led to war among the Illini and surrounding tribes. The Illini and Miami’s influence and numbers dwindled, reduced by war with other tribes; and as result of siding with the French who were driven from the area by the British.

Early settlements were generally founded along the river systems by settlers seeking to profit from the fur trade. Illinois became part of the United States territory at the close of the American Revolution. Shortly thereafter the United States government began constructing forts in Illinois with a corresponding increase in immigration into the territory in the early 19th century. Illinois joined the Union as the 21st state in 1818 (IL SOS 2012).

The fertile soils in Illinois support a strong agricultural economy. A history of natural resource extraction, including coal mining and oil drilling has also supported the local economies across the state. Chicago, Illinois is the third largest city in the country and Illinois has the fifth largest state population in the country (IL SOS 2012).

2.11.2 Pre-construction Known Historic and Archaeological Resources

In 1973, the University of Wisconsin-Milwaukee (UWM) completed a pedestrian Phase I Archaeological survey of the proposed Byron Station property. During this survey, seven previously unrecorded archaeological sites and one previously recorded archaeological site were identified. Phase II subsurface investigations of these sites were conducted to further evaluate their eligibility for listing in the National Register of Historic Places (NRHP). The recommendations developed during the Phase II investigations were to fence the known sites along the Rock River and leave a 15-meter (m) (50-ft) buffer between the archaeological sites and any new construction. In 1974, the Illinois State Historic Preservation Office (SHPO) concluded that no historic properties would be affected by the construction of the Byron Station if the Phase II recommendations were implemented. Site 11OG153 was the only site near enough to construction activity to require a physical barrier. Site 11OG153 was fenced and avoided during construction (Exelon Nuclear 2010a).

In the early 1980s, UWM completed a Phase I Archaeological survey of Byron's three transmission ROWs. Seven archaeological sites were recorded and subsequently avoided during construction of the transmission lines. In 1981, the Illinois SHPO concurred that the construction of the transmission lines would have no effect on archaeological sites within the transmission line ROWs (ComEd 1981a).

At the time of the original licensing, two properties listed on the NRHP were within 10 km (6 mi) of the Byron Station: the Pine Hill Hotel and the Ogle County Courthouse. Both are in Oregon, IL, approximately 8 km (5 mi) southwest of the Byron Station. The construction of Byron had no effect on these resources as determined by the Illinois SHPO (NRC 1982).

2.11.3 Post-construction Known Historical and Archaeological Resources

For this Environmental Report, the National Register Information System (NRIS) on-line database was searched for any historic properties listed on the NRHP within a 10 km (6-mi) radius of the Byron Station, or within 3.2 km (2 mi) of the three transmission line ROWs. Eight properties listed on the NRHP were identified (Table 2.11-1).

A search of the Illinois State Archaeological Site Files, a proprietary database maintained by the Illinois SHPO open only to cultural resource professionals, identified 204 previously recorded archaeological sites within 10 km (6 mi) of Byron or within 3.2 km (2 mi) of a transmission line ROWs. Eight sites are on the Byron property, and seven are within or partially within one of the transmission line ROWs. No new archaeological resources have been found on the Byron property or in the three transmission line ROWs since the original surveys were completed. Table 2.11-2 provides an overview of the known archaeological resources on the Byron Station property or within the transmission ROWs.

Table 2.11-1. Sites listed on the National Register of Historic Places within 10 km (6 mi) of Byron or within 3.2 km (2 mi) of a Transmission ROW

Site Number	Address	City, County
Soldier's Monument	Chestnut and 2nd Streets	Byron, Ogle
Stillman's Run Battle Site	Roosevelt and Spruce Streets	Stillman Valley, Ogle
Chana School	201 N. River Road.	Oregon, Ogle
Ogle County Courthouse	Courthouse Square	Oregon, Ogle
Pinehill	400 Mix Street	Oregon, Ogle
Oregon Commercial Historic District	Roughly Bounded by Jefferson, Franklin, 5th and 3rd Streets	Oregon, Ogle
Oregon Public Library	300 Jefferson Street	Oregon Ogle
Chicago, Burlington, and Quincy Railroad Depot	400 Collins Street	Oregon Ogle

Table 2.11-2. Archaeological Sites within the Byron Property or a Transmission Line ROW

Site Number	Site Type	Location
11OG153	Archaic	Byron Station Property
11OG154	Archaic	Byron Station Property
11OG155	Unknown Prehistoric	Byron Station Property
11OG156	Unknown Prehistoric	Byron Station Property
11OG157	Unknown Prehistoric	Byron Station Property
11OG158	Unknown Prehistoric	Byron Station Property
11OG175	Unknown Prehistoric	Byron Station Property
11OG176	Unknown Prehistoric	Byron Station Property
11OG223	Archaic	Transmission Line ROW
11OG224	Prehistoric Isolated Find	Transmission Line ROW
11OG225	Middle to Late Woodland	Transmission Line ROW
11OG227	Prehistoric Unknown	Transmission Line ROW
11OG228	Prehistoric Unknown	Transmission Line ROW
11OG232	Archaic to Woodland	Transmission Line ROW
11OG234	Archaic	Transmission Line ROW

2.12 Known or Reasonably Foreseeable Projects in Site Vicinity

As indicated on Figure 2.1-2 and described in Section 2.1, there are few urban areas within the 10-km (6-mi) radius of Byron. The area surrounding Byron is fairly rural and primarily agricultural.

In its “Envirofacts Data Warehouse” online database access tool, the EPA provides information about environmental activities that may affect air, land, and water. A search of the Envirofacts database for facilities that hold major NPDES permits to discharge to waters of the United States identified 30 heavy industries, electric generation or manufacturing, in the vicinity of Byron (80-km [50-mi] radius). A search of the Envirofacts database for facilities that hold major air permits to discharge air pollutants in the 80-km (50-mi) vicinity of Byron identified 81 industries. The industries that currently hold NPDES and air permits represent existing facilities; they also represent the types of industrial facilities that could be permitted near Byron in the future. Additional information concerning these facilities may be accessed through the EPA’s “Envirofacts Warehouse” (http://www.epa.gov/enviro/) (EPA 2012c).

Apex Wind Energy is developing plans for a proposed wind farm near the Village of Adeline located near the northern boundary of Ogle County, IL and approximately 19 km (12 mi) northwest of the plant. The proposed wind farm will consist of 40 wind turbines and is expected to generate 80 megawatts of energy. Project construction is expected to begin in 2013 (APEC 2012). The Apex Wind Farm is of interest to Byron license renewal because it would be located within Ogle County, could be operating before the end of the renewed license term, and would affect land use.

The 80-km (50-mi) radii of four other Exelon Generation nuclear plants intersect the 80-km (50-mi) radius of Byron Station. These plants are of interest to Byron license renewal because all have operations similar to Byron. A brief description of each is provided in the following paragraphs.

Braidwood Station, also owned and operated by Exelon Generation, is applying to renew the NRC operating licenses for its two units in a common application with Byron. Both Braidwood units are pressurized water reactors (PWRs) having the same design as the Byron PWRs. The Braidwood operating licenses expire in 2026 and 2027. The cooling water source for Braidwood is an approximately 1,030-ha (2,540-ac) cooling pond for which the Kankakee River is both the makeup water source and the destination for cooling pond blowdown. The closest city to Braidwood is Joliet, IL. Braidwood is of interest to Byron license renewal because its 80 km (50-mi) radius intersects Byron’s, and both plants, which have similar operations, are seeking license renewal via a single application. Braidwood is approximately 127.3 km south southeast (79.1 mi) from Byron.

LaSalle County Station (LaSalle) is 18 km (11 mi) southeast of Ottawa IL. The two LaSalle units are boiling water reactors (BWRs) with a total net generating capacity at December 32, 2011, of 2,316 MW(e). The cooling water source for LaSalle is an 833 ha (2,058 ac) cooling reservoir for which the Illinois River is both the makeup water source and the destination for plant blowdown discharge. LaSalle is approximately 105.3 km south southeast (64.4 mi) from Byron.

Dresden Nuclear Power Station (Dresden) is in Morris IL. Dresden Units 2 and 3 are BWRs with a total generating capacity of 1,751 MW(e). The cooling water source for Dresden is the

Kankakee River. Its cooling system discharges to the Illinois River. The retired Dresden Unit 1, which was the first full-scale privately owned nuclear power plant when it began operations in 1960, has been named a Nuclear Historic Landmark by the American Nuclear Society. Dresden is approximately 113.6 km south southeast (70.6 mi) from Byron.

Quad Cities Nuclear Power Station (Quad Cities), located on the Mississippi River, in Cordova, IL, has two BWRs with a total generating capacity of approximately 1,824 MW(e). Quad Cities uses a once-through cooling system that withdraws cooling water from and discharges to the Mississippi River. Quad Cities is approximately 93.5 km southwest (58.1 mi) from Byron.

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Chapter 3

Proposed Action

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3.1 General Plant Information

NRC

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

Exelon Generation proposes that the NRC extend the term of the operating license for each Byron unit for 20 years beyond its current term of 40 years. License renewal would give Exelon Generation and the State of Illinois the option of relying on Byron to meet future electricity needs. Section 3.1 discusses the station in general. Sections 3.2 through 3.4 address potential changes that could occur as a result of license renewal.

General information regarding Byron Station Units 1 and 2 is available in several documents. In 1982, the NRC published the Final Environmental Statement (FES) related to the operation of Byron (NRC 1982). The Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC 1996b) describes Byron features. Finally, in accordance with NRC requirements, Exelon Generation routinely updates the Updated Final Safety Analysis Report for Byron to reflect changes to plant design and operating features (Exelon Nuclear 2010a). Exelon Generation has referred to each of these and additional documents while preparing this Environmental Report for license renewal.

Figure 3.1-1 illustrates the Byron site. Byron's major structures and facilities are shown in Figure 3.1-2. Major structures and facilities include:

- Unit 1 and Unit 2 natural draft cooling towers and the essential service water cooling towers
- Unit 1 and Unit 2 containment structures, which house the nuclear steam supply systems including the reactors, steam generators, reactor coolant pumps, and related equipment
- the auxiliary building, which houses major components of the component cooling water system, emergency core cooling system, boric acid storage tanks and pumps, and other safety-related equipment
- the turbine building, where the turbine generators, main condensers, plant heat exchangers, and related equipment are housed
- support facilities such as the fuel handling building, the Independent Spent Fuel Storage Installation (ISFSI), electrical switchyard, training buildings, service buildings, steam generator storage building, and gate house

Other structures of interest include the circulating water pumphouse and the river screen house and circulating water blowdown discharge structure on the Rock River.

3.1.1 Reactor and Containment Systems

Each Byron unit is a pressurized water reactor (PWR) with four steam generators. The reactors were designed and fabricated by Westinghouse Electric Corporation. Westinghouse Electric Corporation, Sargent & Lundy, and Commonwealth Edison Company jointly designed and constructed each unit (Exelon Nuclear 2010a). Byron Units 1 and 2 entered commercial service on September 16, 1985, and August 21, 1987, respectively (Scientech 2010). Exelon has requested from NRC an amendment to the current operating licenses for both Byron units that would revise the maximum power levels, and the rated thermal power, based on measurement uncertainty recapture.[1] At 100 percent reactor power, the combined net electrical output from both Byron units is approximately 2,370 MWe.

The nuclear steam supply system for each unit consists of a pressurized water reactor and four closed reactor coolant loops connected in parallel to the reactor vessel, with each loop having a reactor coolant pump and a steam generator. An electrically heated pressurizer connected to one reactor coolant loop maintains system pressure within design limits. Auxiliary systems charge makeup water in the reactor coolant system, purify reactor coolant water, inject chemicals to inhibit corrosion, cool system components, remove decay heat, and provide for emergency safety injections (Exelon Nuclear 2010a).

The Unit 1 steam generators are Babcock & Wilcox re-circulating vertical U-tube units. The Unit 2 steam generators are Westinghouse re-circulating vertical U-tube units. All the steam generators utilize Inconel tubes. Integral moisture separating equipment reduces the moisture content of the steam. The original Byron Unit 1 steam generators were replaced in 1998 (Exelon Nuclear 2011e); the Byron Unit 2 steam generators are original to the plant. The reactor coolant pumps are Westinghouse vertical, single-stage, centrifugal pumps equipped with controlled-leakage shaft seals (Exelon Nuclear 2010a).

The reactor containment structure for each unit is a steel-lined, post-tensioned concrete vertical cylinder with a reinforced concrete base and a shallow dome. The containment design ensures a high degree of leak tightness. The engineered safety features can maintain containment integrity and limit personnel exposure to less than 10 CFR 50.67 limits following a loss-of-coolant accident (Exelon Nuclear 2010a).

The containment systems and their engineered safeguards are designed to ensure that off-site doses resulting from postulated accidents are well below the guidelines in 10 CFR Part 100.

3.1.2 Fuel Enrichment, Burn-Up, and Storage

Both Byron units are licensed for low-enriched uranium-dioxide fuel with enrichment to a nominal 5.0 percent by weight of uranium-235 and an allowable fuel burn-up not to exceed 60,000 megawatt-days per metric ton uranium. The uranium-dioxide fuel is in the form of high-density ceramic pellets enclosed in Zircaloy-based tubing (AEC 1974).

[1] By letter to the U.S. Nuclear Regulatory Commission (NRC) dated June 23, 2011, Exelon Generation submitted a request to increase the licensed power based on measurement uncertainty recapture for the Braidwood and Byron Stations, Units 1 and 2. The request was accepted by the NRC for review on September 19, 2011. Although NRC's review is pending, Exelon believes it is conservative, for purposes of assessing license renewal environmental impacts, to assume a Byron power level that includes the measurement uncertainty recapture.

Pursuant to the general license issued in 10 CFR 72.210, Exelon Generation operates an ISFSI at the Byron site. The general license allows Exelon Generation, as a reactor licensee under 10 CFR Part 50, to store spent fuel at the ISFSI, provided that such storage occurs in pre-approved casks in accordance with the requirements of 10 CFR Part 72, subpart K (General License for Storage of Spent Fuel at Power Reactor Sites). Spent fuel transfers to the ISFSI began in September, 2010 (Exelon Nuclear 2010f).

The 1996 GEIS (NRC 1999a) noted that 10 CFR 51.23 codifies the NRC's generic determination that storage and disposal of spent fuel during the licensed life for operation of nuclear power plants (which may include the term of a renewed license) can be accomplished safely and without significant environmental impact. In accordance with this determination, the 1996 GEIS concluded that no discussion of environmental impacts of spent fuel storage for the period following the term of a reactor operating license, including a renewed license was required. In 2010, the Commission updated and continued the provisions in 10 CFR 51.23 (referred to as the Waste Confidence Decision Update and Temporary Storage Rule, or WCD Update and Rule) based on experience in the storage of spent nuclear fuel and the increased uncertainty in the siting and construction of a permanent geologic repository for the disposal of spent nuclear fuel (75 FR 81031; December 23, 2010). On June 8, 2012, the D.C. Circuit Court of Appeals vacated and remanded the WCD Update and Rule (New York v. NRC, 681 F.3d 471 (D.C. Cir. 2012)). In response, the NRC Commissioners suspended the issuance of licenses for which the NEPA review would depend on the WCD Update and Rule (NRC 2012b). Because the Commissioners consider responding to the D.C. Circuit Court's concerns to be a generic issue, they further directed the NRC staff to conduct a rulemaking (NRC 2012c). This effort by the NRC staff is ongoing. The updated rule and supporting EIS will provide the NEPA analyses of waste-confidence-related human health and environmental impacts needed to support renewal of the Byron operating license.

3.1.3 Cooling and Auxiliary Water Systems

The Byron circulating water system uses two natural draft cooling towers (see Figure 3.1-2), one tower per unit, to dissipate excess heat from condenser cooling water and nonessential service water. Water chemistry in this closed cycle system is controlled by continuous blowdown from the condenser supply water and makeup to an open flume between the two natural draft cooling towers. Makeup water comes from the Rock River and blowdown water is directed back to the Rock River.

In addition to the two natural draft cooling towers, Byron also has two mechanical draft cooling towers to cool essential service water, which removes heat from safety-related equipment, and to serve as the ultimate heat sink for the reactors. Because of their safety function, the mechanical draft cooling towers operate continuously when the reactors are operating, and they must have a makeup water supply that is capable of supporting 30 days of continuous operation in support of safe shutdown. Normally, makeup water to replace evaporation and blowdown from the mechanical draft cooling towers is supplied from the Rock River via the circulating water system. Emergency backup sources of makeup water are also available from essential service water makeup pumps located at the Rock River intake structure (river screen house) and from the two on-site deep wells described in Section 3.1.3.2 (NRC 1982; Exelon Nuclear 2010a). Blowdown from the mechanical draft cooling towers is routed to the flume between the two natural draft cooling towers.

The following subsections describe the water systems at Byron in greater detail.

3.1.3.1 Surface Water

Byron has an agreement with the Illinois DNR to limit consumption of water from the Rock River for makeup to the Byron cooling systems to no more than 9 percent of total river flow during times when the river flow rate drops below 19,200 L/sec (679 cfs). To maintain compliance, Byron would adjust the CWS makeup and blowdown flows, and if necessary, would reduce the power output from the units. The makeup water required by the condenser cooling system varies seasonally. The anticipated maximum gross withdrawal rate from the Rock River is 2,860 L/sec (101 cfs or 45,200 gpm) (Exelon Nuclear 2005). The average makeup withdrawal rate from the Rock River at 100 percent load is 2,320 L/sec (81.9 cfs or 36,750 gpm), out of which 821 to 1,070 L/sec (29 to 38 cfs or 13,000 to 17,000 gpm) is returned to the river as blowdown (Exelon Nuclear 2005).

Under IAC Title 35, Section 302.102, "a [temperature] mixing zone must not contain more than 25 percent of the cross-sectional area or volume of flow of a stream." In Special Condition 3 of NPDES permit IL0048313, IEPA has determined that Byron meets this criteria as well as the thermal water quality standard in Title 35, Section 302.211. The NPDES Permit requires Byron to monitor and report to IEPA the flow and temperature of its blowdown discharge each month. (IEPA 2011b).

As specified in Special Condition 12 of NPDES permit IL0048313, Byron must also explicitly demonstrate compliance with the thermal water quality standard on a daily basis during times when the Rock River flow is less than 67,944 L/sec (2,400 cfs), or the temperature difference between the main river temperature and the water quality standard is less than 3°F. (IEPA 2011b).

Blowdown is discharged to the Rock River about 61 m (200 ft) downstream of the river screen house. Blowdown is discharged from the outfall structure via an 84-m (275-ft) rip-rapped channel to the river (Exelon Nuclear 2005).

The surface water drainage system at Byron directs storm water runoff from areas associated with industrial activities in four ways, as described in the Byron Storm Water Pollution Prevention Plan (Exelon Nuclear 2003a). First, general drainage within the immediate vicinity of the protected area is into a large oil separator that discharges to an on-site retention pond referred to as the Construction Runoff Pond (CROP). Water collected in the CROP is normally sampled and pumped to the Unit 2 natural draft cooling tower basin where it mixes with circulating water, but in exceptional circumstances, the CROP can overflow directly to Woodland Creek, a tributary of the Rock River north and east of Byron. Second, runoff from the area collectively designated as the East Area is directed to Woodland Creek through permitted Outfall 003. The East Area includes the area east of the natural draft cooling towers and the mechanical draft essential service water cooling towers as well as areas around the east half of the main site. Third, runoff from the area collectively designated as the West Area is directed to an unnamed tributary of the Rock River through permitted Outfall 004. The West Area, which is mostly outside the protected area, includes the areas around the west portion of the main site and the 345 kV switchyard. Finally, sheet flow drains from a small area north of the protected area into Woodland Creek, and from a small area adjacent to the river screen house directly to the Rock River. All storm water discharge paths are subject to the storm water pollution prevention provisions in Special Condition 16 of NPDES Permit IL0048313 and the Byron Storm Water Pollution Prevention Plan (Exelon Nuclear 2003a).

Circulating Water System (CWS)

The river screen house at the Rock River intake has three circulating water makeup pumps, two for normal operations and one for backup. Each pump's rated capacity is 1,500 L/sec (24,000 gpm or 54 cfs) (NRC 1982; Exelon Nuclear 2010a). The bays housing the pumps are protected from ice and debris by bar grills, traveling screens and trash rakes. Debris removed from the traveling screens and trash racks at the river screen house is collected in a trash basket and disposed of off site by an independent contractor at a permitted landfill (NRC 1982).

The CWS includes six 13,531 L/sec (214,500 gpm) circulating water pumps (three per unit). The main condenser of each unit requires 43,700 L/sec (693,000 gpm) of circulating water flow to remove waste heat at 100 percent load. One cooling tower per unit is used to dissipate waste heat to the environment. Following cooling in the tower, water is directed from the tower basin through an open flume to a basin pump and screen house servicing both units. From this point, three circulating water pumps per unit pump water to the main condensers. Water chemistry is controlled by continuous blowdown to the Rock River and simultaneous makeup from the Rock River to the open flume between the two towers (Exelon Nuclear 2010a).

The CWS and service water systems (essential and nonessential) are treated for scaling and corrosion control. Sodium hypochlorite and sodium bromide are added for biofouling control; sulfuric acid, polyphosphate, potassium phosphonate, acrylic polymer, and triazole for scaling control; zinc for corrosion control; and polyacrylate for silt dispersal (Exelon Nuclear 2005). CWS makeup water is treated with a low concentration of copper ions to prevent zebra mussel infestation. Copper monitoring is performed during periods when the Station's copper ion system is in use. In addition, the total mass of copper used during zebra mussel dosing is reported in the month following cessation of copper ion system discharge (IEPA 2011b).

Service Water Systems

Two service water systems support the Station: the nonessential service water system supplies non-safety related systems, and the essential service water system supplies cooling water to the reactor safeguard and auxiliary systems.

The nonessential service water system has three dedicated 2,208 L/sec (35,000 gpm) pumps in the circulating water pump house. Normally two pumps are in operation, one per unit, with the third available to provide full capacity backup for either unit. The pumps take their suction from the circulating water pump house forebay. This bay is fed by a flume approximately 9.7 m (32 ft) wide and 6.7 m (22 ft) deep which connects the basins of the two natural draft cooling towers serving the two units. The non-essential service water is treated to control corrosion, scale, and organic slime buildup (Exelon Nuclear 2010a).

Two 100-percent capacity essential service water pumps are associated with each unit. All four pumps, which are located in the auxiliary building, remove water from the essential service water cooling towers. Each pump is rated at 1,514 L/sec (24,000 gpm) (Exelon Nuclear 2010a). Corrosion and scale inhibitors are used to control water chemistry in the system (Exelon Nuclear 2010a). Makeup from the river is treated with a low concentration of copper ions to prevent zebra mussel infestation.

Service water discharges to the Rock River, and effluent residual oxidant limits are met in accord with the NPDES Permit No. IL0048313.

3.1.3.2 Groundwater

Byron uses groundwater from two deep wells (W-1 and W-2) for potable water, demineralized water, and as a backup supply for makeup water to the mechanical draft cooling towers in the essential service water system. The wells are pumped on rotation, and are piped to a common manifold (Exelon Nuclear 2006).

Groundwater Usage

The average annual groundwater requirement for the plant's potable water supply is approximately 0.6 L/sec (10 gpm), and 1.3 L/sec (20 gpm) for above-average demand. Groundwater for the demineralizer is required at an average rate of 28 L/sec (450 gpm). The total peak groundwater demand for potable water and demineralized water is approximately 30 L/sec (470 gpm), or 9.3 x 10^8 liters per year (2.5 x 10^8 gallons per year) (Exelon Nuclear 2010a).

In the event that makeup water to the essential service water system is not available from either of the two Rock River supply paths, the two groundwater wells would provide a third alternative maximum supply of 101 L/sec (1,600 gpm) for maintaining adequate essential service water system cooling tower basin inventory during the required 30-day safe shutdown period (Exelon Nuclear 2010a).

Groundwater Monitoring for Tritium and Other Radionuclides

Exelon Generation has a radiological groundwater protection program at Byron that includes routine sampling and analysis of surface water and groundwater to identify adverse trends, which would allow Exelon Generation to take early corrective actions to prevent potential impacts to groundwater. The program monitors gamma emitters, strontium, and tritium in both surface water and groundwater (Exelon Nuclear 2011a).

Because tritium is produced by above-ground testing of nuclear weapons, which occurred primarily in the 1950s and 1960s in the US, and continued into the 1980s and later for other nations, tritium from those tests can still be measured in surface and groundwater. Currently, concentrations in precipitation and surface water in the Midwest are typically below 100 picocuries/liter (pCi/L). However, ambient groundwater concentrations may be detectable because of the high concentrations in precipitation and surface water in the 1960s that have now migrated into the groundwater (Exelon Nuclear 2011a).

In 2006, Exelon Generation identified elevated tritium concentrations in groundwater beneath the blowdown line as a result of leaks of tritiated water from malfunctioning vacuum breakers (see Section 2.3). Exelon Generation sealed the vacuum breaker vaults, implemented a groundwater monitoring program along the pipeline as well as an inspection program for the vacuum breakers, and has installed a leak detection and alarm system on the discharge pipeline.

In a separate fleet-wide effort during 2006, Exelon Generation installed groundwater monitoring wells at all of its nuclear power stations, including Byron, to monitor possible groundwater tritium migration resulting from earlier on-site leaks and to provide information about site-specific geology and hydrogeology (see Section 2.3.4.1.3). This information has been used to develop a fleet-wide RGPP, which provides the methodology and criteria for detecting, assessing, and reporting the on-site presence of tritium, strontium, gross alpha emissions, gross beta emissions, and gamma emitters in groundwater at Exelon Generation's nuclear power stations.

The fleet-wide RGPP is implemented through an Exelon Generation corporate procedure. Site-specific procedures list each site's sample points and describe the sampling protocols specific to that site. The ongoing groundwater monitoring program is described in Section 2.3.4.1.4 Radiological Groundwater Monitoring Program.

3.1.4 Radioactive Waste Management Systems

The following descriptions of the radioactive waste management systems at Byron are taken from the Byron Updated Final Safety Analysis Report (Exelon Nuclear 2010a) unless otherwise referenced.

3.1.4.1 Liquid Radioactive Waste Systems

The Liquid Radioactive Waste System collects, monitors, and releases, after an appropriate level of treatment, all potentially radioactive liquid wastes produced by plant operations. The system is designed to minimize exposure to station personnel and the general public, in accord with NRC regulations. Radioactive fluids are collected in tanks, sampled, and analyzed to determine the quantity of radioactivity with an isotopic breakdown, if necessary, prior to treatment and release or disposal. Discharge streams are appropriately monitored, and safety features are incorporated to ensure radionuclide concentrations comply with 10 CFR Part 20 and 10 CFR Part 50, Appendix I. The descriptions of the liquid radioactive waste systems provided in this section are based on Section 11.2.2 in the Byron/Braidwood Nuclear Stations Updated Final Safety Analysis Report (UFSAR), Revision 13 (Exelon Nuclear 2010a), unless otherwise indicated.

The liquid radioactive waste processing system consists of two subsystems: the steam generator blowdown subsystem and the non-blowdown subsystem. The non-blowdown subsystem treats waste streams from the auxiliary building equipment drains and floor drains, the chemical waste drains, the regeneration waste drains, the laundry drains, the turbine building equipment and floor drains (if those streams are contaminated), and the condensate polisher sump when its stream is contaminated.

The liquid radioactive waste processing system is shared by both units. Each liquid radioactive waste stream is collected in a dedicated monitor tank. When the tank volume is sufficient, the waste is mixed and sampled as a batch. If sampling indicates that the batch needs further processing prior to release, the batch is recycled through the same waste processing subsystem or through another subsystem with a different treatment process. Processing systems utilize filtration and demineralization. If no further processing is required, the batch is transferred to a release tank, where the batch is sampled prior to discharge to verify that it meets discharge limits (Exelon Nuclear 2010a).

After processing, the purified effluent can be reused as primary cycle makeup or released to the Rock River via the blowdown line. The radioactive waste discharge rate is determined so that, when mixed with the cooling water blowdown, the water leaving the plant has a radioactivity level less than the applicable effluent concentration limit. As further backup, a radiation detector monitors the liquid in the discharge line prior to the point where it mixes with the cooling water blowdown. (Exelon Nuclear 2010a).

Effluents from the condensate polisher sump and the turbine building fire and oil sump are monitored by radiation monitors that automatically halt sump pump operations if an unacceptable activity level is detected in the sump effluent. (Exelon Nuclear 2010a)

3.1.4.2 Gaseous Radioactive Waste Systems

The gaseous waste processing system (GWPS) provides controlled handling and release of gaseous wastes generated during station operation. The system is designed and operated to ensure that total plant gaseous releases are as low as reasonably achievable and comply with 10 CFR Part 50, Appendix I and 10 CFR Part 20. The descriptions of the gaseous radioactive waste systems provided in this section are based on section 11.3.2 in the Byron/Braidwood Nuclear Stations UFSAR, Revision 13 (Exelon Nuclear 2010a), unless otherwise indicated.

The GWPS consists of two waste-gas compression packages, six decay tanks, and the associated piping, valves, and instrumentation. It is maintained at greater than atmospheric pressure to avoid the intrusion of air. Gaseous wastes are generated during the following activities: degassing the reactor coolant and purging the volume control tank, displacing the cover gases in some tanks, purging some equipment, and operating the sampling and gas analyzers. Radioactive gases are collected in one of six decays tanks to allow for decay and isotopic analysis. Before the contents of a decay tank are released to the atmosphere via the plant vent, a sample is taken to determine the activity of the gas.

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

3.1.4.3 Solid Radioactive Waste System

The descriptions of the solid radioactive waste systems provided in this section are based on section 11.4 in the Byron/Braidwood Nuclear Stations UFSAR, Revision 13 (Exelon Nuclear 2010a), unless otherwise indicated. The solid radioactive waste system collects, processes, packages, and provides temporary storage for radioactive wet solid wastes until off-site shipment to a licensed disposal facility. The system has the capability to transfer wet solids to vendor-supplied processing and disposal systems. The system also receives, decontaminates, compacts, and provides temporary storage for dry solid wastes prior to shipment and disposal off site. The radioactive solid wastes are packaged in approved disposal and shipping containers which meet NRC and Department of Transportation regulations. Some wastes may be sent to a vendor for processing prior to disposal, including volume reduction, sorting or decontamination.

Storage space is sized to accommodate approximately a 2-year volume of waste, to allow for some decay, transport delays, or unavailability of disposal facilities (Exelon Nuclear 2010a). Wastes include resins, cartridge filters, intermediate-level dry wastes such as core components, and low-level dry wastes from radioactive control areas or contaminated tools, clothing and equipment parts (Exelon Nuclear 2010a).

The solid waste processing capability is adequate to handle the maximum expected volume with excess capacity. Annual design volumes of solid wastes requiring on-site storage prior to off-site disposal are as follows (Exelon Nuclear 2010a):

- Resins – 45 m^3 (1,600 ft^3) in 2,393 drums or 10 liners
- Filter elements – 2 m^3 (75 ft^3) in 190 drums or 2 liners
- Sludges/liquids – 530 m^3 (18,690 ft^3) in 5,140 drums
- Dry active wastes – 1,025 m^3 (36,220 ft^3) in 1,160 drums and 73 boxes

These wastes are classified for purposes of near-surface disposal. The waste classification with the least stringent disposal requirements is Class A, followed by Class B and Class C.

Spent resins from the demineralizers and filter cartridges may be classified in Class B or Class C.

Prior to July 1, 2008, Class B and Class C (Class B/C) low-level radioactive wastes from Byron were transported, for disposal to the Energy*Solutions,* LLC Barnwell Disposal Facility in South Carolina. On July 1, 2008, the Barnwell facility, which is located within the Atlantic Interstate Low-Level Radioactive Waste Management Compact ("Atlantic Compact"), ceased accepting Class B/C LLRW shipments from out-of-compact generators—an action authorized by the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA). Because Illinois is not a member of the Atlantic Compact, this action has precluded subsequent shipments of spent resins as well as other Class B/C wastes from Byron to the Barnwell Facility.

By letter and Safety Evaluation dated July 21, 2011, the NRC issued license amendment numbers 202 and 189 to the Facility Operating Licenses for LaSalle County station Units 1 and 2. These license amendments allow the storage of Class B and Class C LLRW from Byron in the LaSalle County Station Interim Radwaste Storage Facility (IRSF) (NRC 2011a).

The LaSalle IRSF has the capacity to hold 270 containers of Class B/C wastes at 135 spots (i.e., two layers of containers). This has been determined to include sufficient excess storage capacity to accommodate extended storage of the Class B/C wastes generated by three other Exelon Generation plants, including Byron. However, storage of Byron Class B/C wastes at the LaSalle IRSF should be unnecessary during the term of a contract, which was executed in February 2013, for treatment and disposal of such wastes at a licensed offsite facility in Texas.

Byron infrequently generates small quantities of mixed waste (i.e., waste having both a hazardous component that is subject to the requirements of the Resource Conservation and Recovery Act and a radioactive component that is subject to the requirements of the Atomic Energy Act). The IEPA regulates the hazardous component of the waste and the Illinois Emergency Management Agency Division of Nuclear Safety and the NRC regulate the radioactive component. When generated, mixed wastes are accumulated in the manner provided under 35 IAC 726, Subpart N, in a specified area within the Radwaste Building pending transport to a licensed off-site facility for treatment and disposal. No mixed waste has been generated at Byron since 2009, and none is being stored on site.

3.1.5 Nonradioactive Waste Management Systems

Exelon Generation expects that during the license renewal term Byron will continue to generate types and quantities of nonradioactive wastes similar to those generated during current and past operations. Types of nonradioactive wastes include hazardous, non-hazardous, and universal wastes. These are managed in accordance with applicable federal and state regulations as implemented through corporate procedures.

Byron generates more than 100 kg but less than 1,000 kg of hazardous waste per calendar month, and thus is registered as a small quantity hazardous waste generator. Even so, hazardous wastes are managed at Byron according to large quantity generator standards. Byron has contracts with waste haulers, and off-site treatment and disposal facilities to properly remove and disposition all hazardous wastes.

Typical non-hazardous wastes generated at Byron that require off-site management include, but are not limited to: potentially infectious medical waste (PIMW) and waste/used oil, grease, antifreeze, adhesives and other petroleum-based liquids. Byron has contracts with waste haulers, and off-site treatment and disposal facilities to properly remove and disposition such non-hazardous wastes. PIMW is generated at Byron in conjunction with the operation of the on-site health facility/on-site nurse station activities and may include used and unused sharps (i.e. hypodermic needles and syringes), and items contaminated with human blood and blood products such as bandages and clothing containing blood. The transportation and disposal of PIMW is regulated in Illinois as a unique category of special waste, and disposal of PIMW is banned at all landfills in Illinois (35 IAC 1420.104(a)).

Universal wastes generated at Byron include spent products such as batteries and mercury-containing lamps. These materials are managed under the standards specified in 35 IAC 733.

Byron recycles universal wastes, oils, batteries, pallets, metals, paper, office wastes, and other recyclables according to Exelon Generation procedures and Illinois regulations.

Byron operates an on-site sewage treatment package plant. Treatment plant effluent combines with the CWS cooling tower blowdown for discharge to the Rock River under NPDES permit IL0048313. Byron periodically disposes of the sewage treatment plant sludge as low-level radioactive waste at a licensed off-site facility. Byron is authorized to transfer up to 18,000 gallons per day of raw sewage to the City of Oregon wastewater collection system for treatment in the city's sanitary wastewater treatment plant, which discharges to the Rock River under the town's NPDES permit (IL0020184), in circumstances where the Station's sewage treatment plant is out of service for maintenance or is temporarily experiencing heavier than normal load due to the on-site presence of supplemental work force (e.g., refueling outages).

River sediments that settle out as sludge in the natural draft cooling towers basins are temporarily stored in an on-site dewatering basin. After the sludge is determined to be dry enough and to meet the criteria in IEPA Permit No. 2009-SC-2169-1 dated April 20, 2010, it is removed from the dewatering basin and land applied to approximately 49 acres located on Byron property (IEPA 2010a).

3.1.6 Transmission Facilities

Figure 3.1-3 is a map of the current transmission system of interest. At the time Byron was constructed, a total of four 345-kV circuits were added to tie the station into the pre-existing transmission system. One new 345-kV transmission line was constructed from Byron to the Wempletown transmission substation (TSS). Also, a pre-existing 345-kV line (Nelson TSS to Cherry Valley TSS) was "cut" and each end was connected to a new circuit constructed from Byron, creating one circuit from Byron to Nelson and one circuit from Byron to Cherry Valley. Finally, a new 345-kV circuit was added to the previously mentioned ROW from Byron to Cherry Valley. The FES for Byron's operating license (NRC 1982) cites the environmental report for the operating license (ComEd 1981a) which describes the five 345-kV transmission lines as being constructed to connect Byron to the electric grid. Included were two new circuits in one ROW from Byron to the Wempletown TSS. After publication of the FES, it was decided to construct only one of the Wempletown lines.

Based on the information above, the 345-kV transmission lines described below are considered in scope for the license renewal analysis because they were constructed to connect Byron to the electric grid. No separate transmission lines exist for the purpose of supplying power to Byron from the grid (off-site power). All lines are owned and operated by ComEd.

- Byron to Wempletown – After exiting the plant to the west, this transmission line runs north and east to the Wempletown TSS approximately 11 km (7 mi) northwest of Rockford, Illinois. The right-of-way ranges from approximately 61 to 116 m (200 to 380 ft) in width, with space for future transmission lines, and is 48 km (30 mi) long. For much of the length of this line, this single-circuit line is strung as a double-circuit line but with jumpers between like phases, making it, electrically, a single-circuit line. In other places it is a standard single circuit.

- Byron to Cherry Valley (two circuits) – This double-circuit line initially heads east from Byron for approximately 10 km (6.5 mi), sharing towers with an existing 138-kV line for the last 6.4 km (4 mi). The total right-of-way width is 130 m (410 ft), with room for future transmission lines. At the 10 km (6.5 mi) point one of the two circuits intersects the pre-existing 345-kV line that ran between the Nelson TSS and the Cherry Valley TSS. Therefore, the part of this line that was constructed for Byron is the 10-km (6.5-mi) segment.

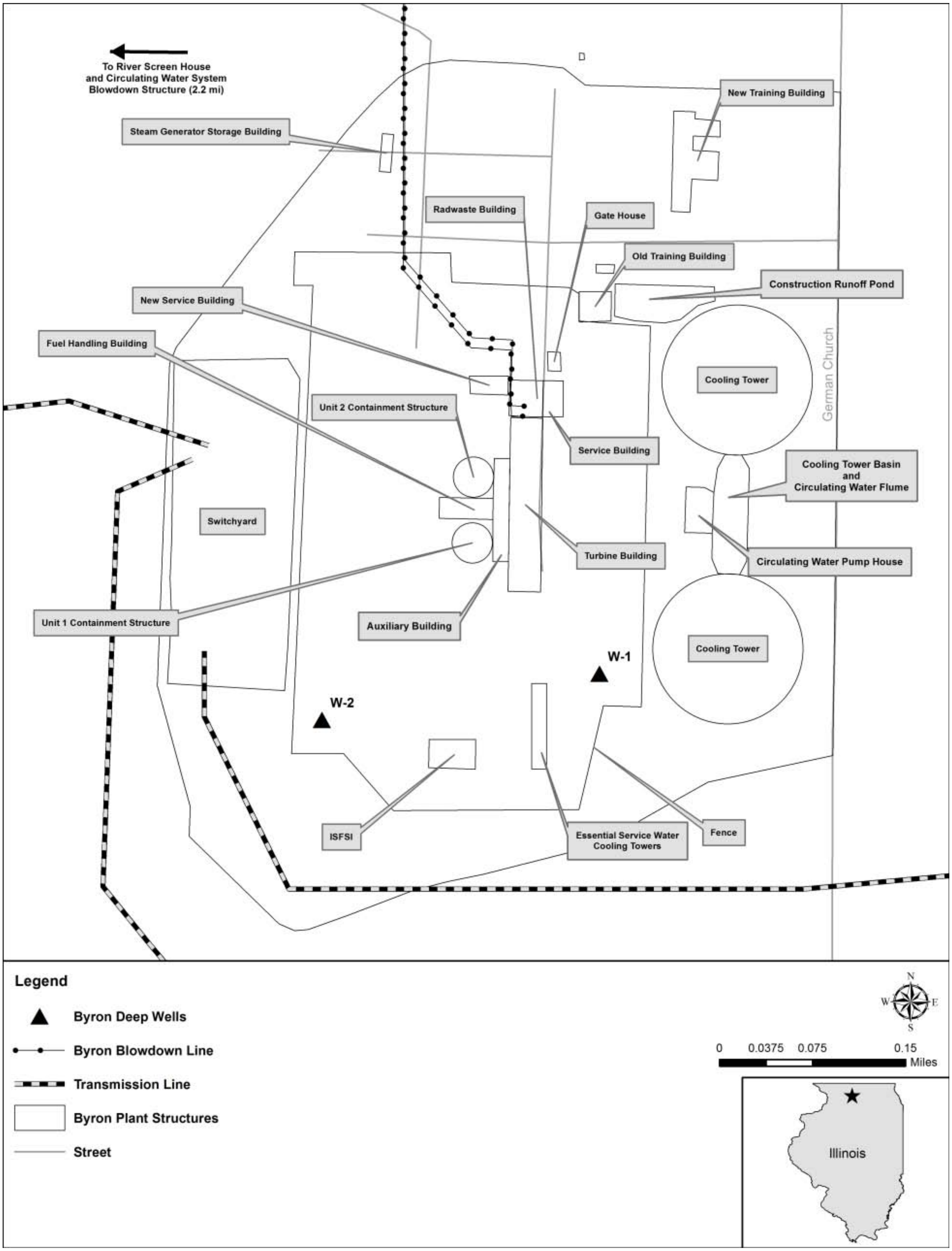
  Also at the 10 km (6.5 mi) point, the other Cherry Valley circuit turns northeast in the same right-of-way as the pre-existing line from Nelson TSS to Cherry Valley TSS. For the first 13 km (8.2 mi), the pre-existing right-of-way was widened 30 m (100 ft) to accept new double circuit towers. For the final 11 km (7.1 mi), this Cherry Valley circuit is installed on pre-existing double-circuit towers, with no widening of the right-of-way. The total length of this circuit is approximately 34 km (21 mi) (including the initial 10-km [6.5-mi] segment).

- South – The operating license environmental report calls this the "south right-of-way." The current UFSAR (Exelon Nuclear 2010a) calls this line the Lee County Station line. Because NRC regulations require analysis of the lines "originally constructed" to connect the plant to the electrical grid, Exelon Generation considers the scope for this line to be solely the 14-km (8.5-mi) south right-of-way from Byron to the intersection with the pre-existing Nelson-to-Cherry Valley transmission line.

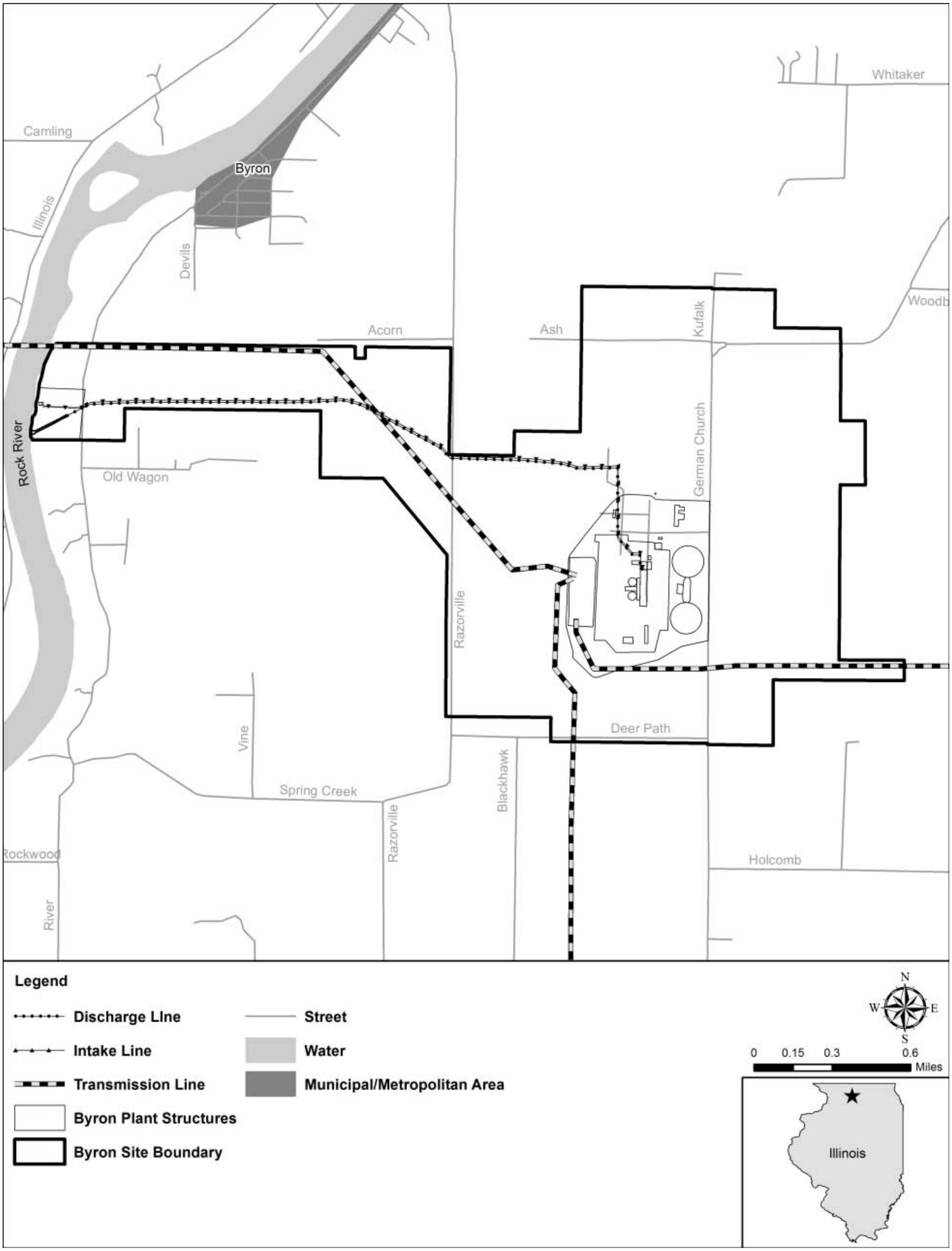
In total, the rights-of-way carrying circuits from Byron extend a distance of approximately 97 km (60 mi) and occupy approximately 490 ha (1,210 ac) of land (ComEd 1981a). The rights-of-way pass through land that is primarily agricultural, with some forest land and lesser land-use categories. The areas are mostly remote, with low population densities. The lines cross numerous county, state, and U.S. highways. Rights-of-way that pass through farmlands generally continue to be used as farmland. ComEd plans to maintain these transmission lines, which are integral to the larger transmission system, indefinitely. The intention is for these transmission lines to remain a permanent part of the transmission system even after Byron is decommissioned.

The transmission lines were designed and constructed in accordance with the Illinois Commerce Commission General Order 160, which is identical to the 6th edition of the National Electrical Safety Code (ComEd 1981a). Ongoing surveillance and maintenance of these transmission facilities are described in Section 4.13.

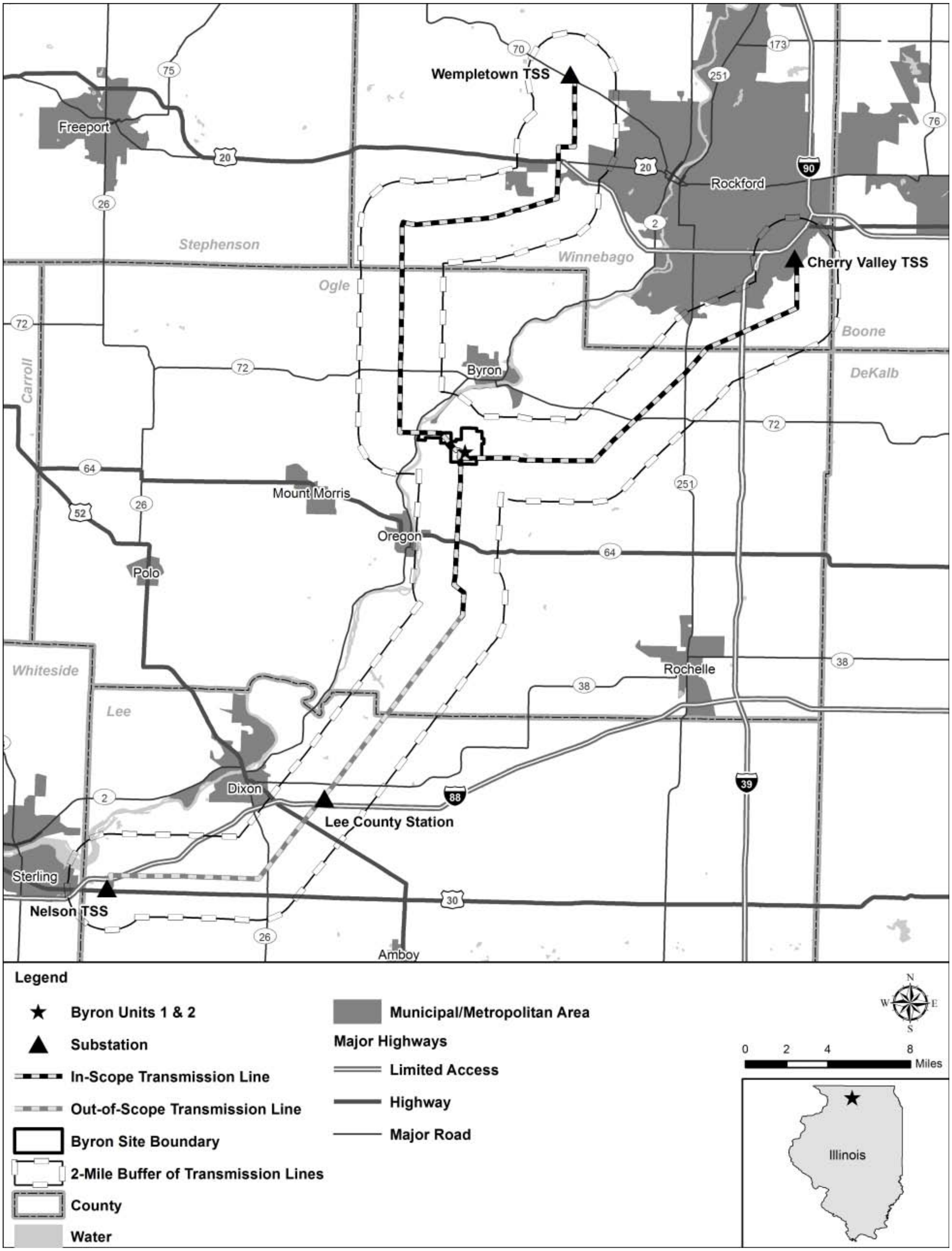
Figures 3.1-1. Byron Plant Layout



Figures 3.1-2. Byron Site Layout



Figures 3.1-3. Byron Transmission System



3.2 Refurbishment Activities

NRC

> **"The report must contain a description of … the applicant's plans to modify the facility or its administrative control procedures as described in accordance with § 54.21...This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)**
>
> **"The environmental report must contain analyses of …refurbishment activities, if any, associated with license renewal…" 10 CFR 51.53 (c)(3)(ii)**
>
> **"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40-year license term will be from one of two broad categories…(2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item...." (NRC 1996b, Section 2.6.3.1, pg.2-41)**

Exelon Generation has no plans for refurbishment or replacement activities at Byron. Exelon Generation has addressed refurbishment activities in this Environmental Report in accordance with NRC regulations and complementary information in the NRC GEIS for license renewal (NRC 1996b). NRC requirements for the renewal of operating licenses for nuclear power plants include preparation of an integrated plant assessment (IPA) (10 CFR 54.21). The IPA must identify systems, structures, and components subject to an aging management review. Items that are subject to aging and might require refurbishment include, for example, the reactor vessel piping, supports, and pump casings (see 10 CFR 54.21 for details), as well as items that are not subject to periodic replacement.

The Byron IPA that Exelon Generation conducted under 10 CFR Part 54 has identified no refurbishment or replacement actions needed to maintain the functionality of important systems, structures, and components during the period of extended operation. Exelon Generation has included the IPA as Appendixes A (Updated Final Safety Analysis Report Supplement) and B (Aging Management Programs) of this Byron and Braidwood Stations, Units 1 and 2 license renewal application.

Although there are no plans for refurbishment or replacement activities at Byron, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur prior to the end of the 40-year initial license term, and potential impacts from such hypothetical steam generator replacement are analyzed in Chapter 4. Exelon Generation has chosen to make this assumption because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced, and although a management strategy has been adopted to address potential failure mechanisms, as the plant ages the steam generators become more susceptible to degradation.

For the purposes of the analyses of hypothetical refurbishment impacts presented in Chapter 4, the following hypothetical conditions are postulated based on the actual replacement in 1998 of the Byron Unit 1 steam generators.

- The replacement steam generators would be transported to the site via rail from Chicago.
- The project would occur during a 90-day period paralleling a refueling or other scheduled maintenance outage.
- In addition to the normal plant personnel, 500 refurbishment personnel would be on site to support the hypothetical refurbishment, in addition to the 1,400 refueling personnel. Exelon Generation conservatively assumes that all temporary personnel would move into and temporarily reside within the 80-km (50-mi) radius for the duration of the project. Based on the historic residential distribution of Byron's normal refueling workforce, Exelon Generation has assumed that most refurbishment workers would reside in temporary housing in Rockford (Winnebago County), Oregon (Ogle County), or Rochelle (Ogle County).
- Personnel access to the plant would be via Rt. 2, which is the route used by normal plant personnel.
- There is ample parking and potable water supply for all additional personnel, and no additional facilities would be required.
- There is sufficient disturbed land to support on-site laydown facilities as well as construction of another steam generator storage facility or expansion of the existing facility.
- The storage facility would be designed and constructed to maintain radiation doses to workers and the public as low as reasonably achievable.

In February 2004, the NRC issued Order EA-03-009 requiring PWR licensees to address the potential for primary water stress corrosion cracking (PWSCC) in the penetration nozzles and related welds of the reactor pressure vessel (RPV) heads. Since then, Exelon Generation has been inspecting the Byron Units 1 and 2 RPV heads in accordance with NRC requirements (codified at 10 CFR 50.5a in 2008). Based on the inspection results, mitigation measures are being implemented to reduce the probability of weld failures. However, the possibility of failures making RPV head replacement necessary in the future cannot be ruled out. Accordingly, consideration is being given to the option of procuring one or more spare RPV heads that would be designed and fabricated to replace either of the Byron RPV heads or either of the Braidwood RPV heads, which are identical to the Byron RPVs. This purely economic procurement decision would ensure that a long lead-time component would be available if needed at either Byron or Braidwood.

Similar to its treatment of steam generator replacement, the Byron IPA does not identify RPV head replacement as a refurbishment or replacement action needed to maintain the functionality of important systems, structures, and components during the period of extended operation for Byron. Therefore, also as for steam generator replacement, Exelon considered whether RPV head replacement at Byron should be analyzed in this Environmental Report as hypothetical refurbishment. Exelon estimates that an RPV head replacement in either reactor could be completed in seven days, with a workforce of 340 people. If both RPV heads were replaced during the same outage, the workforce would remain constant, and the duration would double, to two weeks. If the RPV heads were stored on site, there is sufficient previously disturbed land to construct an adequately sized warehouse. Therefore, Exelon Generation considers that the analyses of environmental impacts for the hypothetical steam generator replacement are bounding for the environmental impacts of RPV head replacement. For this reason, and because it is unlikely that both refurbishment projects would be conducted simultaneously, only analyses of environmental impacts from hypothetical refurbishment in the form of steam generator replacement at Byron are presented in Chapter 4.

3.3 Programs and Activities for Managing the Effects of Aging

NRC

> **"…The report must contain a description of … the applicant's plans to modify the facility or its administrative control procedures…. This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)**
>
> **"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40 year license term will be from one of two broad categories: (1) SMITTR actions, most of which are repeated at regular intervals …." NRC 1996b, (SMITTR is defined in NRC 1996b as surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping.)**

The IPA required by 10 CFR 54.21 identifies the programs and activities for managing aging effects at Byron. These programs are described in the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application, Appendixes A (Updated Final Safety Analysis Report Supplement) and B (Aging Management Programs). Other than implementation of the programs and activities identified in the IPA, there are no planned modifications of Byron's administrative control procedures associated with license renewal.

3.4 Employment

Current Workforce

Exelon Generation employs 870 permanent employees and 20 long-term contract employees at Byron, a two-unit facility. The permanent staff at a nuclear plant with two reactors normally ranges between 600 and 800 employees per unit (NRC 1996b); Byron employment falls below that range. Approximately 81 percent of the permanent employees live in Ogle, Lee, or Winnebago Counties in Illinois. The remaining employees are distributed across 18 counties in Illinois and five counties outside of Illinois, with numbers ranging from 1 to 53 employees per county.

The Byron units are on staggered 18-month refueling cycles. During refueling outages (lasting about 20 days), the normal plant staff of 898 (permanent plus long-term contract employees) is supplemented by a maximum on any one day of approximately 1,400 additional workers.

3.4.1 License Renewal Increment

Performing the license renewal activities described in Section 3.3 would necessitate increasing the Byron staff workload by some increment. The size of this increment would be a function of the schedule by which Exelon Generation must accomplish the work and the amount of work involved. The analysis of the license renewal employment increment focuses on programs and activities for managing the effects of aging.

The GEIS (NRC 1996b) assumes that the NRC would renew a nuclear power plant license for a 20-year period, beyond the duration remaining on the current license, and that the NRC would issue the renewal approximately 10 years prior to expiration of the current license. In other words, the renewed license would be in effect for approximately 30 years. The GEIS further assumes that the utility would initiate surveillance, monitoring, inspections, testing, trending, and recordkeeping (SMITTR) activities at the time of issuance of the new license and would conduct license renewal SMITTR activities throughout the remaining 30-year life of the plant, sometimes during full-power operation (NRC 1996b), but mostly during normal refueling and the 10-year in-service inspection outages (NRC 1996b).

Exelon Generation has determined that the GEIS scheduling assumptions are reasonably representative of the Byron station incremental license renewal workload scheduling. Many Byron license renewal SMITTR activities would have to be performed during outages. Although some Byron license renewal SMITTR activities would be one-time efforts, others would be recurring periodic activities that would continue for the life of the plant.

In the GEIS, the NRC estimates that the most additional personnel needed to perform license renewal SMITTR activities would typically be 60 persons during the 3-month duration of a 10-year in-service inspection and refueling outage. Having established this upper value for what would be a single event in 20 years, the GEIS uses this number as the expected number of additional permanent workers needed per unit attributable to license renewal. GEIS Section C.3.1.2 uses this approach in order to "...provide a realistic upper bound to potential population-driven impacts…."

Exelon Generation anticipates that existing "surge" capabilities for routine activities, such as outages, will enable Exelon Generation to perform the increased SMITTR workload resulting from license renewal without increasing the Byron staff. However, for purposes of analysis in this Environmental Report, Exelon Generation conservatively assumes that Byron would require 60 additional permanent workers to perform all license-renewal SMITTR activities and that all 60 employees would migrate into the 80-km (50-mi) radius. Adding 60 full-time employees to the plant work force for the period of extended operation creates additional indirect jobs. Considering the population in the 80-km (50-mi) radius and the fact that most indirect jobs would be service-related, Exelon Generation assumes that all workers filling those indirect jobs would already reside within the 80-km (50-mi) radius.

3.4.2 Refurbishment Increment

The hypothetical refurbishment activities described in Section 3.2 would require additional outage workers beyond those typical for a normal refueling outage, temporarily increasing the Byron workforce by some increment. The size of this increment would be a function of the schedule to accomplish the work and the amount of work involved.

In the GEIS (NRC 1996b), the NRC analyzed the impacts of license renewal at seven operating nuclear reactors sites, including the impacts of refurbishment at each of the sites. The NRC selected a variety of nuclear plants that would represent the range of plant types in the United States. The NRC based its analyses on bounding work force estimates derived from refurbishment scenarios at the case study sites. The GEIS estimates that, at peak, the most additional personnel needed to perform refurbishment activities at a pressurized water reactor would be 2,273 persons during a 9-month major refurbishment outage, immediately before the expiration of the initial operating license. The GEIS also states that refueling would occur during the time the refurbishment workforce was at its peak. In an effort to account for uncertainty surrounding workforce numbers[2], the NRC performed a sensitivity analysis of the socioeconomic impacts of a refurbishment and refueling work force roughly 50 percent larger than the projected bounding case for a pressurized water reactor work force, or 3,400 workers. Having established this upper value for what would be a single event in the remainder of the life of the plant, the GEIS uses this number as the expected number of additional workers needed per unit attributable to refurbishment.

Exelon Generation has identified no refurbishment activities as being necessary for Byron license renewal. However, Unit 2 may require replacement of its steam generator in the future. The Unit 1 steam generators were replaced in 1998. Therefore, Exelon Generation has chosen to analyze potential Unit 2 steam generator replacement as a hypothetical refurbishment project in this Environmental Report. Exelon Generation estimates that the hypothetical steam generator replacement outage duration would be 90 days, occurring in parallel with a normal refueling outage, and that concurrent refueling and refurbishment would require 1,900 additional workers (including 500 steam generator replacement and 1,400 refueling workers). Exelon Generation expects some percentage of this temporary workforce to migrate into the 80-km (50-mi) radius for the duration of the refurbishment. However, to provide a more conservative analysis in Chapter 4, for the purposes of this Environmental Report, Exelon Generation has assumed that 100 percent of these workers will migrate into the 80-km (50-mi) radius.

RPV head replacement at one or both Byron units is another possible refurbishment project. As indicated in Section 3.2, Exelon Generation believes that simultaneous execution of both projects at the same time is unlikely and that hypothetical impacts from RPV head replacement would be bounded by impacts from hypothetical steam generator replacement.

[2] More overlap of the refurbishment and refueling workforces and/or schedule adjustments could cause peak work force numbers to increase.

Exelon Generation has determined that the GEIS refurbishment work force size and scheduling assumptions amply bound Byron hypothetical refurbishment and refueling work force sizes and scheduling.

Although temporary workers performing refurbishment would spend money in the region, they would not be resident in the region long enough to create indirect jobs. Therefore, Exelon Generation assumes no indirect jobs would be created by this project, and the application of a multiplier would not be necessary.

Chapter 4

Environmental Consequences of the Proposed Action and Mitigating Actions

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4.0 Environmental Consequences of the Proposed Action and Mitigating Actions

NRC

> **"The report must contain a consideration of alternatives for reducing adverse impacts…for all Category 2 license renewal issues…." 10 CFR 51.53(c)(3)(iii)**
>
> **"…The environmental report shall include an analysis that considers…the environmental effects of the proposed action…and alternatives available for reducing or avoiding adverse environmental effects.…" 10 CFR 51.45(c) as adopted by 10 CFR 51.53(c)(2) and 10 CFR 51.53(c)(3)(iii)**
>
> **The environmental report shall discuss "The impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance" 10 CFR 51.45(b)(1) as adopted by 10 CFR 51.53(c)(2).**
>
> **"…The information submitted…should not be confined to information supporting the proposed action but should also include adverse information." 10 CFR 51.45(e) as adopted by 10 CFR 51.53(c)(2)**

4.0.1 Discussion of 1996 GEIS License Renewal Categories

Chapter 4 presents an assessment of the environmental consequences and potential mitigating actions associated with the renewal of the Byron operating licenses. The NRC's 1996 GEIS identifies and analyzes 92 environmental issues that the NRC considers to be associated with nuclear power plant license renewal. In its analysis, the NRC designated each of the issues as Category 1, Category 2, or NA (not applicable) and required plant-specific analysis of only the Category 2 issues.

The NRC designated an issue as Category 1 if, based on the result of its analysis, the following criteria were met:

- the environmental impacts associated with the issue were determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic
- a single significance level (i.e., SMALL, MODERATE, or LARGE) was assigned to the impacts that would occur at any plant, regardless of which plant was being evaluated (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal); and
- mitigation of adverse impacts associated with the issue were considered in the analysis, and it was determined that additional plant-specific mitigation measures were likely to be not sufficiently beneficial to warrant implementation.

Absent new and significant information (Chapter 5), NRC regulations do not require analyses of Category 1 issues because the NRC resolved them using generic findings presented in 10 CFR Part 51, Appendix B, Table B-1. An applicant may reference the generic findings or GEIS analyses for Category 1 issues.

If the NRC analysis concluded in the 1996 GEIS that one or more of the Category 1 criteria could not be met for an issue, the issue was designated as Category 2. The NRC requires plant-specific analyses for Category 2 issues.

The NRC designated two issues in the 1996 GEIS as NA (chronic effects of electromagnetic fields and environmental justice), signifying that the categorization and impact definitions do not apply to these issues. Appendix A, Table A-1 of this Environmental Report lists the 92 issues and provides a summary of the applicability of each to Byron. Appendix A, Table A-1 also identifies the section in this environmental report that addresses each issue and, where appropriate, references supporting analyses in the 1996 GEIS.

Category 1 License Renewal Issues

NRC

> **"The environmental report for the operating license renewal stage is not required to contain analyses of the environmental impacts of the license renewal issues identified as Category 1 issues in Appendix B to subpart A of this part." 10 CFR 51.53(c)(3)(i)**
>
> **"…[A]bsent new and significant information, the analysis for certain impacts codified by this rulemaking need only be incorporated by reference in an applicant's environmental report for license renewal…." 61 FR 28483**

Exelon Generation determined that, of the 69 Category 1 issues identified in the 1996 GEIS, 10 do not apply to Byron because they apply to design or operational features that do not exist at the facility. Among the remaining 59 Category 1 issues there are seven that pertain only to refurbishment. As explained in Section 3.2, Exelon Generation hypothesizes that refurbishment activities may occur during the term of the renewed Byron license; therefore, for the purposes of this environmental report, the NRC findings for the seven refurbishment Category 1 issues identified in the 1996 GEIS apply to Byron.

As discussed in Chapter 5.0, Exelon Generation is not aware of any new and significant information that would make the findings in the 1996 GEIS for any Category 1 issue inapplicable to Byron. Therefore, Exelon Generation adopts by reference the NRC findings for the 59 applicable Category 1 issues in the 1996 GEIS.

Category 2 License Renewal Issues

NRC

> **"The environmental report must contain analyses of the environmental impacts of the proposed action, including the impacts of refurbishment activities, if any, associated with license renewal and the impacts of operation during the renewal term, for those issues identified as Category 2 issues in Appendix B to subpart A of this part…." 10 CFR 51.53(c)(3)(ii)**
>
> **"The report must contain a consideration of alternatives for reducing adverse impacts, as required by § 51.45(c), for all Category 2 license renewal issues…." 10 CFR 51.53(c)(3)(iii)**

The NRC designated 21 issues as Category 2 in the 1996 GEIS. As is the case with Category 1 issues, some Category 2 issues apply to operational features that Byron does not have.

Sections 4.1 through 4.20 in this environmental report address the Category 2 issues identified in the 1996 GEIS (Section 4.17 addresses two issues). For the 16 Category 2 issues, including those for refurbishment, that Exelon Generation has determined apply to Byron, analyses are provided. These analyses include conclusions regarding the significance of the impacts relative to the renewal of the operating licenses for Byron and, when applicable, discuss potential mitigation alternatives. Except in the cases of cultural resources and federally-protected species, Exelon Generation has identified the significance of the impacts associated with each issue as SMALL, MODERATE, or LARGE, consistent with the following criteria that the NRC established in 10 CFR Part 51, Appendix B, Table B-1, Footnote 3:

> SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.
>
> MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
>
> LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with National Environmental Policy Act practice, Exelon Generation considered ongoing and potential additional mitigation in proportion to the significance of the impact to be addressed (i.e., impacts that are SMALL receive less mitigative consideration than impacts that are MODERATE and impacts that are MODERATE receive less mitigative consideration that are LARGE).

Consistent with NRC guidance provided in SECY-12-0063, Enclosure 1 (Draft Federal Register notice for the final rule implementing the updated GEIS, April 20,2012), Exelon Generation has adopted the impact determinations described below for historic and cultural resources, and for federally protected species.

The National Historic Preservation Act requires a determination of whether historic properties are present at or near the project site, and, if present, whether the project would result in any adverse effects on the property. Thus, the NRC has revised its determinations to be (1) no historic properties present; (2) historic properties are present, but not adversely affected; or (3) historic properties are adversely affected. Exelon Generation has used these determinations in the conclusion of license renewal impacts to historic and cultural resources.

In complying with the Endangered Species Act, NRC determines whether the effects of continued nuclear power plant operations and refurbishment (1) would have no effect on protected species, (2) would not likely affect protected species, (3) would likely affect protected species, (4) would likely jeopardize a protected species found to be affected or (5) would adversely modify designated critical habitat. Exelon Generation has used these determinations in the conclusion of license renewal impacts to species that are federally-listed proposed, or candidate for listing as threatened or endangered.

NA License Renewal Issues

The NRC determined in the 1996 GEIS that its categorization and impact-finding definitions did not apply to two issues (Issues 60 [chronic effects of electromagnetic fields] and 92 [environmental justice]); however, Exelon Generation includes both issues in Appendix A, Table A-1. Even so, because NRC regulations implementing both the 1996 GEIS and the updated GEIS (see Section 4.0.2) instruct applicants not to submit information on chronic effects from electromagnetic fields (10 CFR Part 51, Appendix B, Table B-1, Footnote 5), Exelon Generation does not otherwise address issue 60.

On the topic of environmental justice Exelon Generation has included minority and low income demographic information in Section 2.6.2 and a discussion of impacts to minority or low-income populations is included in Section 4.0.2.

4.0.2 Discussion of Revised GEIS License Renewal Categories

On April 20, 2012, the NRC staff requested Commission approval to publish a final rule amending the environmental protection regulations for the renewal of nuclear power plant operating licenses (SECY-12-0063). The updated GEIS that supports the final rule discussed in SECY-12-0063 reviews the 92 environmental issues that were identified and categorized in the 1996 GEIS. It retains many without change in definition or categorization, but others are combined and redefined, and some have been re-categorized from Category 2 to Category 1. Also, one issue (Environmental Justice) is re-categorized from NA to a new Category 2 issue. According to SECY-12-0063, Enclosure 1, fifteen new issues were identified in all, of which 11 were determined to be Category 1 and four were determined to be Category 2 issues.

Appendix A Table A-2 of this Environmental Report lists the 15 new issues. Exelon Generation has determined that the 11 new Category 1 issues identified in the updated GEIS apply to Byron. For new Category 1 issues, references to sections in the updated GEIS that contain supporting analyses, which are adopted herein by reference, are provided where appropriate.[1]

As discussed in Chapter 5.0, Exelon Generation is not aware of any new and significant information that would make the findings in the updated GEIS for any Category 1 issues

[1] Exelon Generation used the draft updated GEIS published by the NRC in July 2009 for the purpose of assigning the updated GEIS section numbers provided in Appendix A, Table A-2.

inapplicable to Byron. Therefore, Exelon Generation adopts by reference the NRC findings for the 11 applicable Category 1 issues identified in the updated GEIS.

Exelon Generation has evaluated the impacts of the new Category 2 issues identified in the updated GEIS. Based on the information provided in this Environmental Report for Byron's license renewal application, Exelon Generation has concluded the following regarding impacts associated with the new Category 2 issues.

- Radionuclides Released to Groundwater

Exelon Generation has described its discovery in 2006 of detectable tritium concentrations in the groundwater associated with leaks from vacuum breaker vaults along the blowdown line (see Section 2.3.4.1.2). Byron eliminated the immediate tritium leaks and assessed the need to remediate tritium in the groundwater. In March 2010, the Circuit Court for the Fifteenth Judicial Circuit, Ogle County, Illinois Chancery Division approved a Consent Order under which Byron agreed to perform additional actions to assure future compliance with applicable Illinois statutes and regulations (Circuit Court 2010).

No off-site tritium concentrations exceeding the EPA's safe level for drinking water (20,000 pCi/L) resulted from the vacuum breaker vault leaks, and the concentrations have decreased since 2006. Therefore, the tritium releases have caused no threat to public health or safety.
In addition, Byron has implemented the guidance provided in the *Industry Groundwater Protection Initiative – Final Guidance Document* (NEI 07-07 [Final], August 2007) through its Radiological Groundwater Protection Program (RGPP), which ensures early detection of tritium releases and elimination of sources. There have been no plant-related strontium or gamma-emitting radioisotopes identified in groundwater at Byron.

A Buried and Underground Piping aging management program has been developed for Byron in accordance with NUREG-1801, Section XI.M41 to support license renewal. Also, Byron will be implementing the industry buried piping initiative program contained in *Guideline for the Management of Buried Piping and Tank Integrity* (NEI 09-14, Rev. 1, December 2010).

Based on this evaluation, Exelon Generation has concluded that Byron is not contributing to changes in groundwater quality that would preclude current or future uses of the groundwater and that impacts are SMALL and do not warrant mitigation beyond that described in this Environmental Report.

- Water Use Conflicts with Terrestrial Resources (plants with cooling ponds or cooling towers using make-up water from a river)

As described in Section 4.1, Exelon Generation has an agreement with Illinois DNR to limit net water consumption to no more than 9 percent of the Rock River's flow when the flow is at or below 19,200 L/sec (679 cfs). Byron has procedures in place to comply with this withdrawal restriction, which will continue during the license renewal term. Hence, withdrawals of surface water for the operation of Byron during the license renewal term would have a SMALL impact on riparian terrestrial resources and would not warrant further mitigation.

- Water Use Conflicts with Aquatic Resources (plants with cooling ponds or cooling towers using make-up water from a river)

As described in Section 4.1, Exelon Generation has an agreement with Illinois DNR to limit net water consumption to no more than 9 percent of the Rock River's flow when the flow is at or below 19,200 L/sec (679 cfs). Byron has procedures in place to comply with this withdrawal restriction, which will continue during the license renewal term. Hence, withdrawals of surface water for the operation of Byron during the license renewal term would have a SMALL impact on aquatic resources and would not warrant further mitigation.

- Minority and Low-income Populations

The impacts of the extended operation of Byron were determined to be SMALL for all issues, as described here in Chapter 4. Disproportionately high and adverse human health or environmental effects to low-income or minority populations may occur when impacts to resources are significant, as defined by NEPA. Because SMALL impacts are not significant as defined by NEPA, no disproportionately high and adverse human health or environmental effects on low-income or minority populations would result from license renewal.

- Cumulative Impacts

Due to NRC interest shown during the license renewal process for other nuclear power plants, Exelon Generation chose to evaluate cumulative impacts in this Environmental Report as a supplement to the analysis of the 1996 GEIS Category 2 issues. Accordingly, cumulative impacts associated with the Byron license renewal term are provided in Section 4.21.

4.1. Water Use Conflicts (Plants Using Cooling Towers or Cooling Ponds and Withdrawing Makeup Water From A Small River With Low Flow)

NRC

> **"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than 3.15x10^{12} ft^3/year (9x10^{10} m^3/year), an assessment of the impact of the proposed action on the flow of the river and related impacts on in-stream and riparian ecological communities must be provided…" 10 CFR 51.53(c)(3)(ii)(A).**
>
> **"…The issue has been a concern at nuclear power plants with cooling ponds and at plants with cooling towers. Impacts on instream and riparian communities near these plants could be of moderate significance in some situations…" 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 13**

The water-use issue associated with operation of cooling towers is the availability of adequate stream flows to provide makeup water, particularly during droughts or in the context of increasing in-stream or off-stream uses (NRC 1996b). Because water use circumstances necessarily vary from site to site, the NRC made surface water use conflicts a Category 2 issue. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will modify this issue by making it applicable to any plant that withdraws make-up water from a river, regardless of the river's flow rate.

As discussed in Section 3.1.3, the Byron circulating water systems use two closed-cycle natural draft cooling towers that receive their makeup water from the Rock River. The Rock River drains an approximately 28,270 square kilometers (km^2) (10,915 square miles [mi^2]) area from southeastern Wisconsin through northern Illinois to its confluence with the Mississippi River downstream from Rock Island, Illinois. The drainage area upstream of the plant is approximately 20,700 km^2 (8,000 mi^2) (NRC 1982).

The U.S. Geological Survey (USGS) maintains a gaging station at Como, Illinois, approximately 74 km (46 mi) downstream of the Byron blowdown discharge at River Mile 62.9 (USGS 2011). For water years 1935 - 2010, annual mean flow at the Como gaging station averaged 204,023 L/sec (6,012 cfs) (USGS 2011) or 1.89 x10^{11} ft^3/year. Therefore, the Rock River meets the NRC definition of a small river.

Prior to 2006, there were no comprehensive statewide or regional plans for managing the water supply in Illinois. Signed in January 2006, Executive Order (EO) 2006-1 called for a comprehensive program for state and regional water supply planning and management, a strategic plan for the program's implementation, and development of regional water supply plans in two priority water quantity planning areas: east central Illinois and northeastern Illinois (CMAP 2010a). In 2009, funding allowed for the inclusion of the Kaskaskia region as the third priority area for water supply planning efforts (ISWS 2012). Byron is not within any of the three priority planning areas.

Fundamental elements of EO 2006-1 include ensuring that water demand and supply result in equitable availability through drought and non-drought conditions, and protecting water quality and in-stream flows. One planning goal of EO 2006-1 is to manage rivers in Illinois to ensure that river flows remain above the interim 1-day, 10-year low (Q1/10) or 7-day, 10-year low (Q7/10) protected flow level.

Byron has an agreement with the Illinois DNR to limit consumption of water from the Rock River for makeup to the Byron cooling systems to no more than 9 percent of total river flow during times when the river flow rate drops below 19,200 L/sec (679 cfs). Fundamental elements of EO 2006-1 include ensuring that water demand and supply result in equitable availability through drought and non-drought conditions, and protecting water quality and in-stream flows. To maintain compliance, Byron adjusts the CWS makeup and blowdown flows, and if necessary, would reduce the power output from the units.

The anticipated maximum gross withdrawal rate from the Rock River is 2,860 L/sec (101 cfs or 45,200 gpm). The average makeup withdrawal rate from the Rock River at 100 percent load factor is 2,320 L/sec (81.9 cfs or 36,750 gpm), out of which 821 to 1,070 L/sec (29 to 37.9 cfs or 13,000 to 17,000 gpm) is returned to the river as blowdown (Exelon Nuclear 2005).

Based on the Rock River's 75-year average annual mean flow at the Como gaging station of 170,241 L/sec (6,012 cfs; see Section 2.2.2), Byron's average makeup withdrawal rate of 2,320 L/sec (81.9 cfs) represents approximately 1.3 percent of the river's average annual mean flow. However, since 821 to 1,070 L/sec (29 to 37.9 cfs) is returned to the river as blowdown, the net makeup withdrawal from the river ranges from 1,250 to 1,500 L/sec (44 to 53 cfs), which represents 0.73 to 0.88 percent of the average annual mean flow of the river at the intake.

Even at a river flow of 19,200 L/sec (679 cfs), at which point the IDNR agreement prevents withdrawal exceeding 9 percent of total river flow, the plant's net makeup withdrawal of 1,250 to 1,500 L/sec (44 to 53 cfs) represents 6.5 to 7.8 percent of the river flow

Based on the information presented above, withdrawals of surface water for the operation of Byron during low-flow periods would have a SMALL impact on the availability of fresh water downstream of the site and would not warrant further mitigation.

Hypothetical refurbishment in the form of steam generator replacement would not increase water withdrawals from the Rock River and therefore, would not change this conclusion.

Impact to alluvial aquifers caused by the Byron makeup water withdrawal is addressed in Section 4.6.

4.2 Entrainment of Fish and Shellfish in Early Life Stages

NRC

> **"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations… or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…entrainment." 10 CFR 51.53(c)(3)(ii)(B)**
>
> **"The impacts of entrainment are small at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems. Further, ongoing efforts in the vicinity of these plants to restore fish populations may increase the numbers of fish susceptible to intake effects during the license renewal period, such that entrainment studies conducted in support of the original license may no longer be valid…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 25**

The NRC made impacts to fish and shellfish resources resulting from entrainment a Category 2 issue because it could not assign a single significance level to the issue. Information needing to be ascertained includes: (1) type of cooling system (whether once-through or closed cycle), and (2) status of Clean Water Act (CWA) Section 316(b) determination or equivalent state documentation. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will combine this issue with the issue of impingement of fish and shellfish to form a single Category 2 issue (Section 4.3).

As discussed in Section 3.1.3, the Byron circulating water system uses closed-cycle natural draft cooling towers to dissipate excess heat from the condenser cooling water and nonessential service water systems. In addition, Byron uses closed-cycle mechanical draft cooling towers to serve as the ultimate heat sink for the reactors and to cool essential service water, which removes heat from safety-related equipment.

The issue of entrainment of fish and shellfish in early life stages does not apply to Byron because the station does not use a once-through cooling or cooling pond heat dissipation system.

4.3 Impingement of Fish and Shellfish

NRC

> **"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations…or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…impingement…." 10 CFR 51.53(c)(3)(ii)(B)**
>
> **"The impacts of impingement are small at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 26**

The NRC made impacts on fish and shellfish resources resulting from impingement a Category 2 issue because it could not assign a single significance level to the issue. Information needing to be ascertained includes: (1) type of cooling system (whether once-through or closed cycle), and (2) status of CWA Section 316(b) determination or equivalent state documentation. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will combine this issue with the issue of entrainment of fish and shellfish to form a single Category 2 issue (Section 4.2).

As discussed in Section 3.1.3, the Byron circulating water system uses closed-cycle natural draft cooling towers to dissipate excess heat from the condenser cooling water and nonessential service water systems. In addition, Byron uses closed-cycle mechanical draft cooling towers to serve as the ultimate heat sink for the reactors and to cool essential service water, which removes heat from safety-related equipment.

The issue of impingement of fish and shellfish does not apply to Byron because the station does not use a once-through cooling or cooling pond heat dissipation system.

4.4 Heat Shock

NRC

> **"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act… 316(a) variance in accordance with 40 CFR 125, or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from heat shock …." 10 CFR 51.53(c)(3)(ii)(B)**
>
> **"Because of continuing concerns about heat shock and the possible need to modify thermal discharges in response to changing environmental conditions, the impacts may be of moderate or large significance at some plants…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 27**

The NRC made impacts on fish and shellfish resources resulting from heat shock a Category 2 issue, because of continuing concerns about thermal discharge effects and the possible need to modify thermal discharges in the future in response to changing environmental conditions (NRC 1996b). Information to be ascertained includes: (1) type of cooling system (whether once-through or cooling tower), and (2) evidence of a CWA Section 316(a) variance or equivalent state documentation. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue.

As discussed in Section 3.1.3, the Byron circulating water system uses closed-cycle natural draft cooling towers to dissipate excess heat from the condenser cooling water and nonessential service water systems. In addition, Byron uses closed-cycle mechanical draft cooling towers to serve as the ultimate heat sink for the reactors and to cool essential service water, which removes heat from safety-related equipment.

The issue of heat shock does not apply to Byron because the plant does not use a once-through or cooling pond heat dissipation system.

4.5 Groundwater Use Conflicts (Plants Using >100 GPM of Groundwater)

NRC

"If the applicant's plant…pumps more than 100 gallons (total onsite) of groundwater per minute, an assessment of the impact of the proposed action on groundwater use must be provided." 10 CFR 51.53(c)(3)(ii)(C)

"…Plants that use more than 100 gpm may cause groundwater use conflicts with nearby groundwater users…." 10 CFR Part 51, Subpart A, Table B-1, Issue 33

The NRC made groundwater use conflicts a Category 2 issue because, at a withdrawal rate of more than 100 gallons per minute (gpm), a cone of depression could extend offsite. This could deplete the groundwater supply available to offsite users, an impact that could warrant mitigation. Information to ascertain includes: (1) Byron Units 1 and 2 groundwater withdrawal rate (whether greater than 100 gpm), (2) drawdown at property boundary location, and (3) impact on neighboring wells. According to SECY-12-0063, Enclosure 1, because Ranney wells withdraw significantly more than 100 gpm of groundwater, the final rule supported by the updated GEIS will combine this issue with the issue of groundwater use conflicts at plants that use Ranney wells (Section 4.7).

As discussed in Section 3.1.3, Byron uses two water sources: the Rock River and groundwater. There are two deep groundwater wells (W-1 and W-2) at Byron (Section 2.3.2) that draw water from the Cambrian-Ordovician Ironton-Galesville and Mt. Simon aquifers. Byron uses groundwater from the two wells, which are pumped on rotation, for potable and demineralizer water as well as for backing up the makeup to the essential service water mechanical draft cooling towers.

The total peak groundwater demand for potable water and demineralizer water is approximately 30 L/sec (470 gpm) (Exelon Nuclear 2010a). In the event that essential service water cooling tower makeup water is not available from either of the two Rock River supply paths, the two groundwater wells would provide a third alternative makeup water supply capable of pumping at a maximum rate of 101 L/sec (1,600 gpm), which could be used to maintain adequate essential service water cooling tower basin inventory during the 30-day safe shutdown period required for the ultimate heat sink (Exelon Nuclear 2010a). Providing this makeup water supply would create the highest demand on the wells.

In 1980, Exelon conducted an aquifer test to evaluate the pumping influence of the Byron deep wells on the Ironton-Galesville and Mt. Simon aquifers and to verify that the wells are capable of pumping enough makeup water to maintain adequate essential service water cooling tower basin inventory during a 30-day safe shutdown period (ComEd 1980). The aquifer test consisted of pumping water from well W-1 at a continuous rate of approximately 50.5 L/sec (800 gpm) for 24 hours. All of the methods used as part of the test (Theis's curve, Jacob's modified time-drawdown and the residual drawdown method) verified that the two wells would provide enough water to maintain adequate essential service water cooling tower basin inventory during the 30-day safe shutdown period.

In addition to verifying that the wells were capable of supplying the necessary water to maintain adequate essential service water cooling tower basin inventory, the aquifer pump tests confirmed that the rate of pumping to maintain the inventory would not depress the water level below what would be necessary to support other simultaneous uses. The Theis analysis indicated that the drawdown in a single pumping well after 30 days of pumping at 50.5 L/sec (800 gpm) would be approximately 21 m (68 ft). The two deep wells are approximately 353 m (1,160 ft) apart. The analysis indicated that the increased drawdown in the second well, caused by pumping the first well, would be approximately 5 m (16 ft) after both wells have been pumping at 50.5 L/sec (800 gpm) for 20 days. Therefore, the total drawdown in both wells after 30 days of pumping at 50.5 L/sec (800 gpm) would theoretically be 26 m (84 ft). With the static water level of 69 m (225 ft) and a maximum pumping depth of 107 m (350 ft) in both wells, the available drawdown is 38 m (125 ft). Assuming that drawdown in each well would be 26 m (84 ft) after 30 days of pumping, there would be 13 m (41 ft) of additional drawdown available to accommodate regional water level decline and decreasing well and pump efficiency with time (ComEd 1980). This estimate remains conservative because the pumping rate necessary to maintain basin water inventory has been established as 35 L/sec (550 gpm) from each deep well (70 L/sec [1,100 gpm]) (Exelon Nuclear 2010a).

As discussed in Section 2.3, the City of Byron, which is 6.4 km (4 mi) northwest of the site, withdraws water from three wells. Two wells withdraw water from the Galesville Aquifer at depths of 205 and 218 m (673 and 715 ft) below ground surface, while the third well withdraws water from the deeper Mt. Simon aquifer at a depth of 610 m (2,000 ft below ground surface) (2010a).

The expected drawdown in the City of Byron well (screened in the Mt. Simon aquifer) from the two Byron site wells is approximately 0.9 m (3 ft) for each site well after 30 days of pumping. Therefore, the total drawdown in the deep City well with both Byron plant wells pumping at 51 L/sec (800 gpm) is approximately 1.8 m (6 ft). However, the construction of the deep City well is different than the Byron plant wells. Therefore, the actual expected drawdown would be less. Based on the differences in well construction and the temporary nature of the additional drawdown, the effect of pumping the two site wells (W-1 and W-2) on the operation of the deeper City of Byron well would be insignificant (ComEd 1980).

It is not expected that changes in operational groundwater needs would occur during the license renewal period. Therefore, Exelon concludes that impacts to Ironton-Platteville and Mt. Simon aquifers from onsite groundwater use over the license renewal period would be SMALL and not warrant mitigation.

Concurrent refurbishment in the form of steam generator replacement, should it occur, and refueling would require a maximum of 1,900 additional workers on the Byron site for 20 days. The average American uses about 340 liters (90 gallons) per day for personal use (EPA 2009a). These workers would increase the potable water requirements by an estimated maximum of 647,305 L/day (171,000 gpd or 119 gpm; 1,900 people X 90 gal/person). As described above, the groundwater wells can provide a maximum of 101 L/sec (1,600 gpm). The impacts to groundwater from refurbishment would be SMALL and temporary, and not warrant mitigation.

4.6 Groundwater Use Conflicts (Plants Using Cooling Towers or Cooling Ponds and Withdrawing Makeup Water From a Small River)

NRC

"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than 3.15 x $x10^{12}$ ft^3/year(9×10^{10} m^3/year)…[t]he applicant shall also provide an assessment of the impacts of the withdrawal of water from the river on alluvial aquifers during low flow." 10 CFR 51.53(3)(ii)(A)

"…Water use conflicts may result from surface water withdrawals from small water bodies during low flow conditions which may affect aquifer recharge, especially if other groundwater or upstream surface water users come on line before the time of license renewal…" 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 34

The NRC made groundwater use conflicts a Category 2 issue because consumptive use by withdrawals from small rivers could adversely impact aquifer recharge. This is a particular concern during low flow conditions and could create a cumulative impact due to upstream consumptive use. Byron Units 1 and 2 use cooling towers, which lose water through evaporation and drift. This lost water is made up by water from the Rock River. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will modify this issue by making it applicable to any plant that withdraws make-up water from a river, regardless of the river's flow rate.

The U.S. Geological Survey (USGS) maintains a gaging station at Como, Illinois, approximately 74 km (46 mi) downstream of the Byron blowdown discharge at River Mile 62.9 (USGS 2011). For water years 1935 - 2010, annual mean flow at the Como gaging station averaged 204,023 L/sec (6,012 cfs) (USGS 2011) or 1.89 $x10^{11}$ ft^3/year. Therefore, the Rock River meets the NRC definition of a small river.

The Rock River and its tributaries are not used for public water supply or navigation in Illinois. A few private users take water from the Rock River at locations from the Wisconsin state line to approximately 80 km (50 mi) downstream of the plant. A farm about 88 km (55 mi) downstream consumes less than 14 L/sec (0.5 cfs) for irrigation during the summer (Exelon Nuclear 2010a).

Future upstream uses of the Rock River are not expected to lower the river flow. Because most communities derive their water supply from groundwater, the trend will be toward higher minimum flows in the future due to increased effluent discharges (Exelon Nuclear 2010a).

The shallow Rock River alluvial aquifer receives recharge from local precipitation and groundwater from upland areas, and infiltrates into the underlying alluvial aquifer, and to nearby ponds, streams, and strip mines.

The alluvial aquifer overlies and is in contact with the Ordovician-age Galena-Platteville dolomite, which outcrops locally along the Rock River near the site (Exelon Nuclear 2006). Relatively low yields, water hardness, and susceptibility of the Galena-Platteville dolomite aquifer to contamination because of thin drift, fractures, and solution channels do not favor development of the dolomites as a water supply (Exelon Nuclear 2006). As discussed in Section 2.3, although numerous alternating layers of sandstones, limestone, and dolomites impart a heterogeneous character to Ordovician-Cambrian Aquifer, these units are hydraulically connected and behave as a single aquifer.

Exelon Generation has an agreement with the Illinois DNR to limit net water consumption to no more than 9 percent of the Rock River's flow when the flow is at or below 19,200 L/sec (679 cfs) (IDC 1978).

The anticipated maximum gross withdrawal rate from the Rock River is 2,860 L/sec (101 cfs or 45,200 gpm). The average makeup withdrawal rate from the Rock River at 100 percent load factor is 2,320 L/sec (81.9 cfs or 36,750 gpm), out of which 821 to 1,070 L/sec (29 to 37.9 cfs or 13,000 to 17,000 gpm) is returned to the river as blowdown (Exelon Nuclear 2005).

As discussed in Section 4.1, the Rock River's 75-year average annual mean flow at the Como gaging station is 170,241 L/sec (6,012 cfs), Byron's average makeup withdrawal rate of 2,320 L/sec (81.9 cfs) represents approximately 1.3 percent of the river's average annual mean flow. However, because 821 to 1,070 L/sec (29 to 37.9 cfs) is returned to the river as blowdown, the net makeup withdrawal from the river ranges from 1,250 to 1,500 L/sec (44 to 53 cfs), which represents 0.73 to 0.88 percent of the average annual mean flow of the river at the intake.

The plant's net makeup withdrawal of 1,250 to 1,500 L/sec (44 to 53 cfs) represents 6.5 to 7.8 percent of the lowest flow rate at which pumping from the river would occur, which is 19,200 L/sec (679 cfs).

Based on the following findings, withdrawals of surface water for the operation of Byron Units 1 and 2 during low-flow periods would have a SMALL impact on recharge to the alluvial aquifer and would not warrant mitigation:

Byron diverts water from the river only after confirming that the flow at the Byron River screenhouse is capable of supporting the withdrawal of surface water in accordance with the Illinois DNR agreement.

The plant's average makeup withdrawal rate of 2,320 L/sec (81.9 cfs) represents approximately 1.3 percent of the river's average annual mean flow. However, because 821 to 1,070 L/sec (29 to 37.9 cfs) is returned to the river as blowdown, the net makeup withdrawal from the river is 1,250 to 1,500 L/sec (44 to 52.9 cfs), which represents 0.73 to 0.88 percent of the low flow of the river at the intake.

The plant's net makeup withdrawal of 1,250 to 1,500 L/sec (44 to 53 cfs) represents 6.5 to 7.8 percent of the lowest flow rate at which pumping from the river would occur, which is 19,200 L/sec (679 cfs).

Byron has an agreement with Illinois DNR to limit net water consumption to no more than 9 percent of the Rock River's flow when the flow is at or below 19,200 L/sec (679 cfs).

Minimum flows in the Rock River are expected to increase due to increased upstream effluent discharges.

Although the alluvial aquifer infiltrates and recharges the Ordovician Galena-Platteville dolomite aquifer, the aquifer is not used as a source of water supply because of poor water quality.

The Ordovician-Cambrian Aquifer units are hydraulically connected and behave as a single aquifer; however, more than 90 percent of the water withdrawn by Byron is returned to the Rock River.

Refurbishment in the form of steam generator replacement, should it occur, would not increase withdrawals from the Rock River or affect any aquifer recharge rate or sources, and therefore, would not change this conclusion.

4.7 Groundwater Use Conflicts (Plants Using Ranney Wells)

NRC

"If the applicant's plant uses Ranney wells…an assessment of the impact of the proposed action on groundwater use must be provided." 10 CFR 51.53(c)(3)(ii)(C)

"…Ranney wells can result in potential groundwater depression beyond the site boundary. Impacts of large groundwater withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal…." 10 CFR Part 51, Subpart A, Table B-1, Issue 35

NRC made this groundwater use conflict a Category 2 issue because large quantities of groundwater withdrawn from Ranney wells could degrade groundwater quality at river sites by induced infiltration of poor-quality river water into an aquifer. According to SECY-12-0063, Enclosure 1, because Ranney wells withdraw significantly more than 100 gpm of groundwater, the final rule supported by the updated GEIS will combine this issue with the issue of groundwater use conflicts at plants that use 100 gallons per minute (gpm) or more of groundwater by means other than Ranney wells (Section 4.5).

This issue does not apply to Byron Units 1 and 2 because Byron does not use Ranney wells. As Section 3.1.2 describes, there are two influent water sources to Byron: the Rock River and groundwater. Groundwater is supplied via deep wells that do not meet the definition of a Ranney well.

4.8 Degradation of Groundwater Quality

NRC

> **"If the applicant's plant is located at an inland site and utilizes cooling ponds, an assessment of the impact of the proposed action on groundwater quality must be provided." 10 CFR 51.53(c)(3)(ii)(D)**
>
> **"…Sites with closed-cycle cooling ponds may degrade groundwater quality. For plants located inland, the quality of the groundwater in the vicinity of the ponds must be shown to be adequate to allow continuation of current uses…." 10 CFR Part 51, Subpart A, Appendix B, Table B 1, Issue 39.**

NRC made degradation of groundwater quality a Category 2 issue because evaporation from closed-cycle cooling ponds concentrates dissolved solids in the water and settles suspended solids. In turn, seepage into the water table aquifer could degrade groundwater quality. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue.

The issue of groundwater quality degradation does not apply to Byron because the plant does not use a cooling pond.

4.9 Impacts of Refurbishment on Terrestrial Resources

NRC

The environmental report must contain an assessment of "…the impacts of refurbishment and other license renewal-related construction activities on important plant and animal habitats…." 10 CFR 51.53(c)(3)(ii)(E)

"…Refurbishment impacts are insignificant if no loss of important plant and animal habitat occurs. However, it cannot be known whether important plant and animal communities may be affected until the specific proposal is presented with the license renewal application…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 40

"…If no important resources would be affected, the impacts would be considered minor and of small significance. If important resources could be affected by refurbishment activities, the impacts would be potentially significant…."(NRC 1996b)

The NRC made impacts to terrestrial resources from refurbishment a Category 2 issue because the significance of ecological impacts cannot be determined without considering site- and project-specific details (NRC 1996b6). Aspects of the site and project to be ascertained are: (1) the nature of refurbishment activities, (2) the identification of important ecological resources, and (3) the extent of impacts to plant and animal habitats. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will expand the scope of this issue to include impacts of continued plant operations and maintenance activities in addition to refurbishment.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced.

As described in Section 3.2 there are sufficient facilities, ample parking, and sufficient disturbed land at the Byron site to support steam generator replacement. All refurbishment activities would occur on previously-disturbed or developed areas that are devoid of natural habitats, and most work would occur inside buildings, with the exception of the construction of a steam generator storage facility. The steam generators would be delivered by rail, eliminating the need to build or upgrade any public roadways. Some songbirds could be temporarily displaced by noise, machinery, and personnel associated with refurbishment activities, but such disturbances would be temporary and minor. Any disturbance associated with temporary use of laydown areas, parking areas, or other facilities would be minor. In summary, Exelon Generation concludes that impacts to terrestrial resources from refurbishment in the form of steam generator replacement, should it occur, would be SMALL and would not warrant mitigation.

As noted above, based on SECY-12-0063, Enclosure 1, this issue will be expanded to include the impacts of continued plant operations and maintenance activities on terrestrial resources. Braidwood operations and maintenance procedures are not expected to change during the license renewal term from existing procedures. The footprint of the facility is small relative to surrounding undeveloped habitats. Noise is minimized. Procedures consider the impacts to nearby resources as part of their planning process. As a result, current operations and maintenance have only small impacts on terrestrial resources; therefore, Exelon Generation concludes that continued operations and maintenance activities would have SMALL impacts on terrestrial resources.

4.10 Threatened or Endangered Species

NRC

> **"Additionally, the applicant shall assess the impact of the proposed action on threatened or endangered species in accordance with the Endangered Species Act." 10 CFR 51.53(c)(3)(ii)(E)**
>
> **"Generally, plant refurbishment and continued operation are not expected to adversely affect threatened or endangered species. However, consultation with appropriate agencies would be needed at the time of license renewal to determine whether threatened or endangered species are present and whether they would be adversely affected." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 49**

The NRC made impacts to threatened and endangered species a Category 2 issue because the status of many species is being reviewed, and site-specific assessment is required to determine whether any species that has been listed or proposed for listing as a federally protected threatened or endangered species could be affected by refurbishment activities or continued station operations through the license renewal period. If yes, then Section 7 in the Endangered Species Act (16 U.S.C. § 1536(a)(2)) requires the NRC to consult with the appropriate federal agency (NRC 1996b) for the purpose of ensuring that license renewal would not be likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of designated critical habitat. . According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will expand the scope of this issue to include impacts to essential fish habitats protected under the Magnuson-Stevens Fishery Conservation and Management Act. The Magnuson-Stevens Fishery Conservation and Management Act is not addressed here because Byron withdraws from and discharges water to an inland, freshwater river. The Magnuson-Stevens Act protects oceanic and anadromous species, none of which occur in the Rock River.

Section 2.2 of this Environmental Report describes the aquatic communities of the Rock River in the vicinity of Byron's intake and discharge structure. Section 2.4 describes important terrestrial habitats at Byron and along the associated Byron-to-Wempletown, Byron-to-Cherry Valley, and Byron South transmission ROWs. Section 2.5 discusses threatened or endangered species that occur or may occur in the vicinity of Byron and along the transmission ROWs, focusing on federally listed species in accordance with the NRC regulation.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Based on the impacts of the Unit 1 steam generator project, ecological impacts would be SMALL. As described in Section 3.2 there are sufficient facilities, ample parking, and sufficient disturbed land at the Byron site to support steam generator replacement. If refurbishment activities in the form of steam generator replacement should occur, they would affect only previously-disturbed or developed areas that are devoid of natural habitats, and most work would occur inside buildings, with the exception of the construction of a storage facility for the old generators. The steam generators would be delivered by rail, eliminating the need to build or upgrade any roadways. Therefore, the ecological impacts of refurbishment, should it occur, would be SMALL and temporary, and impacts to threatened and endangered species would not occur.

With the exception of the species identified in Section 2.5, Exelon Generation is not aware of any species that are listed as threatened or endangered, or have been nominated for listing, that could occur at Byron or along associated transmission ROWs. Byron's activities do not affect any listed terrestrial or aquatic species or its habitat. Similarly, ComEd vegetation management practices along the transmission ROWs are developed and implemented in conjunction with appropriate regulatory agencies to minimize potential impacts on threatened or endangered species. Furthermore, plant operations and transmission line maintenance practices are not expected to change significantly during the license renewal term. Therefore, no adverse impacts to terrestrial or aquatic species from current or future operations beyond those previously identified are anticipated.

Exelon Generation has queried the Illinois DNR EcoCAT system regarding state-listed species and initiated contact with the U.S. Fish and Wildlife Service (USFWS), requesting information on any listed species or critical habitats that might occur on the Byron site or along the associated transmission ROWs, with particular emphasis on species that might be adversely affected by continued operation over the license renewal term. The Illinois DNR EcoCAT reports do not provide information of sufficient detail to determine impacts to threatened or endangered species from license renewal. Instead, the EcoCAT reports simply provide information on whether Byron and its associated transmission ROWs are in the general vicinity (typically within 1.6-3.2 km [1-2 mi]) of protected natural resources. Correspondence with the Illinois DNR and USFWS is provided in Appendix C.

Renewal of the Byron Unit 1 and Unit 2 operating licenses is not expected to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of any critical habitat. Because current operational practices that could affect the environment will not be modified by license renewal, Exelon Generation concludes that impacts to threatened or endangered species from license renewal are not likely to adversely affect any listed species and would not warrant additional mitigation.

Refurbishment, in the context of hypothetical steam generator replacement, should it occur, would have no effect on threatened or endangered species.

4.11 Air Quality During Refurbishment

NRC

> **"If the applicant's plant is located in or near a nonattainment or maintenance area, an assessment of vehicle exhaust emissions anticipated at the time of peak refurbishment workforce must be provided in accordance with the Clean Air Act as amended." 10 CFR 51.53(c)(3)(ii)(F)**
>
> **"Air quality impacts from plant refurbishment associated with license renewal are expected to be small. However, vehicle exhaust emissions could be cause for concern at locations in or near nonattainment or maintenance areas. The significance of the potential impact cannot be determined without considering the compliance status of each site and the numbers of workers expected to be employed during the outage…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 50**

The NRC made impacts to air quality during refurbishment a Category 2 issue because vehicle exhaust emissions could be of concern, and a general conclusion about the significance of the potential impact could not be drawn without considering (1) the compliance status of each site and (2) the number of workers expected to be employed during an outage for refurbishment (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Class 2 to Class 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced.

As discussed in Section 2.10, Ogle County is in the Rockford (Illinois)-Janesville-Beloit (Wisconsin) Interstate Air Quality Control Region (EPA 2011a) and is designated as either unclassifiable or attainment for all of the National Ambient Air Quality Standards (NAAQS). The nearest nonattainment area is McHenry County, Illinois, which is located approximately 48 km (30 mi) northeast of Byron and is designated as nonattainment under the annual $PM_{2.5}$ and the 8-hour ozone NAAQS (EPA 2011c). Therefore, refurbishment, in the context of hypothetical steam generator replacement, should it occur, could affect McHenry County's air quality, and the impacts of such refurbishment to air quality are analyzed here. Activities and the workforce associated with hypothetical refurbishment at Byron are discussed in Sections 3.2 and 3.4.

Most hypothetical refurbishment activities would be performed inside existing buildings and would not generate atmospheric emissions. However, laydown areas and several temporary facilities would be needed to support such activities. Additionally, a permanent steam generator storage facility would be constructed at the site.

Exelon Generation estimates that the total area used for construction and laydown during hypothetical refurbishment activities would be less than 4 ha (10 ac). All construction-associated activities would occur on previously disturbed land. The small land requirements and implementation of construction best management practices (e.g., dust suppression, silt fences, covering soil piles, etc.) would reduce the fugitive dust generated during refurbishment, which would mitigate possible contributions to airborne $PM_{2.5}$. Also, because particulate matter in the form of fugitive dust consists primarily of large particles that settle quickly, adverse public health effects from fugitive dust generated by Byron's hypothetical refurbishment would be minimal. Hence air quality impacts caused by fugitive emissions from the hypothetical refurbishment activities would be SMALL and would not warrant further mitigation.

During hypothetical refurbishment activities, temporary and localized increases in greenhouse gas (GHG) emissions could result from refurbishment-related commuter traffic and construction equipment, including diesel generators, heavy construction vehicles, tools, and other machinery. Because of the small size of the steam generator storage facility, the short duration of the entire project, and the small area which would be affected by the construction of the storage facility, the impact of GHG emissions from the hypothetical refurbishment activities would be SMALL and would not warrant mitigation.

During hypothetical refurbishment activities, temporary and localized increases in atmospheric concentrations of nitrogen oxides (NO_X), carbon monoxide (CO), sulfur dioxide (SO_2), volatile organic compounds (VOC), ammonia (NH_3) and particulate matter (PM) could result from exhaust emissions from workers' vehicles, heavy construction vehicles, diesel generators, and other machinery and tools. The NRC determined that vehicle emissions from refurbishment activities occurring in geographical areas of poor or marginal air quality could be cause for concern, based on a refurbishment and refueling workforce of 2,300 and a duration of 9 months. As described in Sections 3.2 and 3.4, the hypothetical replacement of the Byron Unit 2 steam generators could last approximately 90 days and require approximately 500 workers. Exelon Generation assumes that the entire hypothetical refurbishment workforce would come from outside the 80-km (50-mi) radius and temporarily reside in Rockford (Winnebago County), Oregon (Ogle County), or Rochelle (Ogle County). By averaging the distances to these towns, Exelon Generation estimated that the average daily commute of the refurbishment workforce would be 80 km (50 mi).

As noted in Section 3.3 of the GEIS (NRC 1996b), a conformity analysis is required for each pollutant where the total of direct and indirect emissions caused by a proposed federal action would exceed established threshold emission levels in a nonattainment or maintenance area. Federal conformity rules are defined in 40 CFR Parts 51 and 93. Because Ogle County is designated as either unclassifiable or attainment for all of the NAAQS, no conformity analysis is required, but an analysis for McHenry County is included because of its relative proximity to Byron. Due to McHenry County's ozone nonattainment status, the generation of NO_X and VOCs, which combine in the presence of heat and sunlight to create ozone, has been evaluated in this Environmental Report. Fine particulates ($PM_{2.5}$) can result from both direct and indirect sources. Gasoline- and diesel-fueled vehicles emit both direct $PM_{2.5}$ and gases (NO_X, SO_2, VOC, NH_3) that react in the air to form $PM_{2.5}$. The EPA requires NO_X emissions to be considered in $PM_{2.5}$ conformity assessments, but consideration of VOC, NO_X and ammonia emissions is only required if the state air agency or the EPA Regional Administrator determine that one or more of these precursors are significant contributors. No such determination has been made for the northeastern Illinois ozone nonattainment area, which includes McHenry County (CMAP 2010b). The threshold emission levels for ozone are 100 tons per year (tpy) for NO_X and 50 tpy for VOC. For $PM_{2.5}$, the threshold emissions levels are 100 tpy for direct $PM_{2.5}$ emissions and 100 tpy for each of the $PM_{2.5}$ precursors, NO_X and SO_2 (40 CFR Part 93, Subpart B).

As discussed in Section 3.2, the hypothetical refurbishment activities at Byron would include construction activities for a steam generator storage facility. The peak period of activity would occur during removal and replacement of the steam generators and would take place during a 90-day outage coincident with a 20-day refueling outage. For this analysis it is conservatively assumed that during this time, 500 refurbishment and 1,400 refueling workers would be traveling separately to Byron. Assuming each of the 1,900 workers would travel an average of 80 km (50 mi) daily to and from Byron; this would result in an additional 152,888 km (95,000 vehicle mi) vehicle miles within the region. In 2011, the average daily miles traveled per day was 2,999,276 km (1,863,664 mi) in Ogle County (IDOT 2011). The additional daily vehicle miles from the hypothetical refurbishment workforce represents 5.1 percent of the total daily miles traveled in Ogle County. Hence, although emissions in Ogle County may affect air quality in McHenry County, which is due west of Rockford, the hypothetical refurbishment traffic would increase the daily vehicle miles in Ogle County by 5.1 percent for 20 days; which would not affect the air quality in McHenry County enough to be measurable.

Furthermore, the amount of pollutants emitted from construction equipment would be small compared to total vehicular emissions in Ogle and McHenry Counties. Therefore, impacts of hypothetical refurbishment on the air quality of McHenry County would be SMALL and temporary and would not require mitigation.

4.12 Microbiological Organisms

NRC

> **"If the applicant's plant uses a cooling pond, lake, or canal or discharges into a river having an annual average flowrate of less than 3.15×10^{12} ft^3/year (9×10^{10} m^3/year), an assessment of the impact of the proposed action on public health from thermophilic organisms in the affected water must be provided." 10 CFR 51.53(c)(3)(ii)(G)**
>
> **"These organisms are not expected to be a problem at most operating plants except possibly at plants using cooling ponds, lakes, or canals that discharge to small rivers. Without site-specific data, it is not possible to predict the effects generically…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 57**

The NRC designated impacts to public health from thermophilic organisms a Category 2 issue, requiring plant-specific analysis, because the magnitude of the potential public health impacts associated with thermal enhancement of such organisms, particularly *Naegleria fowleri*, could not be determined generically. The NRC noted in the GEIS that impacts of nuclear power plant cooling towers and thermal discharges are considered to be of small significance if they do not enhance the presence of microorganisms that are detrimental to water quality and public health (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue.

The NRC requires [10 CFR 51.53(c)(3)(ii)(G)] an assessment of the potential impact of thermophilic organisms in receiving waters on public health if a nuclear power plant uses cooling ponds, cooling lakes, or cooling canals or discharges to a river with an average annual flow rate less than 9×10^{10} m^3 per year (3.15×10^{12} ft^3 per year). Byron discharges to a small river (see Section 4.1) so this issue applies.

As discussed in Section 3.1.3, the two generating units at Byron dissipate waste heat from their condensers using a closed cycle system that recycles the condenser cooling water through two natural draft cooling towers (one per unit). Cooling system blowdown (consisting of cooling tower blowdown combined with several much-smaller discharges including blowdown from the essential service water system mechanical draft cooling towers) is discharged to the Rock River at a point 61 m (200 ft) downstream of the screenhouse/makeup water intake. A buried pipe conveys cooling system blowdown from the powerblock area for approximately 3.2 km (2 mi) west to the Rock River discharge structure, which is an 84-m-long (275-ft-long) by open channel lined with rip-rap. Blowdown is continuous.

Organisms of concern include the enteric pathogens *Salmonella* and *Shigella*, the *Pseudomonas aeruginosa* bacterium, thermophilic *Actinomycetes* ("fungi"), the many species of *Legionella* bacteria, and pathogenic strains of the free-living *Naegleria* amoeba.

Thermophilic bacteria exist at temperatures from 25°C to 80°C (77°F to 176°F), with optimum growth at 50°C to 60°C (122°F to 140°F) (Joklik and Smith 1972). The optimum temperature is usually a reflection of the normal environment of the organism. Accordingly, these bacteria are able to survive in the human digestive tract, which has a temperature around 37°C (99°F) (Joklik and Smith 1972). Many of the pathogenic microorganisms (e.g., *Pseudomonas, Salmonella*, and *Shigella*) are ubiquitous in nature, occurring in the digestive tracts of wild mammals and birds (and thus in natural waters), but are usually only a problem when the host is immunologically compromised.

Thermal modeling conducted for the construction-phase FES indicated that Byron's cooling system blowdown would have a modest effect on downstream temperatures in summer, creating a thermal plume of from 0.2 to 1.1 ha (0.45 to 2.8 ac) between May and August (AEC 1974).

The Byron NPDES permit (IL0048313) does not contain a discharge temperature limit, but does require monitoring of blowdown temperatures. Blowdown temperatures (Outfall 001) are monitored daily and reported monthly to the IEPA along with a range of other Discharge Monitoring Report parameters. Also, as specified in Special Condition 12 of NPDES permit IL0048313, Byron must explicitly demonstrate compliance with the thermal water quality standard on a daily basis during times when the Rock River flow is less than 67,944 L/sec (2,400 cfs), or the temperature difference between the main river temperature and the water quality standard is less than 3°F. When the Rock River flow is less than 67,944 L/sec (2,400 cfs) or the temperature difference between the river temperature and the water quality standard is less than 3°F, Exelon Generation performs daily calculations to demonstrate compliance with the water quality standard. The calculations are based on hourly measurements, averaged over a 24-hour calendar day for river flow, main river temperature (measured as circulating water makeup temperature), blowdown flow, and blowdown temperature values (IEPA 2011b).

The highest daily blowdown temperature reported in recent years was 36°C (97°F), in August 2009 (Byron Station Monthly Discharge Monitoring Report for August 2009). Water at this temperature could, in theory, allow limited survival of thermophilic microorganisms, but is well below the optimal temperature range for their growth and reproduction.

Another factor controlling the survival and growth of thermophilic microorganisms in the Rock River is the chlorination of water in the circulating and service water systems to minimize the growth of algae and other bio-fouling microorganisms. This reduces the likelihood that a thermophilic pathogen would be introduced into the Rock River. Water from the circulating water system is de-chlorinated with sodium bisulfite before being returned to the Rock River to minimize effects on the environment.

Because (1) Byron's circulating water system is treated with sodium hypochlorite and sodium bromide to control biofouling, and (2) its blowdown discharge temperatures are well below those known to stimulate the growth of thermophilic pathogens, Exelon Generation concludes the risk to public health from exposure to thermophilic organisms associated with discharges to the Rock River from Byron Units 1 and 2 is SMALL and does not warrant mitigation.

Refurbishment in the form context of steam generator replacement, should it occur, would not change the likelihood of human exposure to thermophilic organisms in the Rock River, and therefore, would not change this conclusion.

Exelon Generation has requested information from the Illinois Department of Public Health on any concerns the agency may have relative to thermophilic organisms in the Rock River downstream of the Byron blowdown structure. Copies of this correspondence are presented in Appendix E.

4.13 Electric Shock from Transmission Line-Induced Currents

NRC

> **The environmental report must contain an assessment of the impact of the proposed action on the potential shock hazard from transmission lines "...[i]f the applicant's transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the National Electric Safety Code for preventing electric shock from induced currents…" 10 CFR 51.53(c)(3)(ii)(H)**
>
> **"Electrical shock resulting from direct access to energized conductors or from induced charges in metallic structures have not been found to be a problem at most operating plants and generally are not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric shock potential at the site…." 10 CFR Part 51, Subpart A, Table B 1, Issue 59**

The NRC made impacts of electrical shock from charges induced by transmission lines a Category 2 issue because, without a site-specific review of transmission line conformance with the National Electrical Safety Code (NESC) (IEEE 2006), the NRC could not determine the significance of the electric shock potential at a particular nuclear power plant site. This section provides an analysis of the Byron transmission lines' conformance to the NESC standard. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue, although the scope of .the transmission lines to be addressed will change.

4.13.1 Production of Induced Currents

Objects located near transmission lines can become electrically charged due to their immersion in the lines' electric fields. This charge results in a current that flows through the object to the ground. The current is called "induced" because there is no direct connection between the line and the object. The induced current can also flow to the ground through the body of a person who touches the object. An object that is insulated from the ground can actually store an electrical charge, becoming what is called "capacitively charged." A person standing on the ground and touching a vehicle or a fence receives an electrical shock due to the sudden discharge of the capacitive charge through the person's body to the ground. After the initial discharge, a steady-state current can develop, the magnitude of which depends on several factors, including the following:

- the strength of the electric field which, in turn, depends on the voltage of the transmission line as well as its height and geometry
- the size of the object on the ground, and
- the extent to which the object is grounded.

In 1977, the NESC adopted a provision that describes how to establish minimum vertical clearances to the ground for electric lines having voltages exceeding 98-kilovolt alternating current to ground. The clearance must limit the induced current due to electrostatic effects to 5 milliamperes if the largest anticipated truck, vehicle, or equipment were short-circuited to ground. By way of comparison, the setting of ground fault circuit interrupters used in residential wiring (special breakers for outside circuits or those with outlets around water pipes) is 4 to 6 milliamperes.

4.13.2 Byron Transmission Lines

As described in Section 3.1.6, there are three rights-of-way for four 345-kilovolt lines that were specifically constructed to distribute power from Byron to the electric grid – the Wempletown, Cherry Valley (two lines), and South (Lee County Station) lines. Exelon's analysis of these transmission lines began by identifying spans along the lines with potential to be the worst-case span. The worst case span is the configuration where the potential for current-induced shock would be greatest. Once the limiting case was identified, Exelon calculated the electric field strength, then calculated the induced current. The induced current analysis for the Cherry Valley right-of-way considered both 345-kV lines located within that right- of-way, as described in Section 3.1.6.

Exelon Generation calculated electric field strength and induced current using the Electric Power Research Institute computer code, ACDCLINE. The results of this computer program have been field-verified through actual electrostatic field measurements by several utilities. The input parameters included the design features of the limiting-case scenario and the maximum vehicle size under the lines (a tractor-trailer).

The result of the analysis is that none of the transmission lines exceed the 5-milliampere standard (IEEE 2006). The worst case road crossing for each of the lines is as follows:

South (Lee County Station)	2.43 milliamperes
Wempletown	4.95 milliamperes
Cherry Valley	4.14 milliamperes

Details of the analysis, including the input parameters, can be found in the calculation package (Tetra Tech 2012c).

ComEd, the owner and operator of the transmission line, has surveillance and maintenance procedures that provide assurance that design ground clearances will not change. These procedures include inspection on a regular basis. Routine aerial patrols of all corridors include checks for encroachments, broken conductors, broken or leaning structures, and signs of trees burning, any of which would be evidence of clearance problems. Ground inspections include examination for clearance at questionable locations, integrity of structures, and surveillance for dead or diseased trees, which might fall on the transmission lines. Problems noted during any inspection are brought to the attention of the appropriate organizations for corrective action.

Exelon Generation's assessment under 10 CFR Part 51 concludes that electric shock from the in-scope Byron transmission lines is of SMALL significance. No mitigation measures are recommended because:

- there are no exceedances of the standard,

- all the locations are remote and unlikely to have tractor-trailer trucks parked under the lines,
- Exelon Generation conservatively used 275 °F sags instead of 120 °F sags,
- ComEd plans to continue using these lines, even after Byron is decommissioned, making the transmission lines unaffected by the proposed action of license renewal.

4.14 Housing Impacts

4.14.1 Housing – Refurbishment

NRC

The environmental report must contain "...[a]n assessment of the impact of the proposed action on housing availability…" 10 CFR 51.53(c)(3)(ii)(I)

"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 63

The NRC made housing impacts a Category 2 issue because the magnitude of an impact would depend on local conditions that the NRC could not predict for all plants at the time of the GEIS publication (NRC 1996b). Local conditions that need to be ascertained are: (1) population categorization as small, medium, or high, (2) applicability of growth control measures, (3) the size and growth rate of the housing market. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

In the GEIS, Section 3.7.2 (NRC 1996b), NRC states that the potential for refurbishment-related impacts to housing would be caused by increased staffing during refurbishment activities. As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Byron.

In 10 CFR Part 51, Subpart A, Appendix B, Table B-1, the NRC concluded that impacts to housing are expected to be of small significance at plants located in medium or high population areas where growth control measures are not in effect.

In Supplement 1 to Regulatory Guide 4.2 (NRC 2000), Section 4.14.1, the NRC states that, if the conditions related to housing in Table B-1 are met and the number of additional on-site workers associated with refurbishment does not exceed the peak workforce estimate of 2,273 persons used for the socioeconomic impact analysis reported in Section 3.7 the GEIS, the finding of "small significance" may be adopted without further analysis.

As described in Section 2.6, Byron is located in a high population area. As stated in Section 3.4, during the period of peak hypothetical refurbishment activities, about 500 refurbishment workers and 1,400 refueling workers would be on site. Hence, the total number of temporary workers at Byron during the period of hypothetical refurbishment would not exceed the peak refurbishment workforce for which impacts were analyzed in the GEIS. Also, based on the residential distributions of normal refueling outage workers, Exelon Generation estimates that most in-migrating refurbishment workers would reside in temporary housing in the cities of Rockford (Winnebago County), Oregon (Ogle County), and Rochelle (Ogle County). As noted in Section 2.8, Land Use Planning, Ogle and Winnebago Counties are not subject to growth control measures that limit housing development. Therefore, consistent with the guidance in 10 CFR Part 51, Subpart A, Appendix B, Table B-1 and Supplement 1 to Regulatory Guide 4.2, Exelon Generation finds that impacts to housing availability resulting from refurbishment-related population growth would be SMALL and would not warrant mitigation.

4.14.2 Housing – License Renewal Term

NRC

> **The environmental report must contain "...[a]n assessment of the impact of the proposed action on housing availability…" 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development…." 10 CFR Part 51, Subpart A, Table B-1, Issue 63**
>
> **"...[S]mall impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion occurs…." (NRC 1996b)**

The NRC made housing impacts a Category 2 issue because the magnitude of impacts would depend on local conditions that the NRC could not predict for all plants at the time of GEIS publication (NRC 1996b). Local conditions that need to be ascertained are: (1) population categorization as small, medium, or high; (2) applicability of growth control measures; and (3) estimates of the additional onsite work force during the license renewal term. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

In 10 CFR Part 51, Subpart A, Appendix B, Table B-1, NRC concluded that impacts to housing are expected to be of small significance at plants located in medium or high population areas where growth control measures are not in effect.

In Supplement 1 to Regulatory Guide 4.2 (NRC 2000), Section 4.14.2, the NRC states that, if these Table B-1 conditions are present at a particular site and the number of additional on-site workers during the license renewal term would not exceed the peak refurbishment workforce estimate of 2,273 persons used for the socioeconomic impact analysis reported in Section 3.7 of NUREG 1437, the finding of “small significance” may be adopted without further analysis.

Sections 2.6 and 2.8 support the conclusion that Byron is located in a high population area not subject to growth control measures that limit housing development. Furthermore, as stated in Section 3.4, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Byron period of extended operation, it is conservatively assumed for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added, and that the 60 additional employees could generate the demand for 60 housing units. Therefore, applying the NRC impacts assessment guidance in Supplement 1 to Regulatory Guide 4.2, as described above, housing impacts during the Byron license renewal term would be SMALL and would not warrant mitigation because (1) the additional on-site workforce would be many fewer than 2,273 workers, and (2) Byron is located in a high population area not subject to growth control measures.

4.15 Public Utilities: Public Water Supply

4.15.1 Public Water Supply – Refurbishment

NRC

The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." 10 CFR 51.53(c)(3)(ii)(I)

"…An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 65

"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC 1996b)

The NRC made impacts to public utilities a Category 2 issue because if an area was experiencing water shortages, additional demands on the water supply as a result of plant demand and plant-related population growth could exacerbate the water shortage (NRC 1996b). Local information needed would include: (1) a description of water shortages experienced in the area, and (2) an assessment of the public water supply system's available capacity. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Byron.

The NRC's analysis in the GEIS of impacts to the public water supply system considered both plant demand and plant-related population growth demands on local water resources. Section 2.9.1 describes the public water supply systems in the area, their design capacities, and current demands. The following discussion focuses on impacts of refurbishment on local public utilities, based on the assumption that should refurbishment occur at Byron, up to 500 supplemental workers would be working at Byron for a period of 90 days.

Plant Potable Water Demand

As Section 3.4 indicates, Exelon Generation estimates that maximums of approximately 500 refurbishment workers and approximately 1,400 refueling workers would be onsite during the Byron hypothetical refurbishment project. Though these two workforce peaks are not expected to overlap, Exelon Generation conservatively combines the peaks for this analysis, for a total of 1,900 workers. Section 2.3 discusses groundwater resources in the vicinity of Byron. Byron gets potable water from two 457-m-deep (1,500–ft-deep) on-site groundwater wells and is not connected to a public water system. The Byron wells draw a peak 30 L/sec (470 gpm) from the Cambrian-Ordovician Ironton-Galesville and Mt. Simon aquifers. However, as described in Section 4.5, the groundwater wells are capable of producing a maximum of 101 L/sec (1,600 gpm) for 30 days.

As described in Section 4.5, the existing groundwater wells could meet the maximum potable water demand anticipated for refurbishment and refueling workers. Exelon Generation has identified no operational changes during the Byron station refurbishment period that would increase potable water use by plant systems. Therefore Byron operations during refurbishment would not affect public water supplies.

Plant-related Population Growth

The maximum impact to area public water supplies from the Byron hypothetical refurbishment project is expected to result from temporary population increases during the 90-day refurbishment period. The extent of such impacts are evaluated using the following assumptions: (1) all refurbishment-related jobs would be filled by in-migrating personnel; (2) the refurbishment work force would temporarily reside within the 80-km (50-mi) radius; and (3) refurbishment-related workers would not bring families due to the temporary nature of the refurbishment project (i.e., about 90 days).

The impact to the local water supply systems from refurbishment-related population increase can be estimated by calculating the amount of potable water that would be required by temporary refurbishment workers, in addition to normal demands. The average American uses about 340 liters (90 gallons) per day for personal use (EPA 2009a). As described above, Exelon Generation estimates that a maximum of 1,900 supplemental workers (refurbishment and refueling) would be onsite during the hypothetical refurbishment project. The plant-related population increase could require an additional 647,305 L/day (171,000 gpd) within the 80-km (50-mi) radius. As depicted in Table 2.9-1, there is ample excess capacity in all of the major public water supply systems. Therefore, Exelon Generation concludes that impacts resulting from station-related refurbishment population increase to public water supplies would be SMALL and temporary, requiring no additional capacity and not warranting mitigation.

4.15.2 Public Water Supply – License Renewal Term

NRC

> **The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." 10 CFR 51.53(c)(3)(ii)(I)**
>
> **"An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 65**
>
> **"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC 1996b)**

The NRC made impacts to public utilities a Category 2 issue because if an area was experiencing water shortages, additional demands on the water supply as a result of plant demand and plant-related population growth could exacerbate the water shortage (NRC 1996b). Local information needed would include: (1) a description of water shortages experienced in the area, and (2) an assessment of the public water supply system's available capacity. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

The NRC's analysis of impacts to the public water supply system considered both plant demand and plant-related population growth demands on local water resources.

Plant Potable Water Demand

Section 2.3 details groundwater resources in the vicinity of Byron. Byron obtains potable water from two 457-m-deep (1,500-ft-deep) on-site groundwater wells, and is not connected to a public water system.

The Byron wells draw a maximum of 30 L/sec (470 gpm) from the Cambrian-Ordovician Ironton-Galesville and Mt. Simon aquifers. The nearest public water system that withdraws water from either of these aquifers is the City of Byron, which is approximately 6.4 km (4 mi) northwest of the Byron site and has one well installed in the Mt. Simon aquifer at a depth of 610 m (2,000 ft). Exelon Generation has identified no operational changes during the Byron license renewal term that would result in a sustained increase in plant groundwater use. Therefore, the effect of Byron operations on nearby public water supplies that rely on groundwater, which has been SMALL, would neither change during the license renewal term nor require mitigation.

Plant-related Population Growth

The maximum impact to area public water supplies is calculated using the following assumptions: (1) all direct jobs would be filled by in-migrating residents; (2) indirect jobs would be filled by workers already residing within the 80-km (50-mi) radius (because most jobs would be service-related), (3) the license renewal term work force would reside in the 80-km (50-mi) radius. As described in Section 3.4, Exelon Generation is analyzing for a maximum in-migration of 60 employees attributable to license renewal.

The impact to the public water systems from plant-related population growth can be determined by calculating the amount of water that would be required by these individuals. The average American uses about 340 liters (90 gallons) per day for personal use (EPA 2009a). In the state of Illinois, average family size is 3.2 persons (USCB 2010c). Multiplying 60 additional employees by the family size of 3.2 equals 192 additional residents in the 80-km (50-mi) radius. The majority of these people would live in Ogle, Lee, or Winnebago Counties. The plant-related population increase could require an additional 17,280 gallons per day (192 additional residents multiplied by 90 gallons per day) within the 80-km (50-mi) radius. As depicted in Table 2.9-1, there is ample excess capacity in all of the major public water supply systems. Therefore, Exelon Generation concludes that impacts resulting from license renewal-related population growth to public water supplies would be SMALL, requiring no additional capacity and not warranting mitigation.

4.16 Education Impacts from Refurbishment

NRC

The environmental report must contain "…[a]n assessment of the impact of the proposed action on…public schools (impacts from refurbishment activities only) within the vicinity of the plant…." 10 CFR 51.53(c)(3)(ii)(I)

"…Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors…." 10 CFR Part 51, Subpart A, Table B-1, Issue 66

"…[S]mall impacts are associated with project-related enrollment increases of 3 percent or less. Impacts are considered small if there is no change in the school systems' abilities to provide educational services and if no additional teaching staff or classroom space is needed. Moderate impacts are generally associated with 4 to 8 percent increases in enrollment. Impacts are considered moderate if a school system must increase its teaching staff or classroom space even slightly to preserve its pre-project level of service….Large impacts are associated with project-related enrollment increases above 8 percent…." (NRC 1996b)

The NRC made refurbishment-related impacts to education a Category 2 issue because site- and project-specific factors determine the significance of impacts (NRC 1996b). Local factors to be ascertained include: (1) project-related enrollment increases and (2) status of the student/teacher ratio. According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Byron.

Exelon Generation estimates that, during the 90-day hypothetical steam generator replacement outage, a peak number of approximately 500 supplemental workers would be engaged in steam generator replacement work, along with approximately 1,400 supplemental workers performing normal refueling and maintenance activities. Based on previous refueling and maintenance outage experience at Byron, Exelon Generation believes workers engaged in refurbishment, refueling, and maintenance activities would not move their families to the Byron area for the short 90-day duration of the hypothetical refurbishment outage. Therefore, Exelon Generation estimates that few, if any, children would be relocated to the region near Byron, impacts would be SMALL, and mitigation would not be warranted.

4.17 Offsite Land Use

4.17.1 Offsite Land Use - Refurbishment

NRC

The environmental report must contain "…an assessment of the impact of the proposed action on... land-use... (impacts from refurbishment activities only) within the vicinity of the plant…." 10 CFR 51.53(c)(3)(ii)(I)

"…Impacts may be of moderate significance at plants in low population areas…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 68

"…[I]f plant-related population growth is less than 5 percent of the study area's total population, off-site land-use changes would be small, especially if the study area has established patterns of residential and commercial development, a population density of at least 60 persons per square mile, and at least one urban area with a population of 100,000 or more within 50 miles…." (NRC 1996b)

The NRC made impacts to offsite land use as a result of refurbishment activities a Category 2 issue because land-use changes could be considered beneficial by some community members and adverse by others. Local conditions to be ascertained include: (1) plant-related population growth, (2) patterns of residential and commercial development, and (3) proximity to an urban area with a population of at least 100,000 (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators may occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Furthermore, although a management strategy has been adopted to address potential failure mechanisms, the steam generators become more susceptible to degradation as the plant ages. Therefore, this issue applies to Byron.

In Supplement 1 to Regulatory Guide 4.2 (NRC 2000), Section 4.17.1, the NRC states that impacts to off-site land use result when the development pressures resulting from the project-related population increases result in changes to local land use and development patterns. Further, the NRC states that, if the following three conditions are met, the effects of refurbishment-related population growth on land use and development patterns will be small, and no further analysis is needed.

- Project-related population growth, when added to other anticipated or reasonably foreseeable population growth, would not increase existing area population by more than 5 percent.

- The project area has established development patterns. Established development patterns are indicated if the community has established land use controls or infrastructure in place to support reasonably foreseeable development.

- The project area is not extremely isolated or sparsely populated. Extreme isolation is indicated if the area is more than 80 km (50 mi) from the nearest urban area with a population of 100,000 or more; sparsely populated is indicated if the population density is less than 60 persons per square mile within a 32 km (20-mi) radius from the plant.

As stated in Section 2.6, Demography, the 2010 population within an 80-km (50-mi) radius was 1,247,087 and the 2010 population within a 32-km (20-mi) radius was 248,387. The 2010 population of Ogle, Lee, and Winnebago Counties combined was 384,794.

As stated in Section 3.4, a conservative maximum of 1,900 workers would migrate into the 80 km (50-mi) region for a Byron refurbishment project in the context of hypothetical steam generator replacement conducted simultaneously with a normal plant refueling outage. Due to the short duration of the resulting temporary population increase, 90 days, there would be few to no indirect jobs created as a result of spending by the 1,900 workers. Also, few to no workers would relocate family members for the same reason. Therefore, the population increase attributed to the refurbishment project would be a maximum of 1,900. A 1,900-person increase in the 2010 population of the 80-km (50-mi) region would result in a 0.15 percent temporary population increase. A 1,900-person increase in the 2010 combined populations of Ogle, Lee, and Winnebago Counties would result in a 0.49 percent temporary population increase.

Exelon Generation assumes that most refueling outage workers would reside in temporary housing in the cities of Rockford, Oregon, or Rochelle. Based on the residential distributions of previous refueling outage workers and the geographical location of Byron, Ogle and Winnebago Counties are where the greatest percentage of refurbishment and refueling workers would be expected to temporarily reside. As stated in Section 2.8, Ogle, Lee, and Winnebago Counties have comprehensive plans and land development ordinances/regulations to guide development.

As stated in Section 2.6, Demography, Byron is in a high population area. Within the 80-km (50-mi) radius, the 2010 population density was 159 persons per square mile. Within the 32-km (20-mi) radius, the population density was 198 persons per square mile. The city of Rockford, with a 2010 population of 152,871, is within an 80-km (50-mi) radius of the Byron station site (Section 2.6).

Therefore, Exelon Generation concludes that impacts to off-site land use resulting from hypothetical refurbishment in the form of stream generator replacement would be SMALL and would not warrant mitigation because (1) hypothetical refurbishment population increases would be less than 5 percent of either the population within the 80-km (50-mi) radius surrounding Byron or the combined population of the three counties surrounding Byron, (2) there are established development patterns in Ogle, Lee, and Winnebago Counties, and (3) the project area has a 32-km (20-mi) population density of 198 persons per square mile and is not isolated (Section 2.6).

4.17.2 Offsite Land Use - License Renewal Term

NRC

The environmental report must contain "…an assessment of the impact of the proposed action on …land-use…within the vicinity of the plant…" 10 CFR 51.53(c)(3)(ii)(I)

"Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 69

"…[I]f plant-related population growth is less than five percent of the study area's total population, off-site land-use changes would be small…" NRC 1996b, Section 3.7.5)

"If the plant's tax payments are projected to be a dominant source 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 in the past." (NRC 1996b)

The NRC made impacts to offsite land use during the license renewal term a Category 2 issue, because land-use changes may be perceived as beneficial by some community members and detrimental by others. Therefore, the NRC could not assess the potential significance of site-specific offsite land-use impacts (NRC 1996b). Site-specific factors to consider in an assessment of land-use impacts include: (1) the size of plant-related population growth compared to the area's total population, (2) the size of the plant's tax payments relative to the community's total revenue, (3) the nature of the community's existing land-use pattern, and (4) the extent to which the community already has public services in place to support and guide development. . According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

The GEIS presents an analysis of offsite land use for the renewal term that is characterized by two components: population-driven and tax-driven impacts (NRC 1996b).

4.17.2.1 Population-Related Impacts

As stated in Section 3.4, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Byron period of extended operation, it is conservatively assumed for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added, and that the 60 additional employees could generate the demand for 60 housing units.

Based on the GEIS case-study analysis, the NRC concluded that all new population-driven land-use changes during the license renewal term at all nuclear plants would be small (NRC 1996b). Population growth in the vicinity of Byron that would be caused by an assumed 60 additional permanent plant employees to support license renewal would represent a very small percentage (0.02 percent) of the total 2010 population of 248,387 within 20 miles (see Section 2.6). Thus, the nature of the community's existing land-use pattern, as described in Section 2.8, is not likely to be changed as a result of license renewal. Furthermore, adequate public services are already in place to support and guide the level of development associated with the additional 60 assumed permanent plant employees. Hence, Exelon Generation concludes that population-driven land use impacts in the Byron vicinity would be SMALL, and mitigation would not be warranted.

4.17.2.2 Tax-Revenue-Related Impacts

Determining tax-revenue-related land use impacts is a two-step process. First, the significance of the plant's tax payments on taxing jurisdictions' tax revenues is evaluated. Then, the impact of the tax contribution on land use within the taxing jurisdiction's boundaries is assessed.

Tax Payment Significance

The NRC has determined that the significance of tax payments as a source of local government revenue would be large if the payments are greater than 20 percent of revenue, moderate if the payments are between 10 and 20 percent of revenue, and small if the payments are less than 10 percent of revenue (NRC 1996b).

Land Use Significance

The NRC defined the magnitude of land-use changes as follows (NRC 1996b):

> SMALL - very little new development and minimal changes to an area's land-use pattern.
>
> MODERATE - considerable new development and some changes to land-use pattern.
>
> LARGE - large-scale new development and major changes in land-use pattern.

The NRC further determined that, "If the plant's tax payments are projected to be a dominant source 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 in the past." (NRC 1996b).

Byron Tax Impacts

Tables 2.7-2 and 2.7-3 provide comparisons of Byron tax payments to the Ogle County and Byron Unit 226 School District property tax levies, respectively. For the three-year period from 2008 through 2010, Byron's property tax payments represented 26.0 to 26.4 percent of the County's annual property tax levy and 72.9 to 73.5 percent of the Byron Unit 226 School District's annual property tax levy. Using the NRC's criteria, Byron's tax payments are of large significance to both taxing entities, especially the school district.

Byron Land Use Impacts

As stated in Section 2.8, Ogle, Lee, and Winnebago Counties are primarily rural. Winnebago and Ogle Counties have experienced some population growth in the past decade (Section 2.6.1), but it has been minimal and largely attributed to the continued expansion of the

Chicago region. Proposed upgrades to the regional transportation network, like the Midwest Regional Rail Initiative, are expected to facilitate growth in the communities between the Chicago metropolitan area and municipalities to the west. Chicago's expansion is being monitored by local planning agents, and accommodations are addressed in each county's planning documents.

As stated in Section 2.8, Ogle County's existing land use is dominated by agriculture (about 90 percent). The County's most intensive development occurs in municipalities, which collectively account for only 4.5 percent of the land area, but 57 percent of the population. Between 2000 and 2010, municipalities in the western region of the County experienced decreases in population and the municipalities in eastern Ogle County had increases in population, reflecting the greater Chicago influence. Planners indicate that some future development (especially residential) is expected. Through county and local planning and zoning practices, planners are guiding future growth toward the county's existing municipalities, where infrastructure and public services already exist.

4.17.2.3 Property Value Impacts

As discussed in Section 2.8, Ogle, Lee, and Winnebago counties have experienced some growth over the last several decades and their comprehensive land use plans account for this growth in the planning process. The three plans share the goals of encouraging growth and development in areas where public facilities, such as water and sewer systems, are planned and discouraging strip development along county roads and highways. They also promote the preservation of the counties' natural features and prime undeveloped areas. Much of the growth in this region has been influenced by the continued expansion of the Chicago metropolitan area. There is room for growth; however, with no new construction activities or significant increases in operational jobs as a result of license renewal, there would be no increased housing demand.

As discussed in the GEIS, land-use changes as a result of a nuclear power plant not having its license renewed could result in SMALL to MODERATE impacts on the surrounding community. The loss of jobs and taxes, and perhaps a loss in population and an increase in housing vacancies as the former employees left the area to take employment elsewhere, this could have a noticeable negative effect on the local economy and, in turn, on local land-use values.

Exelon Generation has considered the impact of Byron on local property values during the license renewal term. The GEIS concluded that the value and marketability of housing units in close proximity to nuclear plants would experience little change (NRC 1996b).

Authors of published literature on this subject are not consistent in their conclusions. The International Association of Assessing Officer (IAAO) guidelines consider the effect of contamination on nearby property values, including the presence of nuclear plants, in valuations of property. Actual contamination may depress offsite property values, but the IAAO discusses the established decommissioning funds required for nuclear plants, noting that the value of the nuclear plant site itself is not decreased and that property off site may increase in value due to competing need for land. IAAO also notes that stigma devaluation of property values may be overstated because land value is often not demonstrably affected despite the presence of nearby contaminated sites. (IAAO 2001).

Some studies, which have concluded that the presence of a nuclear plant decreases property values, are based on information derived from opinion polls rather than evidence of actual property values (Pasqualetti and Pijawka 1996). Other studies conclude that the negative impact on land value correlate to whether the property is within visual range of the plant, or to the distance from the nuclear plant (up to 97 km [60 mi]) (Folland and Hough 2000; Metz, et al. 1997). It should be noted that Folland and Hough based their study of negative externality effects on return on investment, rather than direct property values, and attempted to control various variables over broad geographical areas while noting that the geographic and market patterns used as the basis for their study did not necessarily control the individualities and idiosyncrasies of the geographical areas, such as terrain, farmland, farmers, and wholesalers (Folland and Hough 2000). In contrast, NEI has studied economic benefits of several nuclear plants (NEI 2006a), and found that property (housing) values are enhanced by the presence of nuclear plants, a conclusion that aligns with the GEIS and other studies (Bezdek and Wendling 2006; Clark, et al. 1997; Farrell and Hall 2004; Metz, et al. 1997; NEI 2003; NEI 2004a; NEI 2004b; NEI 2004c; NEI 2004d; NEI 2005a; NEI 2005b; NEI 2006b; NEI 2006c; NEI 2006d; NEI 2006e; NEI 2008).

4.17.2.4 Conclusion

Byron's property tax payments account for more than 20 percent of Ogle County's and the Byron Unit 226 School District's property tax levies, above the highest NRC significance level of 20 percent for taxes. As such, Byron has been and would likely continue to be a major source of tax revenue for both entities. Exelon Generation views the continued operation of Byron as a benefit to the taxing entities within Ogle County through direct and indirect salaries and tax contributions to the County's economy.

Despite Byron's presence, Ogle County's land use remains dominated by agriculture and land use changes have not been large. Most development over the last decade is attributed to the continued expansion of greater Chicago and has occurred in and around the county's existing municipalities. Byron's presence is not expected to directly attract any more industries and commercial development or to encourage or deter additional residential development. Because population growth related to the license renewal of Byron is expected to be small and there would be no new tax impacts to Ogle County land use, the renewal of Byron's licenses would continue to have a SMALL but beneficial impact on Ogle County. Therefore, mitigation would not be warranted.

Because population growth related to the license renewal of Byron (i.e., an assumption of 60 additional plant personnel) is expected to be less than 5 percent of the current and projected population for the study area, off-site land use changes would be SMALL.

Exelon Generation concludes, consistent with the GEIS, NEI, and the other studies cited above, that Byron's impacts on property values, if any, are positive, and that license renewal would not alter this status.

4.18 Transportation

4.18.1 Transportation - Refurbishment

NRC

The environmental report must "...assess the impact of highway traffic generated by the proposed project on the level of service of local highways during periods of license renewal refurbishment activities and during the term of the renewed license." 10 CFR 51.53(c)(3)(ii)(J)

"Transportation impacts…are generally expected to be of small significance. However, the increase in traffic associated with the additional workers and local road and traffic control conditions may lead to impacts of moderate or large significance at some sites." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 70

"Small impacts would be associated with a free flowing traffic stream where users are unaffected by the presence of other users (level of service A) or stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished (level of service B)." (NRC 1996b)

The NRC originally made impacts to transportation a Category 2 issue because impact significance is determined primarily by road conditions existing at the time of refurbishment, which the NRC could not, at the time of the original GEIS, forecast for all facilities (NRC 1996b). Information to be determined is: (1) level of service on affected roads, and (2) incremental increases in traffic associated with refurbishment activities and license renewal staff. . According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As discussed in Section 3.2, no refurbishment activities are necessary or planned during the Byron period of extended operation. However, for the purposes of this License Renewal Environmental Report, Exelon Generation is hypothetically assuming that replacement of the Unit 2 steam generators would occur during the license renewal term because, unlike the Byron Unit 1 steam generators, the Unit 2 steam generators have not been previously replaced. Therefore, the impact on transportation of refurbishment is an issue that hypothetically could apply to Byron.

In the 1996 GEIS, the NRC used the Transportation Research Board's level of service (LOS) definitions to assess significance levels of transportation impacts. LOS is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists (NRC 1996b). Section 2.9.2 presents employee access routes to Byron, and associated LOS estimates and AADT counts. As stated in Section 2.9.2, IDOT has indicated that the only locations that would be significantly affected by increases in employment at Byron are the intersections of German Church Road/IL 72/County Highway 33 and German Church Road/IL 64. Engineers have calculated LOS values for both locations and they are LOS B. IDOT predicts that an additional 300 southbound vehicles per hour on German Church Road would change its intersection with IL 64 LOS value to D, and that an additional 225 vehicles per hour on German Church Road would change its intersection with IL 72 to a LOS value to D. (McCormick 2012).

Exelon Generation estimates that during approximately 20 days of a 90-day outage, a peak number of approximately 500 supplemental workers divided between two shifts (250 per shift) would support refurbishment activities, and simultaneously, a peak number of approximately 1,400 supplemental workers (700 per shift) would support normal refueling and maintenance activities that would be occurring independent of the hypothetical refurbishment project. Impacts on area transportation of normal refueling and maintenance activities are evaluated in Section 14.8.2, and determined to be SMALL. Added impacts to area transportation during the 20 days of peak workforce overlap are evaluated here using the following assumptions: (1) all direct jobs would be filled by in-migrating temporary residents; (2) because the duration of the hypothetical refurbishment project would be short, no indirect jobs would be created, (3) the greatest percentage of refurbishment and refueling supplemental workers would reside temporarily in Ogle and Winnebago Counties, (4) each supplemental worker would represent one additional vehicle on area roadways, and (5) the refurbishment and refueling workforces would be split between two, 12-hour shifts, with the concluding shift workers leaving the site as the oncoming shift workers arrive to relieve them.

During the refurbishment/refueling outage, workers would park at Byron.

Most vehicles would approach the station through one of the two intersections at the ends of German Church Road. Exelon Generation reports that the majority of all workers approach the station from the north during normal operation and refueling outages. As described in Section 2.9.2, LOS at both intersections is LOS B. IDOT traffic engineers estimate that an increase of 225 vehicles per hour at the intersection of German Church Road and IL 72 and an increase of 300 vehicles per hour at the intersection of German Church Road and IL 64 would change the LOS at both intersections to D.

Conservatively assuming one worker per vehicle, 250 hypothetical refurbishment supplemental workers per shift would be added to 700 supplemental refueling workers per shift, yielding approximately 950 vehicles approaching Byron during the time before shift change, and approximately 950 vehicles leaving Byron during the time after shift change, with some overlap in the immediate vicinity of German Church Road during a short period surrounding the times of shift change. These vehicles would be in addition to vehicles driven by the full-time Byron Station workforce. This localized traffic increase would occur only on approximately 20 peak days during the one-time hypothetical refurbishment project. During the remaining 70 days of the 90-day hypothetical refurbishment project, when refueling was not occurring, the added traffic from the supplemental workforce would be below the level of a normal refueling outage, the impacts of which have been determined to be SMALL (see Section 4.18.2).

As stated in Section 2.9.2, during normal refueling outages, Byron opens both entrances to the plant to alleviate potential congestion. Additionally, Exelon Generation could enlist the support of local law enforcement officers to direct traffic during shift changes and other periods of high activity. Therefore, it is expected that, during the approximately 20 peak days of the one-time hypothetical refurbishment project, the impacts of the relatively small incremental increase in traffic volume beyond the increase associated with a normal refueling could be mitigated by staggering shift change times, encouraging carpooling, or requesting traffic control from law enforcement.

In conclusion, because of the short duration of the one-time hypothetical refurbishment project, and expected mitigation measures, increased traffic volumes would have little or no lasting impact. Therefore, the impact of the hypothetical refurbishment activities on the overall local transportation system would be SMALL and temporary. No impacts would warrant mitigation beyond that described here.

4.18.2 Transportation – License Renewal Term

NRC

> **The environmental report must "...assess the impact of highway traffic generated by the proposed project on the level of service of local highways during periods of license renewal refurbishment activities and during the term of the renewed license." 10 CFR 51.53(c)(3)(ii)(J)**
>
> **"Transportation impacts…are generally expected to be of small significance. However, the increase in traffic associated with the additional workers and local road and traffic control conditions may lead to impacts of moderate or large significance at some sites." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 70**
>
> **"Small impacts would be associated with a free flowing traffic stream where users are unaffected by the presence of other users (level of service A) or stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished (level of service B)." (NRC 1996b)**

The NRC made impacts to transportation a Category 2 issue because impact significance is determined primarily by road conditions existing at the time of the project, which the NRC could not forecast for all facilities (NRC 1996b). Local road conditions to be ascertained are: (1) level of service conditions, and (2) incremental increases in traffic associated with refurbishment activities and increased staff after license renewal. The discussion in this section focuses on impacts on transportation of increased staff after license renewal. . According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will re-categorize this issue from Category 2 to Category 1.

As stated in Section 3.4, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the Byron period of extended operation, it is conservatively assumed for the purpose of analyzing socioeconomic impacts in this report that 60 new permanent employees would be added.

In the GEIS, the NRC used the Transportation Research Board's level of service (LOS) definitions to assess significance levels of transportation impacts. LOS is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists (NRC 1996b). Section 2.9.2 presents employee access routes to Byron, and associated LOS estimates and AADT counts. As stated in Section 2.9.2, IDOT has indicated that the only locations that would be significantly affected by increases in employment at Byron are the intersections of German Church Road/IL 72/County Highway 33 and German Church Road/IL 64. The LOS value for both locations is LOS B. IDOT engineers predict that an additional 300 southbound vehicles per hour on German Church Road would change the LOS value of the intersection with IL 64 to LOS D and that an additional 225 vehicles per hour on German Church Road would change the LOS value of its intersection with IL 72 to LOS D (McCormick 2012).

The maximum impact to area transportation was analyzed using the following assumptions: (1) all direct jobs would be filled by in-migrating residents; (2) most indirect jobs would be service-related and filled by workers already residing within the 80-km (50-mi) radius; (3) the greatest percentage of the workers are expected to reside in Ogle, Lee, and Winnebago Counties, and (4) each new direct job created would represent one additional vehicle on the area roadways.

Exelon Generation conservatively estimates that approximately 60 new permanent workers would be added to the Byron workforce for the 20-year period of extended operation beginning in 2030. These workers would add 60 additional vehicles to the existing traffic streams entering and leaving the Byron site daily. However, this would not significantly alter the LOS values at either of the closest intersections to the site. Therefore, Exelon Generation concludes that impacts to the overall transportation system would be SMALL, and mitigation would not be warranted.

4.19 Historic and Archaeological Resources

NRC

The environmental report must "…assess whether any historic or archeological properties will be affected by the proposed project." 10 CFR 51.53(c)(3)(ii)(K)

"…Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 71

"…Sites are considered to have small impacts to historic and archeological resources if (1) the State Historic Preservation Officer (SHPO) identifies no significant resources on or near the site; or (2) the SHPO identifies (or has previously identified) significant historic resources but determines they would not be affected by plant refurbishment, transmission lines, and license-renewal-term operations and there are no complaints from the affected public about altered historic character; and (3) if the conditions associated with moderate impacts do not occur." (NRC 1996b, Section 3.7.7, pg. 3-23)

The NRC made impacts to historic and archaeological resources a Category 2 issue. Determinations of impacts to historic and archaeological resources are site-specific in nature and the National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Office (SHPO) (NRC 1996b). According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make no substantive change to this issue.

In the context of the National Historic Preservation Act, the NRC has determined that the area of potential effect (APE) for a license renewal action is the power plant site and its immediate environs which may be affected by post-license renewal land disturbing activities specifically related to license renewal, regardless of ownership or control of the land of interest. For Byron, the APE is assumed to also include the rights-of-way for the cooling tower makeup and blowdown lines and three transmission lines that are currently in service and were constructed for the purpose of connecting the main plant substations to the grid. ComEd now owns the transmission lines, and their continued future operation by ComEd is not directly related to whether or not the NRC renews the licenses for Byron Units 1 and 2.

Exelon Generation is not aware of any historic or archaeological resources that have been affected by Byron Station operations. Avoidance measures were developed and approved by the Illinois State Historic Preservation Office (SHPO) to ensure no negative effects occurred to previously recorded archaeological sites located on Byron Station and within the three transmission line ROWs during construction. Operation and maintenance of the station and associated transmission lines have not resulted in any negative impacts to previously recorded archaeological sites listed in Section 2.11. In addition, consideration of effects to cultural resources is part of ComEd's planning process for work to be done along the transmission lines. The Byron license renewal will not affect the operation and maintenance practices in the transmission line corridors. Therefore, license renewal will have no adverse effect on significant archaeological and historic resources in the transmission line rights-of-way. Exelon Generation assumes that ComEd will continue to protect such resources in the future, regardless of whether or not the NRC renews the licenses for Byron Units 1 and 2. Hence, license renewal will not adversely affect archaeological and historic resources in the transmission line rights-of-way.

Exelon Generation is evaluating hypothetical refurbishment in the form of steam generator replacement, which could involve construction of a steam generator storage facility on previously disturbed land. Therefore, the hypothetical construction, should it occur, would have no effect on cultural resources.

In addition, Exelon Generation is implementing specific procedures for protecting cultural resources from activities related to operation and maintenance at Byron, including a Cultural Resources Management Plan (CRMP) for the Byron site property and Exelon Generation-owned properties associated with the Byron cooling tower makeup and blowdown line right of way. Future land-disturbing activities on the properties would be done in a manner consistent with the provisions in the CRMP. The purpose of the CRMP is to manage known, potentially existing, or discovered archaeologically or historically significant cultural resources within Byron and adjacent Exelon Generation-owned land. The CRMP addresses possible impacts from land-disturbing or other activities that could introduce new noise, air, or visual element impacts to known cultural resources. A proposed activity that introduces a new noise, air, or visual element, which potentially could impact a culturally sensitive area is evaluated prior to disturbance. Appropriate measures are defined and implemented, including contact with SHPO, if appropriate, to protect the resource. Additional direction is provided to personnel performing a land-disturbing activity defining actions in the event that apparent cultural resources are discovered. Special protection measures are employed if there is a potential impact to any recorded archaeological site, following the consultation with SHPO. Therefore, Exelon Generation concludes that license renewal would not adversely affect archaeological or historic resources on the Byron property or Exelon Generation-owned properties associated with the Byron cooling tower makeup and blowdown line right-of-way, and no additional mitigation would be warranted.

Exelon Generation has initiated consultation with and has requested concurrence from the Illinois SHPO that operation of Byron during the license renewal term would have no effect on historic or archaeological resources. Copies of correspondence are presented in Appendix D.

4.20 SAMA Analysis

NRC

The environmental report must contain a consideration of alternatives to mitigate severe accidents "…if the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an environmental impact statement or related supplement or in an environment assessment..." 10 CFR 51.53(c)(3)(ii)(L)

"…The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to groundwater, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives…." 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 76

Section 4.20 summarizes an analysis of alternative ways to mitigate the impacts of severe accidents at Bryon. Appendix F provides a detailed description of the severe accident mitigation alternatives (SAMA) analysis.

The term "accident" refers to any unintentional event (i.e., outside the normal or expected plant operation envelope) that results in release or a potential for release of radioactive material to the environment. NRC categorizes accidents as "design basis" or "severe." Design basis accidents are those postulated accidents that, should they occur, NRC requires that the plant design and construction be robust enough to maintain systems, structures and components. Severe accidents are postulated accidents that may challenge safety systems (NRC 1996b).

NRC concluded in its license renewal rulemaking that the unmitigated environmental impacts from severe accidents met its Category 1 criteria. However, NRC made consideration of mitigation alternatives a Category 2 issue because not all plants had completed ongoing regulatory programs related to mitigation (e.g., individual plant examination for internally initiated events [IPE] and individual plant examination for externally initiated events [IPEEE]) (NRC 1996b). Site-specific information to be presented in the license renewal environmental report includes: (1) potential SAMAs; (2) benefits, costs, and net value of implementing potential SAMAs; and (3) sensitivity of analysis to changes in key underlying assumptions.

Exelon Generation maintains a probabilistic risk assessment (PRA) model to evaluate the most significant risks of radiological release from Bryon fuel into the reactor and from the reactor into the containment structure. The original Bryon IPE was submitted to the NRC in 1994 and subsequently updated and released as Revision 0 of the PRA in 1999. In order to maintain fidelity with the operating plant, to reflect the latest PRA technology, and to support application specific efforts, the PRA model was updated numerous times between 1999 and 2012. The most recent update was performed to upgrade the Large Early Release Frequency (LERF) model to a full Level 2 model to support the SAMA analysis.

For the SAMA analysis, Exelon Generation used the Bryon PRA model output as input to an NRC-approved consequence assessment code that calculates economic costs and dose to the public from hypothesized releases from the containment to the environment. This Level 3 PRA model uses the MELCOR Accident Consequences Code System Version 2 (MACCS2). MACCS2 requires certain site specific information, such as agricultural-based economic data, population estimates, and meteorological data, which are described in more detail in Appendix F. These inputs were developed using data in the 2007 National Census of Agriculture (USDA 2009) and from the Bureau of Economic Analysis (BEA 2012) for each of the 21 counties surrounding the plant, to a distance of 50 miles. Then, using the NRC regulatory analysis techniques documented in NUREG/BR-0184 (NRC 1997), Exelon Generation calculated the monetary value of the unmitigated Bryon severe accident risk. The result represents the monetary value of the baseline risk of dose to the public and workers, offsite and onsite economic costs, and replacement power cost. This value was used as a cost/benefit-screening tool for potential SAMAs; a SAMA whose cost of implementation exceeded the baseline cost-risk value was rejected as being not cost-beneficial for Bryon.

Bryon Units 1 and 2 are essentially identical in design and operation. Such differences that do exist are not believed to be significant from a risk perspective. Hence, the Unit 1 PRA model results employed to estimate the baseline cost-risk and the averted cost risk for each un-screened Unit 1 SAMA were assumed to be representative of the results that would be obtained from the Unit 2 PRA model. That is, if a particular SAMA proved cost beneficial for Unit 1, it was assumed to also be cost beneficial for Unit 2. The exception was for fire based SAMAs that were developed to mitigate unit-specific fires; the cost benefit calculations for those SAMAs required the use of unit-specific risk insights.

Exelon Generation used industry, NRC, and Bryon-specific information to create a list of 30 SAMAs for consideration. Exelon Generation analyzed this list to screen out any SAMAs that (1) would not apply to the Bryon design, (2) had already been implemented at Bryon, or (3) would achieve results that Exelon Generation had already achieved at Bryon by other means. None of the SAMAs were screened out based on these criteria. Therefore, Exelon Generation prepared cost estimates for implementing each of the 30 SAMAs and used the baseline cost-risk value to screen out SAMAs that would not be cost-beneficial to implement.

For each of the un-screened SAMAs, Exelon Generation calculated the cost-risk value for the plant configuration in which the SAMA was implemented. The difference between the baseline cost-risk value and the cost-risk value of the plant configuration in which the SAMA was implemented was defined as the “averted cost-risk”. The averted cost-risk represents the monetary the value of the risk reduction (the benefit) associated with implementing the SAMA. Exelon Generation then compared the benefit of each un-screened SAMA to its cost of implementation; SAMAs with benefits that exceeded their implementation costs were defined as “potentially cost-beneficial”.

Exelon Generation performed additional sensitivity analyses to evaluate how the SAMA analysis would change if certain key parameters were changed. The results of the sensitivity analyses are discussed in Appendix F.

Based on the results of this SAMA analysis, Exelon Generation identified 18 SAMAs for Bryon that have the potential to reduce plant risk and be cost-beneficial at the 95th percentile. None are related to managing the effects of plant aging during the period of extended operation. The potentially cost beneficial SAMAs have been submitted to the Bryon Plant Health Committee, which will consider them for implementation in accordance with an established plant procedural process.

4.21 Cumulative Impacts

According to SECY-12-0063, Enclosure 1, the final rule supported by the updated GEIS will make the consideration of cumulative impacts a new Category 2 issue. Applicants will be required to provide information about past, present, and reasonably foreseeable future actions occurring in the vicinity of the nuclear plant that may result in a cumulative effect.

In this section, past, present, and reasonably foreseeable future actions that are federally authorized or funded and will take place in the vicinity of Byron are identified and possible cumulative effects are discussed. For the purposes of this analysis, past and present actions include actions up to and including the time that the Byron license renewal application will be submitted to the NRC. Reasonably foreseeable future actions are those that are ongoing (and will continue into the future), are funded for future implementation, or are included in firm, near-term plans covering the 20-year period of extended operation. The geographic area affected by cumulative impacts depends on the resource being impacted (NRC 2009b).

Past, present and reasonably foreseeable actions may include individually minor but collectively significant actions taking place over a period of time because the SMALL impacts of minor actions, when considered in combination with the impacts of other actions on the affected resources, could result in MODERATE or LARGE cumulative impacts to the affected resource (NRC 2009b).

As indicated in Section 2.12, 30 major industrial facilities within the 80-km (50-mi) radius of Byron hold NPDES permits and 81 have air permits. Ogle County is recommended by IEPA as being designated as unclassifiable relative to air quality.

No nuclear power plants are within an 80-km (50-mi) radius of Byron. However, the 80-km (50-mi) radius for Byron intersects the 80-km (50-mi) radii for Braidwood, Dresden, LaSalle and Quad Cities Generating Stations, which are also nuclear power plants.

Apex Wind Energy is developing plans for a proposed wind farm near the Village of Adeline located near the northern boundary of Ogle County, IL and approximately 19 km (12 miles) northwest of Byron. The proposed wind farm will consist of 40 wind turbines and is expected to generate 80 megawatts of electrical energy. Project construction is expected to begin in 2013 (APEC 2012). The Apex Wind Farm is of interest to Byron license renewal because it would be located within Ogle County, could be operating before the end of the renewed license term, and would affect land use. The wind farm is not expected to employ a large workforce. So, cumulative impacts to socioeconomic resources from both projects would be SMALL. Because the large tax payments by Exelon Generation for Byron have historically had a SMALL impact on land use, the cumulative impacts of tax payments by Apex Wind Energy and Exelon Generation are expected to be SMALL.

The public groundwater well nearest to Byron is located 6.4 km (4 mi) away and is screened in the Mt. Simon aquifer. It is one of three wells serving the City of Byron. Several public wells and private wells are located closer to the plant but they are screened in shallower aquifers. The Rock River and its tributaries are not used for public water supply in Illinois. Hence, cumulative impacts to public water supply quantity and quality is expected to be SMALL.

Threatened or endangered species, critical habitats and cultural resources are protected by state and federal regulations. Therefore, impacts to those resources would be SMALL.

Because there are limited industrial facilities in the 80-km (50-mi) radius of Byron, and IEPA regulates emissions and discharges through permits, cumulative impacts from releases to air or water would be SMALL, and are expected to remain SMALL during the license renewal term.

Because no large project that would affect land use, or terrestrial or aquatic resources have been identified, cumulative impacts to land use, or aquatic and terrestrial resources, are expected to be SMALL and are expected to remain SMALL during the license renewal term.

Sections 2.6 through 2.9 describe the aspects of the region's socioeconomics that could be affected by renewal of the Byron operating licenses. Exelon Generation does not anticipate adding additional staff during the license renewal term, but the Environmental Report's analyses conservatively assumed an additional 60 staff could be added to implement aging management programs. Exelon Generation also evaluated the anticipated temporary workforce during refueling outages, and a hypothetical refurbishment in the form of Byron Unit 2 steam generator replacement. The analyses looked at impacts to housing, public water supply, transportation, and education (refurbishment only), and determined that all impacts would be SMALL. As previously noted, Ogle, Lee, and Winnebago Counties are planning for increased populations over the next 20 years. It is not possible to project where this growth will occur, however, because Ogle, Lee, and Winnebago Counties are high population areas with no growth control measures, it is expected that cumulative impacts to socioeconomic resources will remain SMALL throughout the license renewal term.

Radiological protection standards for the public and workers have been developed by EPA and implemented by NRC to address the cumulative impacts of acute and long-term exposure to radiation and radioactive material, regardless of the source or sources. These standards are codified in 10 CFR Part 20 and 40 CFR Part 190. Radiological impacts, which previously have been SMALL, will remain SMALL through the license renewal term.

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Chapter 5

Assessment of New and Significant Information

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5.1 Discussion

NRC

> **"…The environmental report must contain any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware." 10 CFR 51.53(c)(3)(iv)**

The NRC licenses the operation of domestic nuclear power plants and provides for license renewal, requiring a license renewal application that includes an environmental report (10 CFR 54.23). NRC regulations, 10 CFR Part 51, prescribe the environmental report content and identify the specific analyses the applicant must perform. In an effort to streamline the environmental review, NRC has resolved most of the environmental issues generically and requires only an applicant's analysis of the remaining issues.

While NRC regulations do not require an applicant's environmental report to contain analyses of the impacts of those Category 1 environmental issues that have been generically resolved [10 CFR 51.53(c)(3)(i)], the regulations do require that an applicant identify any new and significant information of which the applicant is aware [10 CFR 51.53(c)(3)(iv)]. The purpose of this requirement is to alert NRC staff to such information, so the staff can determine whether to seek the Commission's approval to waive or suspend application of the rule with respect to the affected generic analysis. NRC has explicitly indicated, however, that an applicant is not required to perform a site-specific validation of Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) conclusions (NRC 1996b).

Exelon Generation expects that new and significant information would include:

- Information that identifies a significant environmental issue not covered in the GEIS and consequently not codified in the regulation, or

- Information or circumstances exist that were not considered in the GEIS analyses and that lead to an impact finding that presents a seriously different picture of the environmental impact of the proposed project in comparison with what was previously envisioned .NRC has not provided specific criteria for evaluating whether new information or circumstances present a seriously different picture of environmental impacts than were previously envisioned, thus making them "significant." Therefore, for the purpose of its review, Exelon Generation used guidance available in Council on Environmental Quality (CEQ) regulations. The National Environmental Policy Act authorizes CEQ to establish implementing regulations for federal agency use. NRC requires license renewal applicants to provide NRC with input, in the form of an environmental report, that NRC will use to meet National Environmental Policy Act requirements as they apply to license renewal (10 CFR 51.10).

CEQ guidance provides that federal agencies should prepare environmental impact statements for actions that would significantly affect the environment (40 CFR 1502.3), focus on significant environmental issues (40 CFR 1502.1), and eliminate from detailed study issues that are not significant [40 CFR 1501.7(a)(3)]. The CEQ guidance includes a lengthy definition of "significantly" that requires consideration of the context of the action and the intensity or severity of the impact(s) (40 CFR 1508.27). Exelon Generation considered that MODERATE or LARGE impacts, as defined by NRC, would be seriously different than previously envisioned impacts. Chapter 4 presents the NRC definitions of SMALL, MODERATE, and LARGE impacts.

The new and significant assessment that Exelon Generation conducted during preparation of this license renewal application included: (1) interviews with Exelon Generation subject matter experts on the validity of the conclusions in the GEIS as they relate to Byron, (2) an extensive review of documents related to environmental issues at Byron and the Rock River (3) 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) credit for Exelon Generation environmental monitoring and reporting required by regulations and oversight of station facilities and operations by state and federal regulatory agencies (permanent activities that would bring significant issues to Exelon Generation's attention), and (5) review of previous license renewal applications for issues relevant to the Byron application.

5.2 Conclusion

In its entirety, Exelon Generation's assessment did not identify any new and significant information regarding the Byron environment or operations that would (1) make any generic conclusion codified by the NRC for Category 1 issues not applicable to Byron, (2) alter regulatory or GEIS statements regarding Category 2 issues, or (3) suggest any other measure of license renewal environmental impact not considered in the GEIS.

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Chapter 6

Summary of License Renewal Impacts and Mitigating Actions

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6.1 License Renewal Impacts

Exelon Generation has reviewed the environmental impacts of renewing the Byron operating licenses and has concluded that most impacts would be SMALL and would not require mitigation. During a hypothetical refurbishment, impacts to transportation could be MODERATE at several intersections near the plant; however, the impacts would be temporary and could be mitigated. This Environmental Report documents the basis for Exelon Generation's conclusions. Chapter 4 incorporates by reference the NRC's findings for the 59 license renewal Category 1 issues, including the 7 refurbishment Category 1 issues, identified in the 1996 GEIS and the 11 new Category 1 issues identified in the updated GEIS that apply to Byron, all of which have impacts that are SMALL (Appendix A, Tables A-1 and A-2). Chapter 4 also presents site-specific analyses for Byron of the Category 2 issues identified in the 1996 GEIS and the five new Category 2 issues identified in the updated GEIS, and concludes that such issues are either not applicable or have impacts that are SMALL.

Table 6.1-1 identifies the impacts that Byron's license renewal would have on resources associated with Category 2 issues identified in the 1996 GEIS and the updated GEIS.

Table 6.1-1 Environmental Impacts Related to License Renewal at Byron

1996 GIES No.	Updated GIES No.	Category 2 Issue	Environmental Impact
		Surface Water Quality, Hydrology, and Use (for all plants)	
13	17	Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	**SMALL**. Byron has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Rock River that is consistent with the intent of Executive Order 2006-1 water supply planning and management goals. The impacts of a hypothetical refurbishment also would be SMALL.
		Aquatic Ecology (for plants with once-through or cooling pond heat dissipation systems)	
25	36	Entrainment of fish and shellfish in early life stages	**NONE**. This issue does not apply because Byron does not use once-through or cooling pond heat dissipation systems.
26	36	Impingement of fish and shellfish	**NONE**. This issue does not apply because Byron does not use once-through or cooling pond heat dissipation systems.
27	39	Heat shock	**NONE**. This issue does not apply because Byron does not use once-through or cooling pond heat dissipation systems.
None	46	Water use conflicts with aquatic resources (plants with cooling ponds or cooling towers using makeup from a river)	**SMALL**. Byron has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Rock River. Therefore, withdrawals of surface water for the operation of Byron license renewal term on aquatic resources would be SMALL.
		Groundwater Use and Quality	
33	22	Groundwater use conflicts (potable and service water, and dewatering; plants that use > 100 gpm)	**SMALL**. Byron analyzed potential drawdown at the City of Byron's deep well from continuous and simultaneous pumping of the Station's two deep potable-water wells and determined that the maximum drawdown in the City of Byron's well from both site wells simultaneously withdrawing a maximum of 101 L/sec (1,600 gpm) over a 30-day period would be 1.8 m (6 ft). The actual expected drawdown would be less because average annual groundwater requirements for the plant's potable water supply is approximately 0.6 L/sec (10 gpm). The impacts of a hypothetical refurbishment also would be SMALL.
34	23	Groundwater use conflicts (plants using cooling towers or cooling ponds and withdrawing makeup water from a small river)	**SMALL**. Byron has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Rock River. The plant's net maximum makeup withdrawal rate of 1,250 to 1,500 L/sec (44 to 53 cfs) represents 6.5 to 7.8 percent of the river's low flow of 19,200 L/sec (679 cfs). The impacts of a hypothetical refurbishment also would be SMALL.

Table 6.1-1 Environmental Impacts Related to License Renewal at Byron (Continued)

1996 GIES No.	Updated GIES No.	Category 2 Issue	Environmental Impact
35	22	Groundwater use conflicts (Ranney wells)	**NONE**. This issue does not apply because Byron does not use Ranney wells.
39	26	Groundwater quality degradation (cooling ponds at inland sites)	**NONE**. This issue does not apply because Byron does not use cooling ponds.
None	27	Radionuclides released to groundwater	**SMALL.** Byron has remediated tritium concentrations in groundwater beneath the site and eliminated the source of the tritium. No off-site tritium exceeded EPA's safe drinking water limits, and Byron has implemented a Radiological Groundwater Protection Program which ensures the early detection of releases to groundwater.
		Terrestrial Resources	
40	28	Refurbishment impacts	**SMALL**. Any refurbishment activities would occur on previously disturbed areas, and would be short term and temporary.
None	33	Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	**SMALL**. Byron has an agreement with the Illinois DNR limiting the volume of water that can be withdrawn from the Rock River. Therefore, withdrawals of surface water for the operation of Byron license renewal term on terrestrial resources would be SMALL.
		Environmental Justice	
None	67	Minority and low-income population	**SMALL**. The impacts of the extended operation of Byron were determined to be SMALL for all issues Because SMALL impacts are not significant as defined by NEPA, no disproportionately high and adverse human health or environmental effects on low-income or minority populations would result from license renewal.
		Threatened or Endangered Species	
49	50	Threatened or endangered species	**Not likely to adversely affect any listed species**. Operational practices during the license renewal term will not be modified from current practices, which are protective of threatened or endangered species. Any hypothetical refurbishment activities would occur on previously disturbed land and would not affect threatened or endangered species and therefore, impacts of refurbishment would not be likely to affect any listed species.
		Air Quality	
50	5	Air quality during refurbishment (non-attainment and maintenance areas)	**SMALL**. Ogle County is designated as unclassifiable or an attainment area for all criteria pollutants. McHenry County, approximately 48 km (30 mi) northeast of Byron, is designated as a nonattainment area under the $PM_{2.5}$ and the 8-hour

Table 6.1-1 Environmental Impacts Related to License Renewal at Byron (Continued)

1996 GIES No.	Updated GIES No.	Category 2 Issue	Environmental Impact
			ozone NAAQS. Should Exelon Generation decide to conduct refurbishment, the duration of the project is estimated to be 90 days, and would require 500 workers. The project would use best management practices to minimize fugitive dust. The estimated daily commute by the refurbishment workforce is 1.2 percent of the total daily miles driven in Ogle County, and would not noticeably affect the air quality in the region.
		Human Health	
57	60	Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	**SMALL**. Discharges from the circulating water and service water systems are chlorinated. Blowdown to the Rock River meets Illinois water quality standards, including those for temperature. The highest blowdown temperature reported in recent years was 36°C (97°F), in August, 2009. Temperatures are too low to stimulate growth and reproduction of thermophilic organisms. The impacts of a hypothetical refurbishment also would be SMALL.
59	64	Electromagnetic fields, acute effects (electric shock)	**SMALL**. Exelon Generation calculations indicate that all lines are in compliance with the NESC limit on induced current.
		Socioeconomics	
63	55	Housing impacts	**SMALL**. Byron is in a high population area not subject to growth control measures which would limit housing development. The impacts of a hypothetical refurbishment also would be SMALL.
65	54	Public water supply: public utilities	**SMALL**. Byron gets its potable water from groundwater and has adequate capacity to support 60 additional license renewal term employees and the peak refurbishment workforce. Water suppliers in the three-county region have excess capacity. The addition of 192 people (60 employees and family members) would not adversely affect the available water supply. The refurbishment workforce would not affect the available public water supply so impacts would also be SMALL.
66	54	Public services: education (refurbishment)	**SMALL**. Refurbishment would require an approximately 90-day outage. The refurbishment workforce would not relocate their families for a project of such short duration.
68	2	Off-site land use (refurbishment)	**SMALL**. The refurbishment-related population increase would be less than 5 percent of the 80-km (50-mi) population and temporary. The region is characterized as having a high population density, and is not isolated.

Table 6.1-1 Environmental Impacts Related to License Renewal at Byron (Continued)

1996 GIES No.	Updated GIES No.	Category 2 Issue	Environmental Impact
69	2	Off-site land use (license renewal term)	**SMALL**. Byron has been and would likely continue to be a major source of tax revenue for both Ogle County and the Byron Community Unit School District No. 226. Ogle County, however, continues to be primarily rural and most development over the last decade is attributed to the continued expansion of the Chicago region. Because population growth related to the license renewal of Byron is expected to be small and there would be no new tax revenues to Ogle County, the renewal of Byron's license would continue to have a SMALL but beneficial impact on Ogle County.
70	56	Public services: transportation	**SMALL**. The addition of 60 permanent employees would not noticeably increase traffic or adversely affect level of service in the vicinity of Byron. Hypothetical refurbishment –related activities and refueling activities could cause temporary congestion at some intersections. All impacts could be mitigated with staggered shift changes and traffic control by law enforcement.
71	51	Historic and archaeological resources	**No adverse effects to archaeological or historic resources**. License renewal operations will not disturb undisturbed areas at Byron or along the transmission ROWs. Activities related to a hypothetical refurbishment would occur on previously disturbed land within the facility footprint, and measures are in place to protect historic or archaeological sites located on Byron property.
		Postulated Accidents	
76	66	Severe accidents	**SMALL**. Exelon Generation identified 18 SAMAs with the potential to reduce plant risk and be cost-beneficial at the 95th confidence percentile. None are related to managing the effects of aging during the period of extended operations. All have been submitted to the Byron Plant Health Committee for review and evaluation, in accordance with an established procedure.
		Cumulative Impacts	
NA	73	Cumulative Impacts	**SMALL.** Evaluations of the historic impacts to the Rock River, groundwater, air, threatened or endangered species, critical habitats, cultural resources, socioeconomics and radiological doses concluded that all impacts from Byron are SMALL. Byron operations will not change during the license renewal terms. Radiological doses are limited by regulation. Threatened and endangered species and cultural resources are protected by state and

Table 6.1-1 Environmental Impacts Related to License Renewal at Byron (Continued)

1996 GIES No.	Updated GIES No.	Category 2 Issue	Environmental Impact
			federal regulations. The region expects some growth during the license renewal term and is planning for the growth. No large projects that would adversely affect these resources were identified.

6.2 Mitigation

NRC

> **"The report must contain a consideration of alternatives for reducing adverse impacts… for all Category 2 license renewal issues…" 10 CFR 51.53(c)(3)(iii)**
>
> **"The environmental report must include an analysis that considers and balances… alternatives available for reducing or avoiding adverse environmental effects…" 10 CFR 51.45(c) as incorporated by 10 CFR 51.53(c)(2) and 10 CFR 51.45(c)**

Impacts of license renewal activities have been determined to be SMALL. Threatened or endangered species were determined to be not likely affected by license renewal activities. Impacts of license renewal activities were determined to have no adverse effect on cultural resources.

Current mitigation measures include monitoring that would continue during the license renewal term. Exelon Generation performs routine monitoring to ensure the safety of workers, the public, and the environment. These activities include the gaseous and liquid radiological environmental monitoring program, radiological groundwater protection program, and the NPDES permit effluent monitoring. These monitoring programs ensure that the station's permitted emissions and discharges are within regulatory limits and that any unusual or off-normal emissions would be quickly detected, allowing for mitigation of potential impacts. Transmission line ROW maintenance incorporates best management practices to ensure the protection of critical habitats and protected resources.

In 2006, Byron identified tritium in groundwater and implemented a radiological groundwater protection program. The radiological groundwater protection program is discussed in Section 2.3.4.1.

This Environmental Report identified no additional mitigation measures beyond those described here that are sufficiently beneficial to be warranted.

6.3 Unavoidable Adverse Impacts

NRC

> **The environmental report shall discuss any "...adverse environmental effects which cannot be avoided should the proposal be implemented..." 10 CFR 51.45(b)(2) as adopted by 10 CFR 51.53(c)(2)**

This Environmental Report adopts by reference the NRC findings for applicable Category 1 issues, including discussions of any unavoidable adverse impacts (Appendix A, Tables A-1 and A-2). Exelon Generation examined 21 Category 2 issues in the 1996 GEIS and five new Category 2 issues identified in the updated GEIS to assess site-specific impacts. Exelon identified the following unavoidable adverse impacts of license renewal and hypothetical refurbishment activities:

- Solid radioactive wastes are a product of plant operations and permanent disposal is necessary.
- Procedures for the disposal of nonradioactive and radioactive wastes are intended to reduce adverse impacts from these sources to acceptably low levels. A small impact will occur as long as the plant is in operation.
- Operation of Byron results in a very small increase in radioactivity in the air and water. Based on data collected since initial operation, the increase is less than the fluctuation in natural background levels and is expected to remain so over the renewal period. Operation of Byron also creates a very low probability of accidental radiation exposure to inhabitants of the area.
- Operation of Byron results in consumptive use of groundwater and surface water.
- Loss of small numbers of adult and juvenile fish impinged on the traveling screens at the intake structure on the Rock River.
- Loss of small numbers of larval fish and shellfish entrained at the intake structure on the Rock River.

6.4 Irreversible and Irretrievable Resource Commitments

NRC

> **The environmental report shall discuss any "...irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." 10 CFR 51.45(b)(5) as adopted by 10 CFR 51.53(c)(2)**

Continued operation of Byron for the license renewal term will result in irreversible and irretrievable resource commitments, including the following:

- Nuclear fuel, which is used in the reactor and is converted to radioactive waste;
- Land required to permanently store or dispose offsite the following: spent nuclear fuel, low-level radioactive wastes generated as a result of plant operations, and nonradioactive industrial wastes generated from normal industrial operations;
- Elemental materials that will become radioactive; and
- Materials used for the normal industrial operations of the station that cannot be recovered or recycled or that are consumed or reduced to unrecoverable forms.

6.5 Short-Term Use Versus Long-Term Productivity of the Environment

NRC

> **The environmental report shall discuss the "...relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity..." 10 CFR 51.45(b)(4) as adopted by 10 CFR 51.53(c)(2)**

The current balance between short-term use and long-term productivity at Byron was established with the decision to convert approximately 721 ha (1,782 ac) to energy production. The Final Environmental Statements (FESs) related to construction (AEC 1974) and operation (NRC 1982) evaluated the impacts of constructing and operating Byron. Natural resources that would be subjected to short-term use include land and water. Land in the immediate vicinity of Byron is largely rural and agricultural. Approximately 490 ha (1,210 ac) of transmission ROW are associated with Byron.

As discussed in Section 4.1, Byron consumes water from the Rock River at a net consumptive loss rate of 1,250 to 1,500 L/sec (44 to 53 cfs) which represents 0.73 to 0.88 percent of the river's annual mean flow at the intake. Byron withdraws approximately 2,562,000 L/day (676,800 gpd) of groundwater from the Ironton-Galesville and Mt. Simon aquifers. Tritium from faulty blowdown line valves contaminated the shallow groundwater beneath Byron. An approved Consent Order, was implemented and ended according to its terms following 12 months of continuous compliance. Monitoring at two wells along the blowdown pipeline has shown a decreasing trend in tritium concentrations. Impacts to surface and groundwater are minor and would cease once the reactors operations, including decommissioning, cease.

After decommissioning the nuclear facilities at the site, most environmental disturbances would cease and restoration of the natural habitat could occur. Thus, the "trade-off" between the production of electricity and changes in the local environment is reversible to some extent.

Experience with other experimental, developmental, and commercial nuclear plants has demonstrated the feasibility of decommissioning and dismantling such plants sufficiently to restore a site to its former use. The degree of dismantlement will take into account the intended new use of the site and a balance among health and safety considerations, salvage values, and environmental impacts. However, decisions on the ultimate disposition of these lands have not yet been made. Continued operation for an additional 20 years would not increase the short-term productivity impacts described here.

Chapter 7

Alternatives to the Proposed Action

Byron Station Environmental Report

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7.0 Alternatives to the Proposed Action

NRC

The environmental report shall discuss "Alternatives to the proposed action…" 10 CFR 51.45(b)(3), as adopted by reference at 10 CFR 51.53(c)(2).

"...The report is not required to include discussion of need for power or economic costs and benefits of ... alternatives to the proposed action except insofar as such costs and benefits are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation...." 10 CFR 51.53(c)(2).

"While many methods are available for generating electricity, and a huge number of combinations or mixes can be assimilated to meet a defined generating requirement, such expansive consideration would be too unwieldy to perform given the purposes of this analysis. Therefore, NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources and only electric generation sources that are technically feasible and commercially viable…" (NRC 1996b).

"…The consideration of alternative energy sources in individual license renewal reviews will consider those alternatives that are reasonable for the region, including power purchases from outside the applicant's service area...." (NRC 1996d)

Chapter 7 evaluates alternatives to Byron Station, Units 1 and 2 (Byron) license renewal. The chapter identifies actions that Exelon Generation might take, and associated environmental impacts, if the NRC does not renew the Byron operating licenses. The chapter also addresses actions that Exelon Generation has considered, but would not take, and discusses the bases for determining that such actions would be unreasonable.

In considering the level of detail and analysis that it should provide for each alternative, Exelon Generation relied on the NRC decision-making standard for license renewal: "…the NRC staff, adjudicatory officers, and Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decision makers would be unreasonable" [10 Code of Federal Regulations (CFR) 51.95(c)(4)].

Exelon Generation has determined that the Environmental Report would support NRC decision-making as long as the document provides sufficient information to clearly indicate whether an alternative would have a smaller, comparable, or greater environmental impact than the proposed action. Providing additional detail or analysis serves no function if it only brings to light additional adverse impacts of alternatives to license renewal. This approach is consistent with regulations of the Council on Environmental Quality (CEQ), which provide that the consideration of alternatives (including the proposed action) should enable reviewers to evaluate their comparative merits (40 CFR Parts 1500-1508). Chapter 7 therefore provides sufficient detail about alternatives to establish the basis for necessary comparisons to the Chapter 4 discussion of impacts from the proposed action. In characterizing environmental impacts from alternatives, this section uses the same definitions of SMALL, MODERATE, and LARGE as those presented in Section 4.0.1.

7.1 No-Action Alternative

The "no-action alternative" refers to a scenario in which the NRC does not renew the Byron operating licenses. Unlike the proposed action, denying license renewal does not expressly provide a means of meeting future electric system needs. Therefore, unless replacement generating capacity is provided as part of the no-action alternative, a large amount of base-load generation would no longer be available, and the alternative would not satisfy the purpose and need for the proposed action. For this reason, the no-action alternative is defined as having two components—replacing the generating capacity of Byron and decommissioning the Byron facility, as described below.

In 2010, Byron provided approximately 20 terawatt-hours of electricity (EIA 2012a) as base-load power to residents and other consumers in the Midwest region. Replacement power could be provided by (1) building new base-load generating capacity using energy from coal, gas, nuclear, wind, solar, other sources, or some combination of these, (2) purchasing power from the wholesale market, or (3) reducing power requirements through demand side reduction. Section 7.2.1 describes each of these possibilities in detail, and Section 7.2.2 describes environmental impacts from alternatives deemed reasonable.

The GEIS (NRC 1996b) defines decommissioning as the safe removal of a nuclear facility from service and the reduction of residual radioactivity to a level that permits termination of the license and release of the property for unrestricted use. The NRC-evaluated decommissioning options include immediate decontamination and dismantlement and safe storage of the stabilized and defueled facility for a period of time, followed by additional decontamination and dismantlement. Regardless of the option chosen, decommissioning must be completed within the 60-year period following permanent cessation of operations and permanent removal of fuel. Under the no-action alternative, Exelon Generation would continue operating Byron until the existing licenses expire, and then initiate decommissioning activities for both units in accordance with the NRC requirements. The GEIS describes decommissioning activities based on an evaluation of the equivalently sized 1,175 megawatt-electric (MWe) Trojan Nuclear Plant (the "reference" pressurized-water reactor). Byron Units 1 and 2 are conservatively assumed throughout this environmental report to operate with measurement uncertainty recapture (MUR) at an approximate annual average net output of 2,394 MWe, or the equivalent of two Trojan plants; this description is applicable to decommissioning activities that Exelon Generation would conduct for each Byron unit.

As the GEIS notes, the NRC has evaluated environmental impacts from decommissioning. NRC-evaluated impacts include those to occupational and public radiation dose, waste management, air and water quality, and ecological, economic, and socioeconomic issues. The NRC indicated in the Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities; Supplement 1 (NRC 2002) that the environmental effects of greatest concern (i.e., radiation dose and releases to the environment) are substantially less than the same effects resulting from reactor operations. Exelon Generation adopts by reference the NRC conclusions regarding environmental impacts of decommissioning for both units.

Exelon Generation notes that decommissioning activities and their impacts are not discriminators between the proposed action and the no-action alternative. Byron will have to be decommissioned regardless of the NRC decision on license renewal; license renewal would only postpone decommissioning for another 20 years. The NRC has established in the GEIS that the timing of decommissioning operations does not substantially influence the environmental impacts of decommissioning. Exelon Generation adopts by reference the NRC findings (10 CFR Part 51, Subpart A, Appendix B, Table B-1) to the effect that delaying decommissioning until after the end of the renewal term would have little effect on environmental impacts. The discriminators between the proposed action and the no-action alternative lay in the choice of generation replacement options that would be part of the no action alternative. Section 7.2.2 analyzes the impacts from these options.

Exelon Generation concludes that the decommissioning impacts under the no-action alternative would not be substantially different from those occurring following license renewal, as identified in the GEIS (NRC 1996b) and in the decommissioning generic environmental impact statement (NRC 2002). These impacts would be temporary and would occur at the same time as the impacts from meeting system generating needs.

7.2 Alternatives that Meet System Generating Needs

Byron has an approximate annual average net capacity of 2,336 MWe (Exelon Nuclear 2011f), but for the purpose of this analysis, Exelon projects that Byron will increase its approximate annual net mean generation by 34 MWe in the future to a total of 2,370 MWe. Byron generated approximately 19.9 terawatt-hours of base-load power in 2010 (EIA 2012a), and 19.7 terawatt-hours of base-load power in 2009 (EIA 2012a). Byron is considered a base-load generation station based on, for example, its 2010 capacity factor of approximately 97 percent (Exelon Nuclear Undated). This base-load power is sufficient to supply the electricity used by over 2,000,000 homes (Exelon Nuclear Undated), and would be unavailable to customers in the event the Byron operating licenses are not renewed.

The electricity consumed in Illinois is not limited to that generated within the state. Northern Illinois relies on electricity from Commonwealth Edison Company (ComEd), an Exelon-owned energy delivery company that provides service to approximately 3.8 million customers, or 70 percent of the state's population ComEd 2012). ComEd is the Illinois-based control zone of the PJM Interconnection, a regional network that coordinates the movement of wholesale electricity. PJM Interconnection is made up of all or most of Delaware, the District of Columbia, Maryland, New Jersey, Ohio, Pennsylvania, Virginia, and West Virginia and parts of Indiana, Illinois, Kentucky, Michigan, North Carolina, and Tennessee. The four fifths of southern Illinois that are not part of the PJM Interconnection and the surrounding states are part of Midwest Independent Transmission System Operator (Midwest ISO). Midwest ISO is made up of all or most of North Dakota, South Dakota, Nebraska, Minnesota, Iowa, Wisconsin, Illinois, Indiana, Michigan and parts of Montana, Missouri, Kentucky, and Ohio. Exelon Generation assumed that the region of interest (ROI) for purposes of this alternatives analysis includes the states of Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin which are the states within the PJM Interconnection and Midwest ISO networks that are geographically closest to Byron.

The current power generation options in the ROI are indicators of what have been considered to be feasible technologies for generating electricity within the area serviced by Byron. In 2010, the ROI's electricity industry had a total generating capacity of 153,230 MWe. This capacity included units fueled by coal (48 percent), natural gas (29 percent), nuclear (12 percent), renewables and other sources (6.4 percent), petroleum (3.4 percent), and hydroelectric (1.0 percent) (EIA 2012b). In 2010, electricity generators provided 652 terawatt-hours of electricity to the ROI. The fuel sources used to produce this electricity were dominated by coal (66 percent), followed by nuclear (23 percent), natural gas (5.5 percent), renewables and other sources (4.2 percent), hydroelectric (1.0 percent), and petroleum (0.25 percent) (EIA 2012b). Figure 7.2-1 and Figure 7.2-2, respectively, illustrate the distribution of fuel types contributing to the 2010 installed generating capacity and the electricity production of the ROI.

Comparing the fuel types of generating capacity with the fuel types actually utilized for electricity production indicates that generating units fueled by nuclear and coal are used by the ROI substantially more relative to their installed capacity than either oil-fired or gas-fired generation. This condition reflects the relatively low fuel cost and baseload suitability for nuclear and coal-fired power plants, and the relatively limited use of gas- and oil-fired units to meet peak loads. Comparison of installed capacity and energy production for oil- and gas-fired facilities indicates a strong preference for gas firing over oil firing, indicative of the higher cost and greater air pollutant emissions associated with oil firing. Energy production from hydroelectric sources is preferred from a cost standpoint over production from plants fueled by nuclear and any of the three fossil fuels, but hydroelectric capacity is limited and utilization can vary substantially depending on water availability.

7.2.1 Alternatives Considered

<u>Technology Choices</u>

For the purposes of this Environmental Report, alternative generating technologies were evaluated to identify candidate technologies that would be capable of replacing the Byron annual average base-load capacity, including MUR, of approximately 2,340 MWe by the end of the first licensed unit's term in 2024. Exelon Generation accounted for the fact that Byron is a base-load generator and that any reasonable alternative to Byron would also need to be able to generate base-load power. Exelon Generation assumed that the ROI for purposes of this alternatives analysis includes the states of Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin which are the states within the PJM Interconnection and Midwest ISO networks that are geographically closest to Byron.

For the purposes of this Environmental Report, Exelon Generation has limited analysis of impacts from new generating plant technology alternatives to the technologies it deems reasonable or potentially reasonable by 2024: new nuclear generation, pulverized coal- and gas-fired generation, wind generation, solar generation, and combinations of these technologies. The generation information presented above, which identifies coal as the most heavily used non-nuclear generating fuel type in the ROI, supports consideration of a coal-fired alternative. The gas-fired technology alternative that Exelon Generation has chosen to evaluate is the combined-cycle (combustion and steam) turbine rather than the simple-cycle (combustion-only) turbine. The combined-cycle option is more efficient and economical to operate because it uses the heated exhaust of the combustion turbines to produce steam in Heat Recovery Steam Generators (HRSGs), which is then used in the steam turbines to generate additional power. The benefits of lower operating costs for the combined-cycle option outweigh its higher capital costs. Exelon Generation assumes the use of natural gas as the primary fuel in combined-cycle combustion turbines because of the economic and environmental advantages of natural gas over oil and other types of gas. Manufacturers now have large standard sized combined-cycle turbines that are economically attractive and suitable for high-capacity base-load operation.

The ROI has 13 nuclear sites containing 20 of the nation's 104 operating nuclear reactors. Illinois has more nuclear plants than any other U.S. state with 6 nuclear sites and 11 reactors. Approximately 19 percent of the nation's nuclear capacity is within the ROI, and more than 11 percent is within Illinois (EIA 2012a). Recently, members of both industry and government have expressed interest in the development of nuclear power plants to provide new base-load generating capacity. Beginning in 2007, several utilities submitted applications for combined construction and operating licenses (COLs) for new nuclear generating units. In February, 2012, the NRC granted Southern Company COLs to build and operate two nuclear reactors at Vogtle Electric Generating Plant, near Waynesboro, Georgia (SNC 2012) and in March, 2012, the NRC granted SCE&G COLs to construct and operate two nuclear reactors at the V. C. Summer Nuclear Station in South Carolina (SCE&G 2012). In light of this, Exelon Generation believes construction of new nuclear capacity within the ROI is a reasonable base-load generation alternative to license renewal for the Byron units. However, in 1987 Illinois issued a moratorium on new nuclear plant construction (220 ILCS 5/8-406(c)). Accordingly, construction in Illinois could not be considered unless the state lifted the ban.

Exelon Generation assumes that provision of wind-generated electricity in the ROI is likely to include both land-based and offshore plants. Two solar technologies have emerged as possible candidates for centralized electricity generation—photovoltaic (PV), and concentrating solar power (CSP) systems. While obstacles exist to the use of wind and solar energy technologies for base-load electrical capacity in the amount that would be needed to replace the Byron units, Exelon Generation assumes that future technological advances may occur such that pure wind generation and pure solar generation could, by 2024, become reasonable base-load generation alternatives to Byron license renewal.

Currently, however, the intermittent nature of both wind and solar generation creates grid-reliability issues that make both energy sources unsuitable for base-load generation unless they are combined with some method of capacity firming. For this reason, Exelon Generation assumes that wind- or solar-generation facilities in combination with capacity-firming methods would also be reasonable alternatives to Byron license renewal. Methods for providing firming capacity involve combining wind or solar energy with another electrical power source capable of providing electrical output when the wind or solar energy source is not available. Thereby, reliability of the electrical grid system is maintained. In addition to traditional fossil-fuel-fired generating units, suggested firming capacity sources include compressed air energy storage (CAES), high energy batteries, pumped hydro storage (PHS), and interconnected wind farms. Traditional fossil-fuel-fired generation options are described in Section 7.2.11. The other sources of firming capacity are described below along with discussions of whether or not Exelon Generation considers them reasonable capacity firming methods for purposes of Byron license renewal.

Firming Capacity Methods

Compressed Air Energy Storage

CAES is a hybrid generation/storage technology with potential for balancing the electrical output from renewable energy power generators to improve their suitability for providing base-load capability. CAES systems are based on conventional gas turbine technology and use the potential energy of compressed air. As of 2010, worldwide installations total 440 MWe (EPRI 2010). Energy would be stored by using wind-generated power to compress air either in an airtight underground storage cavern, a surface vessel, or a surface piping system. A principal method to extract the stored energy uses compressed air drawn from the storage vessel, heated, and then expanded through a high-pressure turbine that captures some of the energy in the compressed air. The air would then be mixed with fuel and combusted, with the exhaust expanded through a low-pressure gas turbine. The turbines would be connected to an electrical generator. As part of a base-load renewable energy generation system, CAES would enable a nearly constant output by smoothing the highly variable output from the renewable energy generator. CAES is considered a hybrid generation/storage system because it requires combustion in the gas turbine. The primary disadvantages of CAES are the need for an underground cavern and its reliance on fossil fuels. Assessments of this concept by the National Renewable Energy Laboratory (NREL) included a combination of 2,000 MWe of wind generation with 900 MWe of CAES generation to produce a nearly constant 900 MWe output (NREL 2006). The largest commercial CAES that has been proposed is an 800 MWe (with a potential expansion to 2,700 MWe) plant planned for construction in Norton, Ohio. This nine-unit plant will compress air to 1,500 pounds per square inch (psi) in an existing limestone mine some 671 m (2,200 ft) underground (UTA 2009). The current estimated cost of such a facility is in the range of $650 per kilowatt hour (kWh) with energy conversion efficiency in the range of 80 percent (PEI 2008). Although site-specific investigations would be needed to determine whether a suitable geologic formation is available to accommodate CAES in the ROI, it is assumed for the purposes of this environmental report that, if costs are ignored, a suitable geologic formation might be available; thus, a combination of wind generation with CAES is analyzed as a hypothetical reasonable alternative to renewal of the Byron operating licenses.

High-Energy Batteries

High-energy batteries can generally provide rapid response, which means that batteries designed for energy management can potentially provide services over all the durations required. Several battery technologies have been demonstrated or deployed for energy management applications. The commercially available batteries targeted to energy management include two general types: high-temperature batteries and liquid-electrolyte-flow batteries. The most mature high-temperature battery as of 2010 is the sodium-sulfur battery, which has a worldwide installation that exceeds 316 MWe (EPRI 2010). Alternative high-temperature chemistries have been proposed and are in various stages of development and commercialization. One example is the sodium-nickel chloride ("ZEBRA") battery. The second type of high-energy battery is the liquid-electrolyte-flow battery which consists of a liquid electrolyte flowing across a membrane. As of 2009, there was limited deployment of two types of flow batteries: vanadium redox and zinc-bromine. Other chemical combinations such as polysulfide-bromine have been pursued, and new chemistries are under development. In the US, a primary application of energy-management batteries has been transmission and distribution deferral. Demonstration projects have been deployed for various other applications, but, there are no current applications or demonstration studies of battery storage systems that approach the reserve capacity required for balancing the output from a wind or solar generation power plant of the size necessary to replace the Byron approximate annual average net base-load generating capacity, including MUR, of 2,370 MWe (EPRI 2010). Because this method for balancing intermittent output from large wind and solar generation facilities has not been demonstrated, Exelon Generation does not consider it to be a reasonable firming capacity method and, thus, impacts of combining it with wind or solar generation are not evaluated further.

Pumped Hydro Storage (PHS)

PHS is the only energy storage technology deployed on a gigawatt (GW) scale in the US and worldwide. In the US, about 20 GW is deployed across 39 sites, and installations range in capacity from less than 50 MWe to 2,100 MWe. The ROI has 2,529 MWe capacity in pumped storage (EIA 2012b). Many of the sites store sufficient water for 10 hours or more of discharge, making the technology useful for supplementing wind or solar energy. PHS uses conventional pumps and turbines and requires a significant amount of land and water for the upper and lower reservoirs. PHS plants can achieve round-trip efficiencies that exceed 75 percent and may have discharge capacities that exceed 20 hours. Environmental regulations may limit large-scale above-ground PHS development. However, given the high round-trip efficiencies, proven technology, and low cost compared to most alternatives, conventional PHS is still being pursued in a number of locations (NREL 2010a). A PHS station costs in excess of $1,500/kW and the overall losses are about 20 percent (EPRI 2010). The ideal operating head is between 500 and 700 m (1,500 and 2,200 ft) of elevation (NWW 2009). The environmental impact of large-scale PHS facilities is becoming an issue, especially where pre-existing reservoirs are not available and sites with large, naturally occurring reservoirs at sufficiently large differential elevations where environmentally benign, inexpensive PHS facilities can be built are increasingly rare (PEI 2008). The feasibility of implementing PHS in the ROI would depend on availability of a suitable water reservoir, which would require detailed site-specific investigation. Because this method for balancing intermittent output from wind and solar generation facilities would be very resource- and capital-intensive, involving construction of a reservoir at an as-yet unidentified location in proximity to a site suitable for wind or solar generation, Exelon Generation does not consider PHS to be a reasonable firming capacity method compared with other available methods. Accordingly, impacts of combining it with wind or solar generation are not evaluated further.

Interconnecting Wind Farms

The concept of developing base-load wind energy by interconnecting wind farms through the transmission grid postulates that, if wind farms are interconnected in an array, wind speed correlation among sites decreases and so does the probability that all sites experience the same wind regime at the same time. As the array size increases, therefore, it behaves more and more like a single wind farm with steady wind speed and, thus, steady deliverable wind power.

One study (Archer and Jacobson 2007) used hourly and daily averaged wind speed measurements from 19 airports in the Texas, New Mexico, Oklahoma, and Kansas to estimate generation duration curves and operational statistics of wind power arrays. Archer and Jacobson (Archer and Jacobson 2007) found that "an average of 33 percent and a maximum of 47 percent of yearly averaged wind power from interconnected farms can be used as reliable, baseload electric power." The area of interest the authors chose for their wind model (the lower Midwestern states) is one of the best locations in the country for harnessing wind energy. Wind farms in the ROI, with the possible exception of western Iowa, would be located where conditions are not as favorable. The authors used capacity factor as an indicator of reliability, but capacity factor and reliability are two separate and distinct parameters. During a scheduled outage of a conventional power plant, the power output is guaranteed to be zero; there is no uncertainty. Maintenance outages scheduled long in advance reduce a plant's capacity factor, not its reliability. Archer and Jacobson (Archer and Jacobson 2007) compare the scheduled down time of conventional power plants with the unscheduled unpredictable downtime of wind power. This comparison demonstrates that wind farms, even when interconnected in an array, are not as reliable as conventional power plants.

Another study (Katzenstein, et al. 2010) used output data from 20 wind plants within the Electric Reliability Council of Texas (ERCOT) region, and wind speed data to analyze the geographic smoothing of wind power's variability. The Katzenstein et al. study also used data from 19 Bonneville Power Authority (BPA) wind farms to determine if results similar to the ERCOT results could be expected from another system. Katzenstein et al. (Katzenstein, et al. 2010) determined that the variability of interconnected wind plants is less than that of individual wind plants and the variability diminishes as more wind plants are interconnected. The Katzenstein et al. study concluded that "these results do not indicate that wind power can provide substantial base-load power simply through interconnecting wind plants. ERCOT's generation duration curve shows wind power reliably provides 3 - 10 percent of installed capacity as firm power; while BPA's generation duration curve shows 0.5 - 3 percent of its wind power is firm power. The frequency domain analyses have shown that the power of interconnected wind plants will vary significantly from day to day and the results of the step change analyses show day-to-day fluctuations can be 75 to 85 percent of the maximum power produced by a wind plant" (Katzenstein, et al. 2010, page 10). Based on this discussion, Exelon Generation believes that interconnected wind farms have some advantages over a single large-scale wind farm, but the predicted low capacity factor and reliability combined with the likely need of extensive right-of-way acquisition and transmission line construction at significant costs, makes interconnected wind farms not a reasonable firming capacity method at this time.

Effects of Restructuring

Nationally, the electric power industry has been undergoing a transition from a regulated industry to a competitive market environment. Efforts to deregulate the electric utility industry began with passage of the National Energy Policy Act of 1992. Provisions of this act required electric utilities to allow open access to their transmission lines and encouraged development of a competitive wholesale market for electricity. The Act did not mandate competition in the retail market, leaving that decision to the states (EIA 2010a). In 1997 and 2000, Illinois and Michigan transitioned to competitive wholesale and retail markets, respectively. The other states in the ROI have not restructured their retail energy markets.

In 1997, Illinois state lawmakers passed the Illinois Electric Service Customer Choice and Rate Relief Law, which deregulated the state's two biggest electricity utilities — Ameren Illinois Utilities (AIU), formerly Illinois Power Co. et al., and ComEd — and gave customers the ability to purchase electricity from alternative retail electric suppliers (ARES) that had been approved to do business in the state (EIA 2009). In the decade between 1997 and 2007, called the Mandatory Transition Period, ARES served mostly large commercial and industrial customers. Residential and small business customers generally remained with their utility, primarily because after residential rate decreases were implemented it was less expensive to stay with their original utility. The price of electricity was ultimately decreased by 20 percent and frozen. During the Mandatory Transition Period, utilities were required to sell their electricity generation assets to affiliated and unaffiliated energy companies and became companies that only delivered electricity (ICC 2009).

In 2006, the General Assembly helped the state's many ARES to begin serving residential and small business customers by passing the Retail Electric Competition Act. The act established the Office of Retail Market Development, removed certain barriers to competition, and encouraged residential and small business customers to switch to an alternative electric provider by promoting temporary, fixed-discount programs (ICC 2009).

When rate caps expired on Jan. 1, 2007, the cost of electricity in Illinois increase significantly. While residential customers saved an estimated $5.2 billion between 1998 and 2006 because of the rate caps, they were insulated from wholesale price increases during that time (ICC 2009). The resulting price shock from the inevitable price increases once the rate caps expired led to significant criticism of, and amendments to, the Customer Choice Act. In the summer of 2007, the state's General Assembly passed the Illinois Power Agency Act, which created the Illinois Power Agency and provided over $1 billion in new electricity rate relief over 4 years to residential and certain commercial customers (ICC 2009). By 2011, there were 54 companies statewide certified as an ARES through the Illinois Commerce Commission (ICC 2011). Of those, 22 have obtained Illinois Commerce Commission certification and registration to serve residential customers. However, in order to offer retail electric services in Illinois, suppliers must also register with the electric utility and complete certain technical testing. Eighteen suppliers have completed the registration process with the AIU territory and 17 of those suppliers were actively selling electricity in the territory as of December 2010. In ComEd's territory, 24 suppliers have completed the registration process and 24 of those suppliers were actively selling electricity as of December 2010 (ICC 2011).

In 1997, the Michigan Public Service Commission ordered Michigan's electric utilities to develop plans to allow all customers to choose their own electric generation supplier. In 2000, Michigan's Customer Choice and Electricity Reliability Act took effect, giving all customers of Michigan's investor-owned utilities the ability to choose an alternative electric supplier.

Michigan's electric industry was restructured so that the generation and supply of electricity became open to competitive suppliers. The electric transmission and distribution businesses remain under a regulated utility structure (MPSC 2012a; EIA 2008).

When electric restructuring was introduced in 2000, Michigan's largest utilities, Detroit Edison and Consumers Energy immediately enacted a 5 percent rate reduction and further reductions were introduced in 2005 (EIA 2008). In 2008, the Michigan legislature passed a bill that essentially "re-regulated" the market and limited customer choice enrollments to 10 percent of the total utility sales in each territory (MPSC 2012b). One aim of this legislation was to provide Detroit Edison and Consumers Energy a stable base of ratepayers upon which the utilities could rely to fund new generation projects. Recently, there has been a groundswell of support among commercial customers to re-open the Michigan electric markets, or at least raise the participation cap. Although, there is no guarantee that any action will be taken, in anticipation of movement by the legislature, many customers have placed their accounts on a waiting list should room become available under the current or revised cap (Coleman Hines 2011).

Renewable Portfolio Standards

A renewable portfolio standard is a state policy that requires electricity providers to get a minimum percentage of their power from renewable energy resources by a certain date. As of January 2012, there are 30 states plus the District of Columbia have renewable portfolio standards (RPS) policies in place, including Illinois, Indiana, Iowa, Michigan, Missouri, and Wisconsin (EIA 2012c).

In August 2007, Illinois enacted legislation (Public Act 095-0481) that created the Illinois Power Agency. The Illinois Power Agency plans and administers the competitive procurement processes that result in bilateral agreements between the utilities and wholesale electric suppliers. The procurement plans must include procurement of cost-effective renewable energy resources per RPS which requires that by 2024, 25 percent of electricity sold by electric utilities (EU) and ARES come from renewable sources such as solar thermal electric, PVs, landfill gas, wind, biomass, hydroelectric, anaerobic digestion, and biodiesel. Additionally, 1.50 percent of EU and ARES sales must be from solar sources, 18.75 percent of EU sales from wind sources, 15.00 percent of ARES sales from wind sources, and 0.25 percent of EU sales from distributed generation. In order for a system to qualify under the distributed generation requirement, systems must be 2 MWe or less and powered by renewable sources (DSIRE 2011).

In May 2011, Indiana passed Senate Bill 251, creating the Clean Energy Portfolio Standard. The program sets a voluntary goal of 10 percent clean energy by 2025, based on 2010 levels. In order to participate in the program, qualifying electric utilities must apply to the Indiana Utility Regulatory Commission. Participation in Clean Energy Portfolio Standard makes utilities eligible for incentives to pay for the compliance projects. Only public utilities may participate in the program; municipally owned utilities, rural electric cooperatives, or electric cooperatives with at least one rural electric cooperative member may not participate in the program. Eligible technologies include wind, solar, dedicated energy crops, organic waste biomass, hydropower, fuel cells, energy storage systems, geothermal energy, coal bed methane, demand side management or energy efficiency initiatives, nuclear energy, natural gas that displaces electricity from coal, and clean coal technology (DSIRE 2011).

Iowa requires its two investor-owned utilities (MidAmerican Energy and Alliant Energy Interstate Power and Light) to own or to contract for a combined total of 105 MWe of renewable generating capacity and associated energy production. Eligible resources include solar, wind, waste management, resource recovery, refuse-derived fuel, agricultural crops or residues, wood-burning facilities, or small hydropower facilities (DSIRE 2011).

In October 2008, Michigan enacted the Clean, Renewable, and Efficient Energy Act, Public Act 295, requiring the state's investor-owned utilities, alternative retail suppliers, electric cooperatives and municipal electric utilities to generate 10 percent of their retail electricity sales from renewable energy resources by 2015. In addition to renewables, the standard allows utilities to use energy optimization (energy efficiency) and advanced cleaner energy systems to meet a limited portion of the requirement. The state's two largest investor-owned utilities, Detroit Edison and Consumers Energy, have additional obligations beyond those of other utilities. Under the standard, eligible renewables include biomass, solar and solar thermal, wind, geothermal, municipal solid waste, landfill gas, existing traditional hydroelectric (i.e., water passed through a dam), tidal, wave, and water current (e.g., run-of-river hydroelectric) resources. The definition of energy optimization is synonymous with what is generally defined as energy efficiency. In order to be counted under the standard, energy efficiency measures must reduce customer consumption of energy, electricity, or natural gas. Advanced cleaner energy facilities are loosely defined as electric generating facilities using a technology that is not in commercial operation. In addition to the percentage-based energy requirements, Consumers Energy must meet a renewable energy capacity standard of 500 MWe by 2015 and Detroit Edison must meet a renewable energy capacity standard of 600 MWe by 2015. Energy production from these new renewable energy facilities can be counted towards the percentage-based component of the standard (DSIRE 2011).

In June, 2007, Missouri created a voluntary renewable energy and energy-efficiency objective for the state's investor-owned utilities. The objective required each utility to make a "good-faith effort" to generate or procure renewable electricity equivalent to 11 percent by 2020. In November, 2008, voters in Missouri repealed the state's existing voluntary renewable energy and energy efficiency objective and replaced it with an expanded, mandatory renewable electricity standard of 15 percent by 2021. The standard also requires that by 2021, 0.3 percent of retail electricity sales must be derived from solar energy. Like the prior voluntary objective, the new standard applies only to the state's investor-owned utilities and does not place any requirements on municipal utilities or electric cooperatives. Eligible renewables are defined as electricity produced using solar PVs; solar thermal; wind; small hydropower; biogas from agricultural operations, landfills and wastewater treatment plants; pyrolysis and thermal depolymerization of waste materials; various forms of biomass; fuel cells using hydrogen from renewable resources; and other renewable-energy resources approved by the Missouri Department of Natural Resources (DSIRE 2011).

In 1998 Wisconsin enacted Act 204, requiring regulated utilities in eastern Wisconsin to install an aggregate total of 50 MWe of new renewable-based electric capacity by 2000. In 1999 Wisconsin enacted Act 9, becoming the first state to enact a RPS without having restructured its electric-utility industry. Wisconsin's RPS originally required investor-owned utilities and electric cooperatives to obtain at least 2.2 percent of the electricity sold to customers from renewable-energy resources by 2012. Legislation enacted in 2006 increased renewable-energy requirements and established an overall statewide renewable-energy goal of 10 percent by 2015. Qualifying electricity generating resources include tidal and wave action, fuel cells using renewable fuels, solar thermal electric and PV, wind power, geothermal, hydropower, and biomass (including landfill gas) (DSIRE 2011).

Descriptions of Alternatives

The following sections present fossil-fuel-fired (coal or natural gas) generation capacity (Section 7.2.1.1), purchased power (Section 7.2.1.2), new nuclear generation capacity (Section 7.2.1.3), wind energy (Section 7.2.1.4), solar energy (Section 7.2.1.5), and combinations of various energy supplies (Section 7.2.1.6) as alternatives that Exelon Generation hypothesizes for purposes of this environmental report would be reasonable alternatives to license renewal. Section 7.2.1.7 discusses additional alternatives that Exelon Generation has determined are not reasonable and the bases for these determinations.

Construction of a hypothetical new power station at Byron or another existing power station would be preferable to construction at a greenfield site. Environmental impacts would be minimized by building on previously disturbed land and by making the most use possible of existing facilities, such as transmission lines, roads and parking areas, office buildings, and components of the cooling system. Therefore, except for the wind and solar generation alternatives, it is assumed that space would be found at Byron or another existing power plant site within the ROI in order to benefit from the existing infrastructure and minimize the environmental impacts that would occur at a greenfield location. This approach avoids overstating the environmental impacts of these alternatives in comparison to the proposed action. Because of the large land use demands of new wind and solar generation facilities, Exelon Generation assumes that even if the Byron site or other existing plant sites were used, doing so would not significantly reduce the total greenfield acreage that would be required.

To compare the environmental impacts of alternative electricity supplies with Byron license renewal on an equal basis, Exelon Generation set the existing approximate net average annual generating capacity of Byron (approximately 2,370 MWe, including MUR) as the approximate net electrical generating capacity that any reasonable alternative would need to supply. However, because some alternative technologies are manufactured in standard unit sizes, it was not always possible to aggregate such technologies to exactly match the Byron capacity.

It must be emphasized, however, that all scenarios are hypothetical. Exelon Generation has no current plans for new facility construction to replace Byron.

7.2.1.1 Construct and Operate New Natural Gas-Fired or Coal-Fired Generation Capacity

Gas-Fired Generation

For purposes of this analysis, Exelon Generation assumed development of a modern natural gas-fired combined-cycle plant with design characteristics similar to those being developed elsewhere in the ROI, and with a net generating capacity comparable to that of Byron. The hypothetical plant would be composed of six pre-engineered natural gas-fired combined-cycle units producing 400 MWe each of net plant power for a total of 2,400 MWe (GE Energy 2007). The characteristics of this plant and other relevant resources were used to define the gas-fired alternative. Table 7.2-1 presents the basic characteristics for the gas-fired alternative, and impacts are described in Section 7.2.2.1.

Coal-Fired Generation

NRC has routinely evaluated coal-fired generation alternatives for nuclear plant license renewal. In defining the coal-fired alternative to Byron, ROI-specific input has been applied for direct comparison with a gas-fired plant producing 2,400 MWe (net).

For purposes of this analysis, Exelon Generation assumed the coal-fired alternative would be composed of four 600-MWe (net) ultra-supercritical coal-fired boilers for a total of 2,400 MWe. Table 7.2-2 presents the basic coal-fired alternative emission control characteristics, and impacts are described in Section 7.2.2.2. The emissions control assumptions are based on the technologies recognized by the EPA for minimizing emissions and calculated emissions based upon the EPA published removal efficiencies (EPA 1998a).

7.2.1.2 Purchased Power

Exelon Generation has evaluated conventional and prospective power supply options that could be reasonably implemented before the existing Byron licenses expire. As noted in Section 7.2.1, electric industry restructuring initiatives in the ROI are designed to promote competition in energy supply markets by facilitating participation by non-utility suppliers. PJM and Midwest ISO have implemented market rules to appropriately anticipate and meet electricity demands in the wholesale electricity market that has resulted from restructuring. However, because retail customers in the ROI now may choose among multiple companies to supply their electricity needs, future load obligations of such companies are uncertain. For the purposes of this analysis, Exelon Generation assumes that the PJM and Midwest ISO member companies will install electricity generation capacity beyond that necessary to meet future demand, although delayed retirement of existing units is not considered available. Thus, it is assumed that purchased power would be available as a reasonable alternative for meeting load obligations in the event the existing operating licenses for Byron are not renewed.

The technologies that would be used to generate purchased power are unknown. Even so, Exelon Generation believes it is likely that the generating technologies analyzed by the NRC in the GEIS would be the primary sources of purchased power. For this reason, Exelon Generation is adopting by reference the GEIS description of the alternative generating technologies to represent the purchased power alternative. Of these technologies, facilities fueled by coal and combined-cycle facilities fueled by natural gas are the most cost effective for providing base-load capacity. Impacts are described in Section 7.2.2.3.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace Byron capacity. From a local perspective, loss of Byron could require construction of new transmission lines to ensure local system stability. From a regional perspective, PJM and Midwest ISO's inter-connected transmission system is highly reliable.

7.2.1.3 Construct and Operate New Nuclear Generating Capacity

Since 1997, the NRC has certified four new standard designs for nuclear power plants under 10 CFR Part 52, Subpart B. Additional designs are undergoing precertification and certification reviews. All of the plants currently certified or undergoing certification reviews are light-water reactors; several of the designs in preliminary pre-application discussions are not, including the Toshiba 4S, GE Hitachi's PRISM, and Gen4 Energy's Gen4 Module (NRC 2012d).

The NRC staff considered new nuclear generating capacity within the ROI for the Clinton Early Site Permit (NRC 2006). In its analysis, the NRC staff evaluated a bounding case of 2,200 MWe of new nuclear generation that would be installed in the form of either one or two units of a certified design. Impact analyses did not reference a particular design, and impacts generally applicable to all certified designs were assumed. Exelon Generation has reviewed the NRC analysis of new nuclear capacity for the Clinton site, believes it to be sound, and notes that it addresses less capacity than the approximate 2,370 MWe discussed in this analysis; however, for comparison with Byron license renewal, that provides a conservative estimate of potential impacts. Exelon Generation has assumed construction at an existing plant site of two new nuclear units of a certified design. Impacts are described in Section 7.2.2.4.

7.2.1.4 Wind Energy

Energy potential in wind is expressed by wind generation classes, ranging from 1 (least energetic) to 7 (most energetic). Current wind technology can operate economically on Class 4 sites with the support of the Federal production tax credit of 2.2 cent per kWh (DOE 2008; DSIRE SOLAR 2012), while Class 3 wind regimes would require further technical development for utility scale application. In the ROI, areas of highest wind energy potential (Class 4 and 5) are the western portions of Iowa; a pocket in Benton County, Indiana about 225 km (140 mi) southeast of Byron; and the offshore areas of Lake Michigan, Lake Superior, and Lake Huron (NREL 2010b). As of September, 2011, the ROI had an installed wind generating capacity totaling approximately 8,600 MWe; Illinois had 2,438 MWe, Indiana 1,339 MWe, Iowa 3,708 MWe, Missouri 459 MWe, Michigan 185 MWe, and Wisconsin 469 MWe (NREL 2011a). PJM Interconnection and Midwest ISO have additional proposed wind projects totaling approximately 34 GW and 27 GW as of 2011, respectively (PJM 2011MISO Undated). No off-shore wind energy projects were operable in the ROI at the end of 2011 (GLWC 2012).

Due to the intermittent nature of wind, wind power plants cannot reliably be turned on quickly to a desired level of output and regional networks grant new wind facilities a percentage of the name plate capacity as credit to meeting peak demand load (effective capacity or capacity credit). PJM Interconnection and Midwest ISO grants new wind facilities a 13 percent and 14.7 percent capacity credit, respectively (PJM 2010a; MISO 2011). Accordingly, to replace the Byron approximate annual average net base-load generating capacity, including MUR, of 2,370 MWe (90 percent or more capacity factor), assuming the Midwest ISO current-day capacity credit for wind generation, approximately 14,510 MWe of new wind capability would be required ([new wind capability] x 0.147 = 2,370 MWe x 0.90). However, by 2025 (one year after the Byron Unit 1 license expires), new land-based and offshore wind projects may have achieved capacity factors (the ratio of actual energy output over the highest-load period and its hypothetical maximum energy output capability over that same period) as high as 49 percent and 51 percent, respectively, as a result of technology improvements and operating experience (DOE 2008). Therefore, assuming a future capacity credit for wind generation based on an average of the projected capacity factors for land-based and offshore projects, approximately 4,350 MWe of new wind capability would be required to replace the base-load generating capacity of Byron.

The intermittent nature of wind causes fluctuations that can change power frequency and lead to grid-reliability issues when wind energy is used to supply electricity to the transmission grid. For this reason, methods to mitigate grid-reliability issues of generating electricity with intermittent wind energy (see Section 7.2.1) must be applied in order to suit current-day wind energy facilities to provide base-load generation capacity NREL 2010a). Even so, for the purposes of this Environmental Report, it is assumed that a wind plant with no firming capacity could be a reasonable alternative in the future. Hence, impacts from a purely wind energy alternative are described in Section 7.2.2.5. Section 7.2.2.7 discusses impacts from wind energy combined with solar energy and gas-fired combined-cycle firming capacity. Section 7.2.2.8 discusses impacts from wind energy combined with CAES firming capacity.

Exelon Generation anticipates that additional transmission infrastructure would be needed to integrate wind energy generation into the regional electricity grid if this alternative is used to replace Byron's base-load generating capacity.

7.2.1.5 Solar Energy

Solar energy potential generally increases as you move southwest across the ROI, resulting in areas of southwest Missouri with the highest solar energy per area values (NREL 2012). As of 2008 the ROI has an installed solar generating capacity totaling approximately 6.3 MWe; Illinois had 2,758 kW, Indiana 19 kW, Iowa 51 kW, Missouri 65 MWe, Michigan 358 kW, and Wisconsin 3,078 kW (NREL 2011b). PJM Interconnection has additional proposed solar projects totaling approximately 4 GW as of 2011 (PJM 2011).

Like wind energy, solar energy is intermittent, which causes fluctuations that can change power frequency and lead to grid-reliability issues when solar energy is used to supply electricity to the transmission grid. PJM Interconnection grants new solar facilities a 38 percent capacity credit (PJM 2010a). Accordingly, to replace the Byron approximate annual average net base-load generating capacity, including MUR, of 2,370 MWe (90 percent or more capacity factor), assuming the PJM Interconnection current-day capacity credit for solar generation, approximately 5,613 MWe of new solar capability would be required ([new solar capability] x 0.38 = 2,370 MWe x 0.90).

Two solar generation technologies have emerged as possible candidates for centralized electricity generation -- photovoltaic (PV) and concentrating solar power (CSP) systems. Solar PV systems are semiconductor devices that convert sunlight directly into electricity. CSP systems use the thermal energy of sunlight to generate electricity.

Two common designs of CSP plants are parabolic troughs and power towers. Both of these designs concentrate sunlight onto a heat-transfer fluid, which is used to generate steam that drives a steam turbine. Cooling towers or once-through cooling would be used to condense the spent steam back to water for reuse. CSP systems can provide base-load capacity without external balancing systems because their designs incorporate integral thermal energy storage (TES) to shift generation to periods without the solar resource and to provide backup energy during periods of reduced sunlight caused by cloud cover. The storage medium is typically a molten salt, which has extremely high storage efficiencies in demonstration systems. Current designs provide a maximum TES of eight hours (NREL 2010c).

Unlike CSP systems, PV generation does not provide all of the characteristics necessary for stable grid operation. For example, PV provides the most electricity during midday on sunny days, but none during evenings or at night (NREL 2010d). PV output can increase and fall rapidly during cloudy weather, making it difficult to maintain balance on a grid with a large penetration of PV (NREL 2010d). Therefore, the use of a PV system would require backup generation or another external balancing system, such as those described in Section 7.2.1. Notwithstanding, PVs can take advantage of direct and indirect (diffuse) exposure to sunlight, whereas CSP is designed to use only direct exposure. As a result, PV modules need not directly face and track incident radiation as CSP systems must. This has enabled PV systems to have broader geographical application than CSP (NREL 2010e). Hence, for the purposes of this environmental report, it is assumed that a solar plant using PV generation with no firming capacity could be a reasonable alternative for base-load generating capacity. Impacts of a purely solar energy alternative using either CSP generation or PV generation without firming capacity are described in Section 7.2.2.6. Section 7.2.2.7 discusses impacts from solar energy combined with wind energy and gas-fired combined-cycle firming capacity.

Exelon Generation anticipates that additional transmission infrastructure would be needed to integrate solar energy generation into the regional electricity grid if this alternative is used to replace Byron's base-load generating capacity.

7.2.1.6 Combinations of Alternatives

For the purpose of comparison, Exelon Generation has crafted alternatives that combine generation alternatives to replace Byron's approximate annual average net base-load generating capacity. Two combinations are considered: (1) wind generation combined with PV solar generation and firming capacity in the form of gas-fired combined-cycle generation, and (2) wind generation combined with CAES.

Exelon Generation assumes that the envisioned scenarios are combinations of generation alternatives that could adequately balance the electrical output from intermittent wind and solar energy sources to allow these sources to replace Byron's base-load generating capacity by the end of the first licensed unit's term in 2024.

Wind Generation, PV Solar Generation, and Gas-fired Combined-Cycle Generation

Wind and solar generation appear to be appropriate components of this combination alternative because renewable energy sources, including wind and solar energy, are projected to be a growing source of electricity through 2035 (EIA 2012d). Moreover, PJM Interconnection reports that as of 2011 about 34 GW of wind generation has been proposed for construction in the PJM region, and about 4 GW of solar generation has been proposed. Additionally, Midwest ISO reports that as of 2011 about 27 GW of wind generation has been proposed for construction in the Midwest ISO region. Because most power plants added to the U.S. electricity grid since 1990 have been powered by gas-fired combined-cycle, it is also appropriate to assume that the method by which firming capacity for wind and solar power would be provided is a new gas-fired combined-cycle generation plant. Furthermore, the Energy Information Administration's Annual Energy Outlook forecasts continued growth in the use of gas-fired combined-cycle plants as a new electricity source through 2035 (EIA 2012d). Hence, gas-fired combined-cycle electricity generation is a proven technology with demonstrated operating characteristics and well-defined resource and capital requirements.

For this combination of alternatives, Exelon Generation assumed that 1,230 MWe of Byron's net base-load capacity (90 percent capacity factor) of 2,370 MWe, including MUR, would be replaced by one land-based wind farm, with the balance (1,140 MWe) replaced by three PV solar facilities. However, since wind and PV solar energy are intermittent, for the purpose of this alternative, the wind farm capacity credit is assumed to be 49 percent (based on the U.S. Department of Energy [DOE]-projected capacity factor for land-based wind energy in 2025 [Section 7.1.2.4]), while the PV solar facility capacity credit is assumed to be 38 percent (the current-day PJM Interconnection capacity credit for solar [Section 7.1.2.5]). As a result, the total capacity assumed to be required for the wind farm is 2,260 MWe and the total capacity assumed to be required for each of the three PV solar facilities is 900 MWe, for a total PV solar generating capacity of 2,700 MWe.

Gas-fired combined-cycle generation has been successfully used to balance intermittent renewable power and thereby maintain electrical grid system reliability. Based on the NREL evaluation in its Eastern Wind Integration and Transmission Study (NREL 2011c), approximately 6 percent of land-based and 4 percent of offshore wind energy capability would be needed in gas-fired combined-cycle backup to support the regulation and operating reserve requirements imposed by wind energy. Assuming 2,260 MWe of land-based wind generation capability, approximately 135 MWe of gas-fired combined-cycle generation would be required as reserve capacity.

Comparable estimates of the amount of gas-fired combined-cycle backup needed to support the regulation and operating reserve requirements imposed by solar generation were not found in the literature. Therefore, for the purposes of this evaluation, Exelon Generation has assumed that approximately 10 percent of PV solar energy capability would be needed in gas-fired combined-cycle backup. Accordingly, for 2,700 MWe of PV solar energy capability (assuming the current PJM Interconnection capacity credit for solar of 38 percent), approximately 270 MWe of gas-fired combined-cycle generation would be required as reserve capacity.

In summary, for this combination of alternatives, Exelon Generation assumed that the Byron base-load capacity of 2,370 MWe, including MUR, would be replaced by one 2,260 MWe wind farm (with a 135 MWe gas-fired combined-cycle backup unit) and three 900 MWe PV solar facilities (each with a 90 MWe gas-fired combined-cycle backup unit). Also, for the purposes of this environmental report, it is assumed that, by 2024, this combination of alternatives would be a reasonable alternative to renewal of the Byron operating licenses. Impacts of this alternative are discussed in Section 7.2.2.7.

Wind Generation Combined With Compressed Air Energy Storage

As previously discussed, wind generation appears to be an appropriate component of a combination of alternatives because renewable energy sources, including wind energy, are projected to be a growing source of electricity through 2035 (EIA 2012d). Furthermore, by 2025 (one year after the Byron Unit 1 license expires), new land-based and offshore wind projects may have achieved capacity factors as high as 49 percent and 51 percent, respectively, as a result of technology improvements and operating experience (DOE 2008). Even so, if wind energy is used to supply electricity to the transmission grid, its intermittent nature causes fluctuations that can change power frequency and lead to grid-reliability issues. For this reason, some method to mitigate grid-reliability issues associated with generating electricity using intermittent wind energy is likely to also be necessary (NREL 2010a).

The Electric Power Research Institute, in cooperation with the Midwest Independent System Operator (MISO), prepared a study (EPRI 2012) to determine the economic potential for energy storage in MISO territory. The energy storage study evaluated CAES, including underground and above-ground installations. The study results demonstrate that there is economic potential for energy storage in the MISO footprint. The benefits of energy storage are expected to be explored in greater depth during a Phase 2 study.

Although site-specific investigations would be needed to determine whether a suitable geologic formation is available to accommodate CAES in the ROI, it is assumed for the purposes of this Environmental Report that, if costs are ignored, a suitable geologic formation would be available; thus, a combination of wind generation combined with CAES would be a reasonable alternative to renewal of the Byron operating licenses.

The combination of alternatives is assumed to include one land-based wind farm and one offshore wind farm coupled with one CAES facility. Conservatively using capacity credits for land-based and offshore wind generation equal to the DOE-projected capacity factors for 2025 (49 percent for land-based projects and 51 percent for offshore projects), approximately 4,265 MWe of new wind capability (approximately 2,175 MWe land-based and 2,090 MWe offshore) would be required to replace Byron's base-load generating capacity. Additionally, based on the NREL assessment of the amount of CAES needed in combination with a wind farm in order to provide a nearly constant energy output (Section 7.2.1), a 4,265 MWe wind farm combined with a 1,920 MWe CAES facility would be capable of providing approximately 1,920 MWe as a nearly constant output. An additional 450 MWe of CAES would be required to provide a nearly constant output of 2,370 MWe from the combined wind and CAES facilities. Impacts of this alternative are discussed in Section 7.2.2.8.

7.2.1.7 Other Alternatives

This section identifies alternatives that Exelon Generation has evaluated and determined are not reasonable for replacing Byron and the bases for these determinations. Exelon Generation accounted for the fact that Byron is a base-load generator and that any feasible alternative to Byron would also need to be able to generate base-load power. Except for the discussion of demand-side management, Exelon Generation relied heavily upon the NRC's GEIS in performing this evaluation (NRC 1996b).

Demand Side Management

Demand side management (DSM) programs include energy conservation and load management measures. As discussed in the GEIS (NRC 1996b), the DSM alternative does not fulfill the stated purpose and need of the proposed action because it does not "provide [full-time baseload] power generation capability."

Companies whose sole business is that of generating electricity and selling energy to the wholesale market have no ability to implement DSM. Consequently, the NRC determined that NEPA does not require that an alternative involving electricity demand reduction through DSM be considered when the project purpose is to authorize a power plant to supply existing and future electricity demand (NRC 2005). The NRC determination was upheld by the US Court of Appeals for the Seventh Circuit (U.S. Court of Appeals for the Seventh Circuit 2006). Nevertheless DSM is considered here because energy efficiency and demand response (also known as load response) are important tools for meeting projected electricity demand.

Historically, state regulatory bodies required regulated utilities to institute programs designed to reduce demand for electricity, and revenues were adjusted through the regulated ratemaking process. In a deregulated, competitive electric wholesale market, however, private companies engage in marketing the energy, capacity, and ancillary services from their generating facilities in wholesale markets managed by regional transmission organizations, such as PJM Interconnection, LLC (PJM).[1]

In parts of Illinois, Indiana, and Michigan, which are within the ROI, PJM operates a capacity market designed to ensure that adequate resources are available to meet the demand for electricity into the future. The resources may include not only generating stations, but also demand response actions and energy efficiency measures by consumers to reduce their demand for electricity. Generally, demand response capacity is created when an electricity consumer agrees to reduce load at PJM's request during narrowly defined peak demand periods. Exelon Generation sells both generation and demand response capacities into the PJM wholesale capacity market in the ROI.

In 2010, the nation's electricity providers reported total peak-load reductions of 33,283 MWe as a result of DSM programs, a 5.1 percent increase from the reduction reported in 2009. This represents 3 percent of the total generating capacity of the nation. Reported DSM costs increased $0.56 billion, up 16 percent from the $3.6 billion reported in 2009. DSM costs can vary significantly from year to year because of business cycle fluctuations and regulatory changes. Because costs are reported as they occur, while program effects may appear in future years, DSM costs and effects may not always show a direct relationship. In the five years between 2006 and 2011, nominal DSM expenditures have increased at a 17 percent average annual growth rate nationally. During the same period, actual peak load reductions have grown at a 5.4 percent average annual rate, from 27,240 MWe to 33,283 MWe nationally. The divergence between the growth rates of load reduction and expenditures was driven in large measure by 2007-2008 expenditures, which were in response to higher overall energy prices (EIA 2011a).

At the regional level, PJM has reported that demand response is a fast- growing component of its wholesale capacity market. The PJM capacity auction held in 2012 for estimated 2015/2016 demand cleared over 14,000 MWe of demand response capacity (PJM 2012). Even so, PJM has recognized that, if demand response is allowed to saturate its market, reliability of the overall power supply could be jeopardized because, as more megawatts of resources that are only available during narrowly defined peak periods are committed, fewer megawatts of more broadly available resources will be committed (PJM 2010b).

The Energy Security and Climate Stewardship Platform endorsed by governors of several states within the ROI in 2007 acknowledged the value of energy efficiency and set the goal of meeting 2 percent of the Midwest's annual retail sales of electricity through energy efficiency improvements by 2015. In 2009, the programs in Iowa, Minnesota, and Wisconsin were capturing savings from energy efficiency of 0.7 percent annual retail energy sales. (ECW 2009). Two percent of the 2010 annual retail sales of the states in the ROI was approximately 11 terawatt-hours. This amount represents just over half of the total electricity produced by Byron in 2010.

The information provided in the paragraphs above suggests that, while it could be possible for PJM to satisfy 2,370 MWe of peak load demand with demand response capacity in 2024, doing so would not be advisable for replacing Byron's 2,370 MWe of base-load capacity, including

[1] PJM is a regional transmission organization that manages the bulk power system and wholesale electricity markets for all of parts of Pennsylvania, Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Tennessee, Virginia, West Virginia, and the District of Columbia.

MUR. Furthermore, it appears unlikely that energy efficiency will increase in the ROI enough by 2024 to replace 2,370 MWe of base-load capacity.

The DSM alternative would produce different impacts than the other alternatives addressed. Unlike the discrete generation options, there would be no major generating facility construction and few ongoing operational impacts. However, the loss of Byron base-load generating capacity could require construction of new transmission lines to ensure local system stability. The most significant effects would likely occur during installation or implementation of conservation measures, when old appliances may be replaced, building climate control systems may be retrofitted, or new control devices may be installed. In some cases, increases in efficiency may come from better management of existing control systems.

In conclusion, although DSM is an important tool for meeting projected electricity demand and the impacts from the DSM alternative are generally small, DSM does not fulfill the stated purpose and need for license renewal of nuclear power plants, which is to "provide [full-time baseload] power generation capability" (NRC 1996b). Demand response measures are already captured in state and regional load projections and additional energy efficiency measures would offset only a fraction of the base-load energy supply lost by the shutdown of Byron. In addition, the purpose of the Byron license renewal is to allow Exelon Generation to sell wholesale power generated by Byron to meet future demand. For these reasons, Exelon Generation does not consider DSM to be a viable supply of replacement base-load electricity. Hence, DSM does not represent a reasonable alternative to renewal of the Byron operating licenses.

Hydropower

About 1,531 MWe of utility generating capacity in the ROI is hydroelectric (EIA 2012b). As the GEIS points out in Section 8.3.4, hydropower's percentage of United States generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern over flooding, destruction of natural habitat, and alteration of natural river courses. Forty-eight hydropower projects, totaling 958 MWe and the largest of which is 214 MWe, are being considered in the ROI (FERC 2012). These small hydropower projects could not replace the 2,370, including MUR, MWe generated at Byron. DOE estimates there to be 2,131 MWe of small hydro or low power capacity spread over 11,881 different sites throughout the ROI (EERE 2006). Some of this additional water power resource potential could be gained from efficiency upgrades to existing hydroelectric facilities and new low-impact facilities (DOE 2011a).

However, Exelon Generation has concluded that due to the large number of sites required and a total feasible capacity less than the energy supply lost by the shutdown of Byron, small site hydropower is not a reasonable alternative to Byron license renewal.

The GEIS estimates land use of 4,000 square km (1,545 square mi) per 1,000 MWe for hydroelectric power (1996b). Based on this estimate, replacement of Byron generating capacity would require flooding approximately 9,480 square km (3,660 square mi), resulting in a large impact on land use. Further, operation of a hydroelectric facility would alter aquatic habitats above and below the dam, which would impact existing aquatic communities. DOE has concluded that there are no remaining sites in the ROI that would be feasible for a large hydroelectric facility (EERE 2006; INEEL 1998).

Exelon Generation has concluded that, due to the lack of suitable sites in the ROI for a large hydroelectric facility and the amount of land needed (approximately 9,480 square km

[3,660 square mi]), large site hydropower is not a reasonable alternative to Byron license renewal.

Geothermal

Geothermal energy is a proven resource for power generation. Geothermal power plants use naturally heated fluids as an energy source for electricity production. To produce electric power, underground high temperature reservoirs of steam or hot water are tapped by wells and the steam rotates turbines that generate electricity. Typically, water is then returned to the ground to recharge the reservoir.

Geothermal energy can achieve average capacity factors of 90 percent and can be used for base-load power where this type of energy source is available (MIT 2006). Widespread application of geothermal energy is constrained by the geographic availability of the resource (NREL 2011d). In the US, high-temperature hydrothermal reservoirs are located in the western continental US, Alaska, and Hawaii. There are no known high-temperature geothermal sites in the ROI (NREL 2011e; NREL 2011f). The ROI has low to moderate temperature resources that can be tapped for direct heat or geothermal heat pumps, but electricity generation is not feasible with these resources (NREL 2011e; NREL 2011f).

Exelon Generation has concluded that, due to the lack of high temperature geothermal sites in the ROI, geothermal power is not a reasonable alternative to Byron license renewal.

Tidal, Ocean Thermal, and Wave

Technologies to harness electrical power from the ocean are tidal power, ocean thermal energy, and wave power conversion. These technologies are still in the early stages of development and are not commercially available to replace a large base-load generator such as Byron. Furthermore, the ROI consists of non-coastal states which, despite having Great Lake shorelines, lack tidal, ocean thermal, or wave power resources.

Tidal power technologies extract energy from the diurnal flow of tidal currents caused by the gravitational pull of the moon. Unlike wind and solar power, tidal streams offer entirely predictable output. All coastal areas consistently experience two high tides and two low tides over a period of approximately 25 hours. However, because the lunar cycle is longer than a 24 hour day, the peak outputs differ by about an hour each day, and so tidal energy cannot be guaranteed at times of peak demand (Feller 2003).

Tidal power technologies consist of tidal turbines and barrages. Tidal turbines are similar in appearance to wind turbines that are mounted on the seabed. They are designed to exploit the higher energy density, but lower velocity, of tidal flows compared to wind. Tidal barrages are similar to hydropower dams in that they are dams with gates and turbines installed along the dam. When the tides produce an adequate difference in the level of the water on opposite sides of the dam, the gates are opened and water is forced through turbines, which turns a generator. For those tidal differences to be harnessed into electricity, the difference in water height between the high and low tides must be at least 5 m (16 ft). There are only about 20 sites on Earth with tidal ranges of this magnitude (EERE 2009). The only sites with adequate tidal differences within the US are in Maine and Alaska (CEC 2011).

Ocean thermal energy conversion (OTEC) technology capitalizes on the fact that the water temperatures decrease with depth. As long as the temperature between the warm surface water and the cold deep water differs by about 20°C (36°F), an OTEC system can produce a significant amount of power. The temperature gradient in the Great Lakes is less than 18°C (32°F) and not a good resource for OTEC technology (EERE 2009).

Wave energy conversion takes advantage of the kinetic energy in the ocean waves (which are mainly caused by interaction of wind with the surface of the ocean). Wave energy offers an irregular, oscillatory, low frequency energy source that must be converted to a 60-Hertz frequency before it can be added to the power grid (CEC 2011). Wave energy resources are best between 30 and 60 degrees latitude in both hemispheres and the potential tends to be greatest on western coasts (RNP 2007).

Offshore technologies that harness the energy of ocean waves and current are in their infancy, and have not been used at utility scale (NREL 2008). Since the late 1990s, new technologies have been introduced to harness the energy of the ocean's waves, currents, and tides. Nearly 100 companies worldwide have joined this effort but most companies struggle to deploy their first prototypes and not all can be funded from the public sector. A viable strategy to help mature the marine renewable energy industry does not exist (NREL 2008). Hence, although some technologies may be available in the future, none has yet been demonstrated to be capable of providing the electrical generating capacity needed to replace Byron's base-load generating capacity.

Exelon Generation believes that tidal, ocean thermal, and wave technologies have not matured sufficiently to provide a viable supply of replacement base-load electricity for Byron. As a result, Exelon Generation has concluded that, due to the lack of tidal, thermal, and wave resources in the ROI, and production limitations, these technologies are not reasonable alternatives to Byron license renewal.

Wood Energy

As discussed in the GEIS, the use of wood waste to generate electricity is largely limited to those states with significant wood resources. The pulp, paper, and paperboard industries in states with adequate wood resources generate electric power by consuming wood and wood waste for energy, benefiting from the use of waste materials that could otherwise represent a disposal problem. It takes roughly 1 ton per hour of wood waste to produce 1 MWe of electricity. Generally, the largest wood waste power plants are 40 to 50 MWe in size.

Further, as discussed in Section 8.3.6 of the GEIS, construction of a wood-fired plant would have an environmental impact that would be similar to that for a coal-fired plant, although facilities using wood waste for fuel would be built on smaller scales. Like coal-fired plants, wood waste plants require large areas for fuel storage, processing, and waste (i.e., ash) disposal. Additionally, operation of wood-fired plants has environmental impacts, including impacts on the aquatic environment and air. Wood has a low heat content that makes it unattractive for base-load applications. It is also difficult to handle and has high transportation costs.

While some wood resources (forest, mill and urban wood residues) are available in the ROI, particularly in Illinois and Iowa (NREL 2005), Exelon Generation believes that, due to the lack of an environmental advantage, low heat content, handling difficulties, and high transportation costs, wood energy cannot provide a viable supply of replacement base-load electricity for Byron. Hence, Exelon Generation has concluded that wood energy is not a reasonable alternative to Byron license renewal.

Municipal Solid Waste

As discussed in Section 8.3.7 of the GEIS, the initial capital costs for municipal solid waste plants are greater than for comparable steam turbine technology at wood-waste facilities. This is due to the need for specialized waste separation and handling equipment.

The decision to burn municipal solid waste to generate energy is usually driven by the need for an alternative to landfills, rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy because of unfavorable economics. Estimates in the GEIS suggest that the overall level of construction impacts from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate and larger than the environmental effects of Byron license renewal.

Exelon Generation believes that, due to the high costs and lack of environmental advantages, burning municipal solid waste to generate electricity cannot provide a viable supply of replacement base-load electricity for Byron. Hence, Exelon Generation has concluded that burning municipal solid waste is not a reasonable alternative to Byron license renewal.

Other Biomass-Derived Fuels

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning energy crops, converting crops to a liquid fuel such as ethanol (ethanol is primarily used as a gasoline additive), and gasifying energy crops (including wood waste). Power plants that employ direct combustion to convert biomass-derived fuels into electricity are commercially available. However, these biomass power plants are generally less than 50 MWe in size. Biomass gas turbine systems that use low-heat value biogas from an anaerobic digester or a biomass gasifier are in the initial stages of commercialization. None of these biogas turbine technologies has progressed to the point of providing utility-scale electricity generating capacity to replace a base-load plant such as Byron (EPA 2007).

Further, estimates in the GEIS suggest that the overall level of construction impacts from a crop-fired plant should be approximately the same as that for a wood-fired plant. Additionally, crop-fired plants would have similar operational impacts (including impacts on the aquatic environment and air). These systems also have large impacts on land use, due to the acreage needed to grow energy crops (NREL 2005).

Exelon Generation believes that, due to the high costs and lack of environmental advantage, burning other biomass-derived fuels to generate electricity cannot provide a viable supply of replacement base-load electricity for Byron. Hence Exelon Generation has concluded that burning other biomass-derived fuels is not a reasonable alternative to Byron license renewal.

Petroleum

The ROI has several petroleum (oil)-fired power plants; however, they produce less than 1 percent of the total power generated in the region (EIA 2012b). From 2005 to 2010, the nation's energy sector has reduced the proportion of power produced by oil-fired generating plants by 70 percent (EIA 2011b). Oil-fired operation is more costly than nuclear or coal-fired operation (IER 2012), and future increases in petroleum prices are expected to make oil-fired generation increasingly more costly. Also, construction and operation of an oil-fired plant would have significant environmental impacts. For example, operation of oil-fired plants would have significant environmental impacts (including impacts on the aquatic environment and air), comparable to those from a coal-fired plant.

Exelon Generation has concluded that, due to the high costs and lack of obvious environmental advantage, burning oil to generate electricity is not a reasonable alternative to Byron license renewal.

Fuel Cells

Fuel cell power plants are in the initial stages of commercialization. While more than 10,000 stationary fuel cell systems have been built and operated worldwide, the global stationary fuel cell electricity generating capacity in 2011 was only 54.6 MWe (Fuel Cell Today 2011). The largest stationary fuel cell power plant ever built is the 11 MWe Goi Power Station in Japan, but they typically generate much less (2 MWe or lower) power (Fuel Cells 2000 2012).

Exelon Generation believes that fuel cell technology has not matured sufficiently to provide a viable supply of replacement base-load electricity for Byron. As a result, Exelon Generation has concluded that, due to cost and production limitations, fuel cell technology is not a reasonable alternative to Byron license renewal.

Next Generation Nuclear Power

The Next Generation Nuclear Plant (NGNP) project was established under the Energy Policy Act in August 2005 (EPACT-2005). EPACT-2005 provided incentives in the form of tax credits and loan guarantees for new or significantly improved energy technologies, including the NGNP for which an overall plan and timetable for two phases of research, design, licensing, construction and operation activities leading to full implementation of the NGNP project by the end of FY 2021 were established. At the time that EPACT-2005 was passed, it was envisioned that a high-temperature gas-cooled nuclear reactor technology (HTGR) capable of generating electricity, producing hydrogen, or both, would be developed by the NGNP project (DOE 2010).

In 2011, the DOE Nuclear Energy Advisory Committee (NEAC) reviewed the readiness of the NGNP project to move from Phase I to Phase II of its plan, concluding that the project was ready to proceed with some but not all aspects of Phase II activities (DOE 2011b) Considering the NEAC's conclusion about the NGNP project's Phase II readiness, Exelon Generation deems it unlikely that full implementation of the NGNP project will occur on schedule (by 2021), or that a commercially viable replacement for Byron using NGNP technology could be sited, planned, licensed, constructed, and brought online by the time the existing Byron operating licenses expire in 2024 and 2026.

Delayed Retirement

As the NRC noted in the GEIS, extending the lives of existing non-nuclear generating plants beyond the time they were originally scheduled to be retired represents another potential alternative to license renewal. In 2011, Exelon Generation retired three fossil-fuel-fired generating units: Cromby Generating Station (Cromby) Units 1 (144 MW coal) and 2 (201 MW gas/oil) and Eddystone Generating Station (Eddystone) Unit 1 (279 MW coal). In addition, Eddystone Unit 2 (309 MW coal) was retired on May 31, 2012. These retirements involved fossil-fuel-fired units the extended operation of which would be inconsistent with Exelon Corporation's strategy of offering more low−carbon electricity in the marketplace (Exelon 2011a). Also, these units are not located within the ROI, and even if they continued to operate, the combined total generating capacity of 933 MWe would not replace the 2,370 MWe, including MUR, generated at Byron.

Emerging EPA regulations on air quality, water use, and ash disposal will likely require existing non-nuclear generating units to choose between installing expensive control equipment and retirement. The Brattle Group's report, "Potential Coal Plant Retirements under Emerging Environmental Regulations" estimates that 50 to 65 GW of coal capacity will be at risk for retirement by 2020; approximately 6 to 11 percent and 11 to 14 percent of the existing total regional capacity for PJM and Midwest ISO, respectively (Brattle 2010). For these reasons, Exelon Generation does not consider the delayed retirement of non-nuclear generating units to be a reasonable alternative to Byron license renewal.

7.2.2 Environmental Impacts of Alternatives

This section evaluates the environmental impacts of alternatives that Exelon Generation has determined to be reasonable alternatives to Byron license renewal: gas-fired generation, coal-fired generation, purchased power, new nuclear generation, wind energy, solar energy, and combination alternatives.

7.2.2.1 Gas-Fired Generation

The NRC evaluated environmental impacts from gas-fired generation alternatives in the GEIS, focusing on combined-cycle plants. Section 7.2.1.1 presents Exelon Generation's reasons for defining the gas-fired generation alternative as a six-unit combined-cycle plant on an existing power plant site. Construction of a gas-fired unit would have impacts on land-use and could impact ecological, aesthetic, and cultural resources. Human health effects associated with air emissions would be of some concern.

Air Quality

Natural gas is a relatively clean-burning fossil fuel that primarily emits oxides of nitrogen (NO_x), a regulated pollutant, during combustion. A natural-gas-fired plant would also emit small quantities of sulfur oxides presented as sulfur dioxide (SO_2), particulate matter (PM), and carbon monoxide (CO), all of which are regulated pollutants. In addition, a natural-gas-fired plant would produce CO_2, a greenhouse gas.

Control technology for gas-fired turbines focuses on NO_x emissions. Using data published by the EIA (EIA 2011b) and the EPA (EPA 2000) the natural-gas-fired alternative emissions are calculated to be as follows:

SO_2 = 32 metric tons (36 tons) per year

NO_x = 536 metric tons (591 tons) per year

CO = 111 metric tons (123 tons) per year

Filterable Particulates = 93 metric tons (103 tons) per year (all particulates are particulates with diameters of 2.5 microns or less [$PM_{2.5}$])

CO_2 = 5,409,000 metric tons (5,963,000 tons) per year

The acid rain requirements of the 1990 CAA amendments capped the nation's SO_2 emissions from power plants. Each company with fossil-fuel-fired units was allocated SO_2 allowances. To be in compliance with the CAA, the companies must hold enough allowances to cover their annual SO_2 emissions. Exelon Generation would need to obtain SO_2 credits to operate a fossil-fuel-fired plant. In 1998, the EPA promulgated the NO_x SIP Call regulation that required 22 states, including all the states in the ROI except Iowa, to reduce their NO_x emissions by over 30 percent to address regional transport of ground-level ozone across state lines (EPA 1998b).

In July 2011, EPA published Cross-State Air Pollution Rule (CSAPR) which requires states to significantly improve air quality by reducing power plant emissions that contribute to ozone and/or fine particle pollution in other states. CSAPR requires all of the states in the ROI to reduce annual SO_2 emissions, annual NO_x emissions, and ozone season NO_x emissions to assist in attaining the 1997 ozone and fine particle and 2006 fine particle NAAQS. The CSAPR allows air-quality-assured allowance trading among covered sources based on existing, successful allowance trading programs (EPA Undated). Hence, to operate a new fossil-fuel-fired plant, Exelon Generation would need to obtain enough NO_x credits and SO_2 allowances to cover annual emissions. Additionally, because the Chicago/Milwaukee and St. Louis areas are non-attainment areas (having air quality worse than the NAAQS) for ozone, a fossil-fuel-fired plant would potentially need to obtain NO_x emission reduction credits in the amount of 1.04 metric tons (1.15 tons) of NO_x for every ton of NO_x emitted (Evolution Markets 2011).

The EPA issued Mandatory Reporting of Greenhouse Gases Rule in December 2009 which requires reporting of greenhouse gas data and other relevant information from large sources and suppliers in the US. The purpose of the rule is to collect accurate and timely greenhouse gas data to inform future policy decisions. In December 2010, the EPA issued a series of rules that put the necessary regulatory framework in place to ensure that industrial facilities can get CAA permits covering their greenhouse gas emissions when needed (EPA 2012d; EPA 2011d).

NO_x effects on ozone levels, SO_2 allowances, NO_x credits, and CO_2 permitting could all be issues of concern for gas-fired combustion. While gas-fired turbine emissions are less than coal-fired boiler emissions, the emissions are still substantial. Exelon Generation concludes that emissions from the gas-fired alternative would noticeably alter local air quality, but would not cause or contribute to violations of NAAQS in the region. Based on these emissions, Exelon Generation believes human health impacts would be SMALL to MODERATE. Air quality impacts would, therefore, be MODERATE.

Waste Management

The solid waste generated from this type of facility would be minimal. The only noteworthy waste would be from spent selective catalytic reduction (SCR) used for NO_x control. The SCR process would generate a small amount of spent catalyst per year (NRC 2011b). Exelon Generation concludes that gas-fired generation waste management impacts would be SMALL.

Water Resources

Cooling water requirements for combined cycle gas-fired plants are less than those for nuclear plants. Impacts to aquatic resources and water quality from a gas-fired plant's cooling water withdrawals from and discharges to an alternative water source would likely be smaller than the impacts of Byron on the Rock River. Potential impacts would be mitigated by permit requirements. Exelon Generation concludes that gas-fired generation aquatic resources and water quality impacts would be SMALL.

Other Impacts

Construction of the gas-fired alternative on an existing plant site would affect the site and the associated utility corridors. New gas pipelines would likely be required for the gas turbine generators in this alternative. To the extent practicable, Exelon Generation would route the pipelines along existing, previously disturbed, ROWs to minimize impacts. Two new pipelines, each approximately 41 centimeters (16 inches) in diameter, would require a 30.5-m (100-ft)-wide ROW. The new construction could also necessitate an upgrade of the statewide pipeline network. Exelon Generation estimates that 38 ha (94 ac) would be needed for a gas-fired plant, but the location on an existing plant site would minimize any impacts. Therefore, land use impacts would be SMALL. Erosion and sedimentation, fugitive dust, and construction debris impacts would be noticeable, but SMALL and temporary with appropriate controls. Compliance with applicable state and federal endangered species protection laws would minimize adverse effects on threatened or endangered species, ensuring a SMALL impact. The potential loss of terrestrial habitat would be mitigated by location on an existing site, thus the impact to ecological resources would be SMALL. Depending on the state hosting the new gas-fired alternative, impacts to cultural resources could be possible because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE. Exelon Generation estimates a peak construction workforce of 1,783; thus, socioeconomic impacts of construction would be SMALL. However, Exelon Generation estimates a significantly reduced workforce of 94 for gas-fired plant operations, and the loss of approximately 890 jobs at Byron, which would cease operations, resulting in adverse socioeconomic impacts. Loss of the operational and temporary personnel would affect various aspects of the local community including employment, taxes, housing, off-site land use, economic structure, and public services. Exelon Generation believes these, mostly adverse, impacts would be MODERATE.

Visual impacts would be consistent with the industrial nature of the selected site. The stacks of the new gas-fired units may add visual impacts at the existing power plant site where they are constructed; but these should be minimal because of the presence of existing plant structures, and the impact on aesthetic resources would be SMALL.

7.2.2.2 Coal-Fired Generation

The NRC evaluated environmental impacts from coal-fired generation alternatives in the GEIS and concluded that construction impacts could be substantial, due in part to the large land area required (which can result in the loss of natural habitat) and the large workforce needed. The NRC identified the major adverse impacts from operations as human health concerns associated with air emissions, waste generation, and losses of aquatic biota due to cooling water withdrawals and discharges.

The coal-fired alternative that Exelon Generation has defined in Section 7.2.1.1 would be located at an existing plant site.

Air Quality

A coal-fired plant would emit SO_x, NO_x, PM, mercury, and CO, all of which are regulated pollutants. A coal-fired plant would also emit CO_2, which is a greenhouse gas. As Section

7.2.1.1 indicates, Exelon Generation has assumed a plant design that would minimize air emissions through a combination of boiler technology and post combustion pollutant removal. Using data published by the Energy Information Administration (EIA 2011b) and the EPA (EPA 1998a; EPA 2010c) the coal-fired alternative emissions are calculated to be as follows:

SO_x = 2,100 metric tons (2,300 tons) per year

NO_x = 1,589 metric tons (1,752 tons) per year

CO = 2,207 metric tons (2,433 tons) per year

Mercury = 0.12 metric tons (0.14 tons) per year

PM:

PM_{10} (particulates having a diameter of greater than 2.5 microns to 10 microns) = 50 metric tons (55 tons) per year

$PM_{2.5}$ (particulates having a diameter 2.5 microns or less) = 13 metric tons (14 tons) per year

CO_2 = 21,230,000 metric tons (23,403,000 tons) per year

The discussion in Section 7.2.2.1 of regional air quality is applicable to the coal-fired generation alternative. In addition, the NRC noted in the GEIS that adverse human health effects from coal combustion have led to important federal legislation in recent years and that public health risks, such as cancer and emphysema, are associated with coal combustion. The NRC also identified global warming and acid rain as potential impacts. In February 2012, the EPA finalized Mercury and Air Toxics Standards to limit mercury, acid gases, and other toxic pollution from power plants. In July 2012, the EPA finalized the Greenhouse Gas Tailoring Rule which requires the use of the best available control technology for greenhouse gas emissions from major industrial facilities, including power plants. Exelon Generation concludes that federal legislation and large-scale effects, such as global warming, acid rain, and mercury emissions are indications of concerns about the destabilization of important of air resources. SO_x emission allowances, NO_x credits, low NO_x burners, over-fire air, fabric filters or electrostatic precipitators, and scrubbers are mitigation measures imposed by regulation. As such, Exelon Generation concludes that the coal-fired alternative would have MODERATE impacts on air quality; the impacts would be noticeable and greater than those of the gas-fired alternative, but would not destabilize air quality in the area. The impacts on human health would likewise be MODERATE.

Waste Management

Exelon Generation concurs with the GEIS assessment that the coal-fired alternative would generate substantial solid waste. The coal-fired plant would annually consume approximately 8,828,000 metric tons (9,731,000 tons) of coal having an ash content of 4.9 percent (Tetra Tech 2012d). In 2010, Exelon Power reused 85 percent, or more than 101,065 tons, of its coal combustion and scrubber byproducts in beneficial applications. Exelon Power's beneficial reuse continued to far outpace the national recycling rate of approximately 45 percent for these types of materials (Exelon 2011b). After combustion approximately 370,000 metric tons (407,000 tons) per year would be marketed for beneficial reuse. The remaining ash, approximately 65,000 metric tons per year (72,000 tons per year), would be collected and disposed of on-site, if space were available. In addition, approximately 75,000 metric tons (83,000 tons) of scrubber sludge per year would be marked for beneficial reuse. The remaining sludge, approximately 13,000 metric tons (14,600 tons) would be disposed of on-site each year (based on annual limestone usage of about 74,000 metric tons or 82,000 tons). Exelon Generation estimates that ash and scrubber waste disposal over a 20-year period would require approximately 11 ha (26 ac). If this acreage is not available at the power plant site where the new coal-fired unit would be sited, off-site disposal would necessary, which would increase disposal impacts.

Exelon Generation believes that proper siting, current waste management practices, and current waste monitoring practices would prevent waste disposal from destabilizing any resources. After closure of the waste site and revegetation, the land would be available for other uses. For these reasons, Exelon Generation believes that waste disposal for the coal-fired alternative would have SMALL impacts; the impacts of increased waste disposal would be noticeable, but would not destabilize any important resource.

Water Resources

Cooling water requirements for coal-fired plants are similar to those for nuclear plants having similar generating capacity. Impacts to aquatic resources and water quality from a coal-fired plant's cooling water withdrawals from and discharges to an alternative water source would likely be similar to the impacts of Byron on the Rock River. Impacts would be mitigated by permit requirements. Exelon Generation concludes that impacts of coal-fired generation on aquatic resources and water quality would be SMALL.

Other Impacts

Exelon Generation estimates that construction of the power block and coal storage area would affect 154 ha (382 ac) of land and associated terrestrial habitat. Exelon Generation has assumed that much of this construction would be on previously disturbed land at an existing power plant site. Hence, land use impacts would be SMALL to MODERATE. Installation of a new rail spur or expansion of an existing spur would likely be required for coal and limestone deliveries under this alternative. Impacts to ecological resources could be consistent with impacts to land use and therefore, could be SMALL to MODERATE. As with any large construction project, some erosion and sedimentation and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of on-site. The resultant loss in terrestrial habitat would be mitigated by siting the new plant at an existing power plant, and waste disposal would require 11 ha (26 ac), thus the impact to ecological resources would be SMALL. Compliance with applicable state and federal endangered species protection laws would minimize any adverse impacts to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new coal-fired alternative, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE. Exelon Generation estimates a peak construction work force of 4,337 people (Tetra Tech 2012e). Socioeconomic impacts from the construction workforce would be SMALL if the construction site is near a large metropolitan area and worker relocation is not necessary. Exelon Generation estimates an operational workforce of 326 people (Tetra Tech 2012e) for the coal-fired alternative. This is a sizable reduction in operating personnel compared to Byron's approximately 890 personnel. Loss of personnel would impact various aspects of the local community including employment, taxes, housing, off-site land use, and public services. Thus, reduction in workforce would result in mostly adverse socioeconomic impacts characterized as MODERATE.

Visual impacts would be consistent with the industrial nature of the site. The stacks, boilers, and rail deliveries would change the visual nature of the site, but the impacts should be minimal because of the presence of existing plant structures. Thus, aesthetic impacts would be characterized as SMALL.

7.2.2.3 Purchased Power

As discussed in Section 7.2.1.2, Exelon Generation assumes that the generating technologies used under the purchased power alternative would be one of those that the NRC analyzed in the GEIS. Exelon Generation is also adopting by reference the NRC analysis of the environmental impacts from those technologies. Under the purchased power alternative, therefore, environmental impacts would still occur, but they would likely originate from an existing power plant located elsewhere in the ROI.

Impacts would occur in areas where purchased power is produced and in the vicinity of Byron. Impact magnitude would be proportional to the increased amount of power being produced at an existing plant. Impacts on all resources from construction would be SMALL because it is assumed that enough excess capacity exists in PJM and Midwest ISO to allow purchase of replacement power without new construction. Purchased power would result in an incremental positive socioeconomic impact in the vicinity of the existing plants and adverse socioeconomic impacts in the Byron region of influence due to the loss of approximately 890 jobs at Byron. Exelon Generation believes these adverse impacts would be SMALL to MODERATE because Byron is in a high population area, and the Byron personnel likely could find jobs within the 80-km (50-mi) radius. The impact to all other resources would be SMALL to MODERATE, depending on the type of fuel used, waste management practices, and locations of the existing plants.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace Byron capacity. From a local perspective, loss of Byron capacity could require construction of new transmission lines to ensure local system stability and impacts to land use and ecological resources from new transmission rights-of-way could be SMALL to MODERATE. Compliance with applicable state and federal endangered species protection act would minimize adverse effects to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new transmission infrastructure, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE. From a regional perspective, PJM and Midwest ISO's inter-connected transmission system is highly reliable.

7.2.2.4 New Nuclear Capacity

As discussed in Section 7.2.1.3, under the new nuclear capacity alternative, Exelon Generation would construct new nuclear generating units comparable in size to the Byron units using an NRC-certified standard design. Although Exelon Generation has not identified a location for a new nuclear plant near the Byron site, Exelon Generation is assuming the new nuclear plant would be sited on an existing plant site. Exelon Generation has reviewed the NRC analysis of new nuclear capacity for the Clinton site (NRC 2006), believes it to be sound, and notes that it addresses less capacity than the approximate 2,370 MWe, with MUR, discussed in this analysis; however, for comparison with Byron license renewal, that provides a conservative estimate of potential impacts.

Air Quality

Air quality impacts would be minimal. Air emissions, primarily from facility equipment (e.g., diesel generators, auxiliary boilers) and non-facility equipment (e.g., vehicular traffic), would be comparable to those associated with the continued operation of Byron. Overall, such emissions and associated impacts are characterized as SMALL. Human health impacts would be comparable to those associated with continued operation of Byron, which are characterized as SMALL.

Waste Management

Management of radioactive and nonradioactive wastes would be similar to that associated with the continued operation of Byron. The overall impacts are characterized as SMALL.

Water Resources

Cooling water requirements would be similar to those of Byron. Impacts to aquatic resources and water quality from a new nuclear plant's cooling water withdrawals from and discharges to an alternative water source would likely be similar to the impacts of Byron on the Rock River. Impacts would be mitigated by permit requirements. Exelon Generation concludes that nuclear generation's impacts to aquatic resources and water quality would be SMALL.

Other Impacts

Exelon Generation estimates that construction of the reactor units and auxiliary facilities would affect 108 ha (266 ac) of land and associated terrestrial habitat. Because much of this construction would be on previously disturbed land, impacts would be SMALL to MODERATE. Installation or expansion of either a new or existing rail spur or barge offloading facility would potentially be required for reactor vessel and other deliveries under this alternative. Effects on ecological resources would be consistent with the impacts of construction on land use, and could be SMALL to MODERATE. As with any large construction project, some erosion and sedimentation and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of on-site. Compliance with applicable state and federal endangered species protection laws would minimize any adverse effects to threatened or endangered species, ensuring a SMALL impact. Impacts to cultural resources would be possible, but would be SMALL because protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements. Due to NRC licensing involvement, consultation with the State Historic Preservation Officer is required by the National Historic Preservation Act (16 U.S.C. 470f).

Visual impacts would be consistent with the industrial nature of the site. The cooling towers and containment buildings would change the visual nature of the site, but the impacts should be minimal because of the presence of existing plant structures. Thus aesthetic impacts would be SMALL.

Based on a review of recent Early Site Permit and COL applications, Exelon Generation estimates a peak construction work force of approximately 4,416 workers. The surrounding communities would experience moderate demands on housing, public services, and transportation during construction, and would experience increased tax revenues. Socioeconomic impacts from construction would be minimal if the site is near a large metropolitan area and worker relocation was not required. Therefore, Exelon Generation concludes that socioeconomic impacts during construction would be SMALL to MODERATE, depending on the location of the plant. Exelon Generation estimates an operational workforce of 770 for the new nuclear alternative, based on recent applications. This is smaller than Byron's workforce of approximately 890 personnel. Exelon Generation concludes that socioeconomic impacts during operation would be SMALL to MODERATE, depending on the location of the plant.

Exelon Generation estimates that other construction and operation impacts would be SMALL. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved.

7.2.2.5 Wind Energy

As discussed in Section 7.2.1.4, between 4,350 MWe and 14,510 MWe of new wind capability could be required to replace Byron's base-load generating capacity, depending on whether the present-day or projected future capacity factors are applied. Each wind turbine needed to provide utility-scale wind generation capability would have a small footprint but would be tall (up to about 121 m [400 ft] to tip of rotor) with large rotors (up to about 88-m [290-ft] rotor diameter) (NWW Undated), requiring an otherwise undisturbed airspace around it. Hence, development of wind energy projects to replace Byron's capacity would require large commitments of land and, although land-based wind projects may be able to coexist with land uses such as farming, ranching, and forestry, wind energy development might not be compatible with land uses such as housing developments, airport approaches, some radar installations, and low-level military flight training routes (DOE 2008). Also, construction and operation of wind turbines could affect ecological, aesthetic, and cultural resources.

Air Quality

Potential benefits of using wind-generated electricity include reduction of fossil-fuel-generated levels of atmospheric CO_2, which is believed to be the major cause of global climate change (DOE 2008). In addition, compared with fossil-fueled generation, levels of regulated atmospheric pollutants such as nitrogen oxides, sulfur dioxide, and mercury, which can cause human health effects, would be reduced (DOE 2008). Hence, air quality impacts from wind generation would be SMALL. Some air emissions from portable diesel generators and vehicular traffic during construction and operation would be comparable to or less than those associated with the continued operation of Byron. Overall, pollutant emissions to air and associated impacts are characterized as SMALL. The impacts on human health would likewise be SMALL.

Waste Management

Minor quantities of construction-related wastes would be generated. During operation, maintenance activities could generate dielectric fluids at the wind turbine locations and substations. Overall, waste produced at wind generation facilities would be non-radioactive and minimal, and associated impacts are characterized as SMALL.

Water Resources

Relatively very little water would be consumed during construction or operation of wind generation facilities, and no water would be diverted for consumptive cooling. Impacts to water quality could occur from accidental spills of petroleum lubricants and fuel, but such impacts are expected to be minimal. Overall, impacts to water quality from wind generation facilities are characterized as SMALL.

Other Impacts

NREL (NREL 2009) reports that there is no uniformly accepted single metric of land use for wind power plants. However, two primary indices of land use do exist – the infrastructure/direct impact area (land temporarily or permanently disturbed by wind power plant development) and the total impact area (overall area of the power plant as a whole) (NREL 2009).

Permanent direct impact caused by road development, turbine pads and electrical support equipment averaged between 0 and 0.6 ha/MWe (1.5 ac/MWe) of capability, while temporary direct impact averaged between 0.1 and 1.3 ha/MWe (0.25 and 3.2 ac/MWe) of capability, for a combined direct impact area (both temporary and permanently disturbed land) of between 0.1 and 1.9 ha/MWe (0.25 and 4.7 ac/MWe) (NREL 2009).

The average value for the total area occupied by a land-based wind power plant was found to be between 12 and 57 ha/MWe (30 and 141 ac/MWe) (NREL 2009). Using the lower end of the ranges of these estimates (to provide a conservative impacts comparison), new wind generating plants to replace the Byron approximate annual average net base-load generating capacity, including MUR, of 2,370 MWe may have a total direct impact area ranging from 446 ha (1,102 ac) (based on estimated 2025 PJM capacity credit) to 1,486 ha (3,673 ac) (based on current-day PJM capacity credit). Meanwhile, the overall area occupied by such wind power plants may range from 53,340 ha (based on estimated 2025 PJM capacity credit) to 177,801 ha (based on current-day PJM capacity credit) (131,804 ac to 439,347 ac). Furthermore, it is unlikely that siting wind generation projects at existing power plant sites to reduce new land development impacts would be possible. Overall, land use impacts from wind energy development are characterized as LARGE.

Development of land-based wind power projects may cause other direct and indirect environmental impacts that are predominately local, but can concern individuals in the affected communities and landscapes (DOE 2008). For example, indirect impacts can include trees being removed around turbines, and the presence of turbines causing some species or individuals to avoid previously viable habitats. Indirect habitat impacts on grassland species are a particular concern, because extensive wind energy development could take place in grassy regions of the country (DOE 2008). Direct impacts can include bird and bat mortality from exposure to the turbine blades or changes in air pressure near the turbine. This is a particular worry with bats because they are relatively long-lived mammals with low reproduction rates, which means that species populations could be adversely affected. Construction of wind farms would result in large land requirements for the construction of a transmission system to support the wind farms. Overall, the direct and indirect environmental impacts of wind energy development on ecological resources are characterized as SMALL to MODERATE.

Compliance with applicable state and federal endangered species protection laws would minimize any adverse impacts to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new wind-powered alternative, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE.

Visual impacts would be considerable due to the number and size of wind turbines that would be required to provide between 4,350 MWe and 14,510 MWe of new wind capability, and because they would be prominent from afar in the open landscape and over a large area. Thus, aesthetic impacts would be characterized as MODERATE to LARGE.

Socioeconomic impacts from the construction workforce could be significant, if worker relocation is required to sites located away from large metropolitan areas. Exelon Generation estimates a construction workforce of 1,000 and a permanent maintenance and operational workforce of 400 for the wind alternative; both estimates could be larger, depending on the selected wind capability requirement (DOE 2008). This is a sizable reduction in operating workforce from Byron's approximately 890 personnel. Loss of jobs would impact various aspects of the local community, usually adversely, including employment, taxes, housing, off-site land use, and public services, which could be significant. However, the communities and land-owners where the wind facilities would be located would receive royalties on land leases, property tax payments, and direct and indirect jobs, which would be a positive effect. Thus, the net socioeconomic impact is characterized as SMALL to MODERATE.

Offshore Facility Impacts

Offshore wind generation projects would create fewer land use conflicts than land-based wind projects, but the costs of offshore wind projects are higher than land-based projects by about 400 percent, which is attributed to the added complexity of siting wind turbines in an aquatic (and a potentially harsher) environment, higher foundation and infrastructure costs, and higher operations and maintenance costs because of accessibility issues and the harsh nature of the aquatic environment (NREL 2010f). NREL's Regional Energy Deployment System model shows nationwide offshore wind potential penetration of between 54 GW and 89 GW by 2030, but only when economic scenarios favoring offshore wind are applied, including combinations of cost reductions (resulting from technology improvements and experience), rising natural gas prices (3 percent annually), heavy constraints on conventional power, and successful new transmission development in congested coastal regions, and national incentive policies including grants and favorable loan policies (NREL 2010f). Further, little information is available regarding other potential impacts of developing offshore wind generation plants in the Great Lakes, including impacts on aquatic and avian life, tourism, and commercial and recreational fishing. As a result, the Great Lakes Commission's Offshore Wind Workgroup has recommended sound planning and caution when moving forward with the development of offshore wind (GLWC 2009). While future development of wind generation in the ROI is likely to include both land-based and offshore wind farms, comparisons of Byron license renewal impacts with offshore wind generation impacts is difficult. However, because Byron license renewal involves no new construction, impacts from Byron license renewal would be less than impacts from construction of a new offshore wind generation plant.

7.2.2.6 Solar Energy

As discussed in Section 7.2.1.5, approximately 5,613 MWe of new solar capability would be required to replace Byron's base-load generating capacity, assuming the current-day capacity credit for solar generating capacity. Development of solar energy projects to replace Byron's capacity would require large commitments of land and would likely need to be constructed on greenfield sites. Also, construction and operation of solar facilities could affect ecological, aesthetic, and cultural resources.

Air Quality

Potential benefits of using solar-generated electricity include reductions from fossil-fuel generated levels of CO_2, which is believed to be the major cause of global climate change (BLM/DOE 2010). Any solar technology will result in emissions during operations because of fugitive dust and engine exhaust from on-site maintenance and repair activities and from commuter/delivery/support vehicles. These emissions would include a small amount of regulated pollutants (e.g., nitrogen oxides, sulfur dioxide, and mercury), volatile organic compounds, carbon dioxide, and hazardous air pollutants (BLM/DOE 2010). Such emissions would be intermittent and would have minor impacts on ambient air quality. Power block emissions at CSP generation facilities would include those from small-scale boilers that maintain heat transfer fluid temperatures and from wet-cooling towers (BLM/DOE 2010). Since PV generation facilities have no power block, potential impacts on ambient air quality associated with operation of a PV facility would be negligible (BLM/DOE 2010). Overall, air pollutant emissions from a CSP facility are characterized as MODERATE, while those from a PV facility are characterized as SMALL. The impacts on human health would be SMALL in either case.

Waste Management

Minor quantities of construction-related wastes would be generated for both CSP and PV facilities. Such wastes would be similar in character and quantity to wastes generated during construction of any large industrial facility (BLM/DOE 2010).

During operation of any solar power facility, industrial wastes, domestic wastes, and wastewaters would be produced in quantities similar to any large industrial facility. Industrial wastes would include discarded materials and equipment, and hazardous wastes such as spent solvents, used oil and filters, oily rags, used hydraulic and transmission fluids, spent glycol-based coolants, spent battery electrolyte, and spent lead-acid batteries (BLM/DOE 2010). The quantities of toxic wastes are expected to be small and would be managed in accordance with applicable environmental regulations (BLM/DOE 2010). At PV facilities, high-performance solar cell materials would contain small amounts of toxic metals such as cadmium, selenium, and arsenic. Under normal conditions, these metals are secured within sealed solar panels and represent no hazard to workers or the public. When removed from service, recycling opportunities would be sought for these panels, but if such opportunities are not available, discarded solar panels containing toxic metals would be characterized, and they might need to be managed as hazardous waste BLM/DOE 2010). On an annual basis, malfunctions or damage sustained in accidents or as a result of weather may result in some panels needing to be replaced. Although critical fluids at CSP facilities such as heat transfer fluids (typically a mix of synthetic organic oils), TES media (e.g., molten salts), and dielectric fluids would be present in substantial quantities, they are expected to last the life of the facility or the component in which they are installed. Thus, wastes consisting of these fluids would be routinely generated only in small amounts as a result of repairs and replacements of system components, or spills and leaks (BLM/DOE 2010) and would be disposed of in accordance with regulations.

Wastewaters would include wastes from industrial activities (spent aqueous cleaning/washing solutions, cooling system and steam cycle blowdowns, brines from water treatment, and spent glycol coolants), sanitary wastewaters, and stormwater runoff from industrial areas (BLM/DOE 2010). Industrial wastewaters generated at a CSP generation facility would also include blowdown from steam cycles and cooling systems and brines from water softening, which may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities (BLM/DOE 2010). In comparison, PV facilities would not generate any wastes associated with the operation and maintenance of a steam cycle or cooling water systems (BLM/DOE 2010).

Overall, waste types and volumes produced at a solar power generation facility would be comparable to or less than those associated with the continued operation of Byron, and associated impacts are characterized as SMALL. Radioactive wastes are not produced at solar power generation facilities.

Water Resources

Water use during construction of a solar power facility would be comparable to water use during construction of any large industrial facility.

During facility operation, a new CSP generation facility would likely use closed-loop cooling towers for removal of heat from the steam cycle. Water use associated with this activity would depend on the size of the facility (BLM/DOE 2010). For a facility with electrical output equivalent to Byron, consumptive water use and quantities of water diverted for non-consumptive use would be comparable to or less than those associated with the continued operation of Byron. Impacts to water quality could occur from accidental spills of petroleum lubricants and fuel or from spills during washing of reflective panels, but such impacts are also expected to be comparable to those associated with the continued operation of Byron. Overall, impacts on aquatic resources and water quality from CSP generation facilities are characterized as SMALL.

Operation of PV facilities would have minimal water consumption impacts because steam cooling is not needed. Impacts to water quality from operation of a PV facility would be comparable to or less than those associated with operation of a CSP facility or continued operation of Byron. Overall, impacts on aquatic resources and water quality from PV facilities are characterized as SMALL.

Other Impacts

Land requirements for solar plants are high. Estimates based on existing installations indicate that utility-scale plants would occupy about 1.6 ha (4.0 ac) per MWe for PV and 2.3 ha (5.7 ac) per MWe for solar thermal systems, such as CSP (Tetra Tech 2012e). Utility-scale solar plants have only been used in regions, such as the western United States, that receive high concentrations of solar radiation (5.24 to 7.65 kilowatt hours per square meter per day). Considering that the ROI receives only 3.25 to 4.56 kilowatt hours of solar radiation per square meter per day (NREL 2006), Exelon Generation estimates that a utility-scale solar plant located in the ROI would occupy about 2.2 ha (5.4 ac) per MWe for PV or 3.8 ha (9.4 ac) per MWe for CSP. The PJM Interconnection currently grants new solar facilities only 38 percent capacity credit (PJM 2010a). Therefore, replacement of the Byron approximate annual average net base-load generating capacity of 2,370 MWe, including MUR, assuming the current-day capacity credit for solar generating capacity, would require dedication of about 12,422 ha (30,695 ac) of land for PV and about 21,624 ha (53,432 ac) of land for CSP. In comparison, the Byron plant site occupies approximately 721 ha (1,782 ac), and no new land development would occur as a result of license renewal.

No existing power plant sites in the ROI are large enough to accommodate either type solar plant of the generating capacity needed to replace the Byron base-load generation capacity. Accordingly, any solar plant constructed to replace Byron would have to be located on a greenfield site. Assuming that sufficient land could be acquired for a solar generation facility, development of the greenfield site would result in large land use impacts. Overall, land use impacts from both CSP and PV solar energy development is characterized LARGE.

Much of the land area occupied by either a CSP or PV generation facility would be cleared and maintained as an unvegetated or sparsely vegetated surface throughout the life of the facility. This would create an extensive loss of habitat for terrestrial, avian and plant communities. Adjacent plant communities could be affected by such factors as increased runoff, altered hydrology, sedimentation, reduced water quality, and erosion (BLM/DOE 2010).

Habitat disturbance from the construction of a solar generation project could impact wildlife, and the presence of the solar generation facilities would create a physical hazard to some wildlife. In particular, birds could collide with certain components of solar generation facilities (e.g., towers and mirrors at CSP facilities), while mammals could collide with project fencing. However, human activity, and the limited quantity and quality of habitat within the project site would discourage the presence of most wildlife in the immediate project area (BLM/DOE 2010). Overall, the direct and indirect environmental impacts on ecological resources of both PV and CSP solar power projects occupying between 12,422 ha (30,695 ac) and 21,624 ha (53,432 ac) are characterized as LARGE.

If a CSP generation facility is in the proximity of a military or civilian airport or a common aircraft flight path, the potential for glint and glare from reflective surfaces to adversely affect pilot control of aircraft would have to be considered as potential aircraft hazards (BLM/DOE 2010).

Compliance with applicable state and federal endangered species protection laws would minimize any adverse effects to threatened or endangered species, ensuring a SMALL impact. Depending on the state hosting the new solar energy alternative, impacts to cultural resources could be possible, because not all states require the protection of cultural resources on private lands. Therefore, impacts to cultural resources could be SMALL to MODERATE.

Visual impacts would be considerable due to the number and size of either solar towers (approximately 91 m [300 ft] high) with arrays of sun-tracking heliostats (mirrors), or arrays of parabolic solar troughs together with ancillary systems that would be required to provide approximately 5,613 MWe of new solar capability (equivalent to Byron’s base-load [90 percent or better capacity factor] generating capacity, based on PJM’s 38 percent capacity credit). These components would be prominent in the open landscape and over a large area. Thus, aesthetic impacts would be characterized as MODERATE to LARGE.

Socioeconomic impacts from the construction workforce could be significant, if worker relocation is required to sites located away from large metropolitan areas. Exelon Generation estimates a peak construction workforce of approximately 3,400 workers and a permanent maintenance and operational workforce of 200, or larger, for the solar alternative (BLM/DOE 2010), depending on the selected solar capability requirement. This is a sizable reduction in personnel compared to Byron’s approximately 890 personnel. Loss of personnel would affect various aspects of the local community including employment, taxes, housing, off-site land use, and public services, and the effects could be significant and adverse. Thus, the net socioeconomic impact is characterized as SMALL to MODERATE.

7.2.2.7 Wind Generation, PV Solar Generation and Gas-fired Combined-cycle Generation

Construction of the wind farm and the gas-fired combined-cycle plants would have relatively larger environmental impacts in comparison to Byron license renewal, which would involve no new construction activities. Operating impacts associated with the wind and PV solar portions of this alternative are described in Sections 7.2.2.5 and 7.2.2.6, respectively. Additional impacts from the backup gas-fired combined-cycle plants would be similar to those described in Section 7.2.2.1. As a whole, the combination of alternatives would have relatively greater impacts than from any of its three components. Furthermore, those impacts would also be greater than the impacts from renewal of the Byron operating licenses.

Exelon Generation concludes that it is very unlikely that the environmental impacts of this or any combination of fossil-fuel-fired and renewable energy alternatives would result in impacts comparable to the small impacts associated with renewal of the Byron operating licenses because most alternatives would require construction activities, and several would require large land commitments.

7.2.2.8 Wind Generation Combined With Compressed Air Energy Storage

Construction of the land-based and off-shore wind farms and the CAES facility would have relatively larger environmental impacts in comparison to Byron license renewal, which would involve no new construction activities. Operating impacts associated with the wind portion of this alternative are described in Section 7.2.2.5. Impacts from the gas-fired portion of the energy recovery process associated with the CAES component would be similar to the impacts described in Section 7.2.2.1 for a gas-fired combined-cycle plant. As a whole, construction and operation of a land-based wind generation facility, an off-shore wind generation facility and construction and operation of a CAES facility would have relatively greater impacts than the wind generation facilities alone. Furthermore, those impacts would also be greater than the impacts from renewal of the Byron operating licenses.

Exelon Generation concludes that it is very unlikely that the environmental impacts of this or any combination of renewable energy alternatives would result in impacts comparable to the small impacts associated with renewal of the Byron operating licenses because most alternatives would require construction activities.

Table 7.2-1 Gas-Fired Alternative

Characteristic	Basis
Plant size = 2,400 MWe ISO rating net consisting of six 400-MWe combined-cycle units	Manufacturer's standard size gas-fired combined-cycle units (total rating approximately Byron's annual net mean generation capacity of 2,370 MWe, including MUR
Plant size = 2,502 MWe ISO rating gross	Based on 4 percent on-site power usage
Number of plants/combined-cycle units = 6 / 6	Assumed
Fuel Type = natural gas	Assumed
Fuel heating value = 1,011 Btu/ft^3	Typical for natural gas used in ROI (EIA 2011b)
Fuel SO_2 emission = 0.00066 lb/MMBtu	(EPA 2000)
NO_x control = selective catalytic reduction (SCR) with steam/water injection	Best available for minimizing NO_x emissions (EPA 2000)
Fuel NO_x emission = 0.0109 lb/MMBtu	Typical for large SCR controlled gas fired units with water injection (EPA 2000)
Fuel CO emission = 0.00226 lb/MMBtu	Typical for large SCR controlled gas fired units. (EPA 2000)
Fuel $PM_{2.5}$ emission = 0.0047 lb/MMBtu	(EPA 2000)
Fuel CO_2 emission = 110 lb/MMBtu	(EPA 2000)
Heat rate = 5,690 Btu/kWh	(GE Energy 2007)
Capacity factor = 87 percent	Assumed based on conservative performance of modern plants (EIA 2010b)

Note: The difference between "net" and "gross" is electricity consumed on-site.
The heat recovery steam generators (HRSGs) do not contribute to air emissions.

Btu = British thermal unit

ft^3 = cubic foot

ISO rating = International Standards Organization rating at standard atmospheric conditions of 59 °F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch

kWh = kilowatt hour

MM = million

MWe = megawatt electrical

NO_x = nitrogen oxides

$PM_{2.5}$ = particulates having diameter of 2.5 microns or less

CO = carbon monoxide

CO_2 = carbon dioxide

SO_2 = sulfur dioxide

Table 7.2-2 Coal-Fired Alternative

Characteristic	Basis
Plant size = 2,400 MWe ISO rating net	Size set equal to gas-fired alternative (approximately Byron's annual net mean generation capacity of 2,370 MWe)
Plant size = 2,552 MWe ISO rating gross	Based on 6 percent on-site power usage
Number of plants = 4	Assumed
Boiler type = tangentially fired, dry-bottom	Minimizes nitrogen oxides emissions. (EPA 1998a)
Fuel Type = sub-bituminous, pulverized coal	Assumed
Fuel heating value = 8,730 Btu/lb	Typical for sub-bituminous coal used in ROI (EIA 2011b)
Fuel ash content by weight = 4.93 percent	Typical for sub-bituminous coal used in ROI (EIA 2011b)
Fuel sulfur content by weight = 0.27 percent	Typical for sub-bituminous coal used in ROI (EIA 2011b)
Uncontrolled NO_x emission = 7.2 lb/ton	Typical for pulverized coal, tangentially fired, dry-bottom, NSPS (EPA 1998a)
Uncontrolled CO emission = 0.5 lb/ton	Typical for pulverized coal, tangentially fired, dry bottom, NSPS (EPA 1998a)
Uncontrolled CO_2 emission = 4,810 lb/ton	Typical for pulverized coal, tangentially fired, dry bottom, NSPS (EPA 1998a)
Heat rate = 8,937 Btu/kWh	Typical for ultra-supercritical coal-fired boilers (EPA 2009b)
Capacity factor = 0.85	Assumed based on conservative performance of modern plants (EIA 2010b)
NO_x control=low NOx burners, over-fire air and selective catalytic reduction (95 percent reduction)	Best available and widely demonstrated for minimizing NO_x emissions (EPA 1998a)
Particulate control = baghouse fabric filters (99.9 percent removal efficiency)	Best available for minimizing particulate emissions (EPA 1998a)
SO_x control = Wet scrubber - limestone (95 percent removal efficiency)	Best available for minimizing SO_x emissions (EPA 1998a)

Note: The difference between "net" and "gross" is electricity consumed on-site.

Btu = British thermal unit

ISO rating = International Standards Organization rating at standard atmospheric conditions of 59 °F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch

kWh = kilowatt hour

NSPS = New Source Performance Standard

lb = pound

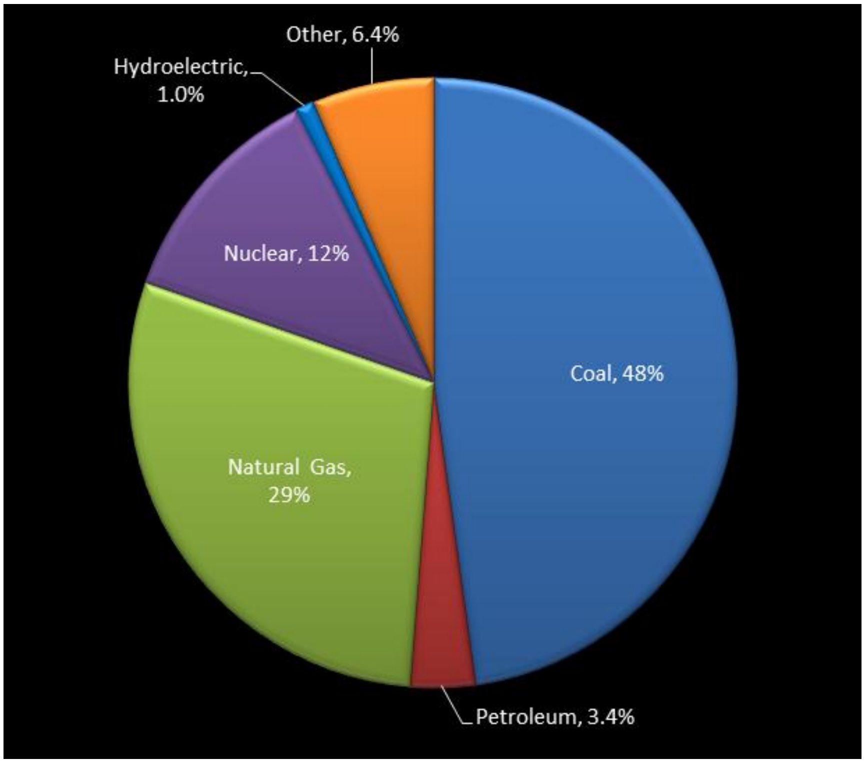
MWe = megawatt electrical

NO_x = nitrogen oxides

SO_x = sulfur oxides

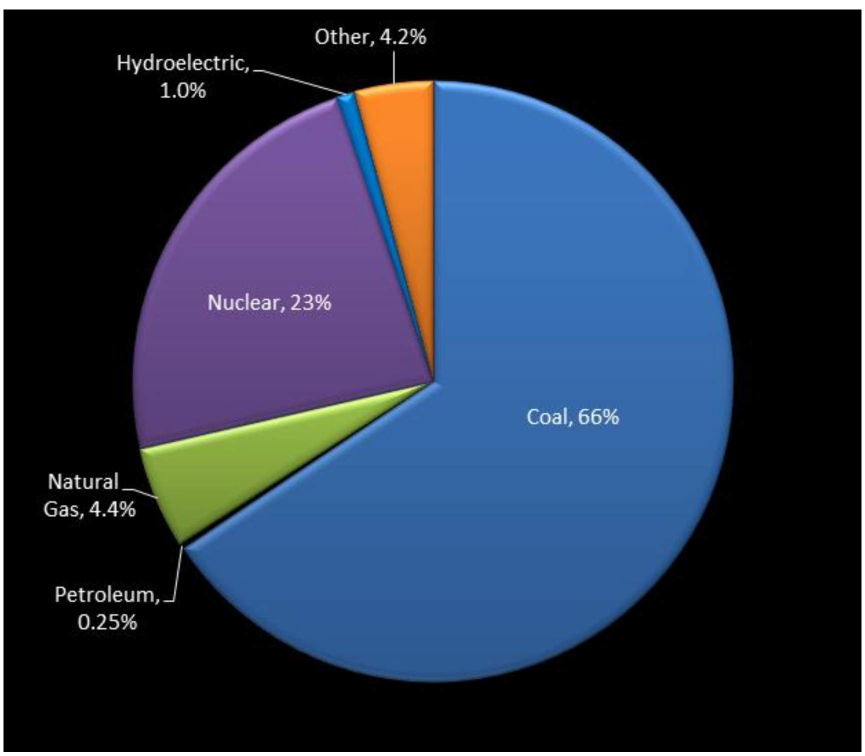
CO = carbon monoxide

CO_2 = carbon dioxide



Source: Derived from EIA 2012b

Figure 7.2-1. ROI Generating Capacity by Fuel Type 2010



Source: EIA 2012b

Figure 7.2-2. ROI Energy Output by Fuel Type 2010

Chapter 8

Comparison of Environmental Impact of License Renewal with the Alternatives

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NRC

> **"…To the extent practicable, the environmental impacts of the proposal and the alternatives should be presented in comparative form..." 10 CFR 51.45(b)(3) as adopted by 51.53(c)(2)**

Chapter 4 analyzes environmental impacts of the Byron license renewal and Chapter 7 analyzes impacts of reasonable alternatives. Table 8.0-1 summarizes environmental impacts of the proposed action (license renewal) and the reasonable alternatives, for comparison purposes. Wind combined with PV Solar and Gas-Fired Combined-Cycle Generation and Wind Generation Combined with Compressed Air Energy Storage Alternatives were also analyzed in Chapter 7 but are not summarized in Tables 8.0-1 and 8.0-2 because environmental impacts of these two alternatives would be at least as large as, and in some cases larger than, the impacts of the solar and wind alternative described here. The environmental impacts compared in Table 8.0-1 are either Category 2 issues for the proposed action or are issues that the GEIS (NRC 1996b) identified as major considerations in an alternatives analysis. For example, although the NRC concluded that impacts from the proposed action would be small (Category 1) for several potential sources of human health risk, the GEIS identified human health concerns associated with air emissions as an impact area to be considered in the comparison of alternatives (Section 7.2.2). Therefore, Table 8.0-1 includes a comparison of the air impacts from the proposed action to those of the alternatives. Table 8.0-2 provides a more detailed comparison of the alternatives.

As shown in Table 8.0-1 and Table 8.0-2, environmental impacts of the proposed action (Byron license renewal) are expected to be SMALL for all impact categories evaluated to which this measure applies. For threatened and endangered species, the proposed action is not likely to affect protected species, and for cultural resources, the proposed action would have no adverse effect on resources. Exelon Generation expects that environmental impacts from the alternative actions identified as reasonable could be SMALL, MODERATE, or MODERATE to LARGE or LARGE for the replacement generation facilities, depending on the impact category to which these measures apply that is being evaluated. For threatened and endangered species, the alternative actions are expected to have no effect or be not likely to affect protected species. For cultural resources, the alternative actions are expected to either occur where no resource is present or have no adverse effect on resources.

Exelon Generation concludes that the environmental impacts of the continued operation of Byron, providing approximately 2,370 MWe of base-load power generation through 2046, would be smaller overall than impacts associated with any of the reasonable alternatives that are analyzed. Byron's continued operation would create significantly less environmental impacts than the construction and operation of new base-load generation capacity. Additionally, Byron's continued operation would have a significant positive economic impact on the communities surrounding the station. Therefore, Exelon Generation concludes that the SMALL adverse environmental impacts of license renewal would not prevent the energy planning decision makers from selecting that option.

Table 8.0-1. Impacts Comparison Summary

			No Action Alternative							
Impact	**Proposed Action (License Renewal)**	**Base (Decom-missioning)**	**With Gas-Fired Generation**	**With Coal-Fired Generation**	**With Purchased Power**	**With New Nuclear Capacity**	**With Wind Energy**	**With Solar Energy**	**With Combined Wind Energy, Solar Power, & Gas-Fired Generation**	**With Combined Wind Energy & Compressed Air Energy Storage**
Land Use	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	LARGE	LARGE	LARGE	LARGE
Water Resources	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
Air Quality	SMALL	SMALL	MODERATE	MODERATE	SMALL to MODERATE	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Ecological Resources	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	LARGE	SMALL to MODERATE	SMALL to MODERATE
Threatened or Endangered Species[1]	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT	NOT LIKELY TO AFFECT
Human Health	SMALL	SMALL	SMALL to MODERATE	MODERATE	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE
Socioeconomics	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE	MODERATE	MODERATE
Waste Management	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL
Aesthetics	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Cultural Resources[2]	NO ADVERSE EFFECTS	NO ADVERSE EFFECTS	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NO ADVERSE EFFECTS	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT	NOT PRESENT to ADVERSE AFFECT

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.
(from 10 CFR Part 51, Subpart A, Appendix B, Table B-1, Footnote 3).

[1] Effects on threatened or endangered species may be characterized as follows:
(1) no effect,
(2) not likely to affect,
(3) likely to affect,
(4) likely to jeopardize continued existence,,
(5) adversely modifies designated critical habitat.
[2] Effects on historic properties may be characterized as follows:
(1) no historic properties present;
(2) historic properties are present, but not adversely affected; or
(3) historic properties are adversely affected.

Table 8.0-2. Impacts Comparison Detail

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Alternative Descriptions									
Renewal of Byron Units 1 and 2 licenses for 20 years each, followed by decommissioning	Decommissioning following expiration of current Byron Units 1 and 2 licenses. Adopting by reference, as bounding for Byron decommissioning, GEIS description (Section 7.1)	New construction at an existing power plant site (Section 7.2.2.1)	New construction at an existing power plant site (Section 7.2.2.2)	Adopting by reference GEIS description of alternate technologies (Section 7.2.2.3)	New construction at an existing power plant site (Section 7.2.2.4)	Would involve construction of wind energy turbine capacity (Section 7.2.2.5)	Would involve construction of solar collector capacity (CSP or PV) (Section 7.2.2.6)	Construction of wind energy turbines, solar Energy Collectors, and gas-fired firming capacity (Section 7.2.2.7)	Construction of wind energy turbines and CAES firming capacity (Section 7.2.2.8)
		Six pre-engineered 400-MWe gas-fired combined-cycle systems with heat recovery steam generators, producing combined total of 2,400 MWe (net); capacity factor: 0.87	Four 600-MWe (net) ultra-supercritical pulverized coal-fired boiler; capacity factor 0.85		Two units using an NRC-certified standard design producing combined 2,400 MWe net; capacity factor 0.90	2011 capacity factor: 0.15 – 14,510 MWe wind turbine capacity; 2025 capacity factor: 0.49 – 4,350 MW wind turbine capacity; Assume no firming capacity	2011 capacity factor: 0.38 – 5,613 MWe solar energy generation; Assume no firming capacity	Wind turbine - 2,260 MWe (capacity factor: 0.49), plus solar - 2,700 MWe (capacity factor: 0.38), plus Firming capacity of 140 MWE from gas-fired combined cycle generation	Wind turbine - 4,265 MWe of wing turbine power (capacity factor: 0.49), plus Firming capacity of 2,370 MWe from CAES generation
		Construct two 41-cm (16 in) diameter gas pipelines in an existing 30 m (100-ft) wide ROW. May require upgrades to existing pipelines	Construct new rail spur or extend an existing spur	Construct new transmission lines to assure local transmission system stability		Construct new transmission lines	Construct new transmission lines	Construct new transmission lines	Construct new transmission lines

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
		Construct intake/discharge system	Construct cooling tower(s) and intake/dis-charge system		Construct cooling tower(s) and intake/discharge system		For CSP plant, construct small gas-fired industrial boiler and cooling towers for TES system support		
		Natural gas, 1,011 Btu/ft^3; 5,690 Btu/kWh; 0.00066 lb SO_2/MMBtu; 0.0109 lb NO_x/MMBtu; 1.07 x 10^{11} ft^3 gas/yr	Pulverized sub-bituminous coal, 8,730 Btu/lb; 8,937 Btu/kWh; 4.9% ash; 0.27% sulfur; 7.2 lb NOx/ton coal; 9.73 x 10^6 tons coal/yr		Low-enriched uranium fuel; refueling every 18 months				
		Selective catalytic reduction with steam/water injection	Low NOx burners, overfire air and selective catalytic reduction (95% NOx reduction efficiency)						
			Wet scrubber – limestone desulfurization system (95% SO_x removal efficiency); 8.2x10^4 tons limestone/yr; fabric filters (99.9% particulate removal efficiency)						

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Approximately 890 employees		Approximately 94 employees (Section 7.2.2.1)	Approximately 326 employees (Section 7.2.2.2)		Approximately 770 employees (Section 7.2.2.4)	Approximately 400 employees (Section 7.2.2.5)	Approximately 200 employees (Section 7.2.2.6)		
				Land Use Impacts					
SMALL – Adopting by reference Category 1 issue findings (Appendix A, Table A-1, Issues 52 and 53)	SMALL – Not an impact evaluated by GEIS (NRC 1996b)	SMALL – 38 ha (94 ac) for facility at existing power plant location. Two new gas pipelines would be built within existing ROW to connect with existing gas pipeline corridor (Section 7.2.2.1)	SMALL to MODERATE – 154 ha (382 ac) on an existing site required for the power block and associated facilities; 11 ha (26 ac) for ash/sludge disposal (Section 7.2.2.2)	SMALL to MODERATE – Most transmission facilities could be constructed along existing transmission ROW (Section 7.2.2.3). Adopting by reference GEIS description of land use impacts from alternate technologies (NRC 1996b)	SMALL to MODERATE – 108 ha (266 ac) required for the power block and associated facilities at an existing power plant site (Section 7.2.2.4)	LARGE – Total direct impact area based on 2011 PJM capacity credit is 1,486 ha (3,673 ac) and based on 2025 PJM capacity credit is 446 ha (1,102 ac). Overall affected area based on 2011 PJM capacity credit is 177,801 ha (439,347 ac) and 53,340 ha (134,804 ac) based on 2025 PJM capacity credits. (Section 7.2.2.5)	LARGE - Requires 12,422 ha (30,695 ac) for PV and 21,624 ha (53,432 ac) for CSP. Large land use precludes availability of land for use appropriate for job generation (Section 7.2.2.6)	LARGE – Large land mass required for wind and solar power generation	LARGE – Large land mass required for wind power generations and large caverns required for CAES

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Water Resource Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 1-3, 6-11 and 31). One Category 2 surface water issue applies (Section 4.1, Issue 13) and two Category 2 groundwater issues apply (Section 4.5, Issue 33 and Section 4.6, Issue 34).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 89).	SMALL – Reduced cooling water demands, inherent in combined-cycle design (Section 7.2.2.1)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to Byron by using cooling tower and discharging to an alternative water source (Section 7.2.2.2)	SMALL TO MODERATE – Adopting by reference GEIS description of water quality impacts from alternate technologies (NRC 1996b)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to Byron by using cooling towers and discharging to an alternate water source (Section 7.2.2.4)	SMALL – No consumptive water use required (Section 7.2.2.5)	SMALL – No consumptive water use for a PV facility; cooling towers and heat transfer systems in CSP facility consumptively use water; Runoff can be controlled with engineered features (Section 7.2.2.6)	SMALL –wind, PV and combined cycle facilities use minimal water	SMALL – CAES and wind turbines consume minimal water
Air Quality Impacts									
SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 51). One Category 2 issue applies (Section 4.11, Issue 50).	SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issue 88)	MODERATE – 36 tons SO_2/yr; 591 tons NO_x/yr; 123 tons CO/yr; 103 tons $PM_{2.5}$/yr[3]; 5,963,000 tons CO_2 /yr (Section 7.2.2.1)	MODERATE – 2,300 tons SOx/yr; 1,752 tons NO_x/yr; 2,433 tons CO/yr; 14 tons $PM_{2.5}$/yr; 55 tons PM_{10}/yr; 0.14 tons mercury/yr; 23,403,000 tons CO_2 /yr (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of air quality impacts from alternate technologies (NRC 1996b)	SMALL – Air emissions are primarily from non-generation equipment and diesel generators and are comparable to those associated with the continued operation of Byron (Section 7.2.2.4)	SMALL - Minimal air emissions during operation (Section 7.2.2.5)	SMALL to MODERATE-Air emissions during operation are from small-scale boilers and wet cooling towers (CSP only); Negligible emissions from PV (Section 7.2.2.6)	SMALL to MODERATE – Gas-fired combustion turbine emits air pollutants similar to gas-fired alternative, but at approximately 6% of the amounts	SMALL to MODERATE – Compression and thermal expansion gas-fired combustion turbine emits air pollutants similar to gas-fired alternative, but in reduced amounts

[3] All TSP for gas-fired alternative is PM-2.5.

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Ecological Resource Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 14-24, 28-30, 41 – 43 and 45 - 48). One Category 2 issue applies (Section 4.9, Issue 40)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 90)	SMALL – Construction of pipeline could alter the terrestrial habitat, but construction on an existing site would minimize habitat disturbances. (Section 7.2.2.1)	SMALL to MODERATE – 154 ha (382 ac) would be required for the new power block and coal storage; 11 ha (26 ac) of the existing site could be required for ash/sludge disposal over a 20 year period. (Section 7.2.2. 2)	SMALL to MODERATE – Adopting by reference GEIS description of ecological resource impacts from alternate technologies (NRC 1996b)	SMALL to MODERATE– Construction could affect terrestrial habitats Impacts of operations would be comparable to those associated with continued operation of Byron (Section 7.2.2.4)	SMALL to MODERATE – Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality (Section 7.2.2.5)	LARGE – Potential for extensive loss of grasslands and habitat area beneath solar collectors due to clearing and maintenance as unvegetated or sparsely vegetated surface during operation (Section 7.2.2.6)	SMALL TO MODERATE - Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality, as wells as solar impacts to habitat	SMALL TO MODERATE - Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Threatened or Endangered Species Impacts[4]									
NOT LIKELY TO ADVERSELY AFFECT – One Category 2 issue applies (Section 4.10, Issue 49)	NOT LIKELY TO ADVERSELY AFFECT – Not an impact evaluated by GEIS (NRC 1996b)	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	NOT LIKELY TO ADVERSELY AFFECT – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats

[4] Effects on threatened or endangered species may be characterized as follows:
(1) no effect,
(2) not likely to affect,
(3) likely to affect,
(4) likely to jeopardize continued existence,,
(5) adversely modifies designated critical habitat.

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Human Health Impacts									
SMALL – Adopting by reference Category 1 issues (Table A-1, Issues 54-56, 58, 61, 62). Two Category 2 issues apply – (1) Impacts from thermophilic organisms (Section 4.12, Issue 57) ; and (2) Risk due to transmission-line induced currents (Section 4.13, Issue 59)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 86)	SMALL TO MODERATE– Adopting by reference GEIS conclusion that some risk of cancer and emphysema exists from emissions (NRC 1996b)	MODERATE – Adopting by reference GEIS conclusion that risks such as cancer and emphysema from emissions are likely (NRC 1996b)	SMALL to MODERATE – Adopting by reference GEIS description of human health impacts from alternate technologies NRC 1996b)	SMALL – Impacts would be comparable to continued operation of Byron (Section 7.2.2.4)	SMALL - Adequate siting distances can minimize sound and vibration impacts (Section 7.2.2.5)	SMALL - Potential for glint and glare from reflective surfaces of CSP system, which could adversely affect pilot control of aircraft (Section 7.2.2.6)	SMALL to MODERATE - Air emissions from combustion turbines	SMALL to MODERATE - Air emissions from combustion turbines / heaters / compressors

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Socioeconomic Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 64 and 67). Six Category 2 issues apply (Section 4.14, Issue 63); (Section 4.15, Issue 65; Section 4.16, Issue 66; and Section 4.18, Issue 70); (Section 4.17.1, Issue 68 and Section 4.17.2, Issue 69)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 91)	SMALL to MODERATE – loss of 898 personnel at the Byron site could adversely affect surrounding counties. (Section 7.2.2.1)	SMALL to MODERATE – loss of 898 personnel at the Byron site could adversely affect surrounding counties (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of socioeconomic impacts from alternate technologies (NRC 1996b)	Construction: SMALL to MODERATE – Peak construction workforce of 4,416 could affect housing and public services in surrounding counties - impacts would depend on location of the plant. Operation: SMALL to MODERATE – reduction in personnel at Byron could adversely affect surrounding counties; new reactor(s) would require 770 personnel (Section 7.2.2.4)	SMALL to MODERATE – Wind energy development might not be compatible with land uses such as housing developments, airport approaches, some radar installations, and low-level military flight training routes requiring worker relocation to remote areas; reduction in 898 personnel at Byron could adversely affect surrounding counties (Section 7.2.2.5) location of the plant. SMALL to MODERATE - reduction in personnel at Byron could adversely affect surrounding counties (Section 7.2.2.5)	SMALL to MODERATE, Large land use precludes availability of land for use appropriate for job generation, reduction in personnel at Braidwood could adversely affect surrounding counties (Section 7.2.2.6)	MODERATE - Reduction in permanent work force at Byron could adversely affect surrounding counties	MODERATE - Reduction in permanent work force at Byron could adversely affect surrounding counties

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Waste Management Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 77 - 85)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 87)	SMALL – The only noteworthy waste would be from spent selective catalytic reduction (SCR) used for NO_x control. (Section 7.2.2.1)	SMALL – 72,000 tons of non-recycled coal ash and 14,600 tons of scrubber sludge annually would require 11 ha (26 ac) over a 20-year period. (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of waste management impacts from alternate technologies (NRC 1996b)	SMALL – Non-radioactive and radioactive wastes would be similar to those associated with the continued operation of Byron (Section 7.2.2.4)	SMALL -Waste generation in minor quantities during operation (Section 7.2.2.5)	SMALL -Waste generation in minor quantities during operation (Section 7.2.2.6)	SMALL-Minimal waste generation during operation	SMALL -Minimal waste generation during operation
Aesthetic Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 72, 73 and 74)	SMALL – Not an impact evaluated by GEIS (NRC 1996b)	SMALL – Visual impacts would be consistent with industrial nature of selected site (Section 7.2.2.1)	SMALL – Visual impacts would be consistent with the industrial nature of the site (Section 7.2.2.2)	SMALL– Adopting by reference GEIS description of aesthetic impacts from alternate technologies (NRC 1996b)	SMALL – Visual impacts would be comparable to those from existing Byron facilities (Section 7.2.2.4)	MODERATE to LARGE – Up to 14,510 MWe required to replace Byron capacity (Section 7.2.2.5)	MODERATE to LARGE -Large land mass occupied by solar collectors would adversely affect habitat and resident animals (Section 7.2.2.6)	MODERATE to LARGE - 750 wind turbines, thousands of acres of solar collectors, and a gas-fired generation unit	MODERATE to LARGE-1,500 wind turbines and the compression / expansion / heating facility for 2,370MW CAES

Table 8.0-2. Impacts Comparison Detail (Continued)

Proposed Action (License Renewal)	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Capacity	With Wind Energy	With Solar Energy	With Combined Wind Energy, PV Solar Energy, & Gas Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Cultural Resources[5]									
NO ADVERSE EFFECTS – One Category 2 issue applies – SHPO consultation minimizes potential for impact (Section 4.19, Issue 71).	NO ADVERSE EFFECTS – Not an impact evaluated by GEIS (NRC 1996b)	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.1)	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.2)	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.3)	NO ADVERSE EFFECTS – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements which must include SHPO consultation due to NRC licensing involvement (Section 7.2.2.4)	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.5)	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements (Section 7.2.2.6)	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements	NOT PRESENT to ADVERSELY AFFECTED – protection of archaeological and cultural resources would be implemented consistent with applicable state and federal requirements

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, an important attribute of the resource.

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

(10 CFR Part 51, Subpart A, Appendix B, Table B 1, Footnote 3).

[5] Effects on historic properties may be characterized as follows:
(1) no historic properties present;
(2) historic properties are present, but not adversely affected; or
(3) historic properties are adversely affected.

Chapter 9

Status of Compliance

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9.1 Proposed Action

NRC

> **"The environmental report shall list all federal permits, licenses, approvals and other entitlements which must be obtained in connection with the proposed action and shall describe the status of compliance with these requirements. The environmental report shall also include a discussion of the status of compliance with applicable environmental quality standards and requirements including, but not limited to, applicable zoning and land-use regulations, and thermal and other water pollution limitations or requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection." 10 CFR 51.45(d), as adopted by 10 CFR 51.53(c)(2)**

9.1.1 General

Table 9.1-1 lists environmental authorizations Exelon Generation has obtained for current Byron operations. In this context, Exelon Generation uses "authorizations" to include any permits, licenses, approvals, or other entitlements. Exelon Generation expects to continue renewing these authorizations, where appropriate, during the current license period and throughout the period of extended operation associated with renewal of the Byron operating license. Because the NRC regulatory focus is prospective, Table 9.1-1 does not include authorizations that Exelon Generation obtained for past activities that did not include continuing obligations.

Preparatory to applying for renewal of the Byron license to operate, Exelon Generation conducted an assessment to identify new and significant environmental information (Chapter 5). The assessment included interviews with subject experts, review of Byron environmental documentation, and communication with state and federal environmental protection agencies. Based on this assessment, Exelon Generation concludes that Byron is in substantive compliance with applicable environmental standards and requirements. Minor deviations from applicable standards or requirements are corrected, and notification is provided to regulatory agencies, as required. Table 9.1-2 lists additional environmental authorizations and consultations related to NRC renewal of the Byron license to operate. As indicated, Exelon Generation anticipates needing relatively few such additional authorizations and consultations. Sections 9.1.2 through 9.1.5 discuss some of these items in more detail.

9.1.2 Threatened or Endangered Species

Section 7 of the Endangered Species Act (16 USC 1531 et seq.) requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of species that are listed, or proposed for listing, as endangered or threatened. Depending on the action involved, the Act requires consultation with the U.S. Fish and Wildlife Service (USFWS), regarding effects on non-marine species, and with National Marine Fisheries Service (NMFS), when marine species could be affected. USFWS and NMFS have issued joint procedural regulations at Title 50 CFR Part 402, Subpart B, that address consultation, and USFWS maintains the joint list of threatened or endangered species at 50 CFR Part 17. Because Byron's continued operations would not affect any endangered or threatened marine species, consultation with NMFS is not required and was not done.

Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comment from USFWS regarding potential effects that Byron license renewal might have. Appendix C includes copies of Exelon Generation correspondence with USFWS.

9.1.3 Historic Preservation

Section 106 of the National Historic Preservation Act (16 USC 470 et seq.) requires federal agencies having the authority to license any undertaking to take into account the effect of the undertaking on historic properties and to afford the Advisory Council on Historic Preservation an opportunity to comment on the undertaking, prior to the agency issuing the license. Advisory Council regulations provide for the State Historic Preservation Officer (SHPO) to have a consulting role (35 CFR 800.2). Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comment on the proposed license renewal for Byron from the Illinois SHPO. Appendix D includes copies of Exelon Generation correspondence with the SHPO regarding potential effects that Byron license renewal might have on historic or cultural resources.

9.1.4 Water Quality (401) Certification

Federal Clean Water Act Section 401 requires an applicant seeking a federal license for an activity that may result in a discharge to navigable waters to provide the federal licensing agency with a certification, or a waiver of certification, by the state where the discharge would originate. If no waiver is issued by the state, its certification must indicate that applicable state water quality standards will not be violated as a result of the discharge (33 USC 1341).

The NRC indicated in its GEIS that issuance of an NPDES permit by a state implies continued Section 401 certification by the state (NRC 1996b). Section 402(b) of the Clean Water Act provides that the Governor of any state can apply to the Administrator of the EPA to administer the NPDES Program in the State. On October 23, 1977, the Illinois State NPDES Permit Program was approved by the EPA, giving Illinois authorization to implement the NPDES permitting program. Accordingly, as evidence of Section 401 certification by Illinois for plant operations during the initial license term, Exelon Generation is providing the existing Byron NPDES permit (IL0048313) (included in Appendix B). The existing NPDES permit was issued January 24, 2011, modified on July 15, 2011, and has an expiration date of December 31, 2015.

In accordance with CWA Section 401 and Illinois EPA guidance, by letter dated July 2, 2012 (see Appendix G), Exelon Generation filed with Illinois EPA, Illinois DNR, and the Army Corps of Engineers, an application for certification that plant operation during the Byron license renewal terms will also comply with Illinois state water quality standards. Determination by Illinois EPA of the application's completeness and initiation of the agency's technical review are expected to occur upon Exelon Generation's filing with the NRC of the Byron and Braidwood Stations, Units 1 and 2 License Renewal Application. Responses from the Illinois DNR and Army Corps of Engineers (see Appendix G) indicate that permits from these agencies are not required to support renewal of the Byron NRC operating licenses, and neither agency objects to issuance of the requested CWA Section 401 certification.

9.1.5 Coastal Zone Management Program

The Federal Coastal Zone Management Act (CZMA) (16 USC 1451 et seq.) imposes requirements on applicants for a federal license to conduct an activity that could affect a state's coastal zone (NRC 2009c). The Act requires the applicant to certify to the licensing agency that the proposed activity would be consistent with the state's federally approved coastal zone management program [16 USC 1456(c)(3)(A)]. The National Oceanic and Atmospheric Administration has promulgated implementing regulations that indicate that the requirement is applicable to renewal of federal licenses for activities not previously reviewed by the state [15 CFR 930.51(b)(1)]. The regulation requires that the license applicant provide its certification to the federal licensing agency and a copy to the applicable state agency [15 CFR 930.57(a)].

Participation in the National Oceanic and Atmospheric Administration (NOAA) Coastal Zone Management Program is voluntary; federal assistance is given to states willing to develop and implement a comprehensive coastal management program. Illinois Department of Natural Resources (IDNR) is the lead agency for implementing a comprehensive coastal management program for protection of the Great Lakes in Illinois. In January 2009, IDNR submitted a draft program document to NOAA's Ocean and Coastal Resource Management's Coastal Programs Division. NOAA approved it on January 31, 2012 (NOAA 2012).

The inland boundary of the Illinois coastal zone includes parts of Cook and Lake Counties and of the Chicago and Calumet River watersheds (NOAA 2011). Byron is outside the boundaries of the Illinois coastal zone, and therefore, no certification of consistency with the Illinois coastal zone management program is required.

Table 9.1-1 Environmental Authorizations for Current Byron Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
		Federal and State Requirements			
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011, et seq.), 10 CFR 50.10	License to operate	NPF-37	Issued: 02/14/1985 Expires: 10/31/2024	Operation of Byron Station Unit 1
			NPF-66	Issued: 01/30/1987 Expires: 11/06/2026 (Scientech 2010)	Operation of Byron Station Unit 2
Illinois Environmental Protection Agency, Division of Water Pollution Control	Clean Water Act (33 USC Section 1251 et seq.), Illinois Administrative Code Title 35, Part 309	NPDES Permit	IL0048313 (IEPA 2011b)	Issued: 01/24/2011 Expires: 12/31/2015	Discharges to Rock River or its tributaries of: (1) cooling tower blowdown water mixed with other processes. and (2) storm water runoff
Illinois Environmental Protection Agency, Division of Water Pollution Control	Environmental Protection Act [415 ILCS 5/13, 13.3 and 27]	Water Pollution Control Permit	2011-EP-1250 (IEPA 2011c)	Issued: 02/16/2011 Expires: 01/31/2016	Hauling of sanitary wastewater to the City of Oregon Wastewater Treatment Facility

Table 9.1-1 Environmental Authorizations for Current Byron Operations (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
		Federal and State Requirements			
U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration	49 USC 5108, Transportation registration; 49 CFR Part 107, Subpart G, Hazardous material shipper/carrier registration	Hazardous Materials Certificate of Registration	040810750001SU (USDOT 2010)	Issued: 06/09/2010 Expires: 06/30/2013	Transportation of hazardous materials.
Illinois Environmental Protection Agency, Division of Air Pollution Control	Federal Clean Air Act (42 USC 7401), 40 CFR Part 70, and Illinois Administrative Code 35 IAC 201	FESOP	Application #78090018 9/11/2007; supplemented 12/10/2007 ID# 141820AA (IEPA 2002)	Issued: 12/01/2001 Expires:12/13/2007[1]	Air emissions from auxiliary boilers, emergency generators, radwaste volume reduction system, cooling towers, and ancillary operations
Illinois Environmental Protection Agency, Bureau of Land	35 IAC 722	Notification of Hazardous Waste Activity	ILD000806521 (Exelon Nuclear 2003b)	Not Applicable	Small quantity generator of hazardous and mixed waste
Illinois Environmental Protection Agency, Bureau of Land	35 IAC 391	Land application of sludge	2009-SC-2169-1 (IEPA 2010b)	Issued: 04/20/2010 Expires: 05/31/2014	Land application of river sediment that accumulates in the cooling towers

[1] 415 Illinois Complied Statutes 5/-, Title II, Air Pollution, Sec. 9.1(f), extends the effective term of the FESOP if the permit holder submits a completed application for renewal to the IEPA at least 90 days prior to the permit expiration. Because Exelon Generation met this requirement, the permit is administratively extended (415 ILCS 5/9.1).

Table 9.1-1 Environmental Authorizations for Current Byron Operations (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
Illinois Emergency Management Agency, Division of Nuclear Safety	32 IAC 609	Waste tracking permit	IL-0105	Not Applicable	Shipments of low-level radioactive waste
Tennessee Department of Environment and Conservation	Tennessee Code Annotated 68-202-206	License to deliver radioactive material	T-IL007-L12 (TDEC 2011)	Renewed annually	License to deliver radioactive material to processing facility in Tennessee
Utah Department of Environmental Quality	Utah Rule 313-26	Permit to deliver radioactive material	0110000032 (Utah 2012)	Renewed annually	Permit to deliver radioactive material to disposal facility in Utah

NPDES – National Pollutant Discharge Elimination System

FESOP – Federally Enforceable State Operating Permit

Table 9.1-2 Environmental Authorizations for Byron License Renewal[a]

Agency	Authority	Requirement	Remarks
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011 et seq.)	License renewal	Applicant for federal license must submit an Environmental Report in support of license renewal application
U.S. Fish and Wildlife Service	Endangered Species Act Section 7 (16 USC 1536)	Consultation	Federal agency issuing a license must consult with the USFWS
Illinois Environmental Protection Agency	Clean Water Act Section 401 (33 USC 1341)	Certification	Applicant seeking federal license for a project with discharge to state waters must obtain either State certification that proposed action would comply with applicable State water quality standards or a waiver
Illinois Historic Preservation Agency	National Historic Preservation Act Section 106 (16 USC 470f)	Consultation	Federal agency issuing a license must consider cultural impacts and consult with State Historic Preservation Officer

[a] No requirements related to NRC license renewal were identified for local or other agencies

9.2 Alternatives

NRC

> **"The discussion of alternatives in the report shall include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements." 10 CFR 51.45(d), as required by 10 CFR 51.53(c)(2)**

The coal, gas, purchased power, new nuclear, and renewables alternatives discussed in Section 7.2 could be constructed and operated to comply with applicable environmental quality standards and requirements. Exelon Generation notes that increasingly stringent air quality protection requirements could make the construction of a large fossil-fueled power plant infeasible in many locations. Exelon Generation also notes that the EPA is revising its requirements for design and operation of cooling water intake structures at new and existing facilities (40 CFR Part 125, Subparts I and J). These requirements could necessitate construction of cooling towers and other technologies for the coal- and gas-fired and new nuclear alternatives.

Chapter 10

References

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10.1 References

Note to reader: Some web pages cited in this document may no longer be available, or may no longer be available through the original URL addresses. Hard copies of cited web pages are available in Exelon Generation files. Some sites, for example the census data, cannot be accessed through their given URLs. The only way to access these pages is to follow queries on previous web pages. The complete URLs used by Exelon Generation have been given for these pages, even though the URLs may not provide direct access to the pages.

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Appendix A

NRC NEPA Issues for License Renewal of Nuclear Power Plants

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Exelon Generation has prepared this environmental report in accordance with the requirements of NRC regulation 10 CFR 51.53. NRC included in the regulation the list of 92 National Environmental Policy Act (NEPA) issues for license renewal of nuclear power plants that were identified in the 1996 GEIS (Appendix B to Subpart A of 10 CFR Part 51, Table B-1).

Table A-1, below, lists the 92 issues from 10 CFR Part 51, Appendix B, Table B-1 and identifies the section in this environmental report in which Exelon Generation addresses each applicable issue. For organization and clarity, Exelon Generation has assigned a number to each issue and uses the issue numbers throughout the environmental report.

As is explained in Section 4.0.2 of this environmental report, on April 20, 2012, the NRC staff requested Commission approval to publish a final rule amending the environmental protection regulations for the renewal of nuclear power plant operating licenses (SECY-12-0063). The updated GEIS that supports the final rule discussed in SECY-12-0063 reviews the 92 environmental issues that were identified and categorized in the 1996 GEIS. It retains many without change in definition or categorization, but others are combined and redefined, and some have been re-categorized from Category 2 to Category 1. Also, one issue (Environmental Justice) was re-categorized from NA to a new Category 2 issue. According to SECY-12-0063, Enclosure 1, 15 new issues were identified in all, of which 11 were determined to be Category 1 and four were determined to be Category 2 issues.

The revised version of Appendix B to Subpart A of 10 CFR Part 51, Table B, as presented in SECY-12-0063, Enclosure 1, lists a total of 78 NEPA issues for license renewal of nuclear power plants. In the same manner as was done for the 92 issues identified in the 1996 GEIS, Exelon Generation has assigned a number to each of the 78 issues. The issue numbers mentioned in Table A-2 below are based on these numbers. Only the 15 new Category 1 and Category 2 issues are named in Table A-2. For each applicable issue, Table A-2 identifies the sections in this environmental report and in the updated GEIS that address the issue.

Table A-1 Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues.

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
Surface Water Quality, Hydrology, and Use (for all plants)			
1. Impacts of refurbishment on surface water quality	1	4.0.1	3.4.1/3-4
2. Impacts of refurbishment on surface water use	1	4.0.1	3.4.1/3-4
3. Altered current patterns at intake and discharge structures	1	4.0.1	4.3.2.2/4-31
4. Altered salinity gradients	1	NA	Issue applies to an activity, discharge to saltwater, which Byron does not do.
5. Altered thermal stratification of lakes	1	NA	Issue applies to a plant feature, discharge to a lake, which Byron does not have.
6. Temperature effects on sediment transport capacity	1	4.0.1	4.3.2.2/4-31
7. Scouring caused by discharged cooling water	1	4.0.1	4.3.2.2/4-31
8. Eutrophication	1	4.0.1	4.3.2.2/4-31
9. Discharge of chlorine or other biocides	1	4.0.1	4.3.2.2/4-31
10. Discharge of sanitary wastes and minor chemical spills	1	4.0.1	4.3.2.2/4-31
11. Discharge of other metals in waste water	1	4.0.1	4.3.2.2/4-31
12. Water use conflicts (plants with once-through cooling systems)	1	NA	Issue applies to a plant feature, a once-through cooling system, which Byron does not have.
13. Water use conflicts (plants with cooling ponds or cooling towers using make-up water from a small river with low flow)	2	4.1	4.3.2.2/4-31

Table A-1. Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
Aquatic Ecology (for all plants)			
14. Refurbishment impacts to aquatic resources	1	4.0.1	3.5/3-5
15. Accumulation of contaminants in sediments or biota	1	4.0.1	4.3.3/4-33
16. Entrainment of phytoplankton and zooplankton	1	4.0.1	4.3.3/4-33
17. Cold shock	1	4.0.1	4.3.3/4-33
18. Thermal plume barrier to migrating fish	1	4.0.1	4.3.3/4-33
19. Distribution of aquatic organisms	1	4.0.1	4.3.3/4-33
20. Premature emergence of aquatic insects	1	4.0.1	4.3.3/4-33
21. Gas supersaturation (gas bubble disease)	1	4.0.1	4.3.3/4-33
22. Low dissolved oxygen in the discharge	1	4.0.1	4.3.3/4-33
23. Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	1	4.0.1	4.3.3/4-33
24. Stimulation of nuisance organisms (e.g., shipworms)	1	4.0.1	4.3.3/4-33
Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)			
25. Entrainment of fish and shellfish in early life stages for plants with once-through and cooling pond heat dissipation systems	2	NA	Issue applies to a once-through and cooling pond heat dissipation system, which Byron does not have.
26. Impingement of fish and shellfish for plants with once-through and cooling pond heat dissipation systems	2	NA	Issue applies to a once-through and cooling pond heat dissipation system, which Byron does not have.
27. Heat shock for plants with once-through and cooling pond heat dissipation systems	2	NA	Issue applies to a once-through and cooling pond heat dissipation system, which Byron does not have.
Aquatic Ecology (for plants with cooling-tower-based heat dissipation systems)			
28. Entrainment of fish and shellfish in early life stages for plants with cooling-tower-based heat dissipation systems	1	4.0.1	4.3.3/4-33
29. Impingement of fish and shellfish for plants with cooling-tower-based heat dissipation systems	1	4.0.1	4.3/4-33

Table A-1. Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
30. Heat shock for plants with cooling-tower-based heat dissipation systems	1	4.0.1	4.3/4-33
Groundwater Use and Quality			
31. Impacts of refurbishment on groundwater use and quality	1	4.0.1	3.4.2/3-5
32. Groundwater use conflicts (potable and service water; plants that use < 100 gpm)	1	NA	Issue applies to a feature, use of <100 gpm of groundwater, which Byron does not have.
33. Groundwater use conflicts (potable, service water, and dewatering; plants that use > 100 gpm)	2	4.5	4.8.1/4-116 4.8.1/4-119
34. Groundwater use conflicts (plants using cooling towers withdrawing make-up water from a small river)	2	4.6	4.8.1/4-117
35. Groundwater use conflicts (Ranney wells)	2	NA	Issue applies to a plant feature, Ranney wells, which Byron does not have.
36. Groundwater quality degradation (Ranney wells)	1	NA	Issue applies to a feature, Ranney wells, that Byron does not have.
37. Groundwater quality degradation (saltwater intrusion)	1	NA	Issue applies to a feature, a coastal location, that Byron does not have.
38. Groundwater quality degradation (cooling ponds in salt marshes)	1	NA	Issue applies to a feature, a coastal location, that Byron does not have.
39. Groundwater quality degradation (cooling ponds at inland sites)	2	NA	Issue applies to a feature, cooling ponds, that Byron does not have.
Terrestrial Resources			
40. Refurbishment impacts to terrestrial resources	2	4.9	3.6/3-6
41. Cooling tower impacts on crops and ornamental vegetation	1	4.0.1	4.3.4/4-34
42. Cooling tower impacts on native plants	1	4.0.1	4.3.4/4-35
43. Bird collisions with cooling towers	1	4.0.1	4.3.5/4-45
44. Cooling pond impacts on terrestrial resources	1	NA	Issue applies to a feature, cooling ponds, which Byron does not have

Table A-1. Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
45. Power line right-of-way management (cutting and herbicide application)	1	4.0.1	4.5.6.1/4-71
46. Bird collisions with power lines	1	4.0.1	4.5.6.2/4-74
47. Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	1	4.0.1	4.5.6.3/4-77
48. Floodplains and wetlands on power line right-of-way	1	4.0.1	4.5.7./4-81
Threatened or Endangered Species (for all plants)			
49. Threatened or endangered species	2	4.10	4.1/4-1
Air Quality			
50. Air quality during refurbishment (non-attainment and maintenance areas)	2	4.11	3.3/3-2
51. Air quality effects of transmission lines	1	4.0.1	4.5.2/4-62
Land Use			
52. Onsite land use	1	4.0.1	3.2/3-1
53. Power line right-of-way land use impacts	1	4.0.1	4.5.3/4-62
Human Health			
54. Radiation exposures to the public during refurbishment	1	4.0.1	3.8.1/3-32
55. Occupational radiation exposures during refurbishment	1	4.0.1	3.8.2/3-43
56. Microbiological organisms (occupational health)	1	4.0.1	4.3.6/4-48
57. Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	2	4.12	4.3.6/4-48
58. Noise	1	4.0.1	4.3.7/4-49
59. Electromagnetic fields, acute effects	2	4.13	4.5.4.1/4-66
60. Electromagnetic fields, chronic effects	NA	4.0.1	4.5.4.2/4-67
61. Radiation exposures to public (license renewal term)	1	4.0.1	4.6.2/4-87
62. Occupational radiation exposures (license renewal term)	1	4.0.1	4.6.3/4-95

Table A-1. Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
	Socioeconomics		
63. Housing impacts	2	4.14	3.7.2/3-10 (refurbishment) 4.7.1/4-101 (renewal term)
64. Public services: public safety, social services, and tourism and recreation	1	4.0.1	Refurbishment 3.7.4/3-14 (public service) 3.7.4.3/3-18 (safety) 3.7.4.4/3-19 (social) 3.7.4.6/3-20 (tour, rec) Renewal Term 4.7.3/4-104 (public safety) 4.7.3.3/4-106 (safety) 4.7.3.44-107 (social) 4.7.3.6/4-107 (tour, rec)
65. Public services: public utilities	2	4.15	3.7.4.5/3-19 (refurbishment) 4.7.3.5/4-107 (renewal term)
66. Public services: education (refurbishment)	2	4.16	3.7.4/3-15
67. Public services: education (license renewal term)	1	4.0.1	4.7.3.1/4-106
68. Offsite land use (refurbishment)	2	4.17.1	3.7.5/3-20
69. Offsite land use (license renewal term)	2	4.17.2	4.7.4/4-107
70. Public services: transportation	2	4.18	3.7.4.2/3-17 (refurbishment) 4.7.3.2/4-106 (renewal term)
71. Historic and archaeological resources	2	4.19	3.7.7/3-23 (refurbishment) 4.7.7/4-114 (renewal term)
72. Aesthetic impacts (refurbishment)	1	4.0.1	3.7.8/3-30
73. Aesthetic impacts (license renewal term)	1	4.0.1	4.7.6/4-111
74. Aesthetic impacts of transmission lines (license renewal term)	1	4.0.1	4.5.8/4-83
	Postulated Accidents		
75. Design basis accidents	1	4.0.1	5.3.2/5-11 (design basis) 5.5.1/5-114 (summary)

Table A-1. Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
76. Severe accidents	2	4.20	5.3.3/5-12 (probabilistic analysis) 5.3.3.2/5-19 (air dose) 5.3.3.3/5-49 (water) 5.3.3.4/5-65 (groundwater) 5.3.3.5/5-95 (economic) 5.4/5-106 (mitigation) 5.5.2/5-114 (summary)
Uranium Fuel Cycle and Waste Management			
77. Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	1	4.0.1	6.2/6-8
78. Offsite radiological impacts (collective effects)	1	4.0.1	Not in GEIS.
79. Offsite radiological impacts (spent fuel and high-level waste disposal)	1	4.0.1	Not in GEIS.
80. Nonradiological impacts of the uranium fuel cycle	1	4.0.1	6.2.2.6/6-20 (land use) 6.2.2.7/6-20 (water use) 6.2.2.8/6-21 (fossil fuel) 6.2.2.9/6-21 (chemical)
81. Low-level waste storage and disposal	1	4.0.1	6.4.2/6-36 (low-level def) 6.4.3/6-37 (low-level volume) 6.4.4/6-48 (renewal effects)
82. Mixed waste storage and disposal	1	4.0.1	6.4.5/6-63
83. Onsite spent fuel	1	4.0.1	6.4.6/6-70
84. Nonradiological waste	1	4.0.1	6.5/6-86
85. Transportation	1	4.0.1	6.3/6-31, as revised by Addendum 1, August 1999
Decommissioning			
86. Radiation doses (decommissioning)	1	4.0.1	7.3.1/7-15
87. Waste management (decommissioning)	1	4.0.1	7.3.2/7-19 (impacts) 7.4/7-25 (conclusions)
88. Air quality (decommissioning)	1	4.0.1	7.3.3/7-21 (air) 7.4/7-25 (conclusions)
89. Water quality (decommissioning)	1	4.0.1	7.3.4/7-21 (water) 7.4/7-25 (conclusions)
90. Ecological resources (decommissioning)	1	4.0.1	7.3.5/7-21 (ecological) 7.4/7-25 (conclusions)

Table A-1. Byron Units 1 & 2 Environmental Report Cross-Reference of License Renewal NEPA Issues. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section/Page)[b]
91. Socioeconomic impacts (decommissioning)	1	4.0.1	7.3.7/7-19 (socioeconomic) 7.4/7-24 (conclusions)
Environmental Justice			
92. Environmental justice	NA	2.6.2	not in GEIS

a. 10 CFR 51, Subpart A, Appendix A, Table B-1. (Issue numbers added to facilitate discussion.)
b. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437).
NA = not applicable
NEPA = National Environmental Policy Act

Table A-2 Byron Units 1 & 2 Environmental Report Cross-Reference of New License Renewal NEPA Issues Identified in the Updated GEIS.

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section)[a]
Geologic Resources			
8. Geology and soils	1	4.0.2	4.4/4-28
Surface Water Resources			
18. Effects of dredging on surface water quality	1	4.0.2	4.5.1.1/4-38
Groundwater Resources			
27. Radionuclides released to groundwater	2	4.0.2	45.1.2/4-46
Terrestrial Resources			
29. Exposure of terrestrial resources to radionuclides	1	4.0.2	4.6.1.1/4-55
33. Water use conflicts with terrestrial resources (plants with cooling ponds or cooling towers using makeup water from a river)	2	4.0.2	4.6.1.1/4-69
Aquatic Resources			
44. Exposure of aquatic organisms to radionuclides	1	4.0.2	4.6.1.2/4-98
45. Effects of dredging on aquatic organisms	1	4.0.2	4.6.1.2/4-100
46. Water use conflicts with aquatic resources (plants with cooling ponds or cooling towers using makeup from a river)	2	4.0.2	4.6.1.2/4-102
48. Impacts of transmission line right-of-way (ROW) management on aquatic resources	1	4.0.2	4.6.1.2/4-104
Socioeconomics			
52. Employment and income, recreation and tourism	1	4.0.2	4.8.1/4-122
53. Tax revenues	1	4.0.2	4.8.1/4-123
55. Population and housing	1	4.0.2	4.8.1/4-125
Human Health			
59. Human health impact from chemicals	1	4.0.2	4.9.1.1/4-141
63. Physical occupational hazards	1	4.0.2	4.9.1.1/4-151

Table A-2 Byron Units 1 & 2 Environmental Report Cross-Reference of New License Renewal NEPA Issues Identified in the Updated GEIS. (Continued)

Issue[a]	Category	Section of this Environmental Report	GEIS Cross Reference (Section)[a]
Environmental Justice			
67. Minority and low-income populations	2	2.6.2 and 4.0.2	4.10.1/4-161
Cumulative Impacts			
73. Cumulative Impacts	2	4.21	4.13/4-220

a. Issue numbers are based on the revised list of issues in the text for Appendix B to Subpart A of 10 CFR Part 51, Table B-1, as presented in SECY-12-0063, Enclosure 1. For each applicable issue, Table A-2 identifies the sections in this environmental report and in the updated GEIS that address the issue.
NEPA = National Environmental Policy Act