U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-1437
Supplement 43

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 43

Regarding Palo Verde Nuclear Generating Station

Draft Report for Comment

Office of Nuclear Reactor Regulation

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Office of Nuclear Reactor Regulation

Proposed Action	Issuance of renewed operating licenses NPF-41, NPF-51, NPF-74 for Palo Verde Nuclear Generating Station, in Maricopa County, Arizona.
Type of Statement	Draft Supplemental Environmental Impact Statement
Agency Contact	David Drucker U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation Mail Stop O-11F1 Washington, D.C. 20555-0001 Phone: 301-415-6223 Email: David.Drucker@nrc.gov
Comments	Any interested party may submit comments on this supplemental environmental impact statement. Please specify NUREG-1437, Supplement 43, draft, in your comments. Comments must be received by October 29, 2010. Comments received after the expiration of the comment period will be considered if it is practical to do so, but assurance of consideration of late comments will not be given. Comments may be emailed to PaloVerdeEIS@nrc.gov or mailed to: Chief, Rulemaking, Directives, and Editing Branch U.S. Nuclear Regulatory Commission Mail Stop T6-D59 Washington, D.C. 20555-0001 Please be aware that any comments that you submit to the NRC will be considered a public record and entered into the Agencywide Documents Access and Management System (ADAMS). Do not provide information you would not want to be publicly available.

ABSTRACT

This draft supplemental environmental impact statement (DSEIS) has been prepared in response to an application submitted by Arizona Public Service Company (APS) to renew the operating license for the Palo Verde Nuclear Generating Station for an additional 20 years.

This DSEIS includes the analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from new supercritical coal-fired generation; natural gas combined-cycle generation; new nuclear generation; a combination of alternatives that includes natural gas combined-cycle generation, energy conservation, and solar; and not renewing the license (the no-action alternative).

The NRC's preliminary recommendation is the adverse environmental impacts of license renewal for PVNGS are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by APS; (3) consultation with Federal, State, and local agencies; (4) the NRC staff's own independent review; and (5) the NRC staff's consideration of public comments received during the scoping process.

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BACKGROUND

By letter dated December 11, 2008, Arizona Public Service Company (APS) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to issue a renewed operating license for the Palo Verde Nuclear Generating Station (PVNGS), for an additional 20-year period.

Pursuant to Title 10, Part 51.20(b)(2) of the *Code of Federal Regulations* (10 CFR 51.20(b)(2)), the Commission indicates that a renewal of a power reactor operating license requires preparation of an environmental impact statement (EIS) or a supplement to an existing EIS. In addition, 10 CFR 51.95(c) states that the Commission shall prepare an EIS, which is a supplement to the Commission's *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, published in May 1996.

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

- conducted public scoping meetings on June 25, 2009, in Tonopah and Avondale, AZ
- conducted a site audit at the plant in October 2009
- reviewed APS's environmental report (ER) and compared it to the GEIS
- consulted with other agencies
- conducted a review of the issues following the guidance set forth in NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC 2000)
- considered public comments received during the scoping process.

PROPOSED ACTION

APS initiated the proposed Federal action by submitting an application for license renewal of PVNGS, for which the existing licenses, NPF-41, NPF-51, and NPF-74, expire on June 1, 2025 (Unit 1), April 24, 2026 (Unit 2), and November 25, 2027 (Unit 3). The NRC's Federal action is the decision whether to renew these licenses for an additional 20 years.

PURPOSE AND NEED FOR ACTION

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

If the renewed licenses are issued, State regulatory agencies and APS will ultimately decide whether the plants will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the operating licenses are not renewed, then the facility must be shut down on or before the expiration date of the current operating licenses.

ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

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

(1) The environmental impacts associated with the issue is determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

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

(3) Mitigation of adverse impacts associated with the issue is considered in the analysis and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For Category 1 issues, no additional site-specific analysis is required in this draft SEIS unless new and significant information is identified. Chapter 4 of this report presents the process for identifying new and significant information. Site-specific issues (Category 2) are those that do not meet one or more of the criterion for Category 1 issues; therefore, an additional site-specific review for these non-generic issues is required, and the results are documented in the SEIS. The NRC staff has reviewed APS's established process for identifying and evaluating the significance of any new and significant information on the environmental impacts of license renewal of PVNGS. Neither APS nor the NRC identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. Similarly, neither the scoping process nor the NRC staff has identified any new issue applicable to PVNGS that has a significant environmental impact. The NRC staff, therefore, relies upon the conclusions of the GEIS for all Category 1 issues applicable to PVNGS.

LAND USE

SMALL. The NRC staff did not identify any Category 2 issues for land use, nor did the staff identify any new and significant information during the environmental review. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

AIR QUALITY

SMALL. The NRC did not identify any Category 2 issues for air quality impacts, nor did the staff identify any new or significant information during the environmental review. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

GROUNDWATER USE AND QUALITY

SMALL. The staff did not identify any new and significant information in regard to Category 1 groundwater issues. Potential groundwater use conflicts for PVNGS are considered a Category 2 issue that requires a plant-specific assessment. Because PVNGS pumps groundwater at rates well below its authorized water right and uses at most 10 percent of the water that flows through the Phoenix Active Management Area, the NRC staff concludes that impacts due to groundwater use conflicts would be SMALL. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

SURFACE WATER USE AND QUALITY

SMALL. PVNGS does not draw its cooling (or makeup) water directly from any natural surface water body. Instead, it uses treated wastewater effluent from the Phoenix area. PVNGS does not release cooling water to any natural surface water body. Instead, cooling water is discharged to man-made lined evaporation ponds with no outlet and no hydraulic connection to any natural water body. As a result, none of the Category 1 or 2 issues set forth in the GEIS apply to this facility. The staff did not identify any new information and issues during its review. Therefore, the NRC staff concludes that the impact of surface water use and quality are SMALL.

AQUATIC RESOURCES

SMALL. PVNGS does not draw its cooling (or makeup) water directly from any natural surface water body. Instead, it uses treated wastewater effluent from the Phoenix area. PVNGS does not release cooling water to any natural surface water body. Instead, cooling water is discharged to man-made lined evaporation ponds with no outlet and no hydraulic connection to any natural water body. No impingement, entrainment, or heat shock impacts to aquatic species result from plant operation. The staff did not identify any new information and issues during its review. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

TERRESTRIAL RESOURCES

SMALL. The NRC staff identified no Category 2 issues related to terrestrial resources for license renewal. The NRC staff did not identify any additional new and significant information during review of the APS's ER, the site audit, the scoping process, or the evaluation of other available information. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

THREATENED AND ENDANGERED SPECIES

SMALL. The NRC staff identified no Category 2 issues related to threatened and endangered species for license renewal. The NRC staff did not identify any additional new and significant information during review of the APS's ER, the site audit, the scoping process, or the evaluation of other available information. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

HUMAN HEALTH

SMALL. The NRC staff's review of the historical radioactive releases from PVNGS and the resultant dose calculation demonstrate that PVNGS is operating in compliance with Federal radiation protection standards. Continued compliance with regulatory requirements is expected during the license renewal term. Therefore, the impacts from radioactive effluents are not expected to change during the license renewal term.

The NRC staff did not identify any new and significant information during its review. Therefore, for plant operation during the license renewal term, there are no impacts beyond those discussed in the GEIS.

SOCIOECONOMICS

SMALL. For Category 1 issues (public services and aesthetic impacts), the NRC staff identified no new and significant information during the environmental review. Therefore, there would be no impacts beyond those discussed in the GEIS. Category 2 socioeconomic impacts include housing impacts, public services (public utilities), offsite land use, public services (public transportation), and historic and archaeological resources.

Since APS has no plans to add additional employees during the license renewal period except during outages, employment levels at PVNGS would remain relatively constant with no additional demand for permanent housing during the license renewal term. Based on this information, there would be no impact on housing during the license renewal term beyond what has already been experienced.

For the same reason, demand for public water services will remain relatively unchanged with no additional demand. Public water systems in the region would be adequate to meet the demands of residential and industrial customers in the area. Therefore, there would be no additional impact to public water services during the license renewal term beyond what is currently being experienced.

Since non-outage employment levels at PVNGS would remain relatively constant during the license renewal period, there would be no land use impacts related to population or tax revenues, and no transportation impacts. Therefore, offsite land use and transportation issues would remain relatively unchanged.

No impacts to known historic and archaeological resources are expected from the continued operation of PVNGS during the license renewal term. This conclusion is based on the results of archaeological surveys conducted on the property prior to initial plant and transmission line construction; review of Arizona State Historic Preservation Office (SHPO) files, published literature, and information provided by APS; and, verified use of existing environmental procedures by PVNGS.

In reviewing potential social environmental justice impacts (i.e., potential disproportionately high and adverse human health and environmental impacts on minority and low-income populations), an analysis of minority and low-income populations residing within a 50-mile (80-kilometer) radius of PVNGS indicated there would be no disproportionately high and adverse impacts to these populations from the continued operation of PVNGS during the license renewal period. Based on recent monitoring results, concentrations of contaminants in air, leafy vegetation, milk, water, sludge and sediment, in areas surrounding PVNGS have been low (at or near the threshold of detection) and seldom above background levels. Consequently, no disproportionately high and adverse human health impacts are expected in special pathway receptor populations in the region as a result of subsistence consumption.

SEVERE ACCIDENT MITIGATION ALTERNATIVES

Since PVNGS had not previously considered alternatives to reduce the likelihood or potential consequences of a variety of highly uncommon but potentially serious accidents, NRC regulation 10 CFR 51.53(c)(3)(ii)(L) requires that PVNGS evaluate Severe Accident Mitigation Alternatives (SAMAs) in the course of the license renewal review. SAMAs are potential ways to reduce the risk or potential impacts of uncommon but potentially severe accidents and may include changes to plant components, systems, procedures, and training.

The NRC staff reviewed the ER's evaluation of potential SAMAs. Based on the staff's review, the NRC staff concluded that none of the potentially cost-beneficial SAMAs relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of the license renewal pursuant to 10 CFR Part 54.

ALTERNATIVES

The NRC staff considered the environmental impacts associated with alternatives to license renewal. These alternatives include other methods of power generation and not renewing the PVNGS operating licenses (the no-action alternative). Replacement power options considered were supercritical coal-fired generation, natural gas combined-cycle generation, new nuclear generation, and a combination alternative that includes a portion of the combined-cycle gas-fired capacity, a conservation capacity component, and a solar power component. The NRC staff initially considered a number of additional alternatives for analysis as alternatives to license renewal of PVNGS; these were later dismissed due to technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the existing PVNGS licenses expire. The no-action alternative by the NRC staff and the effects it would have were also considered. The NRC staff evaluated each alternaqtive using the same impact areas that were used in evaluating impacts from license *renewal*. The results of this evaluation are summarized in the table on page 7 of this Executive Summary.

COMPARISON OF ALTERNATIVES

The coal-fired alternative would have the greatest overall adverse environmental impact. This alternative would result in MODERATE waste management and air quality impacts from nitrogen oxides, sulfur oxides, particulate matter, polycyclic aromatic hydrocarbons, carbon monoxide, carbon dioxide, and mercury (and the corresponding human health impacts).

The gas-fired alternative would result in SMALL impacts in all areas. This alternative would result in substantially lower air emissions, and lesser amounts of operational wastes than the coal-fired alternative. Gas-fired generation would release greenhouse gases, in lesser quantities per unit of power produced than the coal-fired alternative, but in significantly greater quantities than would result from continued operation of the PVNGS reactors.

Although impacts of installing and operating new nuclear-generating capacity on the PVNGS would be SMALL for all impact categories, there would be impacts during construction that would not occur if operation of the existing reactors were to continue under license renewal.

The combination alternative would have lower air emissions and waste management impacts than both the gas-fired and coal-fired alternatives, however it would have relatively higher construction impacts in terms of land use, and potential disruption to historic and archaeological resources, mainly as a result of construction of the solar portions of the combination alternative which is likely to occur in areas off the PVNGS site.

Under the No Action Alternative, plant shutdown would eliminate approximately 2200 jobs and would reduce tax revenue in the region. The loss of these contributions, which may not entirely cease until after decommissioning, would have a SMALL impact. However, the no-action alternative does not meet the purpose and need stated in this draft SEIS.

Of the alternatives that meet the purpose and need for this draft SEIS, the natural gas-fired alternative, the new nuclear alternative, and the continued operation of PVNGS all have SMALL environmental impacts. Given the need to construct new facilities for gas-fired and new nuclear alternatives, however, NRC staff concludes that continued operation of the existing PVNGS is the environmentally-preferred alternative.

Summary of Environmental Impacts of Proposed Action and Alternatives

Alternative	Impact Area						
	Air Quality	**Groundwater**	**Surface Water**	**Aquatic and Terrestrial Resources**	**Human Health**	**Socioeconomics**	**Waste Management**
License renewal	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Supercritical coal-fired alternative at the PVNGS site	MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	MODERATE
Gas-fired alternative at the PVNGS site	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
New Nuclear alternative at the PVNGS site	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Combination of alternatives	SMALL	SMALL	MODERATE to LARGE	SMALL	SMALL	SMALL to MODERATE	SMALL
No-action alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL

RECOMMENDATION

The NRC's preliminary recommendation is the adverse environmental impacts of license renewal for PVNGS are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by APS; (3) consultation with Federal, State, and local agencies; (4) the NRC staff's own independent review; and (5) the NRC staff's consideration of public comments received during the scoping process.

ABBREVIATIONS AND ACRONYMS

AAC	Arizona Administrative Code
AADT	average annual daily traffic
ac	acre
ADAMS	Agencywide Documents Access and Management System
ADEM	Arizona Division of Emergency Management
ADEQ	Arizona Department of Environmental Quality
ADEQPPP	Arizona Department of Environmental Quality Pollution Prevention Program
ADWR	Arizona Department of Water Resources
AEA	Atomic Energy Act of 1954
AEC	U.S. Atomic Energy Commission
AERC	Arizona Emergency Response Commission
AGFD	Arizona Game and Fish Department
ALARA	as low as reasonably achievable
AMA	Active Management Area
AMSL	above mean sea level
ANSI	American National Standards Institute
APE	area of potential effect
APP	Aquifer Protection Permit
APS	Arizona Public Service Company
AQL	aquifer quality limit
AQCR	Air Quality Control Region
AQRVs	air quality-related values
ARS	Arizona Revised Statutes
AWQS	Arizona Water Quality Standards
BACT	best available control technology
BP	before present
Btu	British thermal unit
Btu/ft^3	British thermal unit per cubic feet
Btu/kWh	British thermal unit per kilowatt-hour
Btu/lb	British thermal unit per pound
BWR	boiling-water reactor

CAA	Clean Air Act
CDFG	California Department of Fish and Game
CDF	core damage frequency
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CH_4	methane
cm	centimeter
cm/s	centimeter per second
CO	carbon monoxide
CO_2	carbon dioxide
CWA	Clean Water Act
dBA	decibels adjusted
DBA	design-basis accident
DNR	Department of Natural Resources
DOE	Department of Energy
DOT	Department of Transportation
DSEIS	draft supplemental environmental impact statement
DSM	demand-side management
E.O.	Executive Order
EDG	emergency diesel generator
EIA	Energy Information Administration
EIS	environmental impact statement
ELF-EMF	extremely low frequency-electromagnetic field
EMF	electromagnetic fields
EMS	environmental management system
EOP	emergency operating procedure
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPRI	Electric Power Research Institute

EPZ	emergency planning zone
ER	environmental report
ERFDADS	Emergency Response Facility Data Acquisition Display System
ESA	Endangered Species Act
ESPS	Essential Spray Pond System
ESRP	Environmental Standard Review Plan
F&O	fact and observation
FES	final environmental statement
FLMs	Federal Land Managers
FR	*Federal Register*
FSAR	final safety analysis report
ft	foot
ft/min	feet per minute
ft^3	cubic feet
g C_{eq}/kWh	grams of CO_2 equivalents per kilowatt-hour
GEIS	generic environmental impact statement
GHG	greenhouse gas
gpm	gallons per minute
GWP	global warming potential
Gy/d	grays per day
ha	hectare
HAP	hazardous air pollutant
HFC	hydrofluorocarbons
HFE	hydrofluorinated ethers
Hg	mercury
HLW	high-level waste
HVAC	heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IGCC	integrated gasification combined-cycle
Inc.	incorporated

IPCC	Intergovernmental Panel on Climate Change
IPE	individual plant examination
IPEEE	individual plant examination of external events
ISFSI	independent spent fuel storage installation
J	joule
kg	kilogram
km	kilometer
km^2	square kilometer
kmh	kilometer per hour
kPa	kilopascal
kV	kilovolt
kWh	kilowatt-hour
lb	pound
lb/MWh	pound per megawatt-hour
LERF	large early release frequency
LLC	limited liability corporation
LLMW	low-level mixed waste
LLW	low-level radioactive waste
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
m	meter
m/min	meter per minute
m/s	meter per second
m^3	cubic meter
m^3/month	cubic meter per month
m^3/s	cubic meter per second
MACCS2	MELCOR Accident Consequence Code System 2
MAG	Maricopa Association of Governments
MCAQD	Maricopa County Air Quality Department
MDTS	meteorological data transmission station
mg/L	milligrams per liter

mgd	million gallons per day
mGy	milligray
mGy/d	milligray per day
mi	mile
mi^2	square mile
MOU	Memorandum of Understanding
mph	mile per hour
mrad	milliradiation absorbed dose
mrem	milliroentgen equivalent man (mrem)
MSA	Magnuson-Stevens Fishery Conservation and Management Act of 1996
msl	mean sea level
MSPI	Mitigating System Performace Index
mSv	millisievert
MT	metric tones
MVAC	motor vehicle air conditioners
MW	megawatt
MWd/MTU	megawatt-days per metric ton uranium
MWe	megawatt-electric
MWt	megawatt-thermal
N_2O	nitrous oxide
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCDC	National Climatic Data Center
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NESC	National Electric Safety Code
NF_3	nitrogen triflouride
ng	nanograms
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide

NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide(s)
NOV	Notices of Violation
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NWS	National Weather Service
ODAM	Offsite Dose Assessment Manual
ODCM	Offsite Dose Calculation Manual
OMB	Office of Management and Budget
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi/L	picocuries per liter
PFC	perfluorocarbons
PM	particulate matter
PM_{10}	particulate matter, 10 microns or less in diameter
$PM_{2.5}$	particulate matter, 2.5 microns or less in diameter
PMF	probably maximum flood
PPP	Pollution Prevention Plan
ppt	parts per thousand
PRA	probabilistic risk assessment
PSD	Prevention of Significant Deterioration
PTE	potential to emit
PVNGS	Palo Verde Nuclear Generating Station
PWR	pressurized water reactor
rad/d	radiation absorbed dose per day
RAI	request for additional information
RCRA	Resource Conservation and Recovery Act
RCS	reactor coolant system
REMP	radiological environmental monitoring program
RHR	residual heat removal
ROI	region of influence

ROW(s)	right-of-way(s)
RPS	reactor protection system
RPV	reactor pressure vessel
SAAQS	State Ambient Air Quality Standards
SAMA	Severe Accident Mitigation Alternative
SAR	safety analysis report
SBO	station blackout
SC	species of concern
SCE	Southern California Edison
SCR	selective catalytic reduction
SEIS	supplemental environmental impact statement
SER	safety evaluation report
SF_6	sulfur hexafluoride
SGTR	steam generator tube rupture
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SO_2	sulfur dioxide
SO_3	sulfur trioxide
SO_x	sulfur oxide(s)
sq	square
SQG	small quantity generator
SRP	Salt River Project
STP	Sewage Treatment Plant
Sv	sievert
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TSP	total suspended particles
TSS	total suspended solids
U	Uranium
U.S.	United States
U.S.C.	*United States Code*
USCB	U.S. Census Bureau

USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGCRP	United States Global Change Research Program
USGS	U.S. Geological Survey
USI	unresolved safety issue
V	volt
VOC	volatile organic compound
WGA	Western Governors Association
WHO	World Health Organization
WRF	Water Reclamation Facility
WSR	Water Storage Reservoir
WTF	Wastewater Treatment Facility
yd^3	cubic yard
yd^3/month	cubic yard per month

1.0 PURPOSE AND NEED FOR ACTION

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of the *Code of Federal Regulations* (10 CFR Part 51), which implement the National Environmental Policy Act (NEPA), renewal of a nuclear power plant operating license requires the preparation of an environmental impact statement (EIS).

The Atomic Energy Act of 1954 originally specified that licenses for commercial power reactors be granted for up to 40 years with an option to renew for another 20 years. The 40-year licensing period was based on economic and antitrust considerations rather than on technical limitations of the nuclear facility.

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

1.1 PROPOSED FEDERAL ACTION

Arizona Public Service Company (APS) initiated the proposed Federal action by submitting an application for license renewal of Palo Verde Nuclear Generating Station (PVNGS), for which the existing licenses, NPF-41, NPF-51, and NPF-74, expire on June 1, 2025 (Unit 1), April 24, 2026 (Unit 2), and November 25, 2027 (Unit 3). The NRC's Federal action is the decision whether to renew these licenses for an additional 20 years.

1.2 PURPOSE AND NEED FOR THE PROPOSED FEDERAL ACTION

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

If the renewed licenses are issued, State regulatory agencies and APS will ultimately decide whether the plants will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the operating licenses are not renewed, then the facility must be shut down on or before the expiration date of the current operating license, June 1, 2025 (for Unit 1), April 24, 2026 (for Unit 2), and November 25, 2027 (for Unit 3).

1.3 MAJOR ENVIRONMENTAL REVIEW MILESTONES

APS submitted an environmental report (APS 2008a) as part of its license renewal application (APS 2008) in December 2008. After reviewing the application and the environmental report for sufficiency, the NRC staff published a Notice of Acceptability and Opportunity for Hearing on May 15, 2009, in the Federal Register (74 FR 22978-81). Then, on May 26, 2009, the NRC published another notice in the Federal Register (74 FR 24884-6) on its intent to conduct scoping, thereby beginning the 60-day scoping period.

The agency held two public scoping meetings on June 25, 2009, near the PVNGS site. The NRC report entitled, “Environmental Impact Statement Scoping Process Summary Report for Palo Verde Nuclear Generating Station, Units 1, 2 and 3,” dated April 2009, presents the comments received during the scoping process in their entirety (NRC 2010). Appendix A to this draft Supplemental Environmental Impact Statement (SEIS) presents the comments considered to be within the scope of the environmental license renewal review and the associated NRC responses.

To independently verify information provided in the environmental report, the NRC staff conducted a site audit at PVNGS from October 26 – 30, 2009. During the site audit, staff met with plant personnel; reviewed specific documentation; toured the facility; and met with interested Federal, State, and local agencies.

Upon completion of the scoping period and site audit, the staff compiled its findings in this document, the draft SEIS (Figure 1-1). This document is made available for public comment for 48 days. During this time, NRC staff will host a public meeting and collect public comments. Based on the information gathered, the staff will amend the draft SEIS findings as necessary, and then publish the final SEIS.

The NRC has established a license renewal process that can be completed in a reasonable period of time with clear requirements to ensure safe plant operation for up to an additional 20 years of plant life. The safety review is conducted simultaneously with the environmental review. The staff documents the findings of the safety

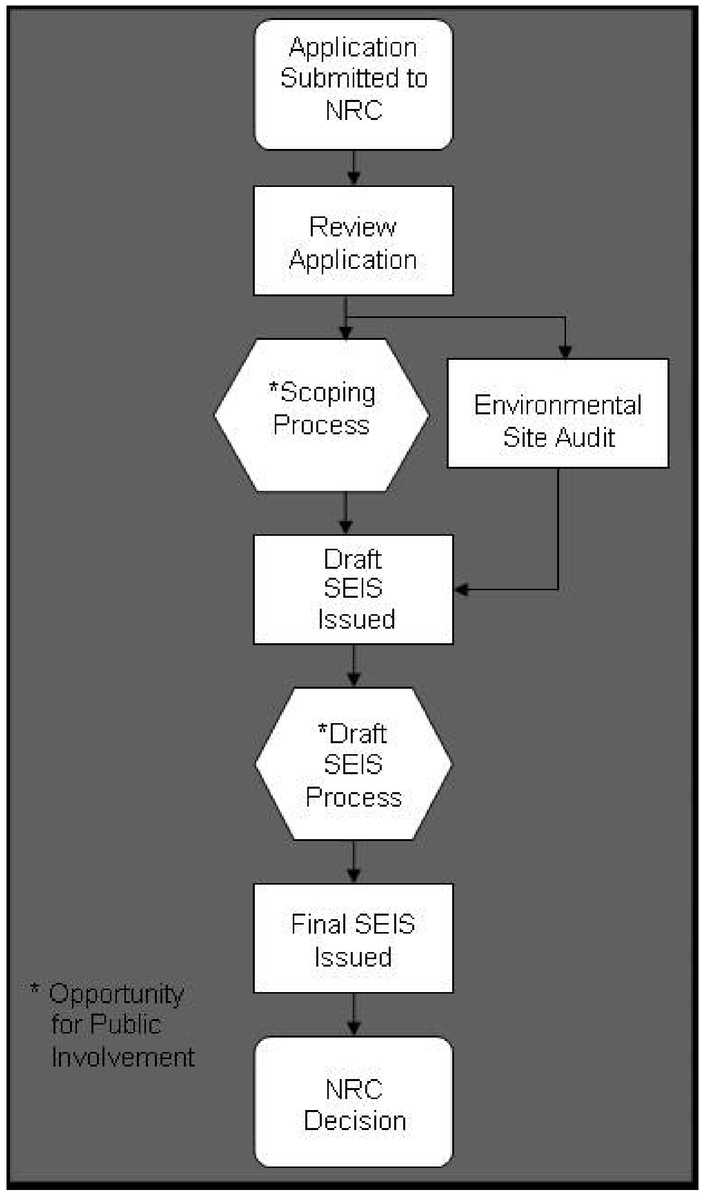


Figure 1-1. Environmental Review Process. The process provides opportunities for public involvement.

review in a safety evaluation report. The Commission considers the findings in both the supplemental EIS and the safety evaluation report in its decision to either grant or deny the issuance of a renewed license.

1.4 GENERIC ENVIRONMENTAL IMPACT STATEMENT

> ***Significance*** indicates the importance of likely environmental impacts and is determined by considering two variables: **context** and **intensity**.
>
> ***Context*** is the geographic, biophysical, and social context in which the effects will occur.
>
> ***Intensity*** refers to the severity of the impact, in whatever context it occurs.

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

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

For each potential environmental issue, the GEIS (1) describes the activity that affects the environment, (2) identifies the population or resource that is affected, (3) assesses the nature and magnitude of the impact on the affected population or resource, (4) characterizes the significance of the effect for both beneficial and adverse effects, (5) determines whether the results of the analysis apply to all plants, and (6) considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

The NRC's standard of significance for impacts was established using the Council on Environmental Quality terminology for "significant." The NRC established three levels of significance for potential impacts—SMALL, MODERATE, and LARGE, as defined below.

SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

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

---

[1] The NRC originally issued the GEIS in 1996 and issued Addendum 1 to the GEIS in 1999. Hereafter, all references to the "GEIS" include the GEIS and Addendum 1.

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

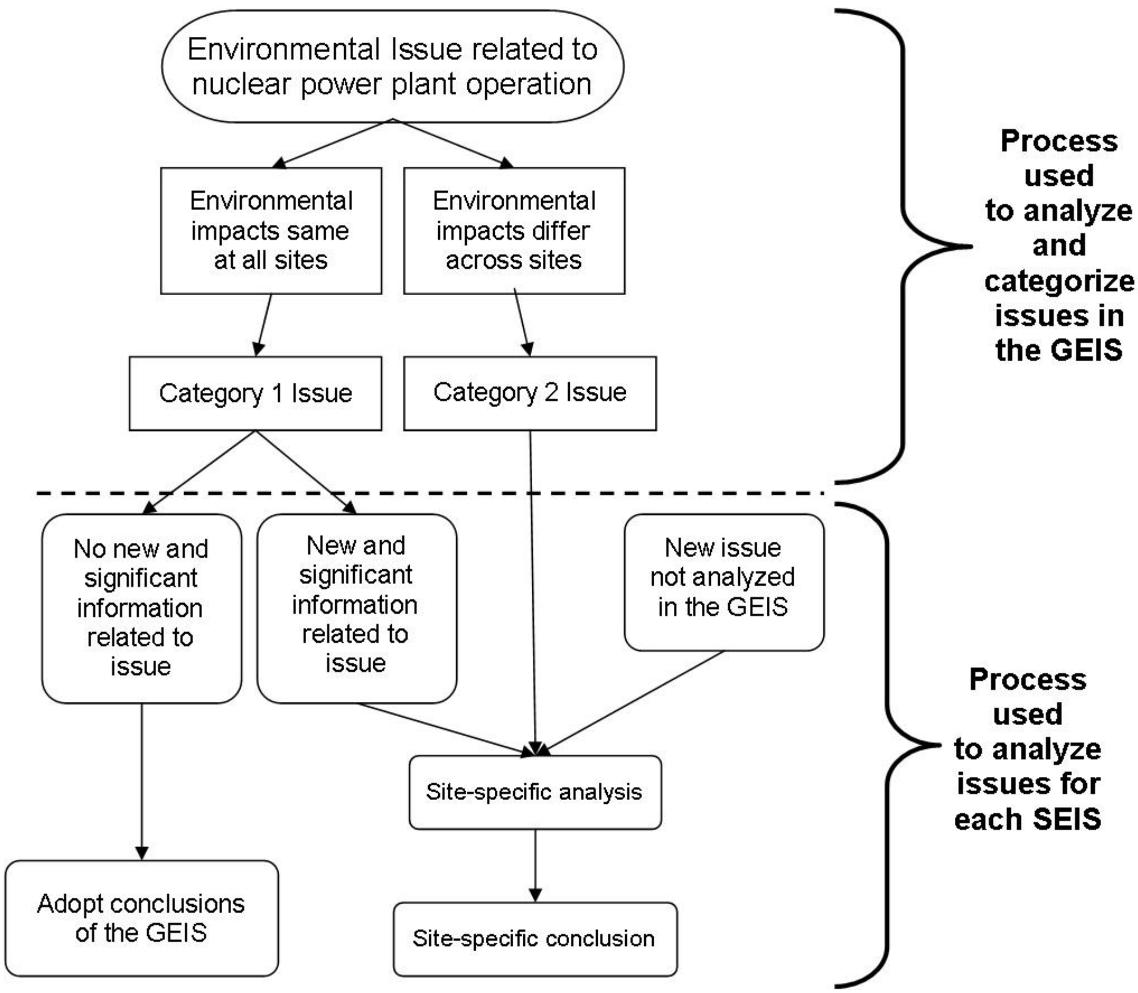
(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics;

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

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

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

Figure 1-2. Environmental Issues Evaluated During License Renewal. *92 issues were initially evaluated in the GEIS. A site-specific analysis is required for 23 of those 92 issues.*



1.5 SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

The SEIS presents an analysis that considers the environmental effects of the continued operation of PVNGS, alternatives to license renewal, and mitigation measures for minimizing adverse environmental impacts. Chapter 8 analyzes and compares the potential environmental impacts from alternatives, while Chapter 9 presents the preliminary recommendation to the Commission as to whether or not the environmental impacts of license renewal are so great that preserving the option of license renewal would be unreasonable. The recommendation will be made after consideration of comments received during the public scoping period and on the draft SEIS.

In the preparation of this SEIS for PVNGS, the staff undertook the following activities:

- reviewed the information provided in the APS environmental report;
- consulted with other Federal, State, and local agencies;
- conducted an independent review of the issues during the site audit; and

- considered the public comments received during the scoping process.

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

> **New and significant information** either: (1) identifies a significant environmental issue not covered in the GEIS, or (2) was not considered in the analysis in the GEIS and leads to an impact finding that is different from the finding presented in the GEIS.

1.6 COOPERATING AGENCIES

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

1.7 CONSULTATIONS

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

Agua Caliente Tribal Council, Palm Springs, California
Ak Chin Indian Community Council, Maricopa, Arizona
Arizona Game and Fish Department, Phoenix, Arizona
Arizona Radiation Regulatory Agency, Phoenix, Arizona
Arizona State Parks, Officer of Historic Preservation, Phoenix, Arizona
City of Phoenix, Office of Environmental Programs, Phoenix, Arizona
Colorado River Tribal Council, Parker, Arizona
Fort McDowell Yavapai Tribal Council, Fountain Hills, Arizona
Fort Yuma-Quechan Tribal Council, Yuma, Arizona
Gila River Indian Community Council, Sacaton, Arizona
Maricopa County Board of Supervisors, Phoenix, Arizona
Pascua Yaqui Tribe, Tucson, Arizona
Salt River Pima-Maricopa Indian Community Council, Scottsdale, Arizona
San Carlos Tribal Council, San Carlos, Arizona
Tohono O’odham Nation, Sells, Arizona
Tonto Apache Tribe, Payson, Arizona
U.S. Environmental Protection Agency, Region IX, Environmental Review Office Communities and Ecosystems Division, San Francisco, California
U.S. Department of the Interior, U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office, Phoenix, Arizona
White Mountain Apache Tribe, Whiteriver, Arizona
Yavapai-Apache Nation Tribal Council, Camp Verde, Arizona
Yavapai-Prescott Board of Directors, Prescott, Arizona

1.8 CORRESPONDENCE

During the course of the environmental review, the NRC staff contacted the following Federal, State, regional, local, and tribal agencies. Appendix E to this report contains a chronological list of all documents sent and received during the environmental review.

Agua Caliente Tribal Council, Palm Springs, California
Ak Chin Indian Community Council, Maricopa, Arizona
Arizona Game and Fish Department, Phoenix, Arizona
Arizona Radiation Regulatory Agency, Phoenix, Arizona
Arizona State Parks, Officer of Historic Preservation, Phoenix, Arizona
City of Phoenix, Office of Environmental Programs, Phoenix, Arizona
Colorado River Tribal Council, Parker, Arizona
Fort McDowell Yavapai Tribal Council, Fountain Hills, Arizona
Fort Yuma-Quechan Tribal Council, Yuma, Arizona
Gila River Indian Community Council, Sacaton, Arizona
Maricopa County Board of Supervisors, Phoenix, Arizona
Pascua Yaqui Tribe, Tucson, Arizona
Salt River Pima-Maricopa Indian Community Council, Scottsdale, Arizona
San Carlos Tribal Council, San Carlos, Arizona
Tohono O’odham Nation, Sells, Arizona
Tonto Apache Tribe, Payson, Arizona
U.S. Environmental Protection Agency, Region IX, Environmental Review Office Communities and Ecosystems Division, San Francisco, California
U.S. Department of the Interior, U.S. Fish and Wildlife Service, Arizona Ecological Services Field Office, Phoenix, Arizona
White Mountain Apache Tribe, Whiteriver, Arizona
Yavapai-Apache Nation Tribal Council, Camp Verde, Arizona
Yavapai-Prescott Board of Directors, Prescott, Arizona

A list of persons who received a copy of this draft SEIS is provided below:

Steve Olea Arizona Corporation Commission	Senior Counsel Law Department, Generation Resources Southern California Edison Company	Senior Resident Inspector, Palo Verde Nuclear Generating Station U.S. Nuclear Regulatory Commission
Regional Administrator, Region IV, NRC	Director Arizona Radiation Regulatory Agency	Director Regulatory Affairs Palo Verde NGS
Chairman Maricopa County Board of Supervisors	Vice President Regulatory Affairs and Plant Improvement, PVNGS	Director, Nuclear Generation El Paso Electric Company
James Ray Public Service Company of New Mexico	Geoffrey Cook Southern California Edison Company	Jeffrey Weikert Assistant General Counsel El Paso Electric Company
Eric Tharp Los Angeles Department of Water & Power Southern California Public Power Authority	Brian Almon Public Utility Commission William B. Travis Building Austin, TX	Environmental Program Manager City of Phoenix Office of Environmental Programs

Chairman, Ak-Chin Indian Community	Tom Kelly Environmental Review Office Communities and Ecosystems Division U.S. Environmental Protection Agency, Region IX	Willian R. Rhodes, Governor Joseph Manual, Lt. Governor Gila River Indian Community Council
Barb Painter	John Arminger	Stephen Brittle
Margaret Cook, Director Department of Environmental Quality of the Gila River Indian Community Gila River Indian Community Council	Randall Edington Executive Vice President Nuclear/CNO Arizona Public Service Company	

1.9 STATUS OF COMPLIANCE

APS is responsible for complying with all NRC regulations and other applicable Federal, State, and local requirements; Appendix H to the GEIS describes some of the major Federal statutes. Table 1-1 lists the permits and licenses issued by Federal, State, and local authorities for activities at PVNGS.

Table 1-1. Licenses and Permits. *Existing environmental authorizations for PVNGS.*

Permit	Number	Dates	Responsible Agency
Operating License	NPF-41	Issued: 6/1/1985 Expires: 6/1/2025	U.S. NRC
Operating License	NPF-51	Issued: 4/24/1986 Expires: 4/24/2026	U.S. NRC
Operating License	NPF-74	Issued: 11/25/1987 Expires: 11/25/2027	U.S. NRC
Aquifer Protection Permit (Operate PVNGS Facilities)	P-3507-100388	Issued: 03/14/2008 Expires: End of facility life	Arizona Department of Environmental Quality
Aquifer Protection Permit (Operate Hassayampa Pump Station Holding Pond)	P-105295	Issued: 02/02/2004 Expires: End of facility life	Arizona Department of Environmental Quality
Aquifer Protection Permit (Operate the WRSS Pipeline Temporary Chlorination Station)	P-105317	Issued: 04/06/2005 Expires: End of facility life	Arizona Department of Environmental Quality
Type 3 Reclaimed Water General Permit	R-105317	Issued: 06/22/2005 Expires: 06/22/2010	Arizona Department of Environmental Quality
WRF Laboratory License	AZ0129	Issued: annually Expires: End of April of each year	Arizona Department of Health Services
Central Laboratory License	AZ0555	Issued: annually Expires: End of April of each year	Arizona Department of Health Services

Permit	Number	Dates	Responsible Agency
Approval to Operate (Evaporation Pond 1)	Application No. 07.54	Issued: 11/27/1992 Expires: Not Listed	Arizona Department of Water Resources
Approval to Operate (Evaporation Pond 2)	Application No. 07.62	Issued: 12/12/1990 Expires: Not Listed	Arizona Department of Water Resources
Type 1 Non-Irrigation Certificate of Grandfathered Groundwater Right	58-114051.0001	Issued: 09/13/1990 Expires: Not Listed	Arizona Department of Water Resources
Irrigation Certificate of Grandfathered Groundwater Right	58-114058.0000	Issued: 12/13/1983 Expires: Not Listed	Arizona Department of Water Resources
Notice of Registration Certificate for Ionizing Radiation Machine	7/1/3340	Issued: 02/13/2007 Expires: 04/30/2014	Arizona Radiation Regulatory Agency
Special Approval (Disposal of Water Reclamation Facility Sludge)	7-368 (Category D18)	Issued: 09/11/2008 Expires: 04/30/2013	Arizona Radiation Regulatory Agency
Pipeline Repair & Maintenance (Repair work on the WRSS Pipeline)	FA20020002	Issued: 08/18/2005 Expires: 07/31/2010	Flood Control District of Maricopa County
Dust Control/Demolition (Annual Block Permit)	E100456	Issued: Annual Expires: 03/19/2011	Maricopa County Air Quality Department
Non-Title V Air Permit	030132	Issued: 08/18/2005 Expires: 07/31/2010	Maricopa County Air Quality Department
Landfill	00008	Issued: Annually Expires: 04/30/2011	Maricopa County Environmental Services Department
Waste Water Treatment Plant	37148	Issued: Annually Expires: 12/31/2010	Maricopa County Environmental Services Department
Water Public/Non-Community	07412	Issued: Annually Expires: 12/31/2010	Maricopa County Environmental Services Department
Special Use - Construct a nuclear power electric generation facility	Zoning Case Z 76-33	Issued: 04/15/1976 Expires: 04/15/2051	Maricopa County Planning & Zoning Commission Services Department
Special Use - Construct additional Evaporation Ponds south of the current ponds	Zoning Case Z2006106	Issued: 12/20/2006 Expires: 04/15/2051	Maricopa County Planning and Development Department

1.10 REFERENCES

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

74 FR 22978-81. U.S. Nuclear Regulatory Commission, Washington, D.C., "Notice of Acceptance for Docketing of the Application and Notice of Opportunity for Hearing Regarding Renewal of Facility Operating License Nos. NPF-41, NPF-51, and NPF-74 for an Additional 20-Year Period; Arizona Public Service Company; Palo Verde Nuclear Generating Station, Units 1, 2, and 3." *Federal Register:* Vol. 74, No. 93, pp. 22978-81. May 15, 2009.

74 FR 24884-6. U.S. Nuclear Regulatory Commission, Washington, D.C., "Arizona Public Service Company; Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process for Palo Verde Nuclear Generating Station, Units 1, 2, and 3." *Federal Register:* Vol. 74, No. 99, pp. 24884-6. May 26, 2009.

Arizona Public Service Company (APS). 2008. *Palo Verde Nuclear Generating Station Unit 1, Unit 2, and Unit 3, License Renewal Application.* ADAMS Nos. ML083510611, 12, 14, 15.

Arizona Public Service Company (APS). 2008a. *Palo Verde Nuclear Generating Station, Units 1, 2, and 3, Applicant's Environmental Report, License Renewal Operating Stage*. ADAMS No. ML083510615, Appendix E.

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

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

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

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

National Historic Preservation Act. 16 U.S.C. 470, et seq.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Volumes 1 and 2, Washington, D.C. ADAMS No. ML061770605.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report." NUREG-1437, Volume 1, Addendum 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2009. "Summary of Public Environmental Scoping Meetings Related to the review of the Palo Verde License Renewal Application (TAC NOS. ME0261, ME 0262, ME0263)." ADAMS No. ML091900138.

U.S. Nuclear Regulatory Commission (NRC). 2010. "Issuance of Environmental Scoping Summary Report associated with the Staff's review of Application by Arizona Public Service Company for Renewal of the Operating License for Palo Verde Nuclear Generating Station, Units 1, 2, and 3, (TAC NOS. ME0261, ME0262, ME0263)" ADAMS Accession No. ML100820451.

2.0 AFFECTED ENVIRONMENT

Palo Verde Nuclear Generating Station (PVNGS) is located approximately 26 miles west of the nearest Phoenix metropolitan area boundary (APS 2008a). Figures 2.1-1 and 2.1-2 present the 50-mile (80-km) and 6-mile (10-km) vicinity maps, respectively. For purposes of the evaluation in this report, the “affected environment” is the environment that currently exists at and around PVNGS. Because existing conditions are at least partially the result of past construction and operation at the plant, the impacts of these past and ongoing actions and how they have shaped the environment are presented here. Section 2.1 of this report describes the facility and its operation, and Section 2.2 discusses the affected environment.

2.1 FACILITY DESCRIPTION

PVNGS is a three-unit nuclear-powered steam electric generating facility that began commercial operation between January 1986 (Unit 1) and January 1988 (Unit 3). The PVNGS site boundary encloses approximately 4,280 acres. The site buildings and adjacent, developed areas comprise approximately 720 acres. There are approximately 605 surface acres of water on the site in various large ponds. The most conspicuous structures on the PVNGS site include the three reactor containment buildings, three turbine buildings, nine cooling towers (three per unit), plus various buildings auxiliary to the reactors (APS 2008a). Figure 2.1-3 provides a general layout of the PVNGS site.

2.1.1 Reactor and Containment Systems

PVNGS is comprised of three individual reactor units each having a Combustion Engineering System 80 pressurized water nuclear reactor with a turbine-generator. Each reactor produces a reactor core power of 3990 megawatts-thermal (MWt) and a nominal net electrical capacity of 1346 megawatts-electric (MWe).

The containment building is a pre-stressed, reinforced concrete cylinder with a slab base and a hemispherical dome. A welded steel liner is attached to the inside face of the concrete shell to insure a high degree of leak tightness. In addition, the 4-foot thick concrete walls serve as a radiation shield.

The nuclear fuel is low-enriched uranium dioxide with enrichments less than 5 percent by weight uranium-235 and fuel burnup levels with a batch average less than 60,000 megawatt-days per metric ton uranium. Typical burnup is approximately 50,000 megawatt-days per metric ton uranium and maximum burnup is up to 60,000 megawatt days per metric ton uranium (APS 2008a).

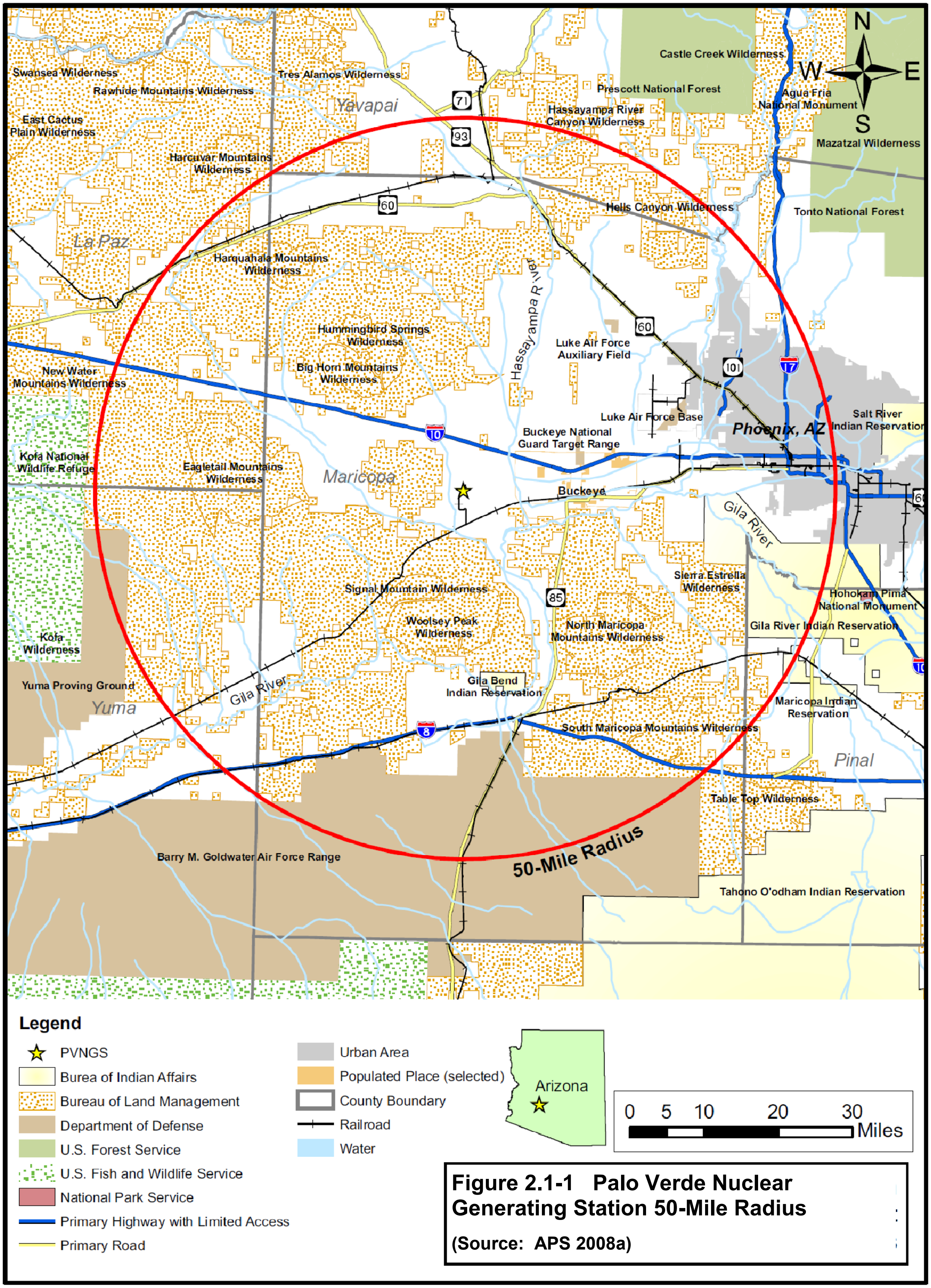


Figure 2.1-1 Palo Verde Nuclear Generating Station 50-Mile Radius

(Source: APS 2008a)

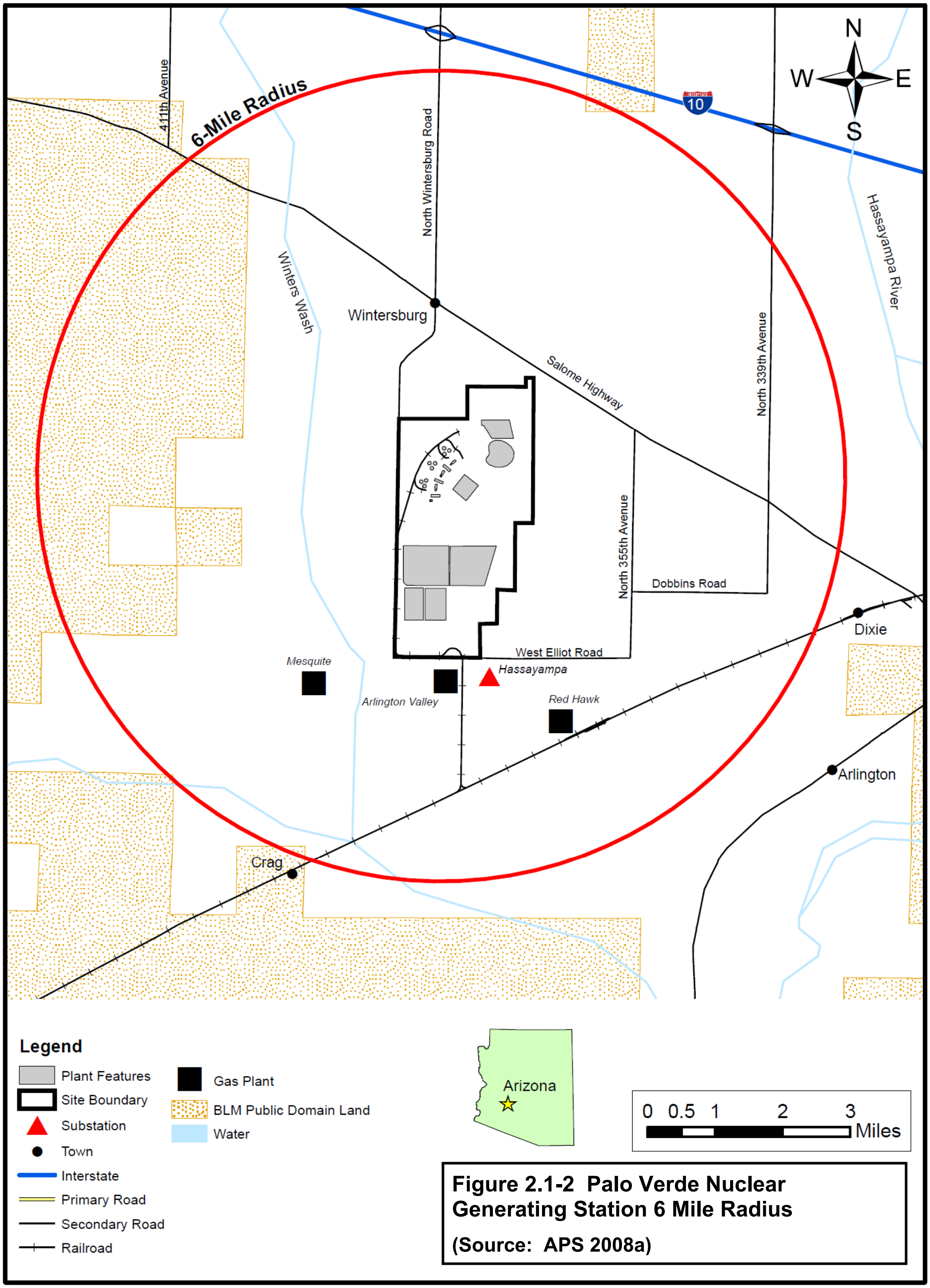


Figure 2.1-2 Palo Verde Nuclear Generating Station 6 Mile Radius

(Source: APS 2008a)

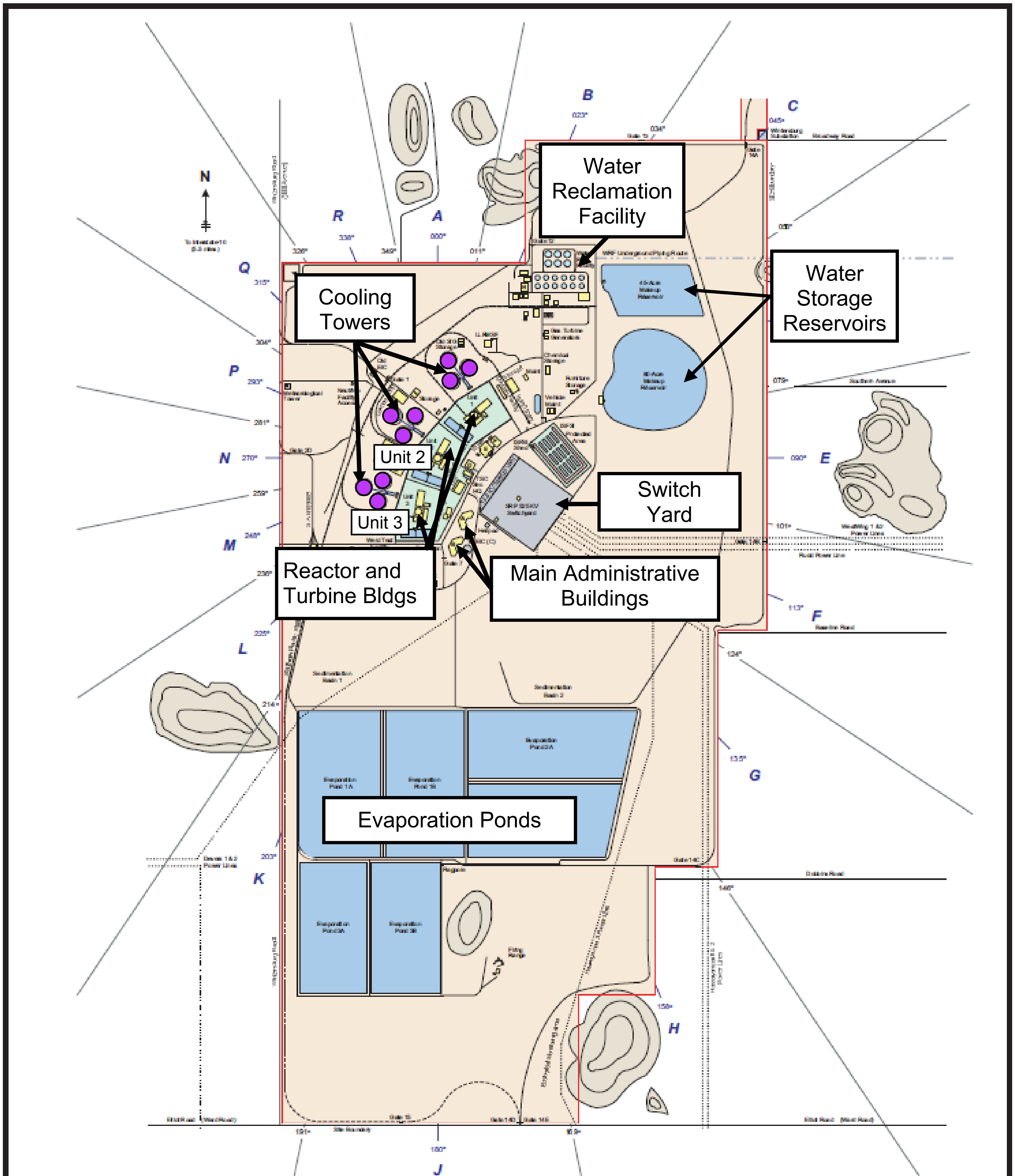


Figure 2.1-3 Palo Verde Nuclear Generating Station General Plant Layout
(Source: APS 2008a)

2.1.2 Radioactive Waste Management

PVNGS's radioactive waste system collects, treats, stores, and disposes of radioactive and potentially radioactive wastes that are byproducts of plant operations. The byproducts are activation products resulting from the irradiation of reactor water and impurities therein (principally metallic corrosion products) and fission products resulting from defective fuel cladding or uranium contamination within the reactor coolant system. Operating procedures for the radioactive waste system ensure that radioactive wastes are safely processed and discharged from the plant within the limits set forth in 10 CFR Part 20, "Standards for Protection against Radiation" (APS 2008a).

Radioactive wastes resulting from plant operations are classified as liquid, gaseous, or solid. Radioactive liquid wastes are generated from liquids received directly from portions of the reactor coolant system or were contaminated by contact with liquids from the reactor coolant system. Radioactive gaseous wastes are generated from gases or airborne particulates vented from reactor and turbine equipment containing radioactive material. Radioactive solid wastes are solids from the reactor coolant system, solids that contacted reactor coolant system liquids or gases, or solids used in the reactor coolant system or the power conversion system.

Reactor fuel that has exhausted a certain percentage of its fissile uranium content is referred to as spent fuel. Spent fuel assemblies are removed from the reactor core and replaced with fresh fuel assemblies during routine refueling outages approximately every 18 months. Spent fuel assemblies are stored in the spent fuel pool and dry casks.

The PVNGS offsite dose calculation manual (ODCM) contains the methodology and parameters used to calculate offsite doses resulting from radioactive effluents. The methodology is used to ensure that radioactive material discharged from the plant meets regulatory dose limits. The ODCM also contains the radioactive effluent controls and radiological environmental monitoring activities and descriptions of the information included in the annual radiological environmental operating report and annual radioactive effluent release report (APS 2007Y6).

2.1.2.1 Radioactive Liquid Waste

The PVNGS liquid drains system collects, holds, treats, processes, provides for leakage detection, stores, and monitors all radioactive liquid wastes. The system collects and transports non-corrosive, radioactive or potentially radioactive liquid wastes from equipment and floor drains of the containment building, the auxiliary building, the fuel building, the main steam support structure, the radwaste building, the hold up tank area, and the decontamination and laundry facilities. The wastes collected are pumped to the liquid radwaste system for processing (APS 2008a).

2.1.2.2 Radioactive Gaseous Waste

The purpose of the radioactive gaseous waste system is to collect and process radioactive and potentially radioactive waste gas. The system also limits the release of gaseous activity so that personnel exposure and activity releases in restricted and unrestricted areas are as low as is reasonably achievable (ALARA). The system consists of piping runs, valves, two waste gas compressors, a waste gas surge tank and three waste gas decay tanks (APS 2008a).

PVNGS discharges gaseous waste in accordance with the procedures and methodology described in the ODCM. The radioactive gaseous waste system is used to reduce radioactive materials in gaseous effluents before discharge to meet the dose limits in 10 CFR Part 20 and the dose design objectives in Appendix I to 10 CFR Part 50. The NRC staff reviewed the PVNGS radioactive effluent release reports for 2004 through 2008 for gaseous effluents (APS 2005Y1, 2006Y2, 2007Y3, 2008Y4, 2009Y5). Variations in the amount of radioactive effluents released from year to year are expected based on the overall performance of the plant and the number and scope of outages and maintenance activities. The radioactive gaseous wastes reported by PVNGS are reasonable and no unusual trends were noted.

No plant refurbishment activities were identified by the applicant as necessary for the continued operation of PVNGS through the license renewal term. Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system, and the lack of any planned refurbishment activities, similar amounts of radioactive gaseous effluents are expected during the license renewal term.

2.1.2.3 Radioactive Solid Waste

The radioactive solid waste management program is designed to safely collect, process, store, and prepare radioactive wet and dry solid waste materials for shipment to an offsite waste processor or for disposal.

Solid wastes consist mainly of dry active waste such as contaminated paper, plastic, wood, metals, and spent resin. Solid wastes are collected, analyzed, packaged, and shipped from the site according to PVNGS's process control program. Solid wastes are prepared in accordance with the requirements of 10 CFR 61 relating to waste form and classification as well as site-specific requirements at the disposal facility (APS 2008a).

The State of South Carolina's licensed low-level radioactive waste disposal facility, located in Barnwell, has limited the access from radioactive waste generators located in States that are not part of the Atlantic Low-Level Waste Compact. Arizona is not a member of the Atlantic Low-Level Waste Compact. This has had a minimal affect on PVNGS's ability to handle its radioactive solid low-level waste. PVNGS has adequate storage capacity for its radioactive waste during the license renewal term (APS 2008a).

The NRC staff reviewed the PVNGS low-level radioactive waste information contained in the annual radioactive effluent release reports for 2004 through 2008 (APS 2005Y1, 2006Y2, 2007Y3, 2008Y4, 2009Y5). Variations in the amount of radioactive solid waste generated and shipped from year to year are expected based on the overall performance of the plant and the number and scope of outages and maintenance activities. The volume and activity of radioactive solid wastes reported by PVNGS are reasonable and no unusual trends were noted.

No plant refurbishment activities were identified by the applicant as necessary for the continued operation of PVNGS through the license renewal term. Routine plant operational and maintenance activities currently performed will continue during the license renewal term. Based on the past performance of the radioactive waste system, and the lack of any planned refurbishment activities, similar amounts of radioactive solid waste are expected to be generated during the license renewal term.

2.1.3 Nonradioactive Waste Management

PVNGS generates nonradioactive solid wastes as part of routine plant maintenance, cleaning activities, and plant operations.

PVNGS generates solid waste that is classified as either nonhazardous or hazardous as defined by the Resource Conservation and Recovery Act (RCRA). The nonhazardous solid waste includes office trash, construction debris, kitchen waste and other rubbish material from routine plant maintenance, operations and cleaning activities as well as sludge material from the PVNGS Water Reclamation Facility.

PVNGS maintains an onsite permitted landfill facility (Maricopa County, Environmental Services Department Permit Number 00008). Information provided during the site audit in October 2009 lists this landfill as both a rubbish landfill and sludge landfill. PVNGS has also acquired a special approval permit (Permit Number 7-368 Category D18) from the Arizona Radiation Regulatory Agency for onsite landfill disposal of the sludge material generated at the PVNGS Water Reclamation Facility (APS 2008a).

The U.S. Environmental Protection Agency (EPA) classifies certain nonradioactive solid wastes as hazardous based on characteristics including ignitability, corrosivity, reactivity, or toxicity (further information on hazardous waste is available in 40 CFR Part 261). State-level regulators may add wastes to EPA's list of hazardous wastes. RCRA provides standards for the treatment, storage, and disposal of hazardous waste for hazardous waste generators (regulations are available in 40 CFR Part 262). RCRA regulations are administered in Arizona by the Arizona Department of Environmental Quality (ADEQ) as incorporated in Title 18 - Environmental Quality (Chapter 8, ADEQ Hazardous Waste Management) of the Arizona Administrative Code (AAC). AAC Title 18 has been periodically updated to keep current with Federal RCRA regulations.

PVNGS generates a variety of hazardous waste streams including spent and expired chemicals, laboratory chemical wastes, spent and unused paint, thinner and solvent, universal wastes (such as mercury-bearing or fluorescent lamps, lead-acid batteries, capacitors, ballasts, etc.), hydraulic cuttings, hydrazine, aerosol cans, antifreeze, rag debris, medical wastes (such as sharps, bio-system cartridges and unused pharmaceutical waste) and occasional project-specific wastes. PVNGS is a small-quantity generator of hazardous waste, meaning the plant generates less than 1,000 kilograms (kg) of non-acute hazardous waste in a month and stores less than 6,000 kg of this waste at any one time. As listed in the information provided by APS during the site audit conducted by NRC staff, PVNGS total annual hazardous waste generation was approximately 6,000 lbs annually from 2005 to 2009. Most of these wastes are associated with paint, thinner, solvent, discarded and unused chemicals, batteries and lamps (APS 2008a).

EPA classifies several hazardous wastes as universal wastes; these include batteries, pesticides, mercury-containing items, and fluorescent lamps. Arizona has incorporated, by reference, the EPA's regulations (available at 40 CFR Part 273) regarding universal wastes in Chapter 8 of AAC Title 18. PVNGS generates fluorescent lamps, batteries and electronic components as universal wastes from normal facility operations, which are sent offsite to an EPA-approved hazardous waste disposal or recycling facility (APS 2008a).

Used oil produced during operation of PVNGS is sent offsite to an EPA-approved used oil disposal facility as verified during the PVNGS Site Audit in October 2009. In 2008, PVNGS listed a total of 205,245 lbs (or 23,325 gallons in volume equivalent) of used oil sent offsite to an EPA-approved waste disposal or recycling facility (APS 2008a).

PVNGS also generates medical wastes including sharps, pharmaceutical materials and bio-system cartridges as part of its operation. The medical wastes, typically less than 100 lbs annually, are shipped offsite to an EPA-approved medical waste disposal facility (APS 2008a).

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires applicable facilities to provide information on hazardous and toxic chemicals to emergency planning authorities and the EPA. PVNGS is subject to EPCRA Section 312 reporting and therefore submits annual reports to local emergency agencies principally to the Arizona Division of Emergency Management (ADEM). Copies of the EPCRA Section 312 Tier II reporting forms (2005 thru 2008) submitted to ADEM by APS listed, among others, the following hazardous and toxic chemicals including: hydrazine, ammonium hydroxide (1-30%), sodium hydroxide (1-100%), sodium hypochlorite (1-16%), boric acid, diesel fuel, lubricating oils, carbon dioxide, dimethylamine (0-2%), laminating resin 2002-3-R-A, polifloc AE 1701, sulfuric acid (1-96%), soda ash (1-100%), anion / cation water treatment resin, 1, 1, 1, 2 tetrafluoroethane (HFC-134a), trisodium phosphate (anhydrous), nitrogen, ethanolamine (monoethanolamine)(1-80%), air blasting abrasives, anthracite (coal), activated carbon (charcoal), cement products, sulfuric acid and lead in batteries, transformer (dielectric oil), unleaded gasoline, bulab 6002, calcium carbonate, and many others. PVNGS annually files Tier II forms electronically in a repository maintained by the Arizona Emergency Response Commission (AERC) (APS 2008a).

2.1.3.1 Pollution Prevention and Waste Minimization

Currently, PVNGS has waste minimization measures in place as verified during the PVNGS site audit conducted by the NRC in October 2009. In 2004, PVNGS submitted a Pollution Prevention Plan to the Arizona Department of Environmental Quality Pollution Prevention Program (ADEQPPP) outlining the facility's waste minimization goals and measures. Included in the Plan are pollution prevention opportunities to eliminate, reduce, reuse or recycle each waste, emission or toxic substance. PVNGS submits an annual Pollution Prevention Plan Progress Report to the ADEQPPP that tracks the facility operating activities in achieving the Plan goals. Examples of PVNGS minimization goals include but are not limited to reduction in the use or generation of hydrazine, ammonium hydroxide (aqueous ammonia), mercury (in portable calibration instruments and fluorescent light bulbs), waste paint, and volatile organic compound emission at gasoline dispensing stations. PVNGS likewise maintains an environmental website and newsletter that post the Plan goals and the facility's progress in achieving those goals. Employees are encouraged by PVNGS management to participate in the pollution prevention program by providing training and by implementing a P2 (Pollution Prevention) award program for their employees (APS 2008a).

In support of the nonradiological waste minimization efforts, the EPA's Office of Pollution Prevention and Toxics has established a clearinghouse that provides information regarding waste management and technical and operational approaches to pollution prevention. The EPA's clearinghouse can be used as a source for additional opportunities for waste minimization and pollution prevention at PVNGS, as appropriate.

2.1.4 Plant Operation and Maintenance

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

Additional programs include those implemented to meet technical specification surveillance requirements, those implemented in response to the NRC generic communications, and various periodic maintenance, testing, and inspection procedures. Certain program activities are performed during the operation of the unit, while others are performed during scheduled refueling outages. Nuclear power plants must periodically discontinue the production of electricity for refueling, periodic in-service inspection, and scheduled maintenance. PVNGS operates on an 18-month refueling cycle (APS 2008a).

2.1.5 Power Transmission System

Seven 525-kilovolt transmission lines connect PVNGS to the regional electric grid. Five of the lines are owned by Salt River Project (SRP), one is jointly owned by SRP and APS, and one of the lines is owned by Southern California Edison (SCE). Unless otherwise noted, the discussion of the power transmission system is adapted from the Environmental Report (ER) (APS 2008a) or information gathered at NRC's environmental site audit conducted in October 2009.

The transmission lines cross through Maricopa and La Paz Counties, Arizona, and Riverside County, California. In total, the transmission lines associated with the operation of PVNGS comprise approximately 13,000 acres (526 ha) and span 530 mi (853 km) of transmission line rights-of-way (ROWs). Generally, the transmission line ROWs pass through regions of low population densities characterized by agriculture and desert habitat, much of which is Federal property.

The Final Environmental Statement (FES) for the Operation of PVNGS (NRC 1982) specifies four 525-kilovolt and one 325-kilovolt transmission lines that were planned to connect PVGNS to the regional electric grid. One of the lines was not constructed, two additional lines were constructed, and a new substation was put into service that split two previously planned lines to PVNGS into smaller portions. Therefore, the discussion of the transmission system in this Supplemental Environmental Impact Statement (SEIS) is different than the FES.

Transmission lines considered in-scope for license renewal are therefore, the Westwing 1 and 2 lines; the Rudd line; the Hassayampa 1, 2, and 3 lines; and the Devers line. Figures 2.1.5-1 and 2.1.5-2 are maps of the PVNGS transmission system. Table 2.1.5-1 summarizes the transmission lines. The seven transmission lines are as follows:

- Westwing 1 and Westwing 2: These lines extend northeast and then east for approximately 45 mi (72 km) to the Westwing Substation just outside of Phoenix, Arizona. These lines are contained within Maricopa County and share a 330-ft (100-m) wide ROW.
- Rudd: This line extends northeast and then east for approximately 37 mi (60 km) to the Rudd Substation in southern Phoenix, Arizona. This line is contained within Maricopa County, shares a 330-ft (100-m) wide ROW with Westwing 1 and Westwing 2 initially, and then splits off to extend eastward, at which point its ROW is 160-ft (49-m) wide.
- Hassayampa 1: This line extends 3 mi (5 km) to the Hassayampa Substation just south of PVNGS, then extends southeast for an additional 20 mi (32 km) to the Jojoba Substation south of Buckeye, Arizona, and then extends an additional 52 mi (84 km) to the Kyrene Generating Station south of Tempe, Arizona. This line is contained within Maricopa County and shares a 330-ft (100-m) wide ROW with Hassayampa 2 to the Hassayampa Substation, and the ROW for the remaining 72 mi (116 km) of line varies from 75 to 200 ft (23

to 61 m).

- Hassayampa 2: This line extends 3 mi (5 km) to the Hassayampa Substation just south of PVNGS. This line is contained within Maricopa County and shares a 330-ft (100-m) wide ROW with Hassayampa 1.
- Hassayampa 3: This line extends south to the Hassayampa Substation and continues south and then west 114 mi (183 km) to the North Gila Substation near Yuma, Arizona. This line is contained within Maricopa County and has a 200-ft (61-m) wide ROW.
- Devers: This line extends west for approximately 235 mi (378 km) to the Devers Substation north of Palm Springs, California. This line traverses Maricopa and La Paz Counties, Arizona, and Riverside County, California, and has a 200-ft (61-m) wide ROW that varies slightly in width in certain areas.

SRP, APS, and SCE follow vegetative maintenance plans to promote low-growing vegetation and minimize vegetation-related interference with transmission systems. The majority of ROWs associated with PVNGS consist of desert habitat or agricultural land, which require minimal maintenance. Generally, trees and tall shrubs are removed in the wire zone, the area immediately beneath conductors, and only tall-growing tree species are removed in the border zone, the area on either side of the wire zone. Herbicides, when necessary, are applied by personnel with an Arizona Pesticide Applicator License. All herbicides used near waterways or in wetland areas are EPA-approved for aquatic application. SRP, APS, and SCE perform regular flyovers to identify areas that require maintenance, followed by a ground inspection in selected areas to identify any conflicts with lines and to plan future maintenance needs. Vegetative maintenance is generally conducted on a five year cycle.

Saguaro cactii (*Carnegiea gigantean*) near power lines require special treatment because the species is capable of conducting electricity due to their high water content and can pose a safety threat. Saguaros that are close enough to lines to pose this risk are transplanted outside of the border zone.

All transmission lines will remain a permanent part of the transmission system and will be maintained by SRP, APS, and SCE, regardless of PVNGS continued operation.

Table 2.1.5-1 PVNGS Transmission Lines

Line	Owner	kV	Approximate Distance mi (km)	ROW Width(a) ft (m)	ROW Area(b) ac (ha)
Westwing 1	Salt River Project	525	45 (72)	330 (100)	1800 (730)
Westwing 2	Salt River Project	525	45 (72)	330 (100)	1800 (730)
Rudd	APS and Salt River Project	525	37 (60)	160 (49)	720 (290)
Hassayampa 1	Salt River Project	525	75 (121)	75 to 200 (23 to 61)	1250 (506)[c]
Hassayampa 2	Salt River Project	525	3 (5)	330 (100)	120 (50)
Hassayampa 3	Salt River Project	525	114 (183)	200 (61)	2800 (1100)
Devers	Southern California Edison	525	235 (378)	200 (61)	5700 (2300)

(a) Value given represents the typical width or typical width range along line, though ROW width may vary at intervals along the length of the line.

(b) Values given for ROW area are not mutually exclusive as West Wing 1 and West Wing 2 share a ROW, as do Hassayampa 1 and Hassayampa 2, and the Rudd line ROW splits off from the West Wing 1 and West Wing 2 ROW.

(c) Value represents the calculated average ROW area.

Source: APS 2008a

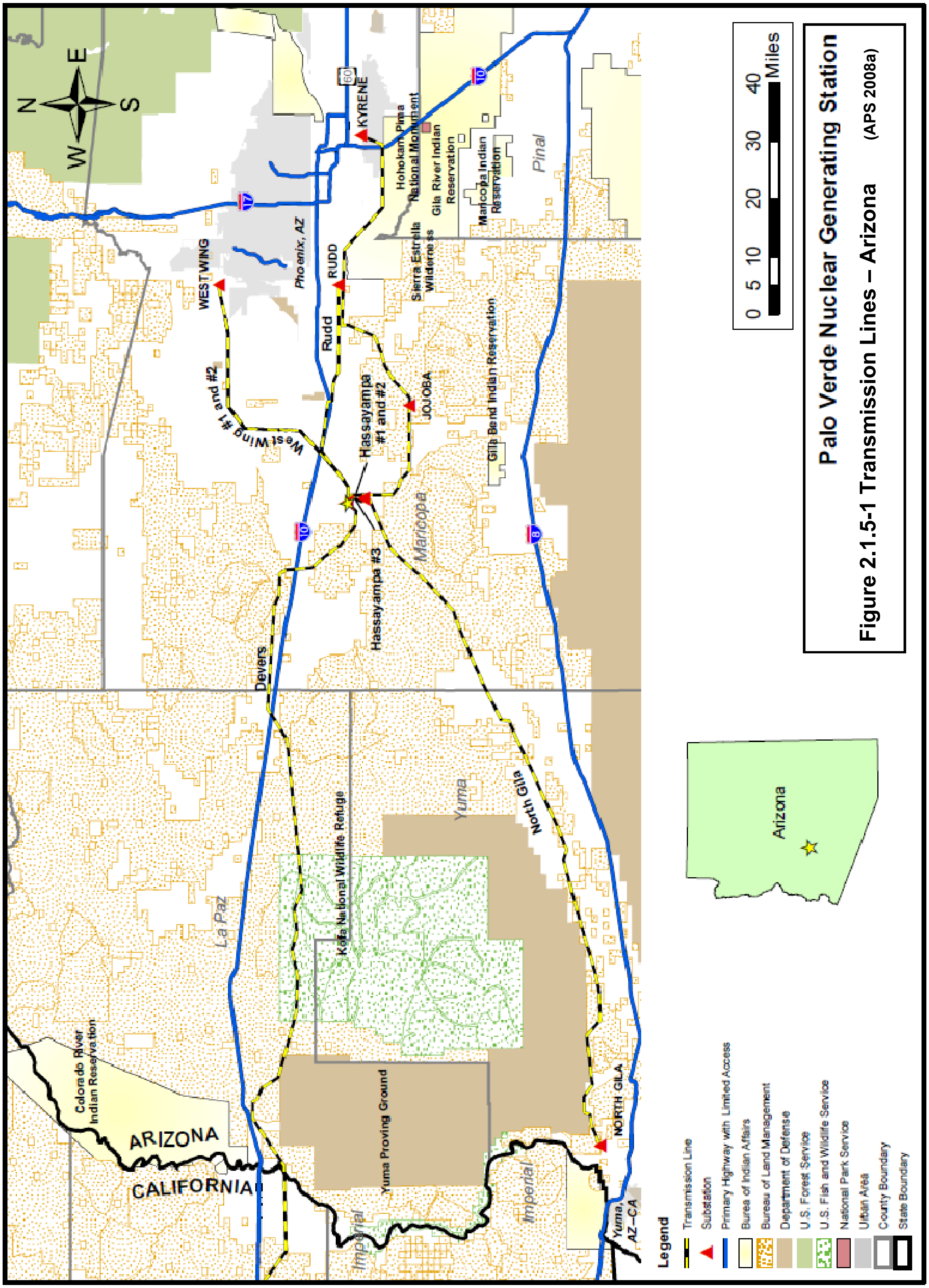


Figure 2.1.5-1 Transmission Lines – Arizona

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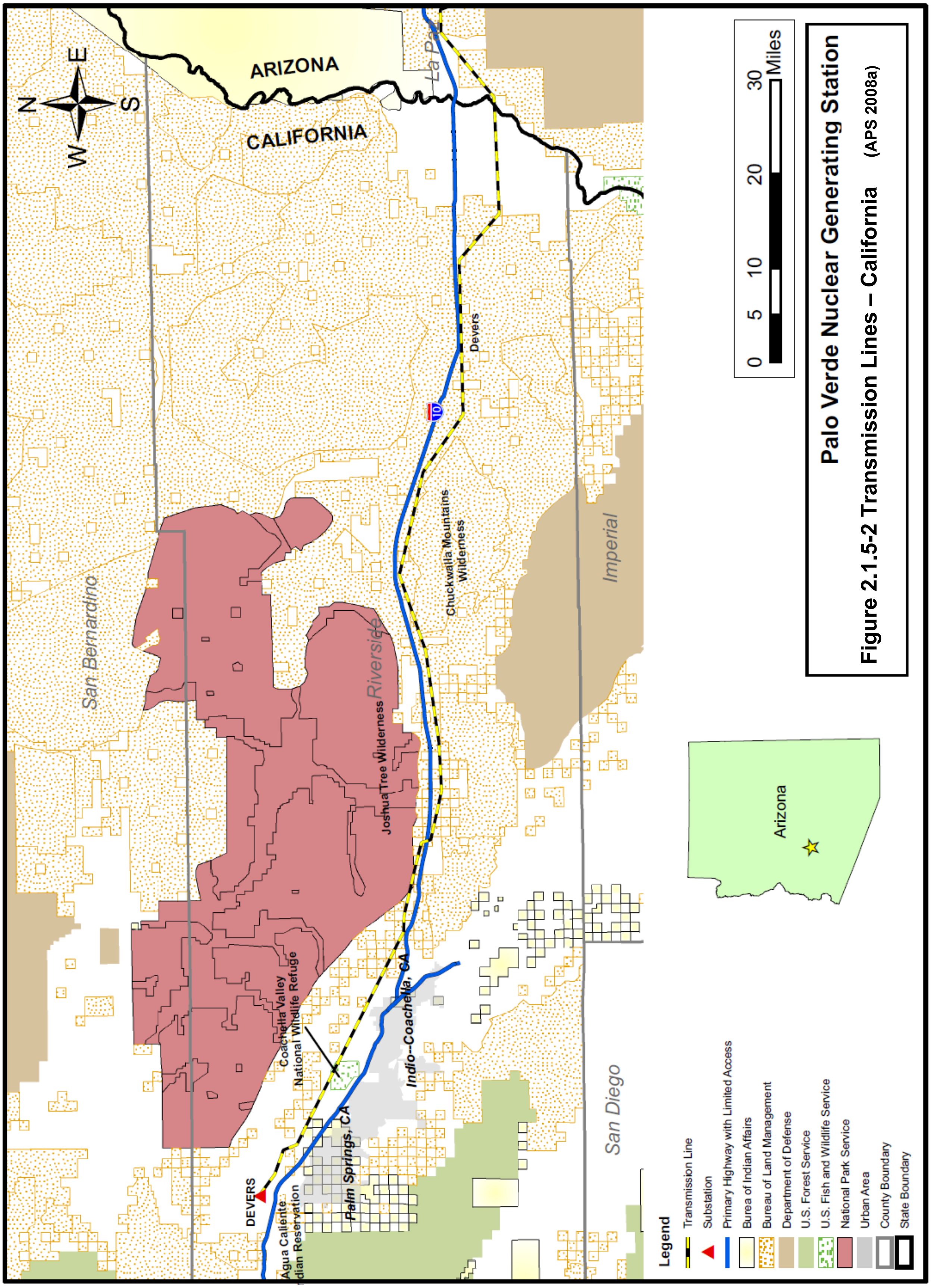

Figure 2.1.5-2 Transmission Lines – California

2.1.6 Cooling and Auxiliary Water Systems

Water systems at PVNGS are supplied by two sources. The main source is wastewater effluent from Phoenix-area wastewater treatment plants. This water is pumped to the on-site Water Reclamation Facility (WRF) where it is treated to meet the plant's water quality requirements. The other source is groundwater from onsite production wells (discussed in Section 2.1.7).

2.1.6.1 Circulating Water System

The Circulating Water System for each generating unit consists of a main condenser, cooling towers, circulating water pumps, a chemical injection system, and makeup and blowdown systems. The Circulating Water System removes waste heat by circulating cooling water through the main condenser in each unit by four 25-percent capacity, vertical, wet-pit pumps, each with a capacity of 140,000 gpm (and a total capacity of 560,000 gpm). Waste heat is then rejected to the atmosphere via three round mechanical draft cooling towers. System blowdown is discharged to above grade evaporation ponds.

Cooling water is predominantly made up of tertiary treated effluent from the WRF that is stored in two lined water storage reservoirs. Water in the reservoirs may also contain secondary treated effluent from the Sewage Treatment Plant and untreated groundwater from the regional aquifer (ADEQ 2009a).

Makeup water to replace evaporative and blowdown losses is provided mainly by the WRF; both the Domestic Water System and the Demineralized Water System, which mainly use groundwater, can also supply makeup water (APS 2008b).

2.1.6.2 Essential Spray Pond System

Each generating unit has an ultimate heat sink consisting of two independent Essential Spray Ponds. The Essential Spray Pond System (ESPS) provides cooling water for normal and emergency shutdown and has a storage capacity that enables it to operate continuously for 26 days without a makeup water supply. During normal plant operations, the ESPS may support several auxiliary systems (APS 2008b).

2.1.6.3 Water Reclamation Facility

The WRF is an advanced wastewater treatment plant that uses a multi-phase, biochemical treatment process. It operates under a Type 3 Reclaimed Water General Permit (ADEQ Inventory No. R105317). Its main function is to provide makeup cooling water, but it also supplies domestic, demineralized, and fire protection water for PVNGS and sends some of its treated water (about 3 to 7 million gpd) (11.4 to 26.5 million liters per day) to the Redhawk Power Plant, a nearby gas-fired power plant owned by Pinnacle West, the parent corporation of APS. WRF-treated water is also used for dust suppression at PVNGS (as required by Air Permit No. 8600896; discussed in Section 2.2.2). At the WRF, water undergoes biological nitrification, lime treatment, filtration, and chlorination. Treated water is then stored in lined water storage reservoirs. Sludge from the treatment processes is centrifuged, dried, and sent to the onsite Sludge Disposal Landfill. The WRF also treats wastewater from the PVNGS Sewage Treatment Plant (STP) and groundwater from onsite production wells. The WRF produces an estimated 45,000 gpm (170.3 cubic meters per minute) or 65 million gpd (246 million liters per day) (ADEQ 2009a).

2.1.6.4 Evaporation Ponds

Evaporation Ponds 1 and 2 are above-grade, double-lined surface impoundments on the southern portion of PVNGS. The ponds are authorized to receive and evaporate Circulating Water System blowdown, nonhazardous reject water from the WRF, and nonhazardous wastewater from other onsite sources.

Evaporation Pond 3 is an above-grade, tripled-lined wastewater impoundment located to the south of Evaporation Pond 1. The pond is divided into two cells, 3A (west) and 3B (east), that operate independently. It is authorized to receive cooling tower blow-down and wastewater from the generating units (ADEQ 2009a).

2.1.6.5 Fire Protection Water System

The fire protection water system consists of two 500,000-gallon (1,893-cubic meter) fire water reserve tanks, an electric-driven pump, two diesel engine driven pumps, one jockey pump, and related piping, valves, hydrants, and hose stations. The system provides water for all plant areas requiring fire protection and is shared by Units 1, 2, and 3 (APS 2008b). The source of the water stored in the fire reserve tanks is groundwater transferred from two onsite production wells (Gunter 2006). The WRF also provides water to this system (ADEQ 2009a).

2.1.6.6 Domestic and Demineralized Water Systems

Groundwater from two onsite production wells is transferred to two 27,000-gallon (102-cubic meter) well water reserve tanks for storage. These tanks provide water to the Domestic Water System where it is filtered and undergoes reverse osmosis and chlorination to produce potable water that is stored and distributed throughout PVNGS. Water from the Domestic Water System is also sent to the Demineralized Water System where it is further processed to remove dissolved gases and solids, then stored and transferred to each generating unit and to common facilities in the Chemical Production System. The WRF also provides water to these systems (ADEQ 2009a). Both the Domestic Water System and the Demineralized Water System can supply reactor makeup water (APS 2008b).

2.1.7 Facility Water Use and Quality

PVNGS does not use public water supplies for plant operations, but instead relies on wastewater effluents from several area municipalities and groundwater from onsite production wells.

2.1.7.1 Recycled Water Use

PVNGS purchases wastewater effluents from Phoenix-area wastewater treatment plants for beneficial use as cooling water and safety-related makeup water for the Essential Spray Ponds. Treated effluent from the Phoenix 91st Avenue Wastewater Treatment Plant, the Tolleson Wastewater Treatment Plant, and the Goodyear Wastewater Treatment Plant is conveyed by gravity through a 36-mile (58-kilometer) long underground pipeline (the Water Reclamation Supply System) until it reaches a low point near the Hassayampa River. From there it is pumped via the Hassayampa Pump Station to the onsite Water Reclamation Facility (WRF) where it is treated to meet the plant's water quality requirements. The treated water is then stored in two onsite storage reservoirs to ensure a continuous supply of water during interruptions or reductions in water flowing to the WRF (APS 2008b; ADEQ 2009a). According to the Arizona Department of Water Resources (ADWR) (ADWR 2008), PVNGS is the largest user of treated wastewater effluent in the Phoenix Active Management Area (AMA), using on average about 53,000 acre-feet (65.4 million cubic meters) per year (APS 2008a).

2.1.7.2 Groundwater Use

PVNGS maintains three onsite production wells (Table 2.1.7-1). These wells are completed in the regional aquifer and are permitted and regulated by the State of Arizona. The average annual pump rate for these wells from 2001 through 2005 was 1,232 gpm (4.7 cubic meters per minute) (Gunter 2006). The total annual pump rates for these wells during 2006, 2007, and 2008 were 1,535 gpm (5.8 cubic meters per minute), 1,108 gpm (4.2 cubic meters per minute), and 1,262 gpm (4.8 cubic meters per minute) (APS 2007a; APS 2008a; and APS 2009a). These pump rates are well below the 3,206 gpm (5,171 acre-feet per year) (6.4 million cubic meters per year) authorized by the ADWR as part of the plant's grandfathered nonirrigation groundwater right within the Phoenix AMA (ADWR 1990).

Groundwater from the Alpha and Bravo wells is transferred to two 500,000-gallon (1,893-cubic meter) fire water reserve tanks and two 27,000-gallon (102-cubic meter) well water reserve tanks for storage. The well water reserve tanks provide water to the Domestic Water System where it is filtered and undergoes reverse osmosis and chlorination to produce potable water that is stored and distributed throughout PVNGS. Water from the Domestic Water System is also sent to the Demineralized Water System where it is further processed to remove dissolved gases and solids, then stored and transferred to each generating unit and to common facilities in the Chemical Production System. Both the Domestic Water System and the Demineralized Water System can supply reactor makeup water (APS 2008b).

Groundwater from the Range well is used primarily for dust control (APS 2004). A new production well (Charlie well) is planned for first use in the summer of 2010. Groundwater from this well will be used for dust control for 4 to 5 years and then Charlie may replace Bravo well.

Table 2.1.7-1 PVNGS Production Wells

Well	Water Uses	Well Depth (ft)	Water Level (ft)	Pump Capacity (gpm)	Maximum Water Demand (gpm)[a]
Range wellb	Industrial	340	195	10	0.058 (2006)
Alpha wellb	Potable; demineralized Water; fire protection and dust control	1,413	220	2,000	1,114 (2008)
Bravo wellb	Potable; demineralized water; fire protection and dust control	1,050	205	2,000	1,208 (2006)
Charlie wellb	Dust control starting summer 2010	1,360	204	750	Not applicable

(a) Values represent the maximum annual water usage during the period 2006 through 2008; year in parentheses is the year during which the maximum annual usage was recorded.

(b) The Range well is classified as an exempt well by the ADWR. An exempt well is used for non-irrigation purposes and has a maximum pump capacity of 35 gpm (133 liters per minute) or less. Wells with this classification do not need a groundwater withdrawal authority (i.e., groundwater right or permit). The Alpha, Bravo and Charlie wells are classified by the ADWR as nonexempt wells because their pump capacity is greater than 35 gpm (133 liters per minute) and they are used for industrial purposes (ADWR 2009a).

Source: APS 1982a, APS 1982b, APS 2004, APS 2007a, APS 2008c, APS 2009d, and ADWR 2009b.

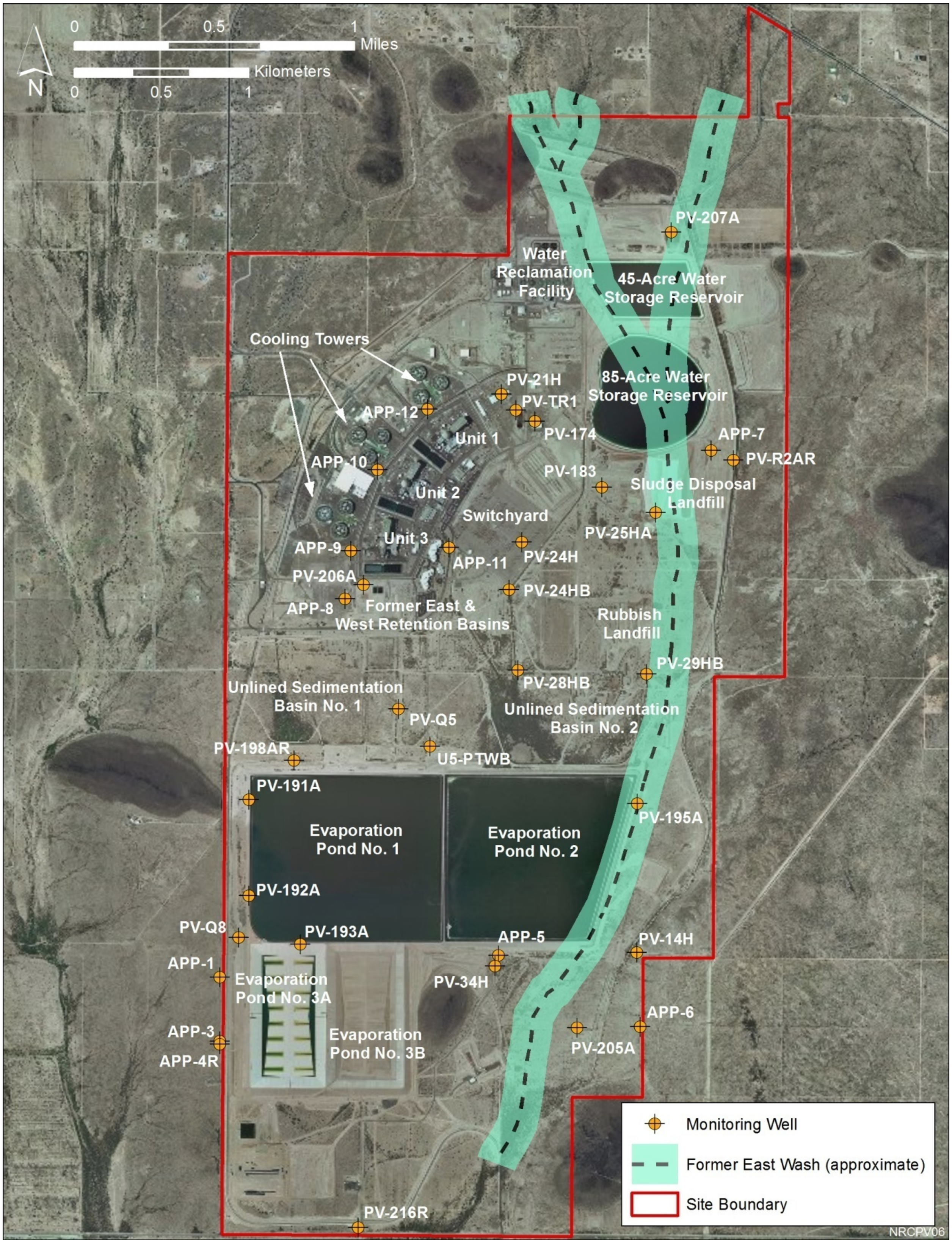

Figure 2.1.7-1 PVNGS Surface Impoundments, Landfills, and Monitoring Wells

(Source: APS 2009b)

2.1.7.3 Surface Water Use

PVNGS does not draw its cooling (or makeup) water directly from any natural surface water body.

2.1.7.4 Groundwater Quality

Groundwater quality throughout Maricopa County is characterized as fair to good; although in some areas, treatment for fluoride and total dissolved solids (TDS) is required before it can be used for drinking water. Poor quality water has been observed in the Upper Alluvial Unit, especially in the East and West Salt River Valley sub-basins. In these sub-basins, contaminants include TDS, sulfates, nitrates, volatile organic compounds (VOCs), pesticides, and metals. The major sources of these contaminants are industry, agriculture, dry well injections, unregulated landfills, and leaking underground storage tanks (Maricopa County 2001).

PVNGS maintains a groundwater monitoring program to comply with the requirements of Aquifer Protection Permit (APP) No. P-100388 LTF 48337, issued by the Arizona Department of Environmental Quality (ADEQ) (ADEQ 2009a). The APP authorizes the operation of seven surface impoundments (including two unlined sedimentation basins) and two landfills at PVNGS (Figure 2.1.7-1). The facilities regulated by the permit are described below and their monitoring requirements are listed in Table 2.1.7-2. Groundwater monitoring well locations are shown in Figure 2.1.7-1. These wells are located and routinely sampled to characterize ambient (background) conditions, ensure compliance with the APP, and provide an early warning system in the event of a release. Water elevations are also measured to provide data for quarterly contour maps and hydrographs for the shallow aquifer. In addition to groundwater monitoring, APS conducts leak detection monitoring for the two water storage reservoirs and the evaporation ponds. The purpose of leak detection monitoring is to ensure immediate identification of potential damage to the liner systems that could result in releases above the discharge limits specified in the APP (ADEQ 2009a; APS 2009f).

85-Acre and 45-Acre Water Storage Reservoirs

The 85-acre (34.4-hectare) Water Storage Reservoir (WSR) is located in the northern portion of PVNGS, on the southeast side of the WRF; the 45-acre (18.2-hectare) WSR is located to the north of the 85-acre (34.4-hectare) WSR (Figure 2.1.7-1). The synthetic-lined impoundments receive tertiary treated effluent from the WRF and store it for use as cooling water for the generating station. The 85-acre (34.4-hectare) WSR has a maximum depth of about 30.5 feet (9.3 meters) (from the top of primary liner) and is designed to store 788 million gallons (2.98 billion liters) of cooling water at its maximum operation elevation. It has a maximum depth of about 46 feet (14 meters) (from the top of the primary liner) and is designed to store 373 million gallons (1.41 billion liters) of cooling water at its maximum operation elevation. Each WSR has a design flow of 60,000 gpm (227 cubic meters per minute) with a peak design flow of 72,000 gpm (273 cubic meters per minute). Each WSR has a double-liner system with a leakage collection and recovery system installed above an underdrain system that allows groundwater to be pumped and removed from underlying soils to protect the liner system. Authorized discharges to the WSRs include final treated water from the WRF, secondary treated effluent from the Sewage Treatment Plant (emergency only), nonhazardous low volume wastewaters during WRF outages, and untreated

Table 2.1.7-2 Facilities Regulated by PVNGS Aquifer Protection Permit Program

Facility	Monitoring Requirements
85-acre and 45-acre Water Storage Reservoirs	• Operational (compliance) monitoring: - Maintenance and visual inspection[a] - Leak collection and recovery system sump (weekly) - Fluid level (weekly and after significant storms) - Flow at discharge point (daily) - Flow meters and other measuring devices (monthly) • Contingency discharge monitoring (in the event of unauthorized discharge or other violation)
Evaporation Ponds 1 and 2	• Routine discharge monitoring (weekly, monthly, annually) • Operational (compliance) monitoring: - Maintenance and visual inspection[a] - Leak collection and recovery system sump (weekly) - Fluid level (weekly and after significant storms) - Flow at discharge point (monthly) - Flow meters and other measuring devices (monthly) • Contingency discharge monitoring (in the event of unauthorized discharge or other violation)
Evaporation Pond 3 (Cells 3A and 3B)	• Monitoring of transfer of wastewater between cells (at pump location) • Operational (compliance) monitoring: - Maintenance and visual inspection[a] - Leak collection and recovery system sump (daily) - Fluid level (weekly and after significant storms) - Flow at discharge point (daily) - Flow meters and other measuring devices (monthly) • Contingency discharge monitoring (in the event of unauthorized discharge or other violation)
Sludge Disposal Landfill (Cooling Tower and WRF Sludge)	• Sludge monitoring prior to disposal on a per disposal event basis • Stormwater run-on/run-off control (monthly) • RCRA TCLP[b] metals monitoring • Contingency monitoring (in the event of unauthorized material disposal or other violation)
Rubbish Landfill	• Stormwater run-on/run-off control (monthly) • Contingency monitoring (in the event of unauthorized material disposal or other violation)

(a) Visual inspection includes freeboard, upper liner integrity, liner leakage rate, and dam and berm integrity.

(b) RCRA TCLP (Toxicity Characteristic Leaching Procedure) analytes include pH, arsenic, barium, cadmium, total chromium, lead, mercury, selenium, and silver. The TCLP test is used to determine whether a solid waste is hazardous in terms of its leaching potential as defined by the Resource Conservation and Recovery Act (RCRA).

Source: ADEQ 2009a.

groundwater from the regional aquifer. The ADEQ has also authorized the use of water from both WSRs for cooling tower makeup water and dust suppression (ADEQ 2009a; APS 2009c).

The original 85-acre (34.4-hectare) WSR had a surface area of 80 acres (32.4 hectares) and a maximum design storage capacity of 670 million gallons (2.54 billion liters). In October 2004, the APS observed that the liner for this reservoir had developed leaks that required repair. To facilitate the repair work, the 45-acre (18.2-hectare) WSR was constructed and put into service so that the 80-acre (32.4-hectare) WSR could be drained and repaired. During the repair project, the inner wall slope was changed from 3:1 to 4:1 and a new double liner with a leachate collection system was installed. The change in wall slope increased the surface area of the reservoir to 85 acres (34.4 hectares). The WSR was put back into service in early 2008 and is now referred to as the 85-acre (34.4-hectare) WSR. APS submitted its final corrective action report to the ADEQ on June 12, 2009 (Eroh 2009).

Evaporation Ponds

Evaporation Ponds 1 and 2 are above-grade, double-lined surface impoundments on the southern portion of PVNGS (Figure 2.1.7-1). The ponds are authorized to receive and evaporate circulating water system blowdown, nonhazardous reject water from the WRF and nonhazardous wastewater from other onsite sources. Each pond has an underdrain and toe drain leakage collection system and a vadose zone monitoring system for dam safety. Evaporation Pond 1 has a surface area of about 250 acres and ranges in depth from 19 to 32 feet (6 to 10 meters); it is designed to hold 1,793 million gallons at its maximum elevation. Evaporation Pond 2 has a surface area of about 220 acres and ranges in depth from 24 to 36 feet (7.3 to 11 meters); it is designed to hold 1,923 million gallons at its maximum elevation. The estimated average annual flow rate to each pond is 3,125 gpm (11.8 cubic meters per minute) (ADEQ 2009a).

Evaporation Pond 3 is an above-grade, tripled-lined wastewater impoundment located to the south of Evaporation Pond 1 (Figure 2.1.7-1). The pond is divided into two cells, 3A (west) and 3B (east), that operate independently. Each cell is equipped with a liner leakage monitoring system. The pond has a total surface area of about 185 acres, a maximum depth of about 71 feet (23 meters), and is designed to hold 2,132 million gallons at its maximum elevation. Evaporation Pond 3 is authorized to receive cooling tower blow-down and wastewater from the generating units; organic solvents and hazardous substances are prohibited. Fluids from other regulated ponds may be temporarily discharged to Evaporation Pond 3 as part of maintenance, repair, or contingency response actions (ADEQ 2009a).

Sludge Disposal Landfill

The Sludge Disposal Landfill is located on the east-central portion of PVNGS, just south of the 85-acre WSR (Figure 2.1.7-1). It is an active, unlined solid waste disposal facility used for the surface drying and landfilling of sludge from the WRF and the cooling towers. The sludge is covered with a foot (0.3 meter) of soil with each application. The landfill covers about 213 acres and is operated in accordance with Arizona Revised Statutes (ARS) §49-762.07 (E) and (F) (ADEQ 2009a).

Rubbish Landfill

The Rubbish Landfill is located on the east-central portion of PVNGS, south of the WSR (Figure 2.1.7-1). It is an active, unlined trench-type solid waste disposal facility that receives noncombustible, nonhazardous, nonradioactive, and nonputrescible solid waste generated at PVNGS; it is authorized to receive landscape-trimming material. The landfill covers an area of about 100 acres and is operated in accordance with ARS §49-762.07 (E) and (F) (ADEQ 2009a).

Aquifer Protection Permit Exempt Facilities

Sedimentation Basins 1 and 2 are located to the north of the evaporation ponds

(Figure 2.1.7-1). The basins are nonengineered, unlined earthen containment ponds designed to collect stormwater and non-stormwater discharges. They are normally dry except during and after storm events. Sedimentation Basin 1 collects drainage from the western portion of PVNGS; it is about 1,000 feet long (305 meters) and 15 acres in area. Sedimentation Basin 2 collects drainage from the eastern portion of PVNGS; it is about 3,000 feet (914 meters) long and 60 acres in area. Both basins meet the criteria for exemption from APP regulation ARS §§49-250(B)(23). In the past, both sedimentation basins have received discharges that are not listed under the exemption for stormwater impoundments. These have included demineralized water from the generating units, cooling water, cooling tower overflow, spray pond water, and oil/water separator discharge, among others. APS is required by the ADEQ to act immediately to correct any condition resulting in an unauthorized, non-exempt discharge and to report the incident in accordance with the emergency response and contingency requirements and the permit violation reporting specifications outlined in Sections 12.4 and 13.3 of the APP. These discharges and their associated corrective actions are provided in Table 2.1.7-3 (ADEQ 2009a).

The East and West Retention Basins were located to the north of Sedimentation Basin 1 (Figure 2.1.7-1). These gunite-lined[2] impoundments once received nonhazardous wastewater from the oily and nonradioactive wastewater collection and transfer system (floor and equipment drains) and from the Sewage Treatment Plant (STP) during periods when the WRF was offline and not able to receive STP discharge. The contents of the basins were tested for pH, hydrazine (a compound used to prevent scaling and corrosion), visible oil, and radioactivity and treated as necessary before being discharged to the evaporation ponds. During construction joint repairs conducted in 2005, APS observed water beneath the gunite flowing to the surface, but not in the leak detection system beneath the retention basins. This water was sampled and found to have low levels of tritium. As a result of these observations, APS designed and constructed two new aboveground, epoxy-lined concrete tanks to replace the existing retention basins. The construction of the new tanks was completed in March 2007, at which time the retention basins were taken offline. APS began removing the retention basins in June 2007 under the compliance schedule in the APP. It submitted its final closure report to the ADEQ in July 2008 (APS 2008c). The new concrete tanks are exempt from regulation under the APP (ADEQ 2009a).

Other water-related PVNGS facilities that are exempt from the APP are the WRF, the STP retention tanks, the Essential Spray Ponds (aboveground tanks), the cooling towers and concrete aprons (located on concrete pads), the Concrete/Inert Material Landfill, the Independent Spent Fuel Storage Installation (in concrete casks on a concrete pad), the truck washing station, and the Fire Training Facility. While discharge from the STP is not exempt, it is not regulated by the APP because it is typically directed to either the exempt STP retention tanks or to the headworks of the WRF (ADEQ 2009).

<u>Aquifer Protection Permit Compliance</u>

The monitoring and compliance activities required by the APP to protect the drinking water aquifer in the vicinity of PVNGS are documented in annual reports to the ADEQ. These reports include the results of groundwater monitoring, impoundment monitoring, sludge monitoring, and compliance status (including permit violations), and document the maintenance and repair activities for the surface impoundments over the past year. The results of the 2008 monitoring

[2] Gunite is a concrete mixture that is pneumatically applied over steel reinforcements. Under the gunite layer was a 6-inch layer of sand over a 0.45 millimeter Hypalon® liner (APS 2008c).

and compliance activities are summarized below. In addition to the annual reports, PVNGS is also required to submit a 5-year monitoring evaluation report that evaluates groundwater and wastewater monitoring data over the prior 5-year period to determine whether changes are needed in the groundwater monitoring program. The latest 5-year report, evaluates data from 2004 through 2008 and its recommendations are provided in the following sections (APS 2009c).

Water Storage Reservoirs

Concentrations of chemical parameters in the 85-acre WSR, such as sodium, potassium, chloride, and sulfate, were stable over the reporting period (2004 to 2008) and well-correlated with the chemical parameters found in evaporation ponds, although concentrations in the evaporation ponds were typically two orders of magnitude higher due to the concentrating action of the cooling tower recycling process and the effect of evaporation that occurs in the ponds by design. The correlation shows that water in the WSR and water in the evaporation ponds, which derives from water in the WSR, remains chemically similar over time.

APS recommended using potassium as an indicator of a release from the WSR and the evaporation ponds. Potassium in the WSR and evaporation ponds derives from human sources (e.g., water softening, sweat, urine) and its form is chemically distinct from the naturally-occurring and fertilizer-related potassium found in groundwater from the shallow aquifer. This recommendation is undergoing ADEQ review (APS 2009c).

Evaporation Ponds

In 2008, weekly water samples collected from Evaporation Ponds 1 and 2 were composited on a monthly basis and analyzed for the indicator parameters (inorganics and organics) specified in Table 17.2-7 of the APP (ADEQ 2009). Weekly samples were also composited on a quarterly basis and analyzed for tritium. None of the radiological parameters were found to exceed the alert levels required by the APP, although tritium was detected in all quarterly samples from both evaporation ponds. Iodine-131 was detected in monthly samples collected in February, March, and November from Evaporation Pond 1 (APS 2009f). Due to elevated TDS concentrations (relative to the surrounding shallow aquifer) and the presence of tritium in the evaporation ponds, APS recommended that monitoring of groundwater near the evaporation ponds include quarterly sampling for tritium and TDS (APS 2009c).

Sedimentation Basins

An unintended non-stormwater release to Sedimentation Basin 2 in December 2008 triggered a sampling event in accordance with requirements of the APP. A composite sample was analyzed for the parameters listed in Table 17.3-3 (Plant Upset Releases to Unlined Facilities) of the APP. None of the analytes were found to exceed Arizona Water Quality Standards (AWQS) or alert levels required by the APP (APS 2009f).

Cooling Tower and Wastewater Treatment Facility Sludge

The APP requires that cooling tower and WTF (Wastewater Treatment Facility) sludge be analyzed prior to disposal in the Sludge Disposal Landfill. In 2008, eight cooling tower sludge samples were collected: one from the canal and one from each of the three cooling towers in Unit 3 (for a total of four samples in March) and one from the canal and one from each of the three cooling towers in Unit 2 (for a total of four samples in May). These samples were analyzed for Resource Conservation and Recovery Act (RCRA) Toxicity Characteristic Leaching Procedure (TCLP) metals as specified in Table 17.2-4 of the APP. None of the samples were found to have TCLP metals above their laboratory reporting limits, and none of the TCLP metals exceeded their respective alert limits.

Indicator Parameters

Levels of indicator parameters in monitoring wells sampled in 2008 were for the most part unchanged from previous years, though some wells did show elevated levels of boron and chloride. Boron is a naturally-occurring element derived from the weathering of volcanic rocks and clay-rich sedimentary rocks (APS 2009b). Chloride is also known to be high in the shallow aquifer due to historical agricultural practices in the area. Tritium was not detected in any wells in 2008 (APS 2009f).

Water Level Data for the Shallow and Regional Aquifers

In general, water level elevations measured in the shallow aquifer during 2008 were consistent with historical shallow groundwater data. Water level elevations measured in the regional aquifer indicate the general groundwater flow direction is south-southwest. This current flow gradient is controlled by pumping in the Centennial Wash area to the south-southwest and by pumping by other power plants south of PVNGS (APS 2009f).

Permit Violations

A partial summary of APP violations between 2004 and 2008 is provided in Table 2.1.7-3. During this period, most discharge-related violations involved unauthorized releases to Sedimentation Basin 2 during storm events. Corrective actions were taken in each event to address the source of the release. These most often included a combination of sampling and reporting, but in some cases also required design modification and repairs.

1 **Table 2.1.7-3 Partial Summary of Aquifer Protection Permit Violations 2004 - 2008[a]**

Year	Day	Affected Facility	Event/Corrective Action
2008	Dec 26	Sedimentation Basin 2	Overflow of the Unit 3, B Spray Pond Filters Head Tank during precipitation event. Estimated release of 1,400 gallons (5,300 liters) over a period of about 6 hours. Corrective action was to backwash the Spray Pond Filters at greater frequency and duration to improve effectiveness of the filters and reduce foam buildup. Analytical results did not exceed the alert levels specified in Table 16.3-3 of the APP. No changes in monitoring were made.
2006	Jul 7[b]	Sedimentation Basin 2	Overflow of North Yard sump during precipitation event. Corrective action was to install a permanent design change to reroute the Turbine Building roof drains away from the yard sumps to the cooling tower canals to eliminate the overloading of sumps during precipitation events. Completed March 13, 2007.
2005	Aug 2[c]	Sedimentation Basin 2	Overflow of Unit 1 yard sump during storm event. Corrective action included sampling the basin and Unit 1 HVAC NA02B to evaluate releases. Proposal to reroute turbine building roof drains from yard sumps submitted to ADEQ on December 22, 2005.
2004	Feb 11	Sedimentation Basin 2	WRF pipeline rupture disc failure. Corrective action was to shutdown the Hassayampa Pump Station and close the isolation valve for the rupture disc. Temporary dirt dam was installed downstream to contain the concrete dam overflow. Design modification to install new piping to allow releases to be returned and maintained in the WRF.
2004	Apr 2	Sedimentation Basin 2	Manhole and evaporator cooler release during storm event. Corrective action was to reinforce and upgrade administrative procedures.
2004	Nov 7	Sedimentation Basin 2	Overflow of Unit 1 yard sump during storm event. Corrective action was to evaluate several design modification options to prevent recurrence.
2004	Nov 7	Sedimentation Basin 2	Unit 3 secondary closed loop cooling water release during storm event. Corrective action was to install swagelock plug valves in Unit 3 to prevent future occurrences.
2004	Nov 12	Sedimentation Basin 2	Unit 3 temporary cooling tower cooling water release during a storm event. Corrective action included rebuilding pump with new seals and instituting new procedures requiring that pumps be tested prior to use to demonstrate their performance.

Year	Day	Affected Facility	Event/Corrective Action
2004	Unknown	Sedimentation Basin 2	Failure of WRS liner. Tears and separations in the liner were discovered during inspection. Corrective action included sampling reservoir, making 5-day notification call, and repairing some tears. Signed Consent Order P-153-04 to provide a corrective action plan for the monitoring of the WRS and repair of the reservoir liner.

(a) Only permit violations related to unauthorized releases are listed here. Types of violations not listed include: (1) failure to submit 5-day notification of performance standard exceedance; (2) failure to report performance standard exceedance; and, (3) failure to provide 30-day notification of failure to sample.

(b) Similar events occurred on July 25, August 9, August 14, September 9 and14 in 2005.

(c) Similar events occurred on August 8, October 17, October 18 in 2004.

Source: APS 2009f, APS 2008f, APS 2007b, APS 2006c, and APS 2005.

Subsurface Assessment of Tritium

In 2006, APS discovered tritium in a PVNGS Unit 3 subsurface concrete pipe vault at concentrations with the potential to exceed the aquifer quality limit (AQL) as provided in the APP (APS 2006a). Tritium was confirmed in subsurface water, but its origin was unknown at that time. Since then, APS has conducted a number of investigations to characterize the extent of the release and to determine its source. These investigations involved identifying and leak-testing underground piping in the area where the tritiated water was found; digging a series of test holes to characterize the extent of tritiated water in the soil; examining other process systems involving tritiated water; and reviewing the operational history of the station.

Initial investigations have found the extent of tritiated water to be limited to the vicinity of the PVNGS Units 2 and 3, with only the Unit 3 Radiological Controlled Area Yard having tritium above action levels. Tritiated water is confined to areas within small shallow basins formed by low permeability compacted soil and foundation structures; these features also limit its migration. No leaks from underground pipes associated with the Fire Protection, Essential Spray Ponds, Liquid Radwaste, and Chemical and Volume Control Systems were detected. Other sources such as those related to leaks in piping, tanks, or sumps near the affected area were also evaluated; no leaks were detected. Based on its ongoing investigations (of other tritium sources and migration pathways) and the results of dispersion modeling analysis, APS reports the most probable sources of tritium are washout related to past operations of the Boric Acid Concentrator when it may have operated during rain events (this practice was discontinued in the 1990s); wash down from roofs or washout from rain during times when tritium condensation from the ventilation system was present; and possibly small historic spills within the area of the small basins (APS 2006a; APS 2006b).

A total of 16 new monitoring wells, to depths of up to 50 feet (15.2 meters), were installed to monitor for tritium releases at Units 1, 2, and 3. Three wells were installed near Unit 1, five near Unit 2, and eight near Unit 3. Three downgradient wells (APP-01, APP-10, and APP-11) were also drilled to depths of 80 to 90 feet (24 to 27 meters) to monitor for tritium downgradient of Units 1, 2, and 3. To date, tritium has not been detected above the Arizona Water Quality Standard of 2×10^{-5} μCi/mL (or 20,000 pCi/L) in these wells or in groundwater from other site monitoring wells screened in the shallow, intermediate, or deeper (regional) aquifer. Asphalt repairs and sealing around structures has been completed (APS 2008g, APS 2009f). APS continues to submit quarterly progress reports to ADEQ.

2.1.7.5 Surface Water Quality

PVNGS does not release cooling water (or cooling water blowdown) effluents to any natural surface water body. Instead, these effluents are discharged to man-made lined evaporation ponds with no outlet and no hydraulic connection to any natural water body. The evaporation ponds are monitored in accordance with APP No. P-100388 LTF 48337 (Section 2.1.7.4).

2.2 SURROUNDING ENVIRONMENT

PVNGS is in the west-central part of Maricopa County in southwest Arizona and is located about 45 miles (72 km) west of central Phoenix. The general area is located in the Sonoran Desert, which covers the southwest part of Arizona, southern California, and northwestern Mexican states. The topography around PVNGS is relatively flat terrain at an elevation of about 950 feet (290 meters), and its surrounding area consists of scattered low hills and buttes. Scattered hills with peak elevations of about 1,400 feet (427 meters) are located about 3 miles (5 km) west of the site. The Palo Verde Hills, located about 5 miles (8 km) northwest of the site, are the highest hills with peaks reaching a maximum elevation of more than 2,100 feet (640 meters).

The nearest population center to PVNGS is the Phoenix metropolitan area (Figure 2.1-1), which includes the following major cities: Phoenix, Tempe, Mesa, Glendale, Peoria, Scottsdale, and Sun City. The nearest town is Wintersburg (Figure 2.1-2) (APS 2008a).

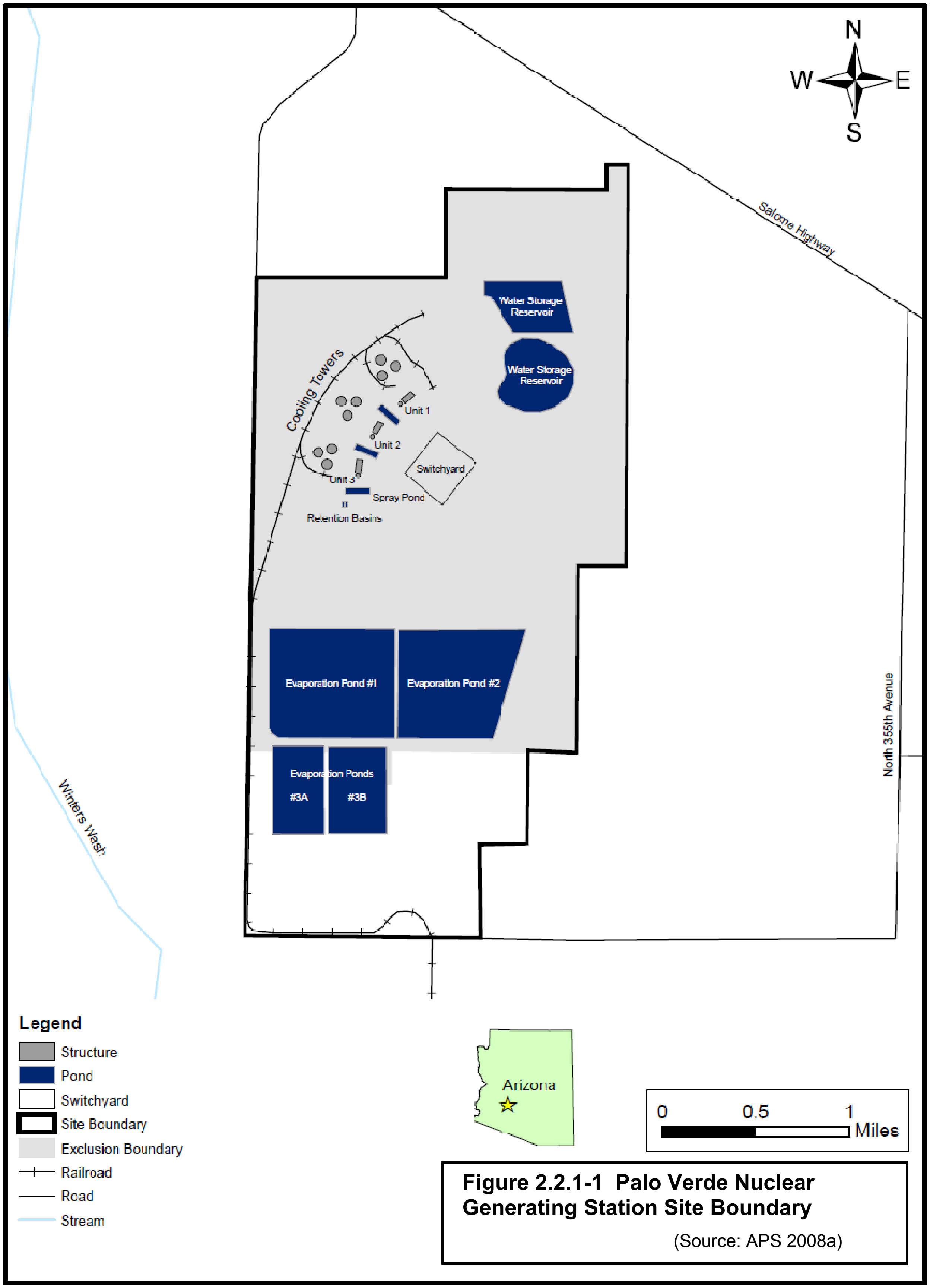

Figure 2.2.1-1 Palo Verde Nuclear Generating Station Site Boundary

(Source: APS 2008a)

2.2.1 Land Use

The PVNGS site occupies 4,280 acres (1732 hectares), about 17 percent (728 acres [294 hectares]) of which is developed. A 20-acre (8-hectare) Independent Spent Fuel Storage Installation facility is located northeast of the switchyard. There are 790 surface acres (247 hectares) of water, including three evaporation ponds covering 660 acres (194 hectares). The two reservoirs of the Water Reclamation Facility, which store water reclaimed from wastewater effluent to provide cooling water for the plant, cover 130 acres (53 hectares) (APS 2008a). The undeveloped area is open desert habitat.

Interstate Highway 10 is located 6 miles (10 km) northeast of PVNGS at its closest point and State Route 80 is located 7 miles (11 km) southeast. An east-west railroad corridor is located approximately 4 miles (6 km) south-southwest of the site. Public access to the plant site is restricted, with no unauthorized public access or activity allowed on APS property. The site boundary, as shown in Figure 2.2.1-1, is posted and fenced to prevent public access. No public roads, railways, or waterways traverse PVNGS.

2.2.2 Climate and Meteorology

The area around PVNGS has a desert-like arid climate characterized by hot summers, mild winters, light precipitation, a high rate of evaporation, low relative humidity, abundant sunshine, and large temperature ranges (NCDC 2009a). The area is characterized by light winds. Based on 2004–2008 wind measurements at PVNGS, average wind speed at a height of 35 feet (10.7 meters) is about 6.7 miles per hour (mph) (10.8 km/hour) (APS 2008a), as shown in Figure 2.2.2. Average wind speeds are the highest in spring and summer at 7.4 mph (11.9 km/hour), lower in fall at 6.1 mph (9.8 km/hour), and lowest in winter at 5.7 mph (9.2 km/hour). At PVNGS, the prevailing wind direction is from the southwest about 15 percent of the time. Winds blow from the southwest during April through August and from the north during October through February, with a transition between southwest and north in March and September. Prevailing wind directions are greatly influenced by local topography (NCDC 2009a).

In Arizona, topography plays a large role in determining the temperature of any specific location. Hot temperatures over 100°F (37.8°C) are common throughout the summer months at the lower elevations in the southwest of the State. For the 1893–2003 period, the annual average temperature at Buckeye, which is located about 14 miles (22.5 km) east of PVNGS, was 69.9°F (21.1°C) (WRCC 2009). January was the coldest month with an average minimum of 34.6°F (1.4°C), and July was the warmest month with an average maximum of 107.1°F (41.7°C). In summer, daytime maximum temperatures frequently exceed 110°F (43.3°C) in the afternoon and remain above 85°F (29.4°C) throughout the night. On average, for more than twelve days in December and January, minimum temperatures are below freezing. For the same period, the highest temperatures reached 125°F (51.7°C) in July 1995 and the lowest reached 11°F (–11.7°C) in January 1913. Annually, about 175 days have maximum temperatures greater than or equal to 90°F (32.2°C), while about 36 days have minimum temperatures at or below freezing.

Throughout Arizona, precipitation patterns largely depend on elevation and the season of the year. Rain comes mostly in two distinct seasons (winter and summer monsoon seasons) (NCDC 2009b). From November to March, periodic rains are associated with

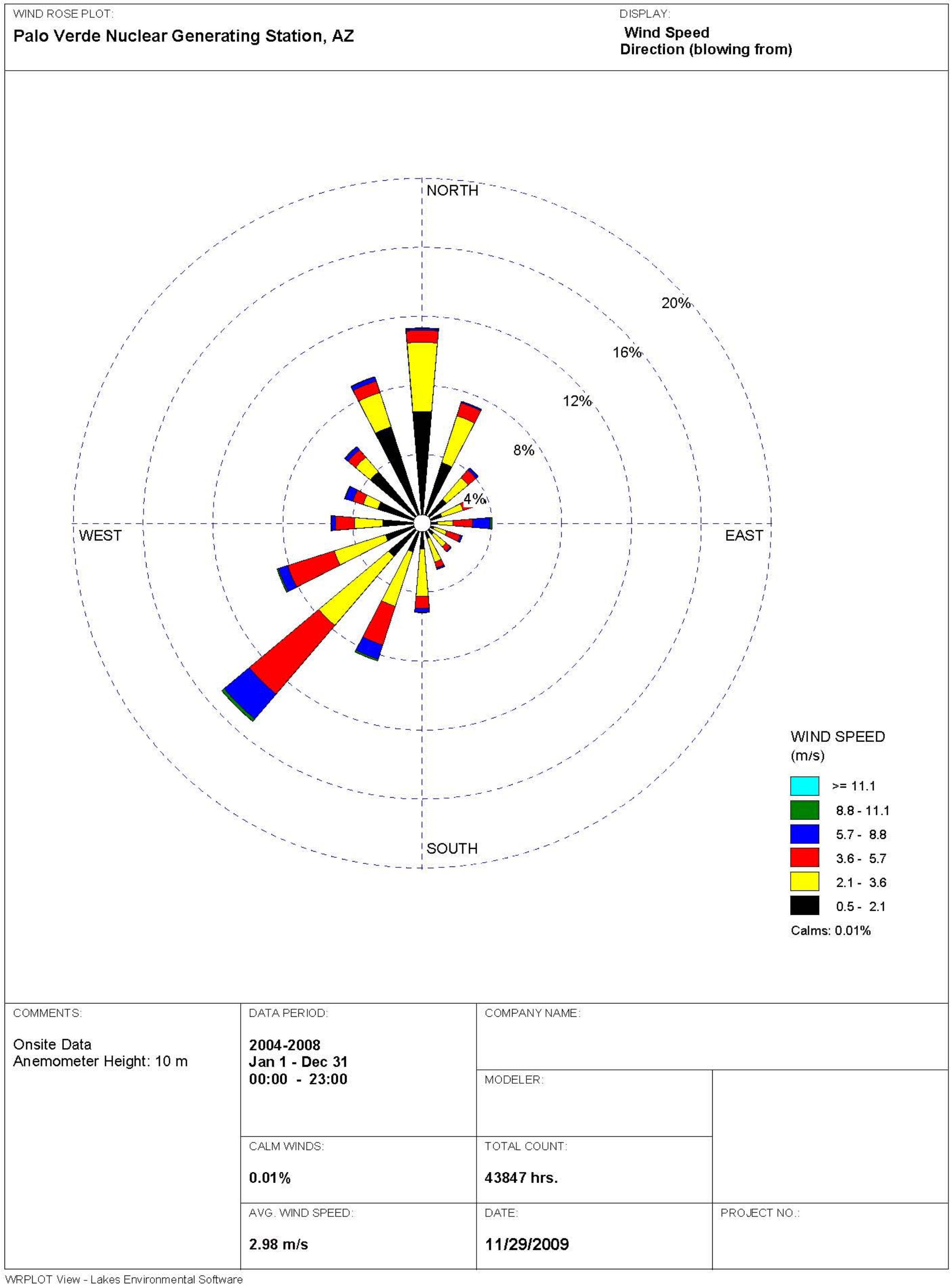

Figure 2.2.2 Wind Rose at 35-foot at PVNGS 2004–2008 (APS 2008a)

winter storms originating from the Pacific Ocean. The summer monsoon usually begins early in July and lasts until mid-September. The intense summer heat causes air pressure over land to drop, forming an area of low pressure that allows cooler and more humid air over the ocean to be drawn into the area. This cooler and more humid air from the ocean overriding the hotter and drier air on land becomes unstable, triggering thunderstorms. Moisture sources include the Gulf of Mexico, the Pacific Ocean off the west coast of Mexico, and the Gulf of California. These summer thunderstorms, which peak in July and August, are often accompanied by strong winds and periods of blowing dust along with occasional hail. Typically, May and June are the driest months. For the 1893–2003 period, annual precipitation at Buckeye averaged about 7.59 inches (19.3 centimeters) (WRCC 2009). Seasonal precipitation was highest at 2.50 inches (6.35 centimeters) in winter, followed by summer at 2.07 inches (5.26 centimeters), and reached a low of 1.13 inches (2.87 centimeters) in spring. Trace amounts of snow occur as early as December or as late as March, but measurable snowfall in the desert areas of southern Arizona including PVNGS is a rarity (NCDC 2009a).

Severe weather events, such as dust storms, thunderstorm winds, flash floods, and tornadoes, have been reported for Maricopa County (NCDC 2009c). On occasion, high winds in combination with dry and loose soil conditions result in blowing dust, which typically occurs during the afternoons of hot summer days. Dust storms can deteriorate air quality and visibility, creating traffic hazards. Dust storms can also have adverse effects on health, particularly for the young, the elderly, and people with asthma or other respiratory problems. Winds accompanying heavy thunderstorms mostly occur in the late afternoon during July through September. For the period 1950–2009, more than 10 thunderstorm wind events per year occurred on average in Maricopa County, sometimes reaching peak gusts of about 115 mph (185 km per hour) in local areas. These thunderstorm winds caused some deaths and injuries and considerable property damage.

Flash flooding, due to excessive rain falling in a small area during a short period, causes considerable local damage in Arizona. Flash floods are usually associated with summer monsoon thunderstorms or the remnants of tropical storms. Between 1950 and 2009, Maricopa County experienced more than five floods per year, and these floods caused some deaths and injuries and considerable damage to property and crops. Tornadoes in Maricopa County occur less frequently and are less destructive than those in the central United States. For the period 1950–2009, a total of 57 tornadoes (about one tornado per year) were reported in Maricopa County. However, most of the tornadoes were relatively weak. These tornadoes caused property damage and 57 injuries, but no deaths were reported.

2.2.2.1 Air Quality Impacts

The Maricopa County Air Quality Department (MCAQD) is a regulatory agency whose primary responsibility is to ensure that Federal clean air standards are achieved and maintained. In doing so, the MCAQD administers several programs, such as air permits to regulate air emission sources including fugitive dust and open burning, air monitoring for compliance with the *National Ambient Air Quality Standards* (NAAQS), and vehicle repair and retrofit. Currently, more than 20 air monitoring stations are established in downtown Phoenix and the surrounding areas in Maricopa County. Buckeye, located about 14 miles (22.5 km) east of PVNGS, is the nearest air monitoring station where particulate matter with an *aerodynamic* diameter of 10 microns or less (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), and ozone (O_3) are monitored.

PVNGS is not listed as a Major Source but instead is a Synthetic Minor Source with respect to its potential to emit (PTE)3 criteria pollutants or hazardous air pollutants (HAPs)4 and is not required to secure a Title V permit for all stationary sources of air pollution. However, PVNGS is required to obtain and maintain a Non-Title V permit from the MCAQD for its stationary emission sources. PVNGS received a Non-Title V (Synthetic Minor) air quality permit (Permit No. 030132) from the MCAQD on August 18, 2005 (MCAQD 2005). (Non-Title V permits are issued to sources having actual emissions that are at least 50 percent of the Major Source emissions thresholds.) Permit stipulations include regulating source-specific emission limits, monitoring, operational requirements, recordkeeping, and reporting.

PVNGS has a number of sources of criteria pollutants and HAPs: fuel burning equipment (including boilers), internal combustion engines and turbines (including emergency generators and two blackout gas turbine generators), petroleum storage tanks, spray coating (including spray booth), solvent cleaning equipment, abrasive blasting equipment, water reclamation equipment (including lime, soda ash, and salt storage silos), cooling towers, steam generator cleaning equipment, and other miscellaneous equipment. Lime/soda ash/salt operations release primarily particulate matter, and cooling towers release particulate matter (chemically treated cooling water) as drift along with the volatile organic compound (VOC) chloroform, present in the cooling water as a by-product from disinfection of the water by chlorination. Combustion sources emit most of the criteria pollutants (to be discussed below), VOCs, and a small amount of HAPs (e.g., benzene). Fuel storage tanks and chemical use operations account for evaporative VOC emissions. Emissions inventory data reported to the MCAQD for calendar years 2004 through 2008 are presented in Table 2.2.2-1, which includes permitted, total (permitted and permit-exempted), and allowable emissions from PVNGS specified in the permit. During the period 2004–2008, emissions of criteria pollutants, VOCs, and HAPs varied from year to year, but all reported emissions (permitted source emissions only) on a calendar-year total basis were under the thresholds specified in the permit on a 12-month rolling total basis, except for the Notice of Violations to be discussed below. For the same period, there were no air emissions from accidental releases and no lead emissions were reported to be released from PVNGS.

Since the issuance of the permit (August 18, 2005), the MCAQD has issued three Notices of Violation (NOVs) to PVNGS (Bement 2008). The first NOV related to failure to comply with trackout requirements pursuant to Maricopa County Air Pollution Control Regulation, on October 26, 2006. This occurred during an earthmoving operation when a contractor for APS was working along the water reclamation supply line. Two of the NOVs were related to cooling tower PM_{10} emission tests: (1) for failure to comply with the permit condition that requires APS Palo Verde to limit PM_{10} emissions to less than 54.0 tons on a 12-month rolling total basis (on November 22, 2006)

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3 Per 40 CFR 52.21(b)(4), "potential to emit means the maximum capacity of a stationary source to emit a pollutant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitations or the effect it would have on the emissions is federally enforceable."

4 Under the Title V operating permit program, the EPA defines a Major Source as a stationary source with the potential to emit (PTE) more than 100 tons per year of any criteria pollutant, more than 5 ton per year of any single HAP, or 25 tons per year of any combination of HAPs. Major Sources are required to obtain a Title V permit. A Synthetic Minor Source is one that can apply administrative controls on its sources to keep emissions of criteria pollutants and HAPs below the above limits. Synthetic Minor Sources are not required to obtain a Title V permit, but may nevertheless be required to obtain a non-Title V permit from an EPA-authorized State or local air program regulatory authority.

Table 2.2.2-1 PVNGS Annual Emissions Inventory Summaries, 2004-8

	Annual Emissions (tons/yr)[a]						
Year	CO	NO_x	PM_{10}	SO_x	VOCs	HAPs	NH_x
2004	13.19 (17.32)[b]	50.11 (58.21)	34.05 (34.62)	0.69 (0.75)	29.03 (29.62)	–[c]	7.47
2005	16.38 (24.61)	62.03 (82.63)	30.83 (31.08)	1.02 (1.27)	26.90 (28.76)	4.08/2.22[d]	5.71
2006	18.53 (26.46)	70.42 (89.51)	27.74 (27.97)	1.15 (1.38)	18.32 (20.06)	3.76/2.23	1.58
2007	14.40 (49.13)	54.08 (97.82)	4.91 (7.99)	0.89 (1.43)	26.72 (31.47)	3.35/1.30	3.42
2008	15.33 (38.22)	58.22 (96.75)	4.01 (6.71)	0.96 (1.43)	21.97 (25.80)	3.18/1.33	2.69
Permitted[e]	45.0	95.0	54.0	4.0	35.0	8.0/3.0	–

[a] CO = carbon monoxide; HAPs = hazardous air pollutants; NH_x = ammonia and ammonium compounds; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate matter ≤10 µm; SO_x = sulfur oxides; and VOCs = volatile organic compounds.

[b] Values in parentheses denote total emissions including permitted and permit-exempted sources.

[c] Not available.

[d] Total HAPs emissions/highest single HAP emission.

[e] Twelve-month rolling total emissions.

Source: APS 2005, 2006, 2007, 2008, and 2009b.

and (2) for failure to comply with the permit condition that requires APS Palo Verde to limit PM_{10} emissions to less than 5.6 tons per month (on November 2, 2007). On February 28, 2008, these three NOVs were resolved with Maricopa County.

Each of the emergency generators is enrolled in a preventative maintenance program, the specific steps of which are outlined in an APS internal procedure. The program requires periodic operation for brief periods during nonemergency conditions to ensure each generator's continuous operability. On average, each generator runs approximately 100 hours each year, notwithstanding responses to power outages. All generators use ultra-low-sulfur diesel (sulfur content of 15 ppm or less) provided through a local commercial vendor. PVNGS maintains records of all generator operation (by recording hours of operation from nonresettable meters) in order to demonstrate continued eligibility for emergency generator status exemptions contained in Federal and Maricopa County regulations.

Internal procedures are in place to ensure proper management of refrigerants present in heating, ventilating, and air-conditioning (HVAC) equipment and in industrial chillers and coolers. HVAC equipment and industrial chillers containing refrigerants are maintained by APS employees with the required EPA training and certification for handling ozone-depleting substances. Maintenance and repair actions are documented by a work order system in which a technician specifies the nature of the activity, the repair that was accomplished, and the amount of refrigerant introduced to complete the repair, if necessary. A commercial software program is used to track refrigerant leakage rates to maintain compliance with leakage rate limitations in Federal regulations. Other properly certified technicians service the air conditioners in APS-owned vehicles in the onsite garage. All vehicles now use R-134a exclusively in their motor vehicle air conditioners (MVACs). Health physics technicians support the servicing and repair of refrigerant-containing equipment located in the industrial area of the facility by performing surveys for radioactive contamination of components removed from that equipment (e.g., air filters), whenever the potential for radioactive contamination exists.

Under the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) has set NAAQS for pollutants considered harmful to public health and the environment (40 CFR Part 50) (EPA 2009a). NAAQS is established for criteria pollutants — CO, lead (Pb), NO_2, PM_{10}, particulate matter with an *aerodynamic* diameter of 2.5 microns or less ($PM_{2.5}$), O_3, and sulfur dioxide (SO_2), as shown in Table 2.2.2-2. The CAA established two types of NAAQS: primary standards to protect public health including sensitive populations (e.g., the young, the elderly, those with respiratory disease) and secondary standards to protect public welfare, including protection against degraded visibility and damage to animals, crops, vegetation, and buildings. Some States established State Ambient Air Quality Standards (SAAQS), which can adopt the Federal standards or be more stringent than the NAAQS. The State of Arizona has no SAAQS but instead has adopted the NAAQS.

Maricopa County is located in the Maricopa Intrastate Air Quality Control Region (AQCR) (40 CFR 81.36). The Maricopa AQCR is designated as a basic (subpart 1)[5] nonattainment area for 8-hour ozone and a serious nonattainment area for PM_{10} (40 CFR 81.303). The Maricopa AQCR is also designated as a serious maintenance area for CO. PVNGS is outside of the PM_{10} nonattainment area and the CO maintenance area, but is about 2.5 miles (4.0 km) inside of the 8-hour ozone nonattainment area (ADEQ 2009). The remaining portions of Maricopa County are designated as an attainment area for all criteria pollutants.[6]

5 An area designated as a basic (or subpart 1) nonattainment is required to attain the standard within 5 to 10 years after its designation.

6 Areas considered to have air quality as good as or better than NAAQS are designated by EPA as “attainment areas”. Areas where air quality is worse than NAAQS are designated by EPA as “nonattainment areas.” Areas that previously were nonattainment areas but where air quality has since improved to meet the NAAQS are redesignated “maintenance areas” and are subject to an air quality maintenance plan.

Table 2.2.2-2 National Ambient Air Quality Standards (NAAQS)[a]

		NAAQS		
Pollutant[b]	Averaging Time	Value		Type[c]
CO	1-hour	35 ppm	(40 mg/m3)	P
	8-hour	9 ppm	(10 mg/m3)	P
Pbd	Quarterly average	1.5 µg/m3		P, S
	Rolling 3-month average	0.15 µg/m3		P, S
NO2	Annual (arithmetic mean)	0.053 ppm	(100 µg/m3)	P, S
PM10e	24-hour	150 µg/m3		P, S
	Annual (arithmetic mean)	50 µg/m3	(revoked, 2006)e	P
PM2.5e	24-hour	35 µg/m3		P, S
	Annual (arithmetic mean)	15.0 µg/m3		P, S
O3	8-hour	0.08 ppm	(1997 standard)	P, S
	8-hour	0.075 ppm	(2008 standard)	P, S
SO2	3-hour	0.5 ppm	(1,300 µg/m3)	S
	24-hour	0.03 ppm		P
	Annual (arithmetic mean)	0.014 ppm		P

(a) Refer to 40 CFR Part 50 for detailed information on attainment determination and reference method for monitoring.

(b) CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter ≤2.5 µm; PM_{10} = particulate matter ≤10 µm; and SO_2 = sulfur dioxide.

(c) P = primary standards, which set limits to protect public health; S = secondary standards, which set limits to protect public welfare including protection against degraded visibility, damage to animals, crops, vegetation, and buildings.

(d) On October 15, 2008, the EPA revised the lead standard from a calendar-quarter average of 1.5 $\mu g/m^3$ to a rolling 3-month average of 0.15 $\mu g/m^3$.

(e) Effective December 17, 2006, the EPA revoked the annual PM_{10} standard of 50 $\mu g/m^3$ and revised the 24-hour $PM_{2.5}$ standard from 65 $\mu g/m^3$ to 35 $\mu g/m^3$.

Source: EPA 2009a.

The Clean Air Act requires states with areas failing to meet the NAAQS to produce a State Implementation Plan (SIP). A SIP is an enforceable plan developed at the state and local level, submitted to and approved by EPA that explains how the area will comply with the NAAQS according to the Clean Air Act. The Maricopa Association of Governments (MAG), together with the Arizona Department of Environmental Quality, is responsible for Arizona SIP requirements in the Maricopa County nonattainment areas. The MAG has an EPA approved eight-hour Ozone Plan for the Maricopa Nonattainment Area that includes PVNGS as part the SIP (MCAQD, 2010; ADEQ, 2010a).

In recent years, three revisions to the NAAQS have been promulgated. Effective December 17, 2006, EPA revoked the annual PM_{10} standard of 50 micrograms per cubic meter ($\mu g/m^3$) and revised the 24-hour $PM_{2.5}$ standard from the original level of 65 $\mu g/m^3$ to 35 $\mu g/m^3$ (71 FR 61144). In Maricopa County, 24-hour and annual PM_{10} concentrations have exceeded their respective standards. The 2006–2008 monitoring data show Maricopa County to be in attainment for 24-hour and annual $PM_{2.5}$ NAAQS, and thus Maricopa County would not be expected to be classified as a nonattainment area for $PM_{2.5}$ in the near future (EPA 2009b). Effective May 27, 2008, the EPA revised the 8-hour ozone standards from 0.08 ppm to

0.075 ppm (73 FR 16436), but the nonattainment status for Maricopa County will continue to be the same under the new standard (Wardwell 2009). Effective January 12, 2009, the EPA revised the Pb standard from a calendar-quarter average of 1.5 μg/m^3 to a rolling 3-month average of 0.15 μg/m^3 (73 FR 66964). A designation letter sent by the Arizona Department of Environmental Quality to the EPA recommends an "unclassifiable" status for Maricopa County.

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the Prevention of Significant Deterioration (PSD) regulations (40 CFR 52.21) mandate stringent control technology requirements for new and modified major sources. As a matter of policy, EPA recommends that the permitting authority notify the Federal Land Managers (FLMs) when a proposed PSD source would locate within 62 miles (100 km) of a Class I area. If the source's emissions are considerably large, EPA recommends that sources beyond 62 miles (100 km) be brought to the attention of the FLMs. The FLMs then become responsible for demonstrating that the source's emissions could have an adverse effect on air quality-related values (AQRVs), such as scenic, cultural, biological, and recreational resources. There are several Class I areas around PVNGS, none of which are situated within the 62-mile (100 km) range. The nearest Class I areas include the Superstition Wilderness Area, the Mazatzal Wilderness Area, and the Pine Mountain Wilderness Area, about 80 miles (129 km) east, northeast, and northeast, respectively, of PVNGS (40 CFR 81.421). All these Class I areas are managed by the U.S. Forest Service. Considering the locations and elevations of these Class I areas, prevailing wind directions, distances from PVNGS, and minor nature of air emissions from PVNGS, there is little likelihood that activities at PVNGS can adversely impact air quality and AQRVs in any of these Class I areas.

The meteorological tower is located approximately 2,200 feet (671 meters) and 3,500 feet (1,067 meters) west-northwest of the Unit 2 cooling tower and the reactor building, respectively. Land areas and topography immediately surrounding the tower, as well as the distance of the tower from the reactor building and other permanent structures, suggest that no significant interferences to air flow exist that would compromise the quality of recovered meteorological data. Two trains of instruments, designated as primary and redundant, are mounted on the meteorological tower. A lower set of instruments, located at a height of 35 feet (10.7 meters), records wind speed and direction, standard deviation of wind direction, temperature, and dew point. The upper set of instruments, located at a height of 200 feet (61.0 meters), also records wind speed and direction, standard deviation of wind direction, and temperature. Precipitation data from a rain gauge are also collected near the base of the tower.

Sensor information from the tower is converted to digital data by four separate reliable digital processor systems, and transmitted by two separate serial links to the meteorological data transmission station (MDTS) translator/server (DataLink). After being converted to a form recognizable to the Emergency Response Facility Data Acquisition Display System (ERFDADS) server, these data is displayed on all ERFDADS terminals and made available for time-history displays in the control room, emergency response facilities, and at external locations. These data serve as inputs to the plume dispersion models to estimate offsite exposures under emergency situations. To guarantee operational reliability, redundant power is supplied to the meteorological instruments and their respective data recorders.

The meteorological data collection program at PVNGS is subject to detailed APS quality assurance and quality control procedures. Meteorological instruments are calibrated at scheduled intervals and are subjected to routine inspection and maintenance in accordance with the manufacturer's specifications and written internal procedures that require visual inspections of the meteorological instruments, verification of the performance through measurements, and documentation of the status of the key performance indicators.

2.2.3 Groundwater Resources

PVNGS is located on a desert alluvial plain in the Hassayampa River valley in an area that was once irrigated (cotton) cropland (APS 2001). The site is within the Lower Hassayampa Sub-basin of the Phoenix Active Management Area (AMA). The Phoenix AMA is one of five AMAs established as part of the Arizona 1980 Groundwater Management Act (ARS §§ 45-401 et seq.) and regulated by the Arizona Department of Water Resources (ADWR 2009). The Hassayampa Sub-basin covers an area of about 1,200 sq mi (3,108 sq km) and is bounded on the north by the Vulture Mountains and the Wickenburg Mountains; on the east by the White Tank Mountains; on the south by the Buckeye Hills and the Gila Bend Mountains; and on the west by the Big Horn Mountains, the Belmont Mountains, and the Palo Verde Hills (Figure 2.2.3-1). The Lower Hassayampa Sub-basin covers about 400 sq mi (1,036 sq km) of the southern Hassayampa Sub-basin (APS 2001).

Groundwater in the Lower Hassayampa Sub-basin occurs regionally in basin-fill alluvial sediments and locally in the thin layers of more recent stream alluvium. Groundwater in the region is predominantly under unconfined (water table) conditions, but may be under confined (artesian) conditions locally. Both confined and perched (saturated zones above the water table) conditions occur in the vicinity of PVNGS (Long 1982; ADEQ 2009a). An estimated 4.8 million acre-feet (5.92 billion cubic meters) of groundwater were available to a depth of 1,200 feet (366 meters) in the Hassayampa Sub-basin in 1995 (Maricopa County 2001). Groundwater flow is generally to the southwest toward cones of depression in the Tonopah Desert and Centennial Wash area (ADWR 2008).

Basin-fill sediments in the Lower Hassayampa Sub-basin are divided into three major hydrogeologic units: the Upper Alluvial Unit, the Middle Fine-Grained Unit, and the Lower Coarse-Grained Unit. The Upper Alluvial Unit, also referred to as the shallow aquifer, occurs in areas along the Hassayampa and Gila Rivers. The unit is 30 to 60 feet (9.1 to 18.3 meters) thick and is predominantly made up of silty and gravelly sands with discontinuous lenses of clay and silty clay. Groundwater in the upper unit is unconfined in most of the sub-basin. Perched groundwater was identified at depths of 13 to 90 feet (4 to 27.4 meters) below PVNGS in the early 1980s, but has been declining since that time, due to cessation of irrigation practices.

Groundwater measurements suggest groundwater flow in the shallow aquifer radiates outward from the center of PVNGS (Figure 2.2.3-2). This flow pattern has been present since at least 1985. It is thought to be due mainly to the 25 years of heavy irrigation that occurred at the site prior to construction and the low permeability of the Middle Fine-Grained Unit which impedes the downward movement of groundwater (APS 2009c). Wells along the PVNGS site's perimeter have groundwater elevations between those measured for the intermediate and shallow aquifers at the center of the site; this is likely due to a steeply sloping gradient in the shallow aquifer and downward movement of groundwater from the shallow and intermediate aquifers. The term "uppermost" aquifer is often used in place of "shallow aquifer" because the shallow and intermediate aquifers may be in hydraulic communication along the perimeter, (Long 1982; APS 2001; ADEQ 2009a).

Figure 2.2.3-1 Surface Features in the Vicinity of the PVNGS

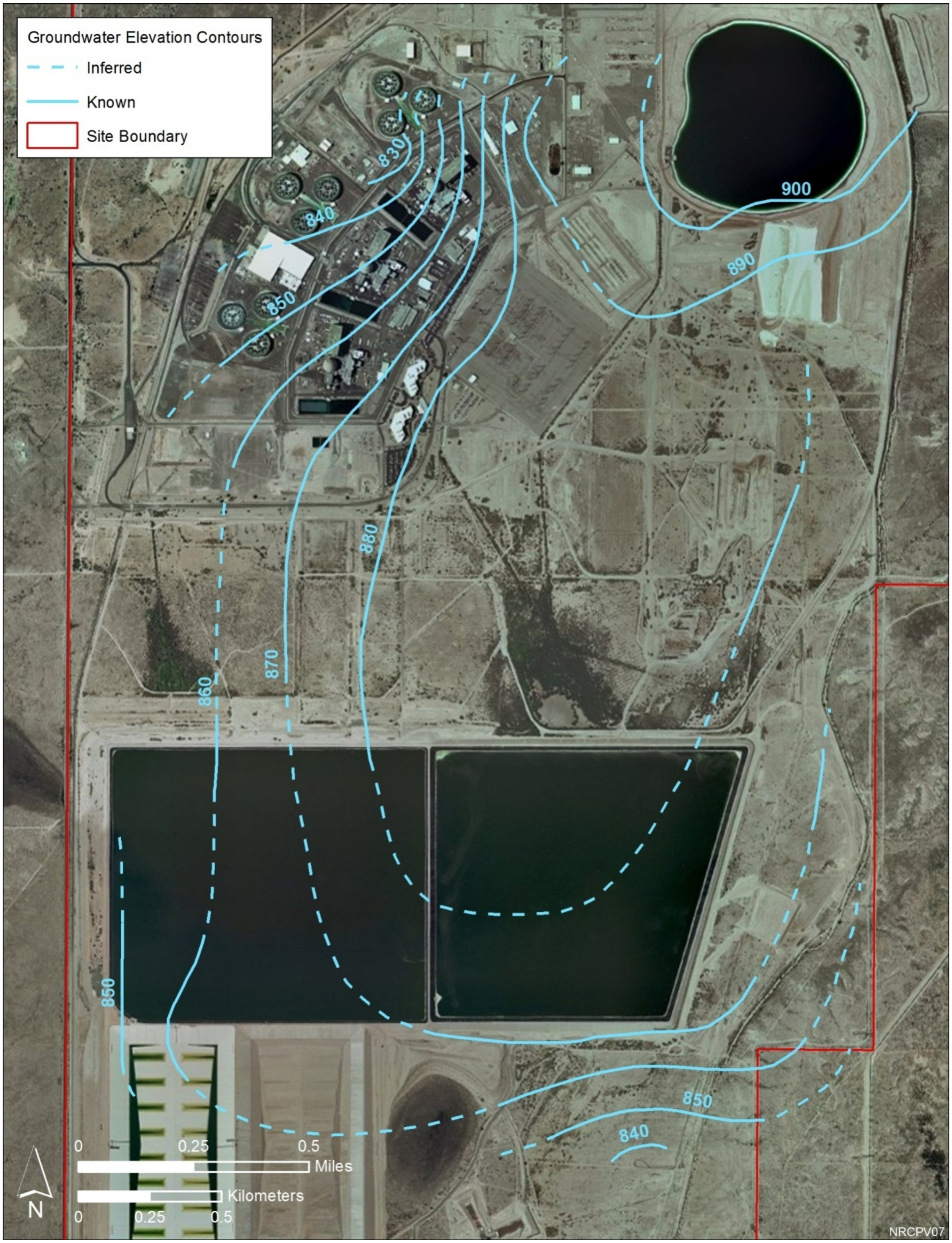

Figure 2.2.3-2 Groundwater Flow in shallow aquifer below PVNGS (APS 2009c)

The Middle Fine-Grained Unit is 230 to 300 feet (70.1 to 91.4 meters) thick and consists of massive, continuous layers of clay and silty clay interbedded with thinner discontinuous lenses of clayey silt, clayey sand, and silty sand. It includes the Palo Verde Clay, a 60- to 80-foot (18.3- to 24.4-meter) clay unit that acts as a confining layer to the regional aquifer in the vicinity of the Palo Verde Hills (to the west) and a perching layer at PVNGS. The Palo Verde Clay is continuous throughout PVNGS and extends at least 5 mi (8 km) to the southeast and northeast. The intermediate aquifer is the portion of the Middle Fine-Grained Unit that lies between the Palo Verde Clay and the shallow aquifer (Long 1982; APS 2001; ADEQ 2009a).

The Lower Coarse-Grained Unit ranges in thickness from about 100 feet (30.5 meters) to as much as 1,400 feet (427 meters) near PVNGS. The unit is predominantly made up of silty sand, sand, and gravelly sand and deeper, more consolidated alluvial fan deposits. Together, the middle and lower units (and various local bedrock units) comprise the regional aquifer and are the main water-bearing units in the area (Long 1982). The regional aquifer in the area of PVNGS is under confined to semi-confined conditions (ADEQ 2009a). Recharge to the regional aquifer is primarily from underflow from the Upper Hassayampa Sub-basin. Maricopa County estimates the annual rate of recharge to the Hassayampa Sub-basin to be on the order of 29,000 acre-feet (35.8 million cubic meters) (MC 2001). Infiltration of precipitation, surface runoff, and irrigation return flow are less important sources of recharge because the low-permeability clays of the middle unit impede the downward migration of water. Groundwater flow in the regional aquifer below the portion of PVNGS just south of the evaporation ponds is to the south-southwest (APS 2001; ADEQ 2009a).

2.2.4 Surface Water Resources

PVNGS is located in the Hassayampa Sub-basin that is drained by the Hassayampa River, an ephemeral river that enters the sub-basin from the northeast and joins the Gila River east of Arlington (Figure 2.2.3-1). The Gila River flows westward with effluent from the west Phoenix metropolitan area, crossing the southeastern tip of the sub-basin and joining the Colorado River near Yuma, Arizona. Flow in the Gila River is perennial below the 91st Avenue and 23rd Avenue Wastewater Treatment Plants, but is ephemeral along most other stretches, flowing only during rainfall events. Local ephemeral drainages include Centennial Wash, Winters Wash, and East Wash. The East Wash does not show up on regional maps but has been mapped by the PVNGS staff (see Figure 2.1.7-1). It has been rerouted to a new drainage ditch running along the east side of PVNGS (APS 2008b).

There are no dams on the Hassayampa River, Winters Wash, or East Wash. Centennial Wash has several small detention dams. The largest is located about 45 mi (72 km) upstream from PVNGS and has a capacity of about 100 acre-feet (123,348 cubic meters). There are several large water-storage dams on the Gila River upstream from the site (APS 2008b).

With the exception of East Wash, there are no natural surface water bodies on or immediately adjacent to PVNGS. The facility does not draw its cooling (or makeup) water from any natural surface water body in the area. It also does not release cooling water (or cooling water blowdown) effluents to any natural surface water body. Instead, these effluents are discharged to man-made lined evaporation ponds with no outlet and no hydraulic connection to any natural water body (discussed in Section 2.1.7).

2.2.5 Aquatic Resources

APS purchases wastewater from Phoenix-area treatment plants for cooling water. PVNGS is the only nuclear plant in the U.S. that does not draw directly from a natural surface water body. Phoenix's 91st Avenue and Tolleson treatment plants supply the majority of wastewater, followed by the city of Goodyear's treatment plant. PVNGS uses about 53,000 acre-feet (17×10^9 gal or 65×10^6 m^3) of wastewater annually (ADWR 2008a).

PVNGS has constructed surface water bodies, described in Section 2.1.7, that APS did not intend to support natural populations (APS 2008a). PVNGS treats incoming wastewater from Phoenix area sewage treatment plants at its Water Reclamation Facility before pumping it to three large, lined storage reservoirs. The treatment process includes chlorination, which kills many microscopic organisms. The storage reservoirs support few aquatic organisms and no brine shrimp. The liner prevents colonization by rooted aquatic plants that might provide food for ducks and other wildfowl, although birds do use the reservoirs (APS 2008a).

Cooling tower blowdown is released to three evaporation ponds rather than to natural surface water bodies. The blowdown recirculates through many cooling cycles in the cooling towers, and so dissolved solid levels are high when the blowdown is released to the evaporation ponds. In terms of salinity, concentrations in the evaporation ponds in 2005 ranged from about 38 to 94 parts per thousand (ppt) (APS 2008a). For perspective, this range exceeds the typical range of open ocean salinities, about 33 to 37 ppt, and overlaps the range of typical salinities in Utah's Great Salt Lake, from below 50 to 270 ppt (Utah Government Services 2010).

Evaporation Pond 1 was constructed in 1981. It is 250 acres and fairly uniform in depth and chemical composition. Evaporation Pond 2 was constructed in 1987. It is 230 acres and shallower at the north end, which has resulted in stratification and a difference between surface and bottom chemical samples (Hillmer 1996). Evaporation Pond 3 was constructed in 2009. It is 180 acres and divided into two cells, 3A (west) and 3B (east), that operate independently.

Biological sampling of Evaporation Ponds 1 and 2 was performed in 1995 and 1996 (Hillmer 1996). The two ponds developed different but relatively simple aquatic communities that changed with the seasons. Various algae formed the base of the food webs: typically filamentous and single cell blue-green algae (Cyanobacteria), centric and pennate diatoms (Bacillariophyceae), flagellated and colonial green algae and desmids (green algae or Chlorophyta), and others. Single-celled animals observed include amoebae, ciliates, and others.

Brine shrimp (Crustacea: *Artemia salina*) fed on protozoa and algae in the water column, and abundant water boatmen (Insecta: *Trichocorixa* sp.) live on the surface. This genus of water boatmen is predaceous and has been observed eating the brine shrimp in the evaporation ponds. Birds, in turn, have been observed eating the water boatmen in the ponds. Damselflies and dragonflies (Insecta, Odonata) have been observed around the storage reservoirs. Ducks and other wildfowl have been observed on and around the ponds. Hilmer (1996) did not mention collecting brine flies, which are an ecologically important component of natural inland saline lakes such as Mono Lake and the Great Salt Lake.

Hillmer (1996) characterized the food web as being typical of coastal and estuarine basins and of inland saline lakes such as Mono Lake. He reported that the algae in the reservoirs and evaporation ponds were not commonly toxic. Although he did not investigate bioaccumulation of contaminants and biomagnification up the food chain, he concluded that with the exception of selenium, heavy metals and contaminants that are typically of concern for these processes had not been detected in the ponds.

These biological observations are over a decade and a half old. The chemical and physical environment of the reservoirs and ponds should not have changed, however, and would support only a limited group of species. The NRC staff therefore believes the observations in Hillmer (1996) adequately characterize the structure and function of the aquatic biological communities in the reservoirs and evaporation ponds today.

2.2.6 Terrestrial Resources

PVNGS lies in the largest and driest subdivision of the Sonoran Desert, and many plants are restricted to drainage cuts. This subdivision contains the lower drainages of both the Colorado River and the Gila River. The valley is dominated by shrubs, principally creosote bush (*Larrea divaricata*) and white bursage (*Ambrosia dumosa*) (CSDS 2009).

The Sonoran Desert has the most vegetative diversity of any desert worldwide. The Saguaro cactus (*Carnegiea gigantean*), the largest of cacti species, is only found within the Sonoran Desert, specifically those portions in southern Arizona, southeastern California, and northern Mexico (NPS 2003). Other common cacti include cholla cactus (*Opuntia fulgida*), organ pipe (*Lemaireocereus thurderi*), silver dollar cactus (*O. chlorotica*), and jojoba (*Simmondsia chinensis)*; (WWF 2001).

Annual and biennial herbs and grasses make up the majority of vegetation. Typical native plant communities include creosote bush plains, saltbush plains, mesquite washes, creosote bush-saltbush plains, and creosote bush-cacti hills (NRC 1975). Creosote bush, burrobush (*Ambrosia dumosa*), and saltbush (*Atriplex* spp.) are the most common shrubs on PVNGS (APS 2008a).

The Sonoran Desert, as a whole, contains relatively high wildlife biodiversity. An estimated 130 mammal species, 20 amphibian species, 150 reptile species, 25 fish species, and 500 bird species inhabit this region. Common wildlife include Sonoran pronghorn antelope (*Antilocapra sonoriensis*), desert bighorn sheep (*Ovis canadensis*), Bailey's pocket mice (*Perognathus baileyi*), black-tailed jackrabbits (*Lepus californicus*), round-tailed ground squirrels (*Spermophilus tereticaudus*), California leaf-nosed bats (*Macrotus californicus*), mountain lions (*Felis concolor*), and coyotes (*Canis lantrans)* (WWF 2001).

Fifty-eight known species of reptiles are found in the United States portions of the Sonoran Desert, including the Sonoran desert tortoise (*Gopherus agassizii*), Gila monster (*Heloderma suspectum*), and tiger salamander (*Ambystoma tigrinum*) (WWF 2001). A variety of reptiles are known to inhabit PVNGS and vicinity, specifically, including the western whiptail lizard (*Cnemidophorus tigris*), western diamondback rattlesnake (*Crotelus atrox*), chuckwalla (*Sauromalus obesus*), and horned lizard (*Phrynosoma*; APS 2008a, NRC 1975).

Forty-one percent of all terrestrial bird species in the United States inhabit, pass or migrate through the Sonoran Desert making it one of the most diverse birding areas in the country (WWF 2001). Species commonly found in this region include the roadrunner (*Geococcyx californianus*), cactus wren (*Calypte costae*), black-tailed gnatcatcher (*Polioptila melanura*), phainopepla (*Phainopepla nitens*), Gila woodpecker (*Melanerpes uropygualis*), and Costa's hummingbird (*Calypte costae)* (WWF 2001).

PVNGS-associated transmission lines cross agricultural land, open range areas, and desert habitat, much of which has been disturbed by cattle grazing (APS 2008a). The Devers line, which extends west from PVNGS for approximately 235 mi (378 km), passes through two wildlife refuges: the northern portion of Kofa National Wildlife Refuge in La Paz County, Arizona, and the northeastern portion of Coachella Valley National Wildlife Refuge in Riverside County, California. The Kofa National Wildlife Refuge covers 665,400 ac (270,000 ha) of pristine desert and contains the Kofa and Castle Dorm Mountains, which provides good habitat for the desert bighorn sheep (USFWS 2008d). The refuge is also home to the only species of native palm in Arizona, the California fan palm (*Washintonia filifera)*; (USFWS 2008d). The Coachella Valley National Wildlife Refuge covers 3709 ac (1500 ha) of desert habitat (USFWS 2008a). The refuge contains Federally designated critical habitat for the Coachella Valley fringe-toed lizard (*Uma inornata*) and contains one of the few remaining undeveloped sand dune ecosystems within the Coachella Valley (USFWS 2008a). The Devers line also passes near two other significant ecological areas: the Chuckwalla Mountains Wilderness Area in Riverside, California, which is just south of the line, and Joshua Tree National Park, which is just north of the line. The Devers line passes through Federally designated critical habitat for the Mojave population of Sonoran desert tortoises and is located in and slightly north of the Chuckwalla Mountains Wilderness Area.

The Sierra Estrella Wilderness, a 14,400-ac (5830-ha) Congressionally designated wilderness area, lies south of the Rudd line and about 15 mi (24 km) southwest of Phoenix, Arizona (BLM 2008). This area contains the Sierra Estrella mountain range with numerous ridgelines and rocky canyons. Mountain peaks harbor shrub live oak (*Quercus turbinella*) and juniper (*Juniperus*) as well as a remnant population of desert bighorn sheep (BLM 2008).

2.2.7 Threatened and Endangered Species

Table 2-6 lists threatened, endangered, or candidate species known to occur in Maricopa County, Arizona, in which PVNGS is located, or La Paz County, Arizona, or Riverside County, California, through which transmission line ROWs associated with PVNGS traverse.

2.2.7.1 Aquatic Species

PVNGS does not draw water from any natural surface water body but instead relies on wastewater effluents from several area municipalities and groundwater from onsite production wells. After use by PVNGS, the water flows to evaporation ponds and is not returned to any natural surface water body. This method of water use does not require a direct intake or discharge to natural surface water bodies, and therefore, no threatened or endangered aquatic species are directly affected.

2.2.7.2 Terrestrial Species

Two Federally listed species, the southwestern willow flycatcher (*Dendrocygna autumnalis*) and the Yuma clapper rail (*Rallus longirostris yumanensis*), and one candidate species, the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), potentially occur on or in the vicinity of PVNGS. Additionally, the Devers transmission line ROW crosses Federally designated critical habitat for the Mojave population of the Sonoran desert tortoise (*Gopherus agassizii*) and Federally designated critical habitat for the Coachella Valley fringe-toed lizard (*Uma inornata*). These species are discussed in the following paragraphs.

Southwestern Willow Flycatcher

The southwestern willow flycatcher is Federally listed as endangered and state-listed as a wildlife species of special concern in Arizona and endangered in California. The species is brownish-olive to grey-green in color with light wingbars and pale rings around the eyes and is about 6 in. (15 cm) in length (USFWS 2009). This subspecies of the willow flycatcher has a distinctive song and occurs most commonly in riparian habitat in desert regions of the southwestern U.S. The southwestern willow flycatcher breeds near surface water, along rivers and streams, or near wetlands in late spring and lays three to four eggs from late May to early June (Ellis et al. 2008). Its breeding range includes Arizona, New Mexico, and southern California, portions of southern Nevada and Utah, and southwest Colorado (USFWS 2004). The species migrates to rainforest habitat in Mexico and Central and South America in the winter (USFWS 2004). Degradation and loss of riparian habitat as well as brood parasitism by the brown-headed cowbird (*Molothrus ater*) are thought to be the main causes of decline of this species. Impoundments and overuse of riparian habitat has altered up to 90 percent of the southwestern willow flycatcher's historical habitat (USFWS 2004). The AGFD have records of this species potentially occurring within a 3-mi (1.8-km) radius of the PVNGS transmission lines (AGFD 2009).

Yuma Clapper Rail

The yuma clapper rail is Federally listed as endangered and state-listed as a wildlife species of special concern in Arizona and threatened in California. The species is brown in color with barred flanks and a long, thin orange bill. It is the largest rail in western North America with an adult length of 14 to 16 in. (36 to 41 cm) (CDPR Undated; Pattern 2007). The Yuma clapper rail is the only subspecies of the clapper rail to occur inland and to inhabit freshwater marshes; it also inhabits brackish marshes within its known range in Mexico (Patten 2007). Its range extends from Topock Marsh along the Lower Colorado River southward to the Salton Sea (Patten 2007). The species generally feeds on crayfish and other crustaceans along marsh borders and open water and nests in mature stands of cattail and bulrush (CDPR Undated). Breeding season extends from March through July, and females lay clutches that vary greatly in size from 5 to 14 eggs with a typical clutch size of 8 to 10 eggs (Patten 2007). Degradation and loss of marsh habitat, river water damming and diversion, dredging operations, and erosion control programs have reduced available nesting habitat for the Yuma clapper rail (CDPR Undated). Because wetlands and marshes serve as sinks for a variety of contaminants, Yuma clapper rail eggs and tissues have been documented to have relatively high levels of selenium, mercury, dichlorodiphenylethane (DDE), polychlorinated biphenyls (PCBs), and other contaminants that can cause hatching defects and other interferences with reproductive success (Conway and Eddleman 2000). The Arizona Game and Fish Department (AGFD) have records of this species potentially occurring within a 3-mi (1.8-km) radius of the PVNGS transmission lines (AGFD 2009).

Western Yellow-billed Cuckoo

The western yellow-billed cuckoo is a candidate species for Federal listing and state-listed as endangered in California (it is not listed in Arizona). The species is grey-brown in color with a white underbelly, red primary flight feathers, and black and white patterned tail feathers. Adults have a yellow ring around the eye and more distinctive tail patterning than juveniles. Western yellow-billed cuckoos inhabit larger riparian areas, especially those with cottonwoods (*Populus* spp.) and willows (*Salix* spp.). Western yellow-billed cuckoos feed by foliage gleaning, and cottonwoods have been shown to serve as important foraging habitat in areas of California where the species has been studied (Laymon 2004). The species' distribution includes most of

North America and ranges from southern Canada to northern Mexico, though the breeding range only extends northward to the Sacramento Valley (USFWS 2007). Individuals migrate to South America during the winter and range from Columbia to Venezuela (USFWS 2007). The western yellow-billed cuckoo requires riparian patches to be a minimum of 20 to 40 ha (50 to 100 ac) in size for successful breeding (Laymon 2004). Loss of riparian habitat, damming, stream channelization, and livestock grazing are the main threats this species' habitat. The dramatic decline observed in this species within California is attributed directly to breeding habitat loss from alteration or removal of riparian habitat for agriculture, urban development, and flood control (USFWS 2007). The Arizona Game and Fish Department (AGFD) have records of this species potentially occurring within a 3-mi (1.8-km) radius of the PVNGS transmission lines (AGFD 2009).

Sonoran Desert Tortoise

The Sonoran Desert tortoise is Federally listed as threatened, Arizona state-listed as a wildlife species of concern, and California state-listed as threatened. The species is long-lived with an average lifespan of 48 to 53 years of age for individuals in the eastern Mojave Desert. Females lay up to three clutches per year of four to six eggs each in burrows or under shrubs. Only an estimated 2 to 5 percent of hatchlings reach maturity. Common predators of hatchlings and juvenile desert tortoises include gila monsters (*Heloderma suspectum*), coachwhip snakes (*Mastiocophis flagellum*), and ravens (*Corvus corax*). The desert tortoise reaches maturity at about 15 to 16 years, at which point individuals are about 8 in. (20 cm) in length. Desert tortoises are most commonly found on valley bottoms and south-facing slopes. The species forages on grass, leaves, stems, flowers, and fruit. Threats to this species' continued existence include habitat loss and degradation, overgrazing, and direct human-induced mortality from vehicle collisions. (Meyer 2008)

One PVNGS-associated transmission line, the Devers line, passes through Federally designated critical habitat for the Mojave population of desert tortoise located in and slightly north of the Chuckwalla Mountains Wilderness Area.

Coachella Valley Fringe-Toed Lizard

The Coachella Valley fringe-toed lizard is Federally listed as threatened, Arizona state-listed as a wildlife species of concern, and California state-listed as endangered. The species is 6 to 9 in. (15 to 23 cm) in length with a white to sand-colored back and belly, eye markings, and a wedged-shaped nose. The species occurs in blowsand habitat in drainage bottoms within the Coachella Valley, California. Breeding occurs from April to August, but little is known about its egg laying habits. The species eats small insects, leaves, buds, and seeds of native plants. Loss and degradation of habitat are the major threats to this species' continued existence. (USFWS 2008a)

One PVNGS-associated transmission line, the Devers line, crosses through the Coachella Valley National Wildlife Refuge, which contains Federally designated critical habitat for the Coachella Valley fringe-toed lizard. The Devers line ROW does not directly intersect this species' critical habitat.

Table 2-6. Listed Terrestrial Species. *The species below are Federally listed, Arizona-listed, and/or California-listed, as threatened, endangered, or candidate species. These species may occur on the PVNGS site or within the transmission line rights-of-way.*

Scientific Name	Common Name	Federal [(a)]	AZ[(b)]	CA[(c)]	Habitat
		Amphibians			
Ambystoma californiense	California tiger salamander	T	-	SSC	large, fishless vernal pools
Batrachoseps aridus	desert slender salamander	E	-	CE	moist cliff sides within Sonoran desert scrub
Bufo californicus	arroyo toad	E	-	SSC	desert washes; riparian areas with sandy streambanks
Bufo microscaphus	Arizona toad	-	-	-	riparian areas
Ensatina klauberi	large-blotched salamander	-	-	SSC	oak woodland; chapparal
Gastrophryne olivacea	Great Plains narrow-mouthed toad	-	WSC	-	montane woodlands; grasslands; desert
Lithobates yavapaiensis	lowland leopard frog	-	WSC	SSC	desert, grassland, and woodland near rivers or streams
Rana draytonii	California red-legged frog	T	-	SSC	lowland forests; grasslands
Rana muscosa	Sierra Madre yellow-legged frog	E	-	SSC	montaine riparian areas; wet meadows
Scaphiopus couchii	Couch's spadefoot	-	-	SSC	desert; grasslands; prairie; mesquite
Spea hammondii	western spadefoot	-	-	SSC	sandy or gravelly soils in mixed woodland, grasslands, and chapparal
Taricha torosa torosa	coast range newt	-	-	SSC	wet forests; chapparal; rolling grasslands
		Birds			
Aechmophorus clarkii	Clark's grebe	-	WSC	-	inland lakes
Agelaius tricolor	tricolored blackbird	-	-	SSC	grasslands; coastal areas
Ardea alba	great egret	-	WSC	-	large lakes; wetland habitat
Asio otus	long-eared owl	-	-	SSC	coniferous forest edges
Athene cunicularia	burrowing owl	-	-	SSC	grasslands; rangelands; desert habitat
Buteogallus anthracinus	common black-hawk	-	WSC	-	coastal areas; mangrove swamps
Campylorhynchus brunneicapillus sandiegensis	coastal cactus wren	-	-	SSC	arid regions containing yucca, mesquite, or saguaro cactii
Charadrius alexandrinus nivosus	western snowy plover	T	WSC	SSC	sandy coasts; brackish inland lakes
Circus cyaneus	northern harrier	-	-	SSC	open country; moorlands; bogs
Coccyzus americanus	yellow-billed cuckoo	C	WSC	-	deciduous forest
Coccyzus americanus occidentalis	western yellow-billed cuckoo	C	-	CE	deciduous forest
Colaptes chrysoides	gilded flicker	-	-	CE	desert habitat containing saguaro cactii
Cypseloides niger	black swift	-	-	SSC	high cliff faces near water
Dendrocygna autumnalis	black-bellied whistling-duck	-	WSC	-	shallow freshwater ponds, lakes, and marshes
Dendroica petechia brewsteri	yellow warbler	-	-	SSC	open, wet woodland and shrubland
Dendroica petechia sonorana	Sonoran yellow warbler	-	-	SSC	open, wet woodland and shrubland
Egretta thula	snowy egret	-	WSC	-	inland and coastal wetlands
Empidonax traillii extimus	southwestern willow flycatcher	E	WSC	CE	riparian areas near desert habitat
Falco peregrinus anatum	American peregrine falcon	-	WSC	-	grasslands; meadowlands
Gelochelidon nilotica	gull-billed tern	-	-	SSC	lakes, marshes, and coastal habitat
Glaucidium brasilianum cactorum	cactus ferruginous pygmy-owl	-	WSC	-	semi-open wooded habitat

Scientific Name	Common Name	Federal [a]	AZ[b]	CA[c]	Habitat
Haliaeetus leucocephalus	bald eagle	D	WSC	CE	forested areas near open water
Icteria virens	yellow-breasted chat	-	-	SSC	dense, brushy areas
Ictinia mississippiensis	Mississippi kite	-	WSC	-	forests and savannahs bordering urban areas
Ixobrychus exilis	least bittern	-	WSC	-	wetlands; coastal plains
Lanius ludovicianus	loggerhead shrike	-	-	SSC	edge habitats; agricultural areas
Laterallus jamaicensis coturniculus	California black rail	-	WSC	-	salt and freshwater wetlands; wet meadows
Megaceryle alcyon	belted kingfisher	-	WSC	-	wetlands; riparian and coastal areas near estuaries and other waterbodies
Melanerpes uropygialis	Gila woodpecker	-	-	CE	low desert scrub in Sonoran desert
Micrathene whitneyi	elf owl	-	-	CE	dense mesquite; wooded canyons
Pandion haliaetus	osprey	-	WSC	-	forested areas near open water
Pelecanus occidentalis	brown pelican	E	-	-	sandy beaches; lagoons; coastal areas
Piranga rubra	summer tanager	-	-	SSC	open wooded areas containing oaks
Plegadis chihi	white-faced ibis	-	-	-	marshes containing shrubs or low trees
Polioptila californica californica	coastal California gnatcatcher	T	-	SSC	low-elevation, relatively flat coasts
Progne subis	purple martin	-	-	SSC	open areas adjacent to developed land
Pyrocephalus rubinus	vermilion flycatcher	-	-	SSC	desert; arid scrubland; farmland
Rallus longirostris yumanensis	Yuma clapper rail	E	WSC	CT	inland freshwater and brackish marshes
Rynchops niger	black skimmer	-	-	SSC	coastal sandy banks and beaches
Sterna antillarum browni	California least tern	E	-	-	tidal flats and coastal beaches
Strix occidentalis lucida	Mexian spotted owl	T	WSC	-	mature forests; steep canyons
Toxostoma bendirei	Bendire's thrasher	-	-	SSC	sparse desert shrubland; degraded grasslands
Toxostoma crissale	Crissal thrasher	-	-	SSC	dense shrubby vegetation near streams and washes
Toxostoma lecontei	Le Conte's thrasher	-	-	SSC	peatlands; wet meadows
Vireo bellii arizonae	Arizona bell's vireo	-	-	CE	low, dense shrubland
Vireo bellii pusillus	least Bell's vireo	E	-	CE	low, dense shrubland
		Insects			
Cicindela oregona maricopa	Maricopa tiger beetle	-	-	-	stream edges; sandy reservoirs
Dinacoma caseyi	Casey's June beetle	C	-	-	sandy soil in arid, alluvial plains
Euphydryas editha quino	Quino checkerspot butterfly	E	-	-	scrubland
Rhaphiomidas terminatus abdominalis	Delhi Sands flower-loving fly	E	-	-	inland dunes
Sonorella allynsmithi	squaw park talussnail	-	-	-	steep slopes containing limestone talus
		Mammals			
Antilocarpa americana sonoriensis	Sonoran pronghorn	E	WSC	-	Sonoran desert
Antrozous pallidus	pallid bat	-	-	SSC	rocky outcrops; caves and mine tunnels
Chaetodipus californicus femoralis	Dulzura pocket mouse	-	-	SSC	chaparral
Chaetodipus fallax fallax	northwestern San Diego pocket mouse	-	-	SSC	chaparral; coastal sage scrub
Chaetodipus fallax pallidus	pallid San Diego	-	-	SSC	chaparral

Scientific Name	Common Name	Federal [(a)]	AZ[(b)]	CA[(c)]	Habitat
	pocket mouse				
Corynorhinus townsendii	Townsend's big-eared bat	-	-	SSC	arid scrublands or pine forests near caves
Dipodomys merriami parvus	San Bernardino kangaroo rat	E	-	SSC	alluvial sage scrub
Dipodomys stephensi	Stephens' kangaroo rat	E	-	CT	flat to rolling grasslands
Euderma maculatum	spotted bat	-	-	SSC	desert scrub; open forest
Eumops perotis californicus	greater western bonneted bat	-	-	SSC	cliff faces near ponds or natural springs
Glaucomys sabrinus californicus	San Bernardino flying squirrel	-	-	SSC	coniferous or mixed coniferous/deciduous forest
Lasiurus blossevillii	western red bat	-	WSC	-	desert scrub; riparian areas
Lasiurus xanthinus	western yellow bat	-	WSC	-	riparian areas; palm groves
Leptonycteris curasoae yerbabuenae	lesser long-nosed bat	E	-	-	desert habitat containing saguaro and agaves
Lepus californicus bennettii	San Diego black-tailed jackrabbit	-	-	SSC	open plains and fields; desert; grasslands
Macrotus californicus	California leaf-nosed bat	-	WSC	SSC	Sonora and Mojave Desert scrub
Myotis occultus	Arizona Myotis	-	-	SSC	desert riparian areas
Myotis velifer	cave myotis	-	-	SSC	caves and rock crevices near desert scrub, wash, or riparian areas
Myotis yumanensis	Yuma myotis	-	-	-	open forests and woodlands near water
Neotoma lepida intermedia	San Diego desert woodrat	-	-	SSC	chaparral; sagebrush; desert
Nyctinomops femorosaccus	pocketed free-tailed bat	-	-	SSC	pinyon-juniper woodlands; desert scrub
Nyctinomops macrotis	big free-tailed bat	-	-	SSC	desert scrub; arid, rocky habitat
Onychomys torridus ramona	southern grasshopper mouse	-	-	SSC	coastal scrub; mixed chaparral; sagebrush
Ovis canadensis	peninsular bighorn sheep	E	-	CT	arid, rocky desert slopes; canyons
Panthera onca	jaguar	E	-	-	highly variable: dense rainforest to dryer open terrain
Perognathus longimembris bangsi	Palm Springs pocket mouse	-	-	SSC	level to sloping terrain with sandy soils
Perognathus longimembris brevinasus	Los Angeles pocket mouse	-	-	SSC	arid grasslands; coastal sage scrub
Perognathus longimembris internationalis	Jacumba pocket mouse	-	-	SSC	sage scrub
Sigmodon arizonae plenus	Colorado River cotton rat	-	-	SSC	arid grasslands near ponds or irrigated fields
Spermophilus tereticaudus chlorus	Palm Springs round-tailed ground squirrel	C	-	SSC	mesquite habitat; sand fields
Taxidea taxus	American badger	-	-	SSC	plains; prairie; farmland; woodland edges
		Plants			
Abutilon parishii	Pima Indian mallow	-	SR	-	higher elevation Sonoran desert scrub; rocky hillsides; cliff bases
Agave arizonica	Arizona agave	-	HS	-	chaparral; higher elevation juniper grasslands
Agave delamateri	Tonto Basin agave	-	HS	-	chaparral; upland pinyon-juniper woodlands
Agave murpheyi	hohokam agave	-	HS	-	alluvial terraces on desert scrub slopes
Agave toumeyana var. bella	tourney agave	-	SR	-	rocky hillsides; chaparral; highland desert
Allium bigelovii	bigelow onion	-	SR	-	Open, sloping grasslands and chaparral with rocky soil
Allium munzii	Munz's onion	E	-	CT	coastal sage scrub habitat with rolling terrain

Scientific Name	Common Name	Federal [(a)]	AZ[(b)]	CA[(c)]	Habitat
Ambrosia pumila	San Diego ambrosia	E	-	-	creek beds; floodplains
Arenaria paludicola	marsh sandwort	E	-	CE	freshwater marshes; boggy meadows
Astragalus lentiginosus var. coachellae	Coachella Valley milk-vetch	E	-	-	sand dunes and flats near sandy washes
Astragalus tricarinatus	triple-ribbed milk-vetch	E	-	-	dry washes with sandy or gravelly soils
Atriplex coronata var. notatior	San Jacinto Valley crownscale	E	-	-	vernal pools and floodplains with silt and clay soils
Berberis nevinii	Nevin's barberry	E	-	CE	chaparral; desert scrub
Brodiaea filifolia	thread-leaved brodiaea	T	-	CE	grasslands and vernal pools with clay soils
Ceanothus ophiochilus	Vail Lake ceanothus	T	-	CE	rocky northeast-facing slopes in chamise chaparral
Cordylanthus maritimus ssp. maritimus	salt marsh bird's-beak	E	-	CE	tidal wetlands
Deinandra mohavensis	Mojave tarplant	-	-	CE	desert edge chaparral; arid coastal slopes
Dodecahema leptoceras	slender-horned spineflower	E	-	CE	floodplains with sandy to silty alluvial soils
Echinomastus erectocentrus var. acunensis	acuna cactus	C	HS	-	well-drained areas and gravel ridges near desert washes
Eriastrum densifolium ssp. sanctorum	Santa Ana River woollystar	E	-	CE	Santa Ana River wash
Erigeron parishii	Parish's daisy	T	-	-	desert washes or canyon bottoms with loose alluvial deposits
Erigeron piscaticus	Fish Creek fleabane	-	SR	-	upper floodplain terraces in shady canyon bottoms
Eriogeonum ripleyi	ripley wild-buckwheat	-	SR	-	tertiary lakebeds with well-drained soils
Eryngium aristulatum var. parishii	San Diego button-celery	E	-	CE	vernal pools with gravelly loam soils
Ferocactus cylindraceus var. cylindraceus	California barrel cactus	-	SR	-	creosote bush scrub; Joshua Tree woodlands
Ferocactus cylindraceus var. eastwoodie	golden barrel cactus	-	SR	-	Mojave and Sonoran desert
Ferocactus emoryi	Emory's barrel-cactus	-	SR	-	Mojave and Sonoran desert
Fremontodendron californicum	flannel bush	-	SR	-	dry slopes in chaparral and pinyon-juniper woodlands
Limnanthes gracilis ssp. parishii	Parish's meadowfoam	-		CE	lake shores; wet meadows
Mammillaria viridiflora	varied fishhood cactus	-	SR	-	rocky gorges; scrubland
Navarretia fossalis	Moran's navarretia	T		-	freshwater marshes; vernal pools
Opuntia echinocarpa	straw-top cholla	-	SR	-	creosote bush scrub; Joshua Tree woodlands
Opuntia engelmannii var. flavispina	cactus apple	-	SR	-	mid-elevation desert
Orcuttia californica	California Orcutt grass	E	-	CE	vernal pools
Perityle saxicola	Fish Creek rock daisy	-	-	-	arid cliffsides
Phacelia stellaris	Brand's phacelia	C	-	-	sandy openings in coastal sage scrub habitat
Pholisma arenarium	scaly sand plant	-	HS	-	coastal creosote bush scrublands
Purshia subintegra	Arizona cliffrose	E	HS	-	arid, rocky limestone slopes
Stenocereus thurberi	organ pipe cactus	-	SR	-	south-facing desert slopes
Trichostema austromontanum ssp. compactum	Hidden Lake bluecurls	T	-	-	Hidden Lake vernal pool in Mount San Jacinto State Wilderness
Tumamoca macdougalii	tumamoc globeberry	-	SR	-	upland Sonoran desert scrubland
Verbesina dissita	big-leaved crown beard	T	-	-	southern maritime chaparral
Reptiles					

Scientific Name	Common Name	Federal (a)	AZ(b)	CA(c)	Habitat
Actinemys marmorata pallida	southwestern pond turtle	-	-	SSC	valleys with slow-moving waterways
Anniella pulchra pulchra	silvery legless lizard	-	-	SSC	loose, moist soils of chaparral, desert scrub, and desert washes
Aspidoscelis hyperythra	orange-throated whiptail	-	-	SSC	semi-arid washes, chaparral, and streamsides with loose soil
Aspidoscelis xanthonota	redback whiptail	-	-	-	upland Sonoran desert scrublands
Charina trivirgata gracia	desert rosy boa	-	-	-	scrublands; rocky desert; canyons
Charina trivirgata trivergata	Mexican rosy boa	-	-	-	riparian areas; scrublands; rocky desert; canyons
Charina umbratica	southern rubber boa	-	-	CT	oak-conifer and mixed-conifer forests
Crotalus ruber ruber	northern red diamond rattlesnake	-	-	SSC	desert slopes; arid coastal areas
Eumeces gilberti arizonensis	Arizona skink	-	WSC	-	mesquite riparian drainages; woodlands near streams
Eumeces skiltonianus interparietalis	Coronado skink	-	-	SSC	grasslands; woodlands; chaparral
Gopherus agassizii	Sonoran desert tortoise	T	WSC	CT	Mojave and Sonoran desert
Heloderma suspectum cinctum	banded gila monster	-	-	SSC	rocky scrublands; semi-desert grasslands
Phrynosoma coronatum (blainvillii population)	San Diego horned lizard	-	-	SSC	
Phrynosoma mcallii	flat-tailed horned lizard	-	-	SSC	desert scrub; desert washes
Salvadora hexalepis virgultea	coast patch-nosed snake	-	-	SSC	creosote desert flats; sagebrush; chaparral
Sauromalus ater	Arizona chuckwalla	-	-	-	rocky, desert outcrops
Thamnophis eques megalops	northern Mexican gartersnake	-	WSC	-	desert scrub or semidesert grasslands near rivers or streams
Thamnophis hammondii	two-striped garter snake	-	-	SSC	desert regions near semi-permanent to permanent water bodies
Uma inornata	Coachella Valley fringe-toed lizard	T	WSC	CE	sand dune habitat
Uma scoparia	Mojave fringe-toed lizard	-	-	SSC	sand dune habitat

(a) C = Candidate for Federal listing; E = Federally Endangered; T = Federally Threatened

(b) HS = Highly Safeguarded: no collection allowed (Arizona Department of Agriculture); SR = Salvage Restricted: collection only with permit (Arizona Department of Agriculture); WSS = Wildlife of Special Concern (Arizona Game and Fish Department)

(c) CE = California State Endangered; CT = California State Threatened; SSC = California Species of Special Concern

Sources: AGFD 2008; AGFD 2009; CDFG 2009; USFWS 2008b; USFWS 2008c; USFWS 2008e

2.2.8 Socioeconomic Factors

This section describes current socioeconomic factors that have the potential to be directly or indirectly affected by changes in operations at PVNGS. The nuclear plant and the people and communities that support it can be described as a dynamic socioeconomic system. The communities provide the people, goods, and services required by power plant operations. The nuclear power plant, in turn, creates the demand for people, goods, and services and pays for them in the form of wages, salaries, and benefits, and payments for goods and services.

Income from wages and salaries and payments for goods and services is then spent on other goods and services within the community, thus creating additional opportunities for employment and income. The measure of the community's ability to support the operational demands of PVNGS depends on the ability of the community to respond to changing socioeconomic conditions at the power plant.

The socioeconomics region of influence (ROI) for PVNGS is defined as the area in which plant employees and their families reside, spend their income, and use their benefits, thereby affecting the economic conditions of the region. The PVNGS ROI consists of Maricopa County, and includes the cities of Phoenix, Tempe, Mesa, Glendale, Peoria, Scottsdale, and Sun City. The nearest incorporated city is Buckeye (estimated 2006 population of 29,615) located about 16 miles (26 kilometers) east of PVNGS, while the nearest town is Wintersburg, approximately 1.5 miles (2 kilometers) northwest of the site.

APS employs approximately 2,200 permanent workers and approximately 620 long-term contract employees at PVNGS (APS 2008a). Approximately 98 percent live in Maricopa County, Arizona (Table 2.2.8–1). The remaining two percent of the APS workforce are divided among 13 Arizona counties, with between 1 and 8 employees per county. Given the residential locations of APS employees, the most significant impacts of plant operations are likely to occur in Maricopa County. The focus of the analysis in this document is therefore based in this county.

Table 2.2.8–1 APS Employee Residence by County in 2008

County	Number of PVNGS Personnel	Percentage of Total
Maricopa	2,156	98
Other	44	2
Total	2,200	100

Source: APS 2008a

Refueling outages at the PVNGS normally occur at 18-month intervals for each unit or one unit every six months on a rotating basis. During each six-month refueling outage, site employment increases by as many as 350 workers for approximately 45 days. Most of these workers are assumed to be located in the same geographic areas as the permanent PVNGS staff. The following sections describe housing, public services, offsite land use, visual aesthetics and noise, population demography, and the economy in the ROI surrounding PVNGS.

2.2.8.1 Housing

Table 2.2.8.1–1 lists the total number of occupied housing units, vacancy rates, and median value in the ROI. According to the 2000 Census, there were more than 1,250,000 housing units in the ROI, about 1,133,000 of which were occupied. The median value of owner-occupied units was $129,200. The vacancy rate was 9.4 percent, partly because of the large number of seasonal and recreational housing units in the county.

By 2008, the estimated total number of housing units in Maricopa County had grown by 286,144 units to 1,536,375, while the total number of occupied units grew by 205,162 units to 1,338,048. As a result, the number of available vacant housing units increased by almost 80,982 units to 198,327, or 12.9 percent of all housing units.

Table 2.2.8.1–1 Housing in Maricopa County

	Maricopa
2000	
Total	1,250,231
Occupied housing units	1,132,886
Vacant units	117,345
Vacancy rate (percent)	9.4
Median value (dollars)	129,200
2006–2008; three-year estimate	
Total	1,536,375
Occupied housing units	1,338,048
Vacant units	198,327
Vacancy rate (percent)	12.9
Median value (dollars)	263,600

Sources: USCB 2009a–d.

2.2.8.2 Public Services

This section presents a discussion of public services, including water supply, education, and transportation.

Water Supply

To relieve the growing problem of groundwater overdraft in parts of Arizona, the Arizona Department of Water Resources (ADWR) has designated Active Management Areas (AMAs) where groundwater overdraft concerns are the most significant (ADWR 2006). Much of Maricopa County is within the Phoenix AMA, which consists of seven groundwater basins and covers 5,646 square miles (14,623 square kilometers). An annual average of 2.3 million acre-feet (2.8 billion cubic meters) of water is used in the AMA (ADWR 2006), including 1.4 million acre-feet (1.7 billion cubic meters) of water from the Colorado River, Salt River, and Verde River, water retrieved from treated effluent from the Phoenix metropolitan area, and 900,000 acre-feet (1.1 billion cubic meters) coming from groundwater sources. The Phoenix AMA annual water overdraft is currently about 251,000 acre-feet (310 million cubic meters) (ADWR 2006).

Although there is a mix of water uses in the Phoenix AMA, municipal and industrial uses are the most significant. Water storage reservoirs have been constructed on the Gila River and four principal tributaries that drain the Phoenix AMA–the Salt, Verde, Gila, and Agua Fria rivers (ADWR, 2006). Table 2.2.8.2–1 provides details on the largest municipal surface water supply systems in Maricopa County.

Table 2.2.8.2–1 Major Maricopa County Public Water Supply Systems (thousand acre-feet)

Water Supplier [a]	Water Source[a]	Average Daily Production (2005)[b]	Maximum Daily Production (2006) [b]
City of Phoenix	Surface Water	302.4	450.1
City of Mesa	Surface Water	90.9	121.9
City of Scottsdale	Surface Water	76.0	106.4
City of Chandler	Surface Water	54.2	77.5
City of Tempe	Surface Water	49.8	77.2
City of Glendale	Surface Water	44.4	64.2
City of Gilbert	Surface Water	37.1	44.1
City of Peoria	Surface Water	21.8	41.7

(a) EPA 2009
(b) APS 2008a

Education

Four school districts are located in the vicinity of PVNGS. Combined, the districts have 19 schools and in 2008 had 17,386 students and 861 teachers. The four districts are listed below, along with the number of schools in each and the number of students and teachers in 2008 (NCES 2009):

- Buckeye Elementary School District: 6 schools, 4,510 students, 202 teachers.
- Buckeye Union High School District: 4 schools, 3,088 students, 152 teachers.
- Liberty Elementary School District: 5 schools, 3,834 students, 222 teachers.
- Agua Fria Union High School District: 4 schools, 5,954 students, 285 teachers.

Transportation

Road access to PVNGS is via Wintersburg Road, which intersects with Salome Highway a few miles north of the plant and, about 6 miles (10 kilometers) north, intersects with Interstate Highway 10 (I-10). Employees traveling from the north, northwest, and west use Salome Highway or I-10 to reach PVNGS, while employees traveling from the southwest and south use Elliot and Wintersburg Roads. Employees traveling from the northeast, east, southeast, and south would use Salome Highway or I-10. Some congestion occurs on the PVNGS access road during shift changes while vehicles pass through the security gate, although this congestion generally does not extend to Wintersburg Road (APS 2008a). PVNGS supports an employee van pool program, providing almost 100 ten-passenger vans to groups of employees who pay a fee for their use, thereby reducing congestion and traffic volume.

Table 2.2.8.2–2 lists roadways in the vicinity of PVNGS and the annual average daily traffic volumes (AADT) on these road segments. Traffic volumes in the vicinity of PVNGS are low, although traffic volumes on road segments have increased somewhat over the period 2005 to 2008.

Table 2.2.8.2–2 Average Annual Daily Traffic[a] (AADT) Counts in the vicinity of PVNGS

Roadway and Location	AADT
I-10, Exit 94, 411th Avenue to Exit 98, Wintersburg Road/383rd Avenue	23,101[b]
I-10, Exit 98, Wintersburg Road/383rd Avenue to Exit 103, 339th Avenue	28,321[b]
355th Avenue at West Salome Highway	462[c]
West Salome Highway at 379th Avenue	1,381[c]
West Salome Highway at Wintersburg Road/383rd Avenue	1,947[c]
West Salome Highway at 411th Avenue	722[c]
West Elliot Road, at 355th Avenue	466[c]
West Elliot Road at Wintersburg Road/383rd Avenue, eastbound	489[c]
West Elliot Road at Wintersburg Road/(383rd Avenue, westbound	265[c]

(a) Annual average daily traffic represents traffic volume during the average 24-hour day.
(b) 2008 data.
(c) 2009 data.

Sources: ADOT 2009; MCDOT 2009

2.2.8.3 Offsite Land Use

A majority of PVNGS workers live in Maricopa County (approximately 98 percent) and PVNGS pays property taxes to Maricopa County. Therefore, this section provides information on offsite land use in that county.

The Phoenix metropolitan region has two primary long-range planning and policy development organizations: the Maricopa County Planning and Development Department and the Maricopa Association of Governments (MAG). Local and regional planners use comprehensive land-use planning, zoning, and subdivision regulations to control development, encouraging growth in areas where public facilities such as water and sewer systems exist or are scheduled to be built in the future. They also promote the preservation of community natural resources, but use no growth control measures.

Maricopa County covers 9,203 square miles (23,835 square kilometers) of land (USCB 2009f). Over the last several decades, urban development has occurred primarily in the West Valley, northern Pinal County, and the North Valley, although some suburban development has occurred to some extent throughout the ROI. From 2000 to 2004, the urbanized portion of the region expanded by 55,000 acres (22,259 hectares) (MAG 2005).

With few topographical constraints, much of this development has been in the form of master planned communities, especially in northern Maricopa County. Active, planned, and proposed developments in Maricopa County are capable of accommodating an additional 100,000 people annually for 20 more years (MAG 2005). The highest concentrations of commercial development are located along the major transportation corridors (MAG 2005). Concentrations of regional open space are located in the mountains, throughout the West Valley, and in northeastern and southern Maricopa County. Land in the immediate vicinity of PVNGS is primarily rural, consisting of open space and scattered low-density residential developments with lower-priced single family housing. Little industrial or commercial activity occurs in the plant vicinity (APS 2008a).

2.2.8.4 Visual Aesthetics and Noise

Power generation facilities at PVNGS are situated in the northwest corner of the property. The major structures at the site constitute a significant feature of the landscape within the immediate viewshed of the site and include several buildings ranging in height from 64 to 250 feet (20 to 76 meters) (NRC 1982). APS sought to diminish the profile of the structures of PVNGS through the use of desert beige and sage green paint and siding and plain concrete exteriors. Elevated evaporation ponds (42 feet [13 meters] in height) are located in the central and southern sections of the property, and water storage reservoirs are located in the northeast corner.

Three natural gas-fired combined-cycle power generation plants are located approximately 2.5 to 3 miles (4 to 5 kilometers) south of PVNGS. The land around PVNGS consists of relatively flat desert terrain with small hills and buttes; the Palo Verde Hills rise abruptly to nearly 2,200 feet (671 meters) approximately 6 miles (10 kilometers) northwest of the site (NRC 1982). As indicated above, land use in the immediate vicinity of PVNGS is primarily open space and scattered low-density residential developments (APS 2008a) in addition to power generation.

The plume from the nine PVNGS 64-foot-high (20-meter-high) cooling towers can be visible to a height of approximately 1,900 feet (580 meters) on an average summer morning, and estimated to be 870 feet (265 meters) during an average winter morning.

PVNGS can be seen from Wintersburg Road, which runs north to south along the west edge of the site, and Elliot Road, which runs east to west at the southern end of the site. PVNGS can also be seen from Interstate Highway 10 located 6 miles (10 kilometers) northeast of the site at its closest point and from State Route 80 located seven miles south east of the site.

Noise from nuclear plant operations can be detected offsite. Sources of noise at PVNGS include the turbines, construction activities, and large pump motors. Given the industrial nature of the station, noise emissions from the station are generally nothing more than an intermittent minor nuisance. However, noise levels may sometimes exceed the 55 dBA level that the U.S. Environmental Protection Agency (EPA) uses as a threshold level to protect against excess noise during outdoor activities (EPA 1974). According to the EPA this threshold does “not constitute a standard, specification, or regulation,” but was intended to provide a basis for state and local governments establishing noise standards. To date, no noise complaints associated with operations at PVNGS have been reported from neighboring communities.

2.2.8.5 Demography

In 2000, approximately 16,000 persons lived within a 20-mile (32-kilometer) radius of PVNGS, which equates to a population density of 13 persons per square mile (APS 2008a). This is a Category 1 density (less than 40 persons per square mile within 20 miles [32 kilometers] and no community with 25,000 or more persons within 20 miles [32 kilometers]) using the generic environmental impact statement (GEIS) measure of sparseness. At the same time, about 1,572,110 people lived within a 50-mile (80-kilometer) radius of the plant, for a density of 200 persons per square mile (APS 2008a). This translates to a Category 4 density (greater than or equal to 190 persons per square mile within 50 miles [80 kilometers]). Therefore, PVNGS is located in a medium-density population area based on the NRC sparseness and proximity matrix.

Table 2.2.8.5–1 shows population projections and growth rates from 1970 to 2030 for Maricopa County. The growth rate in Maricopa County since 1970 has been substantial, and population growth is projected to continue through 2050.

Table 2.2.8.5–1 Population and Percent Growth in Maricopa County

Year	Population	Percent Growth[a]
1970	967,522	-----
1980	1,509,052	56.0
1990	2,122,101	40.6
2000	3,072,172	44.8
2008	3,954,598	28.7
2010	4,217,427	37.3
2020	5,276,074	25.1
2030	6,207,980	17.7
2040	7,009,664	12.9
2050	7,661,423	9.3

— = No data available.

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

Sources: Population data for 1970 through 1990 (USCB 2009e); 2000 and 2008 estimate (USCB 2009f); projected population data for 2010 to 2050 (ADES 2006)

The 2000 demographic profile of the ROI population is provided in Table 2.2.8.5–2. Persons self-designated as minority individuals constituted 33.8 percent of the total population. This minority population is composed largely of Hispanic or Latino persons.

Table 2.2.8.5–2 Demographic Population Profile in PVNGS ROI in 2000

	Maricopa County	Percent
Total Population	3,072,149	--
White	2,376,359	77.4
Race (Not-Hispanic or Latino)		
Black or African American	114,551	3.7
American Indian and Alaska Native	56,706	1.8
Asian	66,445	2.2
Native Hawaiian and Other Pacific Islander	4,406	0.1
Some other race	364,213	11.9
Two or more races	89,469	2.9
Ethnicity		
Hispanic or Latino	763,341	24.8
Minority Population (including Hispanic or Latino ethnicity)		
Total minority population	1,459,131	47.5

Source: USCB (2009g)

According to the U.S. Census Bureau's 2006-2008 American Community Survey 3-Year Estimates, minority populations were estimated to have increased by approximately 525,000 persons and comprised 40.5 percent of the county population (see Table 2.2.8.5–3). Most of this increase was due to an estimated influx of Hispanic or Latinos (over 406,000 persons), an increase in population of over 53 percent from 2000. The next largest increase in minority population was Asian, an increase of approximately 44,000 persons or 68 percent from 2000.

Table 2.2.8.5–3 Demographic Population Profile in PVNGS ROI 2006-8 Estimate

	Maricopa County	Percent
Total Population	3,862,036	--
Race (percent of total population, Not-Hispanic or Latino)		
White	2,299,208	59.5
Black or African American	158,092	4.1
American Indian and Alaska Native	61,869	1.6
Asian	108,145	2.8
Native Hawaiian and Other Pacific Islander	6,147	0.2
Some other race	4,086	0.2
Two or more races	52,997	1.4
Ethnicity		
Hispanic or Latino	1,169,740	30.3
Minority Population (including Hispanic or Latino ethnicity)		
Total minority population	1,562,828	40.5

Source: USCB 2009h

Transient Population

Within 50 miles (80 kilometers) of PVNGS, colleges and recreational opportunities attract daily and seasonal visitors who create demand for temporary housing and services. In 2009, about 99,324 students were attending four-year colleges and universities within 50 miles (80 kilometers) of PVNGS (NCES 2009).

In 2000, four percent of all housing units in Maricopa County were considered temporary housing for seasonal, recreational, or occasional use; with higher percentages elsewhere within 50 miles (80 kilometers) of the plant (La Paz County 34.6 percent, Yuma County 15.7 percent and Pinal County 14.5 percent). Table 2.2.8.5–4 provides information on seasonal housing within 50 miles (80 kilometers) of PVNGS.

Table 2.2.8.5–4 Seasonal Housing within 50 miles (80 km) of PVNGS, 2000

County[a]	Number of Housing Units	Housing Units for Seasonal, Recreational, or Occasional Use	Percent
La Paz	15,133	5,237	34.6
Maricopa	1,250,231	49,584	4.0
Pinal	81,154	11,764	14.5
Yavapai	81,730	6,048	7.4
Yuma	74,140	11,662	15.7
Total	1,502,388	84,295	5.6

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

Source: USCB 2009a

Migrant Farm Workers

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

Migrant workers may be members of minority or low-income populations. Migrant workers may not be included in the local Census because they travel and can spend a significant amount of time in an area without being actual residents. If uncounted, these workers would be “underrepresented” in U.S. Census Bureau minority and low-income population counts.

The 2007 Census of Agriculture collected information on migrant farm and temporary labor. Table 2.2.8.5–5 provides information on migrant farm workers and temporary (less than 150 days) farm labor within 50 miles (80 km) of PVNGS. According to the 2007 Census of Agriculture, Maricopa County hosts relatively small numbers of migrant workers, with 467 temporary farm laborers employed on 136 farms in the county (USDA 2009).

Table 2.2.8.5–5 Migrant Farm Worker and Temporary Farm Labor within 50 miles (80 km) of PVNGS, 2007

County[a]	Number of Farm Workers Working for Less that 150 Days	Number of Farms Hiring Workers for Less than 150 Days	Number of Farms Reporting Migrant Farm Labor	Number of Farms with Hired Farm Labor
La Paz	128	15	2	46
Maricopa	467	136	40	526
Pinal	124	51	37	279
Yavapai	199	81	10	185
Yuma	318	81	49	244
Total	1,236	364	138	1,280

(a) Counties within 50 mi of PVNGS with at least one block group located within the 50-mile (80-kilometer) radius

Source: USDA 2009

2.2.8.6 Economy

This section discusses of the economy, including employment and income, unemployment, and taxes, within the ROI.

Employment and Income

Between 2000 and 2008, the civilian labor force in Maricopa County increased at an annual average rate of 2.9 percent to 1,999,092 (USDOL 2009). In 2007, retail, health care and social assistance, and construction employment represented the largest sectors of employment in Maricopa County, followed closely by waste management services and accommodation and food services (USCB 2009i). The largest employer in the Greater Phoenix area (Maricopa County and Pinal County) in 2009 was the State of Arizona with 50,936 employees (Table 2.2.8.6-1). The majority of employment in the Greater Phoenix area is located in the cities of Chandler, Glendale, Guadalupe, Mesa, Phoenix, Scottsdale, and Tempe (GPEC 2009a).

Table 2.2.8.6-1 Major Employers in the Phoenix Metropolitan Area, 2009

Firm	Number of Employees
State of Arizona	50,936
Wal-Mart Stores, Inc.	32,814
Banner Health	23,100
City of Phoenix	17,068
Maricopa County	14,014
Wells Fargo	14,000
Arizona State University	13,005
Honeywell Aerospace	12,600
U.S. Postal Service	10,545
Basha's Inc.	10,460

Source: GPEC 2009b

Estimated income information for the PVNGS ROI is presented in Table 2.2.8.6-2. According to the U.S. Census Bureau's 2008 estimates, both the median household and per capita incomes in Maricopa County were above the Arizona average. In 2008, 13.0 percent of the population in Maricopa County was living below the official poverty level (USCB 2009f).

Table 2.2.8.6-2 Income Information for PVNGS, 2008

	Maricopa County	Arizona
Median household income (dollars) [a]	56,555	51,124
Per capita income (dollars) [a]	27,745	25,639
Percent of persons below the poverty line	13.0	14.3

(a) In 2008 inflation-adjusted dollars.

Sources: USCB 2009f; USDOC 2009

Unemployment

According to the U.S. Census Bureau's 2008 estimates, the annual unemployment average for Maricopa County was 4.9 percent, which was lower than the annual unemployment average of 5.6 percent for the state as a whole (USDOL 2009).

Taxes

The owners of PVNGS pay annual property taxes to Maricopa County. From 2004 through 2008, Maricopa County collected between $3.3 and $4.3 billion annually in property tax revenues from all PVNGS owners (see Table 2.2.8.6–3). The county retains a portion of revenues to fund county government operations and disburses the remainder to certain local tax jurisdictions, including Ruth Fisher Elementary School District, Arlington Elementary School District, Buckeye Union High School District, and Maricopa County Junior College District. For the years 2004 through 2008, property taxes paid by PVNGS have represented 1.1 to 1.6 percent of Maricopa County's total property tax revenues.

Although the deregulation of energy markets in Arizona began in 1998, electricity markets are only partially deregulated, and consequently, open access to utility providers does not exist for all electricity consumers (Macfie 2008). Any changes in assessed valuation of plant property and equipment that may occur in the future could affect property tax payments to Maricopa County and other jurisdictions in the county, including school districts. However, any changes to PVNGS property tax rates due to deregulation would be independent of license renewal.

Table 2.2.8.6–3 Maricopa County Tax Revenues, 2005 to 2008; APS Property Tax, 2005 to 2008; and APS Property Tax as a Percentage of Tax Revenues

Year	Maricopa County Total Tax Revenues (in millions of dollars)	Property Tax Paid by APS (in millions of dollars)	APS Property Tax as Percentage of Total County Tax Revenues
2004	3,299	51.1	1.6
2005	3,539	53.0	1.5
2006	3,709	46.8	1.3
2007	3,981	49.2	1.2
2008	4,271	48.1	1.1

Source: APS 2009a, b

2.2.9 Historic and Archaeological Resources

This section discusses the cultural background and known historic and archaeological resources in and around PVNGS.

2.2.9.1 Cultural Background

The area in and around PVNGS has the potential for significant prehistoric and historic resources. Human occupation in this region is categorized based on the following chronological sequence: Paleoindian (12,000 years before present (BP) to 9500 BP), Archaic (9500 BP to 1500 BP), Hohokam Culture (1700 BP to 600 BP), Pima Culture (600 BP to 400 BP [i.e., AD 1400 to 1600]), and Historic (AD 1600 to present) periods.

In general, the Paleoindian Period is characterized by highly mobile bands of hunters and gatherers, hunting small game and now-extinct megafauna (e.g., mastodon, saber-tooth tiger, and camel) and gathering wild plants. A typical Paleoindian site might consist of an isolated stone point or knife (of a style characteristic of the period) near a former Pleistocene-age water source. Known Paleoindian sites in the area have been found predominantly in southern Arizona; none have been recorded in the vicinity of PVNGS (ACS 2006).

The Archaic Period represents a transition from a highly mobile to more sedentary existence. It is also a period of increased local resource exploitation (e.g., hunting deer, waterfowl, and small mammals; and gathering nuts and seeds), more advanced tool development, construction of more permanent settlements, cultivation of maize, and increased complexity in social organization. Few Archaic sites have been recorded in this region and none have been recorded near PVNGS (ACS 2006).

The Hohokam Culture practiced farming, built canals for irrigation and culturally dominated southern Arizona (300 BC to AD 1400). The early Pioneer Period (300 BC to AD 700) was a period of agricultural development with evidence of pottery and the establishment of village settlements. The Colonial and Sedentary Period (AD 700 to 1150) introduced irrigation systems, arts and crafts industry, public architecture (e.g., ball courts, mounds), ritualized burials, and geographic expansion. The Classic Period (AD 1150 to 1390) was a period of shifting settlement patterns and architectural styles from pit house structures to above ground walled villages, and a reorganization of trade networks. Burial patterns and the arts and crafts industry also experienced change. Between 1390 and 1450 some of these more organized practices (e.g., large-scale irrigation, rituals) seem to have disappeared in the Lower Salt and Middle Gila River Valleys and may represent a separate period, called the Polvorón Phase.

The Protohistoric Period is the transition period between Hohokam Classic Period to Spanish Mission Period. During this period, most activity is replaced by the Pima Culture (AD 1400 to 1600), descendants of the Hohokam Culture. The Papago Indians (Tohono O'odham) and the Pima Indians are two Pima Culture groups in the region. Descendants of these groups can be linked to the Hopi, Yuman, Piman speakers, and Zuni (ACS 2006). PVNGS is located between the areas where the Western Yavapai historically would hunt and gather to the north and the where the Maricopa and Pima Indians would practice agriculture to the south (Stein 1981a).

The Historic Period in this region begins with the arrival of Spanish conquistadors searching for precious metals. The area was claimed by Spain in 1537, but the first documented Spaniards in the area are Fray Marcos de Niza and Francisco Coronado in 1539 and 1540 on their searches to find Cibola, the seven cities of gold. The Spanish controlled the area until 1821, when Mexico gained its independence. The first settlers came in 1846 in association with the Mexican-American War. The Arizona lands north of the Gila River became part of the United States under the Treaty of Guadalupe Hidalgo in 1848. Arizona lands south of the Gila River did not belong to the United States until after the Gadsen Purchase in 1853. The paths traveled by General Stephen Kearney and Lt. Colonel Philip Cooke in the Mexican-American War later became the main routes for future travel and settlement in Arizona, such as those during the gold rush in the 1850s. The U.S. military also established a presence during this time due to increased conflict with Native Americans resulting from increased mining activities in the area. The increase in settlement meant an increased need for goods and services and spurred the development of irrigated farming along the Gila River. Phoenix was founded in 1865, and the Southern Pacific Railroad was operating in the area by 1882 (APS 2008a).

A cattle ranch was established in 1885 on land adjacent to what is now the present-day location of PVNGS. In 1920, the town of Wintersburg was settled in the same location. The town was initially a farming community established by World War I-veteran homesteaders, some claiming lands under the homestead and desert land statutes for future sale, and some hoping to receive government assistance in receiving irrigated water. Between 1920 and 1927, the attempts to farm and raise livestock were not successful, and, of the ten initial claims, all of them failed. The first successful claim was made in 1927 with a patent issued in 1932. Over the next 20 years, only about 50 percent of the attempted claims were successful. The eventual growth of the town as it is today is related to the development of PVNGS in the mid-1970s, as many employees made Wintersburg their home (ACS 2006; Stein 1981b).

Construction of PVNGS began in 1975 and was completed in 1988. PVNGS is one of the largest power producers in the United States, producing nearly 4000 megawatts of electricity and serving over four million people. It is the largest nuclear generation facility in the United States. It is also the only nuclear plant in the United States that is not located on a large natural body of water. It meets its cooling water needs uniquely, using treated effluent (sewage) from Phoenix area municipalities.

Three hundred twenty-eight properties are listed on the *National Register of Historic Places* (NRHP) within Maricopa County, but only one of them is within a six-mile radius of PVNGS. The property listed that is nearest PVNGS is the Hassayampa River Bridge.

2.2.9.2 Historic and Archaeological Resources

PVNGS encompasses approximately 4,280 acres (1,732 hectares) of land. Approximately 728 acres (294 hectares) of the site are developed or maintained (Section 2.2.1). Prior to the construction of the plant (between 1950 and 1970), approximately 60 percent of the site was under cotton cultivation.

An archaeological survey of 9,300 acres (3,760 hectares) in the Palo Verde Hills area was conducted in 1973, prior to the selection of the PVNGS plant site. The survey identified 53 archaeological sites. Thirteen of the 53 sites were located within the 3,880-acre (1570-hectare) site ultimately chosen for the plant. No sites were recorded in the area previously cultivated. Of the 13 sites recorded, seven were identified as prehistoric, five were historic, and one contained both prehistoric and historic components. A follow-up mitigation study was conducted in 1975 that completed data recovery at each of the 13 sites and concluded that the PVNGS site was likely a hunting and gathering locality for aboriginal groups (Stein 1981a, b). Expansion of the evaporation pond capacity at the facility in 2006 resulted in the purchase and survey of an additional 526 acres (213 hectares) of private land. The 2006 archaeological survey identified four historic sites; none is eligible for listing on the NRHP (ACS 2006).

Archaeological surveys of the Salt River Project's Westwing and Kyrene (Hassayampa #1) transmission lines were completed in the 1970s, in addition to data recovery at sites that would be impacted during construction. Along the Kyrene line, 10 sites and 43 isolated artifacts were recorded (Powers, Keane, and Weaver 1978) and four of the sites were investigated further to mitigate the impacts of construction (Yablon 1982). Along the Westwing lines, seven sites and 26 isolated artifacts were recorded (Stein, Granger, and Freeman 1977), and two of the sites underwent data recovery to mitigate the impacts of construction (Yablon 1979). The Rudd transmission line, also known as the Southwest Valley line, was surveyed in 2001 and 2002; the surveys identified 3 historic structures and 3 previously recorded sites on private land (Dobschuetz and Darrington 2002) and 3 archaeological sites on state land (Hackbarth 2001). All three structures and five of the archaeological sites were either determined eligible for listing on the NRHP previously or were treated as eligible for purposes of the project. A treatment plan was developed for the eight eligible properties in 2002. A survey was also conducted along the Southern California Edison Palo Verde-Devers line; 35 sites and 40 isolated finds were recorded (Carrico, Quillen, and Gallegos 1982). As a result of further studies on the 35 sites, two districts were listed on the NRHP (North Chuckwalla Mountains Quarry District and North Chuckwalla Mountains Petroglyph District). Mitigation of adverse effects on the two districts was achieved through some project redesign and construction of barriers to limit access to the sites (Eckhardt, Walker, and Carrico 2005). An archaeological survey was conducted along the APS North Gila (Hassayampa #3) transmission line prior to construction of the line (Effland and Green 1983). APS is conducting a four-year phased archaeological survey of its transmission lines; the survey is scheduled to be completed in 2011.

Agency consultation undertaken by the U.S. Atomic Energy Commission (AEC) in November 1973 for issuance of an operating license for PVNGS generated a response letter from the

Arizona State Parks, dated December 14, 1973. The letter indicated that the property had been surveyed and that no sites meeting eligibility criteria for inclusion in the NRHP had been identified (McCarthy 1973).

APS contacted the Arizona State Historic Preservation Office (SHPO) on September 28, 2007, requesting information on historic and archaeological resources located in the vicinity of the PVNGS and associated transmission lines (Fox 2007). The letter to the SHPO stated that the operation of PVNGS through the license renewal term will not have an adverse effect on any historic or cultural property in the region. In a letter dated October 29, 2007, the Arizona SHPO concurred with the no adverse effect determination as long as no land disturbance occurs (Howard 2007).

Correspondence between the Arizona SHPO and the NRC, dated May 21, 2009, is provided in Appendix E (Wrona 2009).

Government-to-Government consultation with appropriate Federally recognized Native American Tribes has been initiated. Copies of the consultation letters, dated June 1, 2009, and September 22, 2009) are provided in Appendix E. To date, no known sites of significance to Native Americans have been identified at PVNGS.

2.3 RELATED FEDERAL PROJECT ACTIVITIES AND CONSULTATIONS

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

The NRC has determined that there are no Federal projects that would make it desirable for another Federal agency to become a cooperating agency in the preparation of the SEIS. Federal lands, facilities, national wildlife refuges, forests, and parks within 50 miles of PVNGS are listed below.

U.S. Bureau of Land Management land (in addition to Public Domain Land)

- Anza National Historic Trail
- Big Horn Mountains Wilderness
- Eagletail Mountain Wilderness
- Harquahala Mountain Wilderness
- Hassayampa River Canyon Wilderness
- Hells Canyon Wilderness
- Hummingbird Springs Wilderness
- North Maricopa Mountains Wilderness
- Sierra Estrella Wilderness
- Signal Mountain Wilderness
- Sonoran Desert National Monument
- South Maricopa Mountains Wilderness
- Woolsey Peak Wilderness

U.S. Bureau of Indian Affairs land

- Gila Bend Indian Reservation
- Gila River Indian Reservation

- Maricopa Indian Reservation

U.S. Department of Defense land
- Barry M. Goldwater Air Force Range
- Buckeye National Guard Target Range
- Luke Air Force Base
- Luke Air Force Auxiliary Field
- Yuma Proving Grounds

U.S. Fish and Wildlife Service land
- Kofa National Wildlife Refuge

NRC is required under Section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA) to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved. The NRC has consulted with the U.S. Fish and Wildlife Service. Federal Agency consultation correspondence is presented in Appendix D.

2.4 REFERENCES

10 CFR Part 20. *Code of Federal Regulations*, Title 10, Energy, Part 20, "*Standards for Protection Against Radiation*."

10 CFR Part 50. *Code of Federal Regulations*, Title 10, Energy, Part 50, "*Domestic Licensing of Production and Utilization Facilities*."

10 CFR Part 61. *Code of Federal Regulations*, Title 10, Energy, Part 61, "*Licensing Requirements for Land Disposal of Radioactive Waste*."

10 CFR Part 71. *Code of Federal Regulations*, Title 10, Energy, Part 71, "*Packaging and Transportation of Radioactive Material*."

40 CFR Part 190. *Code of Federal Regulations*, Title 40, *Protection of Environment*, Part 190, "*Environmental Radiation Protection Standards for Nuclear Power Operations*."

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3.0 ENVIRONMENTAL IMPACTS OF REFURBISHMENT

Environmental issues associated with refurbishment activities are discussed in NUREG-1437, "*Generic Environmental Impact Statement (GEIS) for License Renewal of Nuclear Plants*, Volumes 1 and 2 (NRC 1996). The GEIS includes a determination of whether or not the analysis of the environmental issues can be applied to all plants and whether or not additional mitigation measures are warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply to all plants, or for some issues, apply only to plants having a specific type of cooling system or other specified plant or site characteristics.

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

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis. It has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required in this supplemental environmental impact statement (SEIS) unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, therefore, an additional plant-specific review of these issues is required.

License renewal actions include refurbishment for the extended plant life. These actions may have an impact on the environment that requires evaluation, depending on the type of action and the plant-specific design. Environmental issues associated with refurbishment, which were determined to be Category 1 issues, are listed in Table 3-1.

Environmental issues related to refurbishment considered in the GEIS that are inconclusive for all plants, or for specific classes of plants, are Category 2 issues. These are listed in Table 3-2.

The potential environmental effects of refurbishment actions are identified, and the analysis will be summarized within this section, if such actions are planned. Arizona Public Service Company (APS) indicated that it has performed an evaluation of systems, structures, and components pursuant to Section 54.21 of Title 10 of the *Code of Federal Regulations* (10 CFR 54.21) to identify the need to undertake any major refurbishment activities that are necessary to support continued operation of PVNGS during the requested 20-year period of extended operation. Items that are subject to aging and might require refurbishment to support continued operation during the renewal period are listed in Table B.2 of the GEIS.

Table 3-1. Category 1 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
Surface Water Quality, Hydrology, and Use (for all plants)	
Impacts of refurbishment on surface water quality	3.4.1
Impacts of refurbishment on surface water use	3.4.1
Aquatic Ecology (for all plants)	
Refurbishment	3.5
Ground Water Use and Quality	
Impacts of refurbishment on ground water use and quality	3.4.2
Land Use	
Onsite land use	3.2
Human Health	
Radiation exposures to the public during refurbishment	3.8.1
Occupational radiation exposures during refurbishment	3.8.2
Socioeconomics	
Public services: public safety, social services, and tourism and recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8

Table 3-2. Category 2 Issues for Refurbishment Evaluation

ISSUE–10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53 (c)(3)(ii) Subparagraph
Terrestrial Resources		
Refurbishment impacts	3.6	E
Threatened or Endangered Species (for all plants)		
Threatened or endangered species	3.9	E
Air Quality		
Air quality during refurbishment (nonattainment and maintenance areas)	3.3	F
Socioeconomics		
Housing impacts	3.7.2	I
Public services: public utilities	3.7.4.5	I
Public services: education (refurbishment)	3.7.4.1	I
Offsite land use (refurbishment)	3.7.5	I
Public services, transportation	3.7.4.2	J
Historic and archaeological resources	3.7.7	K
Environmental Justice		
Environmental justice	Not addressed	Not addressed

The results of the evaluation of systems, structures, and components for PVNGS, as required by 10 CFR 54.21, do not identify the need to undertake any major refurbishment or replacement actions associated with license renewal to support the continued operation of PVNGS beyond the end of the existing operating license.

3.1 REFERENCES

10 CFR Part 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." 10 CFR Part 54. *Code of Federal Regulations*, Title 10, *Energy*, Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437, Volumes 1 and 2, Office of Nuclear Regulatory Research, Washington, D.C. ADAMS Accession Nos. ML040690705 and ML040690738

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plant*. NUREG-1437, Volume 1, Addendum 1, Office of Nuclear Reactor Regulation, Washington, D.C.ADAMS Accession No. ML0400690720.

4.0 ENVIRONMENTAL IMPACTS OF OPERATION

This chapter addresses potential environmental impacts related to the period of extended operation of Palo Verde Nuclear Generating Station (PVNGS). These impacts are grouped and presented according to resource. Generic issues (Category 1) rely on the analysis provided in the generic environmental impact statement (GEIS) prepared by the U.S. Nuclear Regulatory Commission (NRC) (NRC 1996, 1999) and are discussed briefly. Category 1 issues have a significance level of SMALL. NRC staff analyzed site-specific issues (Category 2) for PVNGS and assigned them a significance level of SMALL, MODERATE, or LARGE. Some remaining issues are not applicable to PVNGS because of site characteristics or plant features. Section 1.4 of this report explains the criteria for Category 1 and Category 2 issues and defines the impact designations of SMALL, MODERATE, and LARGE.

4.1 LAND USE

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B–1, which are applicable to onsite land use and power line right-of-way impacts during the renewal term are listed in Table 4.1. As stated in the GEIS, the impacts associated with these Category 1 issues were determined to be SMALL, and plant-specific mitigation measures would not be sufficiently beneficial to be warranted. Section 2.2.1 of this document describes the land use around PVNGS.

The NRC staff reviewed and evaluated the PVNGS Environmental Report (ER) (APS 2008a), scoping comments, other available information, and visited PVNGS in search of new and significant information that would change the conclusions presented in the GEIS. No new and significant information was identified during this review and evaluation. Therefore, it is expected that there would be no impacts related to these Category 1 issues during the renewal term beyond those discussed in the GEIS.

Table 4-1. Land Use Issues

Issues	GEIS Section	Category
Onsite land use	4.5.3	1
Power line right-of-way	4.5.3	1

4.2 AIR QUALITY

The air quality issue applicable to PVNGS is listed in Table 4-2. Based on the information in the GEIS, the Commission found that “production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases.” This was considered a Category 1 issue. No Category 2 issues have been identified for air quality. The NRC staff did not identify any new and significant information during the review of PVNGS ER, the site audit, or the scoping process. Therefore, there are no impacts related to this issue beyond those discussed in the GEIS. For this issue, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to be warranted. Section 2.2.2 of this document describes the air quality around PVNGS.

Table 4-2. Air Quality Issue

Issues	GEIS Section	Category
Air Quality Effects of Transmission Lines	4.5.2	1

4.3 GROUNDWATER

4.3.1 Generic Groundwater Issues

None of the Category 1 issues set forth in the GEIS apply to PVNGS. Category 2 issues related to groundwater use that are applicable to PVNGS during the renewal term are discussed in the sections that follow.

4.3.2 Groundwater Use Conflicts (Plants That Use >100 gpm)

For power plants that pump more than 100 gallons per minute (gpm) (379 liters per minute) of groundwater from onsite wells, groundwater use conflicts with nearby groundwater users are considered a Category 2 issue that requires a plant-specific assessment before license renewal. As described in Section 2.1.7.2, PVNGS maintains three onsite production wells, two of which pump more than 100 gpm. The highest total annual pump rate for these wells during 2006, 2007, and 2008 was 1,535 gpm (5,811 liters per minute). This pump rate is well below the 3,206 gpm (5,171 acre-feet per year) (6.4 million cubic meters per year) authorized by the Arizona Department of Water Resources (ADWR) as part of the plant's grandfathered nonirrigation groundwater right within the Phoenix Active Management Area (AMA) (ADWR 1999).

The estimated annual rate of natural recharge to the Phoenix AMA is on the order of 24,100 acre-feet (30 million cubic meters) (ADWR 2008). Using the highest total annual pump rate of 1,535 gpm (5,811 liters per minute) or 2,476 acre-feet per year (3.1 million cubic meters per year) (reported for 2006 through 2008), it is estimated that PVNGS uses, at most, about 10 percent of the water that flows through the Phoenix AMA.

Because PVNGS pumps groundwater at rates well below its authorized water right and uses at most 10 percent of the water that flows through the Phoenix AMA, the NRC staff concludes that impacts due to groundwater use conflicts would be SMALL, and no additional mitigation is warranted.

4.3.3 Groundwater Use Conflicts (Make-Up From a Small River)

Groundwater use conflicts are considered a Category 2 issue for power plants with cooling ponds or cooling towers using make-up water from a small river with low flow, i.e., less than 3.15×10^{12} cubic feet per year (8.92×10^{10} cubic meters per year) because consumptive use of water from small rivers could adversely impact aquifer recharge (10 CFR 51.53(a)(3)(ii)(A)). PVNGS uses a closed-loop cooling system with cooling towers. Although it does not directly draw river water for its cooling water system, it does rely on treated effluent from the Phoenix area. Because PVNGS diverts treated effluent that would otherwise be discharged to the Gila River, which is a small river, the potential for groundwater use conflicts is of concern.

Natural recharge in the Phoenix AMA occurs along mountain fronts and streambeds and is estimated to be about 24,100 acre-feet (30 million cubic meters) per year. Although the AMA has deep alluvial aquifers and significant volumes of water in storage, its low recharge rates and large pumping volumes have left its aquifers in an overdraft condition. The Arizona Water Atlas (ADWR 2008) defines overdraft as a condition where groundwater is pumped in excess of safe-yield. An AMA has achieved safe-yield when it can maintain a long-term balance between the annual amount of groundwater withdrawn and the annual amount of natural and artificial groundwater recharge. Currently, the ADWR has a management goal of achieving safe-yield in the Phoenix AMA by 2025 through recharge, replenishment, retirement of agricultural pumpage, and conservation, and providing incentives to industrial and agricultural users to increase their use of renewable water supplies (such as treated wastewater effluent). As a result, the use of renewable water supplies, such as that by PVNGS, has increased over the past 20 years. Efforts to improve access and facilitate full utilization of renewable water supplies in the Phoenix AMA are currently under way (ADWR 2009, 1999).

Although flow in the Gila River is primarily ephemeral between the Ashurst-Hayden Diversion Dam and the river's confluence with the Salt River (Figure 4.4-1), it is primarily perennial downstream of the confluence due to effluent discharges from wastewater treatment plants. At Estrella Parkway near Goodyear (Station No. 09514100), just downstream of the confluence, the average annual flow of the Gila River is 2.64×10^{10} cubic feet (7.48×10^{8} cubic meters) (USGS 2006). As a result, the river does provide groundwater recharge to the Upper Alluvial Unit aquifer. Loss of Gila River water due to the diversion of treated effluent to PVNGS is about 53,000 acre-feet (65 million cubic meters) annually (APS 2008a). While this represents about a 10 per cent loss for the Gila River, it supports the ADWR's management goal of increasing the use of renewable water supplies in the Phoenix AMA to preserve its groundwater resources, even though such use reduces the perennial flow and recharge capacity of the river. Also it represents only a small portion (about 2.5 percent) of the total annual water demand (2.3 million acre-feet [2.84 billion cubic meters]) in the Phoenix AMA (ADWR 2009). For these reasons, the NRC staff concludes that impacts due to groundwater use conflicts would also be SMALL, and no additional mitigation is warranted.

4.3.4 Groundwater Quality Degradation (Cooling Ponds at Inland Sites)

Closed-cycle cooling ponds at inland power plants have the potential to degrade groundwater quality because evaporation from ponds concentrates dissolved solids and settles suspended solids, and pond effluents could seep into the underlying aquifer. As a result, the quality of groundwater in the vicinity of the ponds is a Category 2 issue that requires a plant-specific assessment before license renewal.

4.3.4.1 Evaporation Ponds

Evaporation ponds at PVNGS store and evaporate cooling tower blowdown water. Cooling water is cycled a minimum of 15 times before discharging to the evaporation ponds to ensure maximum utilization in accordance with ADWR water conservation requirements for the Phoenix AMA. Evaporation Ponds 1 and 2 are above-grade, double-lined surface impoundments with underdrain and toe-drain leakage collection systems. These ponds are also authorized to receive nonhazardous reject water from the Water Reclamation Facility (WRF) and other onsite sources. Evaporation Pond 3 is a new pond, constructed in 2009. It is an above-grade, triple-lined surface impoundment, divided into two cells (3A and 3B) that operate independently. Each cell is equipped with a liner leakage monitoring system. Evaporation Pond 3 is also authorized to receive fluids from other regulated ponds during maintenance and repair activities and as part of contingency response actions. All evaporation ponds are regulated under the facility's Aquifer Protection Permit (APP) (No. 100388 LTF 48337) issued by the Arizona

Department of Environmental Quality (ADEQ) (ADEQ 2009a).

The dissolved solids content of pond influent ranges from about 7,000 mg/L to 24,000 mg/L. It is estimated that the influent carries about 100 tons (90.7 tonnes) of solids (dry weight) per day per unit (Evaporation Ponds 1 and 2). Each evaporation pond has a reserve storage capacity of 1.5 feet (0.46 meter) of pond depth to contain a 6-hour thunderstorm probable maximum precipitation and a minimum 5 feet (1.5 meters) freeboard is provided to accommodate waves and runup (APS 2008a).

In 2008, a total of 929 million gallons (3.52 million cubic meters) were discharged to Evaporation Ponds 1 and 2. Water samples collected from Evaporation Ponds 1 and 2 had detectable amounts of two radionuclides (tritium and Iodine-131); however, no radionuclides were found to exceed the alert levels required by the APP. Tritium was not detected in any monitoring wells at PVNGS in 2008 (APS 2009). Iodine-131 is present in the influent to PVNGS due to its use in medical procedures in the Phoenix area and therefore detectable in the evaporation ponds.

Because the evaporation ponds are designed to retain wastewater and residual solids and are equipped with leakage collection systems, and because PVNGS is in compliance with the requirements of its APP, the NRC staff concludes that the potential impacts to groundwater quality as a result of the operation of evaporation ponds at PVNGS are SMALL, and no additional mitigation is warranted.

4.3.4.2 Water Storage Reservoirs

The 85-acre (34.4 hectare (ha)) and 45-acre (18.2 ha) Water Storage Reservoirs (WSRs) located in the northern portion of the PVNGS site are synthetic-lined impoundments that receive tertiary treated effluent from the WRF and store it for use as makeup water for the cooling water system. Makeup water replaces water losses due to evaporation, blowdown, and drift from the unit cooling towers (APS 2008). Each WSR has a double-liner system with a leakage collection and recovery system above an underdrain system that allows groundwater to be pumped and removed from underlying soils to protect the liner system. The WSRs are also authorized to receive secondary treated effluent from the Sewage Treatment Plant (STP), nonhazardous low-volume wastewaters during WRF outages, and untreated groundwater from the regional aquifer. Both WSRs are regulated under the facility’s APP (No. 100388 LTF 48337) (ADEQ 2009a).

The APP requires that each WRS has a minimum freeboard of 2 feet (0.6 meter) to prevent overtopping and stipulates that fluid in the collection sumps be monitored for liner leaks. In 2008, a total of 22,737 million gallons (86.1 million cubic meters) flowed into the WSRs from three Phoenix-area wastewater treatment plants and the STP. No exceedances of alert levels (due to overtopping or leakage) and no unauthorized discharges to either WRS were reported (APS 2009).

Because each WSR is designed to retain treated water and equipped with a leakage collection system, and PVNGS is in compliance with the requirements of its APP, the NRC staff concludes that the potential impacts to groundwater quality as a result of the operation of WSRs at PVNGS are SMALL, and no additional mitigation is warranted.

4.4 SURFACE WATER

4.4.1 Generic Surface Water Issues

PVNGS does not draw its cooling (or makeup) water from any natural surface water body in the area. Instead, it uses treated wastewater effluent from the Phoenix area.

PVNGS does not release cooling water to any natural surface water body. Instead, cooling water is discharged to man-made lined evaporation ponds with no outlet and no hydraulic connection to any natural water body. As a result, none of the Category 1 issues set forth in the GEIS apply to this facility.

4.4.2 Water Use Conflicts (Plants Using Make-Up Water from a Small River with Low Flow)

For power plants with cooling ponds or cooling towers using makeup water from a small river with low flow, i.e., less than the 3.15×10^{12} cubic feet per year (8.92×10^{10} cubic meters per year), water use conflicts are considered a Category 2 issue that require plant-specific assessment (10 CFR 51.53). PVNGS uses a closed-loop cooling system with cooling towers. Since PVNGS uses treated wastewater effluent that might otherwise be discharged to the Gila River, which is a small river, the potential for water use conflicts is of concern.

The Phoenix area is drained by the Gila River and its principal tributaries: the Salt River, the Verde River, the Agua Fria River, and the Hassayampa River (Figure 4.4-1). Diversion dams have been constructed on all these rivers for the purpose of regulating flow and storing water to meet high-use demand (mainly irrigation). All of the streams and washes in the area are ephemeral, either naturally or due to upstream diversion. Flow in the Gila River is primarily ephemeral between the Ashurst-Hayden Diversion Dam and the river's confluence with the Salt River. Downstream of the confluence, the Gila River is primarily perennial due to effluent discharges from wastewater treatment plants. At Estrella Parkway near Goodyear (Station No. 09514100), just downstream of the confluence, the average annual flow is 2.64×10^{10} cubic feet (7.48×10^{8} cubic meters) (USGS 2006).

Most of the treated wastewater effluent in the Phoenix AMA is generated at the 91st Avenue Wastewater Treatment Plant. The treatment plant processes about 139,000 acre-feet (171.5 million cubic meters) of wastewater annually from Glendale, Mesa, Phoenix, Scottsdale, and Tempe (ADWR 2008). Treated effluent is used by local municipalities and industries, and for urban and agricultural irrigation. In 2008, PVNGS received about 59,249 acre-feet (73.1 million cubic meters) (43 percent) of the 91st Avenue Wastewater Treatment Plant's treated effluent for use in its cooling water system (APS 2009). Currently, the volume of available treated effluent exceeds demand, especially during winter months; unused effluent is discharged to the Salt and Gila Rivers, creating perennial flow in these rivers (ADWR 2008). To conserve its drinking water supplies, the city of Phoenix is investigating ways to fully utilize treated effluent (City of Phoenix 2005).

The annual flow volumes of treated effluent from the 91st Avenue Wastewater Treatment Plant are projected to increase to 264,260 to 297,840 acre-feet (326 to 367 million cubic meters) by 2030 as the treatment plant expands to meet demand (SROG 2005). Given PVNGS's current annual usage of 59,249 acre-feet (73.1 million cubic meters), the proportion of treated effluent from the 91st Avenue Wastewater Treatment Plant being used by the nuclear plant is expected to decrease from 43 percent (2009) to about 20 to 22 percent in 2030. Based on this estimate, the NRC staff concludes that the potential impacts of water use conflicts are SMALL, and no additional mitigation is warranted.

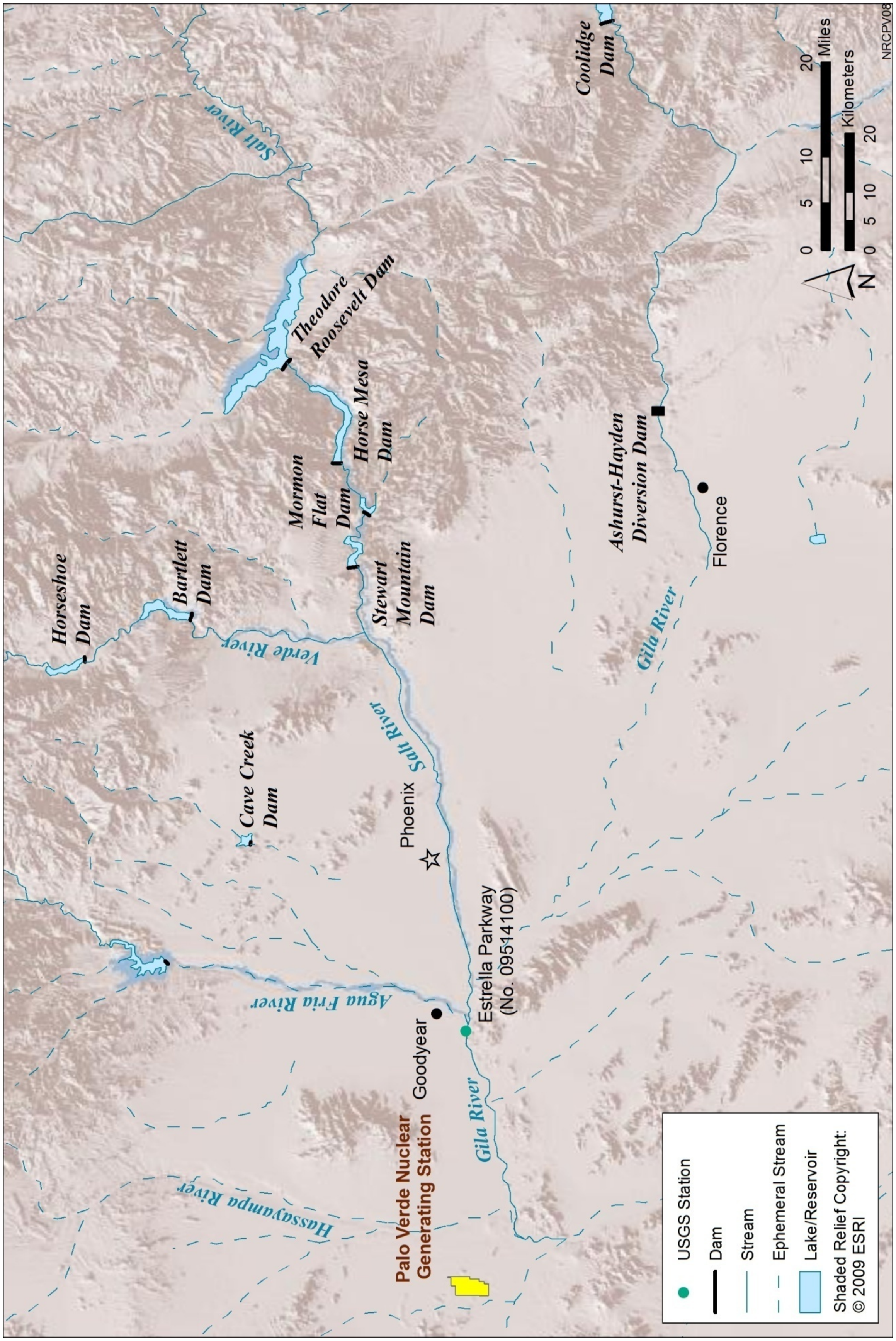


Figure 4.4-1 Gila River and its Principal Tributaries

4.5 AQUATIC RESOURCES

Table 4.5 lists the issues related to aquatic resources applicable to PVNGS. All issues are generic (Category 1) and addressed in the GEIS, Section 4.2 and 4.3. Section 2.1.6 of this document describes PVNGS's cooling water system, and Section 2.2.5 describes the aquatic resources.

Table 4-5. Aquatic Resources Issues

Issues	GEIS Sections	Category
For All Plants		
Accumulation of contaminants in sediments or biota	4.2.1.2.4	1
Entrainment of phytoplankton and zooplankton	4.2.2.1.1	1
Cold shock	4.2.2.1.5	1
Thermal plume barrier to migrating fish	4.2.2.1.6	1
Distribution of aquatic organisms	4.2.2.1.6	1
Premature emergence of aquatic insects	4.2.2.1.7	1
Gas supersaturation (gas bubble disease)	4.2.2.1.8	1
Low dissolved oxygen in the discharge	4.2.2.1.9	1
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.2.2.1.10	1
Stimulation of nuisance organisms	4.2.2.1.11	1
For Plants with Cooling-Tower-Based Heat Dissipation Systems		
Entrainment of fish and shellfish in early life stages	4.3.3	1
Impingement of fish and shellfish	4.3.3	1
Heat shock	4.3.3	1

4.5.1 Generic Aquatic Ecology Issues

No new and significant information was identified during the review of the APS's ER (APS 2008a), the site audit, or the scoping process. Therefore, no impacts related to these issues occur beyond those discussed in the GEIS. PVNGS uses treated wastewater effluent to supply makeup water for its cooling towers and blowdown flows to evaporation ponds, so no impingement, entrainment, or heat shock impacts to aquatic species result from plant operation. For these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

4.5.1.1 Water Diversion

The NRC's Final Environmental Statement (NRC 1982) for PVNGS and the applicant's ER (APS 2008a) both address the potential effects of water diversion on aquatic communities. These reports address the potential impact to natural resources that results from PVNGS using about 53,000 acre-feet (65 million cubic meters) of wastewater annually that are lost to evaporation. None of this diverted wastewater is discharged after use to a natural water body to support aquatic and riparian communities. The reports do not question that natural habitat has been lost due to water diversion. NRC 1982 concluded, however, that "this diversion will not adversely affect characteristic desert aquatic population structure because the existing stream management programs and water quality do not allow such communities to develop."

In relation to the present application, NRC staff considers the potential use of cooling water blowdown to support aquatic resources impractical and speculative. First, practically no natural surface water bodies occur on or adjacent to the site that could receive the blowdown. Second, salt and other dissolved material in the cooling tower blowdown is highly concentrated; therefore, the blowdown would require extensive treatment before release to support natural resource communities. Furthermore, it is not clear whether wastewater diverted to PVNGS would be used to support natural resources or support irrigation, municipal, and industrial uses. Therefore, NRC staff concludes that water diversion during the period of relicensing will not adversely affect aquatic resources.

4.6 TERRESTRIAL RESOURCES

The issues related to terrestrial resources applicable to PVNGS are listed in Table 4.6. There are no Category 2 issues related to terrestrial resources. The NRC did not identify any new and significant information during the review of the applicant's ER (APS 2008a), the site audit, or the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation. Section 2.2.6 provides a description of the terrestrial resources at PVNGS and in the surrounding area.

Table 4-6. Terrestrial Resources Issues

Issues	GEIS Section	Category
Cooling tower impacts on crops and ornamental vegetation	4.3.4	1
Cooling tower impacts on native plants	4.3.5.1	1
Bird collisions with cooling towers	4.3.5.2	1
Power line right-of-way management (cutting herbicide application)	4.5.6.1	1
Bird collisions with power lines	4.5.6.1	1
Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	4.5.6.3	1
Floodplains and wetland on power line right-of-way	4.5.7	1

4.7 THREATENED OR ENDANGERED SPECIES

The impact to threatened and endangered species is a site-specific, or Category 2 issue. It requires consultation with the appropriate agencies to determine whether threatened or endangered species are present and whether they would be adversely affected by continued operation of PVNGS during the license renewal term. The characteristics and habitats of threatened and endangered species in the vicinity of PVNGS are discussed in Sections 2.2.6 and 2.2.7 of this document.

The NRC contacted the U. S. Fish and Wildlife Service (USFWS) on June 12, 2009, regarding threatened and endangered species at PVNGS (letter provided in Appendix D). A description of the site and the in-scope transmission lines and a preliminary assessment of the Federal threatened, endangered, and candidate species potentially occurring on or near PVNGS was provided in this letter. The USFWS responded to this request on July 16, 2009 (letter provided in Appendix D).

The NRC contacted the Arizona Game and Fish Department (AGFD) on June 12, 2009, to request data to aid in determining which State-listed species may be affected by continued operation of PVNGS and associated transmission line rights-of-way (ROWs) (letter provided in Appendix D). On July 16, 2009, the AGFD provided information on State-listed species known to occur within 5 miles (8 km) of PVNGS and species with the potential to occur within the vicinity of the transmission lines associated with PVNGS (letter provided in Appendix D).

4.7.1 Aquatic Species

With the exception of East Wash, there are no natural surface water bodies on or immediately adjacent to PVNGS. PVNGS does not draw its cooling (or makeup) water from any natural surface water body in the area. It also does not release cooling water (or cooling water blowdown) effluents to any natural surface water body. Therefore, the NRC staff concludes that there is no adverse impacts to aquatic species during the license renewal term.

4.7.2 Terrestrial Species

Currently, no Federally-listed threatened or endangered terrestrial species are known to occur on the PVNGS site. Operation of PVNGS and its associated transmission lines are not expected to adversely affect any threatened or endangered terrestrial species during the license renewal term.

One PVNGS-associated transmission line, the Devers line, crosses Federally-designated critical habitat for the Mojave population of desert tortoise (Gopherus agassizii) located in and slightly north of the Chuckwalla Mountains Wilderness Area. The desert tortoise is Federally listed as threatened, Arizona state-listed as a wildlife species of concern, and California state-listed as threatened. Southern California Edison (SCE), which owns and maintains the Devers line, has an Endangered Species Awareness Program and maintains a comprehensive field guide entitled Endangered Species Alert Program Manual: Species Accounts and Procedures (SCE 2006) to ensure that employees are properly trained to identify and take appropriate precautions when working in desert tortoise habitat (SCE 2009).

The Devers line also crosses through Coachella Valley National Wildlife Refuge, which contains Federally-designated critical habitat for the Coachella Valley fringe-toed lizard (Uma inornata); however, the line’s ROW does not directly intersect this species’ critical habitat.

The NRC staff concludes that adverse impacts to threatened and endangered species during the license renewal term would be SMALL. A potential mitigation measure that could further reduce this SMALL impact would be for APS to report existence of any Federally- or State-listed endangered or threatened species within or near the transmission line ROWs to the AGFD, California Department of Fish and Game (CDFG) and/or USFWS if any such species are identified during the renewal term. In particular, if any evidence of injury or mortality of migratory birds, State-listed species, or Federally-listed threatened or endangered species is observed within the corridor during the renewal period, coordination with the appropriate state or

Federal agency would minimize impacts to the species and, in the case of Federally-listed species, ensure compliance with the Endangered Species Act.

4.8 HUMAN HEALTH

The human health issues applicable to PVNGS are discussed below and listed in Table 4-8 for Category 1, Category 2, and uncategorized issues. Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 contains more information on these issues.

Table 4-8. Human Health Issues

Issues	GEIS Section	Category
Microbiological organisms (occupational health)	4.3.6	1
Microbiological organisms (public health, for plants using small rivers)	4.3.6	2
Noise	4.3.7	1
Radiation exposures to public (license renewal term)	4.6.1, 4.6.2	1
Occupation radiation exposures (license renewal term)	4.6.3	1
Electromagnetic fields – acute effects (electric shock)	4.5.4.1	2
Electromagnetic fields – chronic effects	4.5.4.2	Uncategorized

4.8.1 Generic Human Health Issues

NRC staff did not identify any new and significant information during its review of the PVNGS ER, the site audit, or the scoping process associated with the human health issues listed in Table 4-8. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these issues, the GEIS concluded that the impacts are SMALL, and additional site-specific mitigation measures are not likely to be sufficiently beneficial to be warranted. The information presented below is a discussion of selected radiological programs conducted at PVNGS.

4.8.1.1 Radiological Environmental Monitoring Program

The Radiological Environmental Monitoring Program (REMP) was established for PVNGS by APS in 1979, approximately six years prior to initial criticality of the first of the three reactors. The REMP is designed to assess the radiological impact, if any, to its employees, the public, and the environment in the environs around the plant site. The REMP is performed in accordance with NRC requirements to provide a complete environmental monitoring program for nuclear reactors and with concern for maintaining the quality of the local environment. An annual radiological environmental operating report is issued which contains a discussion and summary of the results of the monitoring. The report contains data on the monitoring performed for the year, graphs which trend the data from prior years, and a comparison to pre-plant operation baseline data. The objectives of the REMP include the following:

- To determine baseline radiation levels in the environs prior to plant operation and to compare the findings with measurements obtained during reactor operations.

- To monitor potential radiological exposure pathways to the public.
- To determine the radiological impact on the environment caused by the operation of PVNGS.

The REMP collects samples of environmental media in the environs around the site to analyze and measure the radioactivity levels that may be present. The media samples are representative of the radiation exposure pathways to the public from all plant radioactive effluents. The assessment program consists of routine measurements of environmental radiation and of radionuclide concentrations in media such as air, groundwater, drinking water, surface water, vegetation, milk, sludge, and sediment. To ensure the REMP samples the appropriate environmental media, a land use census is performed annually to identify the nearest milk animals, residents, and gardens. This information is used to evaluate the potential dose to members of the public for those exposure pathways that exist in the environs around PVNGS. There is also an onsite groundwater protection program designed to monitor the onsite plant environment to aid in the early detection of leaks from plant systems and pipes containing radioactive liquid. Monitoring wells monitor onsite subsurface water. These wells are monitored monthly and quarterly for chemical and radioactive material. These wells are part of the State of Arizona Area-Wide Aquifer Protection Permit No. P-100388 and contain specific regulatory criteria for groundwater protection (ADEQ 2009a). Additional information on the groundwater protection program is contained in Section 2.1.7 of this document.

The staff reviewed PVNGS radiological environmental operating reports for 2004 through 2008 to look for unusual trends in the data or significant impacts to the environment (APS 2005b, 2006X2, 2007c, 2008h, 2009f). No unusual trends were observed, and the data showed no measurable impact to the environment from the operations at PVNGS.

4.8.1.2 Radioactive Effluent Release Program

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

The NRC staff reviewed the annual radioactive effluent release reports for 2004 through 2008 (APS 2005Y1, 2006Y2, 2007c, 2008h, 2009f). The review focused on the calculated doses to a member of the public from radioactive gaseous effluents released from PVNGS. There are no radioactive liquid effluent release pathways that impact members of the public. The doses were compared to the radiation protection standards in 10 CFR 20.1301 and the ALARA dose design objectives in Appendix I to 10 CFR Part 50.

Dose estimates for members of the public are calculated based on radioactive gaseous effluent release data and atmospheric transport models. The 2008 annual radioactive material release report (APS 2009Y5) contains a detailed presentation of the radioactive gaseous effluents and the resultant calculated doses. The following summarizes the calculated annual dose to a member of the public located outside the PVNGS site boundary from radioactive gaseous effluents released during 2008:

Unit 1

- The air dose at the site boundary from gamma radiation in gaseous effluents was 1.10×10^{-3} mrad (1.10×10^{-5} mGy), which is well below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents was 5.08×10^{-4} mrad (5.08×10^{-6} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The organ (teen thyroid) dose to an offsite member of the public from radioactive iodine and radioactive material in particulate form from gaseous effluents was 3.13×10^{-1} mrem (3.13×10^{-3} mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.

Unit 2

- The air dose at the site boundary from gamma radiation in gaseous effluents was 1.86×10^{-2} mrad (1.86×10^{-4} mGy), which is well below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents was 4.10×10^{-2} mrad (4.10×10^{-4} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The organ (teen thyroid) dose to an offsite member of the public from radioactive iodine and radioactive material in particulate form from gaseous effluents was 2.26×10^{-1} mrem (2.26×10^{-3} mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.

Unit 3

- The air dose at the site boundary from gamma radiation in gaseous effluents was 8.87×10^{-4} mrad (8.87×10^{-6} mGy), which is well below the 10 mrad (0.1 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The air dose at the site boundary from beta radiation in gaseous effluents was 3.13×10^{-4} mrad (3.13×10^{-6} mGy), which is well below the 20 mrad (0.2 mGy) dose criterion in Appendix I to 10 CFR Part 50.
- The organ (teen thyroid) dose to an offsite member of the public from radioactive iodine and radioactive material in particulate form from gaseous effluents was 1.78×10^{-1} mrem (1.78×10^{-3} mSv), which is well below the 15 mrem (0.15 mSv) dose criterion in Appendix I to 10 CFR Part 50.

Based on the staff's review and assessment of the PVNGS radioactive waste system performance in controlling radioactive effluents and the resultant doses to members of the public in conformance with the ALARA criteria, the NRC staff found that the 2008 radiological effluent data for PVNGS are consistent, with reasonable variation attributable to operating conditions and outages, with the historical radiological effluent releases and resultant doses. These results demonstrate that PVNGS is operating in compliance with Federal radiation protection standards.

The applicant has no plans to conduct refurbishment activities during the license renewal term, thus, no change to radiological conditions is expected to occur. Continued compliance with regulatory requirements is expected during the license renewal term; therefore, the impacts from radioactive effluents are not expected to change during the license renewal term.

4.8.2 Microbiological Organisms

PVNGS does not draw water from any natural surface water body in the area. It also does not release water to any natural surface water body. Therefore, the staff concludes that there would be no adverse impacts on public health from thermophilic microbiological organisms from continued operation of PVNGS in the license renewal period.

4.8.3 Electromagnetic Fields – Acute Shock

Based on the GEIS, the Commission found that electric shock resulting from direct access to energized conductors or from induced charges in metallic structures has not been a problem at most operating plants and generally is not expected to be a problem during the period of extended operation. However, a site-specific review is required to determine the significance of the electric shock potential along the portions of the transmission lines within the scope of the Supplemental EIS.

The GEIS states that it is not possible to determine the significance of the electric shock potential without a review of the conformance of each nuclear plant transmission line with National Electrical Safety Code (NESC) (IEEE 2007) criteria. Evaluation of individual plant transmission lines is necessary because the issue of electric shock safety was not addressed in the licensing process for some plants. For other plants, land use in the vicinity of transmission lines may have changed, or power distribution companies may have chosen to upgrade line voltage. To comply with 10 CFR 51.53(c)(3)(ii)(H), the applicant must provide an assessment of the potential shock hazard if the transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the NESC for preventing electric shock from induced currents.

All transmission lines associated with PVNGS were constructed in accordance with NESC and industry guidance in effect at that time (NRC 1982). Since the lines were constructed, a new criterion has been added to the NESC for power lines with voltages exceeding 98 kV. This criterion states that the minimum clearance for a line must limit induced currents due to static effects to 5 mA. APS has reviewed the transmission lines for compliance with this criterion (APS 2008a) and indicated that all transmission lines within the scope of this review have been restudied and the results show there are no locations under the transmission lines that have the capacity to induce more than 5 mA in a vehicle parked beneath the line. No induced shock hazard to the public should occur, since the lines are operating within original design specifications and meet current NESC clearance standards.

APS, Salt River Project and Southern California Edison implement transmission line assessment procedures at PVNGS to ensure continued monitoring and documenting of current conditions of the transmissions lines, maintenance and compliance with current standards. Routine aerial inspections and ground inspections are conducted to identify any ground clearance problems and the integrity of the transmission line structures (APS 2008a).

NRC staff has reviewed the available information, including the applicant's evaluation and computational results. Based on this information, the NRC staff evaluated the potential impacts for electric shock resulting from operation of PVNGS and its associated transmission lines. NRC staff concludes that the potential impacts from electric shock during the renewal period would be SMALL.

NRC staff identified a variety of measures that could mitigate potential acute electromagnetic field impacts resulting from continued operation of the PVNGS transmission lines. These mitigation measures would include erecting barriers along the length of the transmission line to prevent unauthorized access to the ground beneath the conductors and installing road signs at road crossings. These mitigation measures could reduce human health impacts by minimizing public exposures to electric shock hazards. NRC staff did not identify any cost benefit studies applicable to the mitigation measures mentioned above.

4.8.4 Electromagnetic Fields – Chronic Effects

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

The potential for chronic effects from these fields continues to be studied and is not known at this time. The National Institute of Environmental Health Sciences (NIEHS) directs related research through the U.S. Department of Energy (DOE). A report by NIEHS (NIEHS 1999) contains the following conclusion which is supported by recently published Environmental Health Criteria Monograph No.238 (WHO 2007a):

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

This statement is not sufficient to cause NRC staff to change its position with respect to the chronic effects of electromagnetic fields. This position is expressed in footnote 5 To Table B-1 of Appendix B to Subpart A of 10 CFR Part 51 as follows:

> If in the future, the Commission finds that, contrary to current indications, a consensus has been reached by appropriate Federal health agencies that there are adverse health effects from electromagnetic fields, the Commission will require applicants to submit plant-specific reviews of these health effects as part of their license renewal applications. Until such time, applicants for license renewal are not required to submit information on this issue.

NRC staff considers the GEIS finding of "Uncertain" still appropriate and will continue to follow developments on this issue.

4.9 SOCIOECONOMICS

The socioeconomic issues applicable to PVNGS are shown in Table 4.9 for Category 1, Category 2, and uncategorized issues. Section 2.2.9 of this report describes the socioeconomic conditions near PVNGS.

Table 4-9. Socioeconomic Issues

Issues	GEIS Section	Category
Housing Impacts	4.7.1	2
Public Services: public safety, social services, and tourism and recreation	4.7.3; 4.7.3.3; 4.7.3.4; 4.7.3.6	1
Public Services: public utilities	4.7.3.5	2
Public Services: education (license renewal term)	4.7.3.1	1
Offsite Land Use (license renewal term)	4.7.4	2
Public Services: transportation	4.7.3.2	2
Historic and Archaeological Resources	4.7.7	2
Aesthetic Impacts (license renewal term)	4.7.6	1
Aesthetic impacts of transmission lines (license renewal term)	4.5.8	1
Environmental Justice	Not addressed(a)	Uncategorized[a]

[a] Guidance related to environmental justice was not in place at the time the GEIS and the associated revisions to 10 CFR Part 51 were prepared. Therefore, environmental justice must be addressed in plant-specific reviews.

4.9.1 Generic Socioeconomic Issues

NRC staff reviewed and evaluated the PVNGS ER (APS 2008a), scoping comments, other available information, and visited the plant site and did not identify any new and significant information that would change the conclusions presented in the GEIS. Therefore, it is expected that there would be no impacts related to the Category 1 issues during the period of extended operation beyond those discussed in the GEIS. For PVNGS, the NRC incorporates the GEIS conclusions by reference. Impacts for Category 2 and uncategorized issues are discussed in Sections 4.9.2 through 4.9.7.

4.9.2 Housing Impacts

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

In 2000, approximately 16,000 persons lived within a 20-mile (32-km) radius of PVNGS, which equates to a population density of 13 persons per square mile (APS 2008a). This translates to a Category 1 density using the GEIS measure of sparseness (less than 40 persons per square mile within 20 miles and no community with 25,000 or more persons within 20 miles). At the same time, approximately 1,572,110 persons lived within a 50-mile (80-km) radius of the plant, for a density of 200 persons per square mile (APS 2008a). This translates to a Category 4 density using the GEIS measure of proximity (greater than or equal to 190 persons per square mile within 50 miles). Therefore, PVNGS is located in a medium population area based on the NRC sparseness and proximity matrix.

Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, states that impacts on housing availability are expected to be of small significance in a medium population area where growth-control measures are not in effect. Maricopa County, in which PVNGS is located, is not subject to growth-control measures that would limit housing development. Therefore, the PVNGS employment-related impact on housing availability would likely be small. Since APS has no plans to add non-outage employees during the license renewal period, employment levels at PVNGS would remain relatively constant with no additional demand for permanent housing during the license renewal term. In addition, the number of available housing units has kept pace with growth in the area population. Based on this information, there would be no impact on housing during the license renewal term beyond what has already been experienced.

4.9.3 Public Services: Public Utility Impacts

Impacts on public utility services are considered SMALL if there is little or no change in the ability of the system to respond to demand and thus there is no need to add capital facilities. Impacts are considered MODERATE if service capabilities are overtaxed during periods of peak demand. Impacts are considered LARGE if services (e.g., water, sewer) are substantially degraded and additional capacity is needed to meet ongoing demand. The GEIS indicated that, in the absence of new and significant information to the contrary, the only impacts on public utilities that could be significant are impacts on public water supplies.

Analysis of impacts on the public water and sewer systems considered both plant demand and plant-related population growth. Section 2.1.3 of this document describes the PVNGS use of water.

As previously discussed in Section 2.2.8.2, PVNGS provides pump seal cooling, sanitation, fire protection and potable water for drinking through the onsite groundwater well system. Since APS has no plans to add non-outage employees during the license renewal period, employment levels at PVNGS would remain relatively unchanged with no additional demand for public water services. Public water systems in the region would be adequate to meet the demands of residential and industrial customers in the area. Therefore, there would be no additional impact to public water services during the license renewal term beyond what is currently being experienced.

4.9.4 Offsite Land Use

Offsite land use during the license renewal term is a Category 2 issue (10 CFR Part 51.4 Subpart A, Appendix B, Table B-1). Table B-1 notes that “significant changes in land use may be associated with population and tax revenue changes resulting from license renewal.” Section 4.7.4 of the GEIS defines the magnitude of land use changes as a result of plant operation during the license renewal term as follows:

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

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

4.9.4.1 Population-Related Impacts

Since APS has indicated that it has no plans to add non-outage employees during the license renewal period, there would be no noticeable change in land use conditions in the vicinity of PVNGS. Therefore, there would be no population-related land use impacts during the license renewal term beyond those already being experienced.

4.9.4.2 Tax-Revenue-Related Impacts

As discussed in Section 2.2.8.6, APS pays annual real estate taxes to Maricopa County. For the 4-year period from 2005 through 2008, PVNGS tax payments to Maricopa County represented between 1.1 and 1.6 percent of the county's total tax revenue collections.

Since APS has no plans to add non-outage employees during the license renewal period, employment levels at the PVNGS would remain relatively unchanged. There would be no change in the assessed value of PVNGS, and annual property tax payments to Maricopa County would be expected to remain relatively unchanged throughout the license renewal period. Based on this information, there would be no tax-revenue-related offsite land use impacts during the license renewal term beyond those already being experienced.

4.9.5 Public Services: Transportation Impacts

Table B-1 in 10 CFR Part 51 states the following:

> Transportation impacts (level of service) of highway traffic generated...during the term of the renewed license are generally expected to be of small significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites.

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

4.9.6 Historic and Archaeological Resources

The *National Historic Preservation Act of 1966* (NHPA), as amended through 2000, requires Federal agencies to take into account the potential effects of their undertakings on historic properties. Historic properties are defined as resources that are eligible for listing on the *National Register of Historic Places*. The criteria for eligibility include (1) association with significant events in history; (2) association with the lives of persons significant in the past; (3) embodiment of distinctive characteristics of type, period, and construction; and (4) association with or potential to yield important information (ACHP 2008). The historic preservation review process mandated by Section 106 of the NHPA is outlined in regulations issued by the Advisory Council on Historic Preservation in Title 36, "Parks, Forests, and Public Property," Part 800, "Protection of Historic Properties," of the *Code of Federal Regulations* (36 CFR Part 800). The renewal of a nuclear power plant operating license is a Federal action that could potentially affect either known or currently undiscovered historic properties located on or near the plant site and its associated transmission corridors. In accordance with the provisions of the NHPA, the NRC is required to identify historic properties in the area of potential effect. If no historic properties are present or affected, the NRC is required to notify the State Historic Preservation Office (SHPO) before proceeding. If it is determined that historic properties are present, the NRC is required to assess and resolve possible adverse effects of license renewal.

APS has formal guidelines in its *Environmental Review and Evaluation Manual* (91DP-0EN02) for protecting archaeological resources and consulting with the SHPO prior to ground disturbing activities. Another procedure, *Excavation, Placement and Backfill* (37DP-9ZZ11) requires work to be stopped if an artifact of possible historical or archaeological interest is found during earthmoving activities. Arizona State burial law also requires a work stoppage if any human remains are unexpectedly uncovered. The NRC staff reviewed these procedures and examples of how APS applied these procedures during the site audit.

Similar reviews of vegetation management plans for transmission lines were conducted. APS procedures incorporate Federal and State regulations regarding protection of archaeological sites from potential impacts of ground-disturbing activities along the transmission lines, including *California Code of Regulations*, Title 14, Section 15000 et seq., "Guidelines for Implementation of the California Environmental Quality Act," and the *National Historic Preservation Act*. APS procedures require surveys prior to mechanical clearing of vegetation. APS is currently conducting a four-year program (2007–2011) to complete cultural resource surveys of all of its transmission corridors to expedite future vegetation management along these transmission lines. The Salt River Project (SRP) owns and operates several of the transmission lines associated with PVNGS. SRP's Vegetation Management Plan states archaeological studies are conducted prior to mechanical clearing when required by the landholding Federal agency.

Records on file at the AZ SHPO and the AZSITE database pertaining to the PVNGS property were reviewed by a qualified archaeologist from Argonne National Laboratory under contract with the NRC. Locations recorded in the AZSITE database corresponded to site locations that were identified during the initial survey and mitigated in 1975 (Stein 1981a,b).

Based on its review of agency files, published literature, and information provided by APS, staff concludes that potential impacts from license renewal of PVNGS on historic and archaeological resources would be SMALL. This conclusion is based on the results of archaeological surveys conducted on the property prior to initial plant and transmission line construction and verified use of existing environmental procedures by PVNGS.

4.9.7 Environmental Justice

Under Executive Order (E.O.) 12898, Federal agencies are responsible for identifying and addressing potential disproportionately high and adverse human health and environmental impacts on minority and low-income populations. Although the Executive Order is not mandatory for independent agencies such as the NRC, the NRC has voluntarily committed to undertake environmental justice reviews. In 2004, the Commission issued a *Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions* (69 FR 52040), which states “The Commission is committed to the general goals set forth in E.O. 12898, and strives to meet those goals as part of its NEPA review process.”

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

> **Disproportionately High and Adverse Human Health Effects.** Adverse health effects are measured in risks and rates that could result in latent cancer fatalities, as well as other fatal or nonfatal adverse impacts on human health. Adverse health effects may include bodily impairment, infirmity, illness, or death. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant (as defined by NEPA [National Environmental Policy Act]) and appreciably exceeds the risk or exposure rate for the general population or for another appropriate comparison group (CEQ 1997).

> **Disproportionately High and Adverse Environmental Effects.** A disproportionately high environmental impact that is significant (as defined by NEPA) refers to an impact or risk of an impact on the natural or physical environment in a low-income or minority community that appreciably exceeds the environmental impact on the larger community. Such effects may include ecological, cultural, human health, economic, or social impacts. An adverse environmental impact is an impact that is determined to be both harmful and significant (as defined by NEPA). In assessing cultural and aesthetic environmental impacts, impacts that uniquely affect geographically dislocated or dispersed minority or low-income populations or American Indian tribes are considered (CEQ 1997).

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

- **Minority individuals.** Individuals who identify themselves as members of the following population groups: Hispanic or Latino, American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, or two or more races meaning individuals who identified themselves on a Census form as being a member of two or more races, for example, Hispanic and Asian.

- **Minority populations.** Minority populations are identified when (1) the minority population of an affected area exceeds 50 percent or (2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis.
- **Low-income population.** Low-income populations in an affected area are identified with the annual statistical poverty thresholds from the Census Bureau's Current Population Reports, Series PB60, on Income and Poverty.

4.9.7.1 Minority Population in 2000

According to 2000 census data, 43.2 percent of the population (689,337 individuals) residing within a 50-mile (80-km) radius of PVNGS identified themselves as minority individuals (USCB 2009). The largest minority group was Hispanic (532,832 individuals, or 33.4 percent), followed by Black or African American (73,281 individuals, or 4.6 percent). Approximately 48 percent of the Maricopa County population is minority, with Hispanic (24.8 percent) the largest minority group, followed by Black or African American (3.7 percent) (USCB 2009).

The 50-mile radius around PVNGS includes any census block located within the 50-mile radius. Of the 1,256 census block groups located wholly or partly within the 50-mile radius of PVNGS, 841 block groups were determined to have minority population percentages that exceeded the state percentages by 20 percentage points or more, while there were 545 block groups where minority populations were more than 50 percent of the total (APS 2008a). The largest number of minority block groups was Hispanic, with 364 block groups that exceeded the State percentage of 20 percent or more, and 322 that were more than 50 percent Hispanic. These block groups are concentrated in urban areas with high population densities, primarily in Maricopa County, and in the city of Phoenix, Arizona, in particular. Census block groups to the south and southwest of PVNGS also have Hispanic populations exceeding threshold levels. Based on 2000 census data, Figure 4-1 shows minority block groups within a 50-mile (80-km) radius of PVNGS.

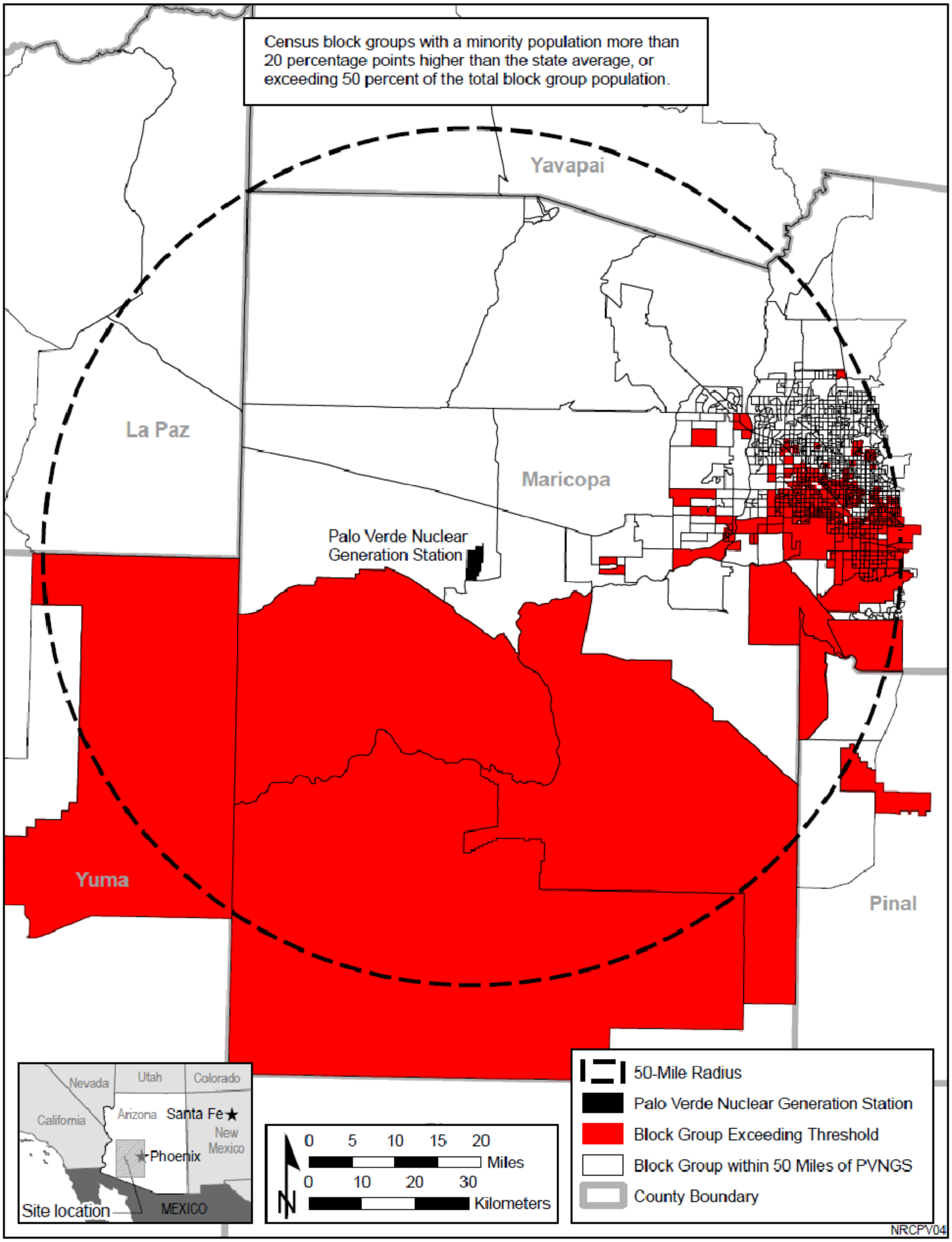
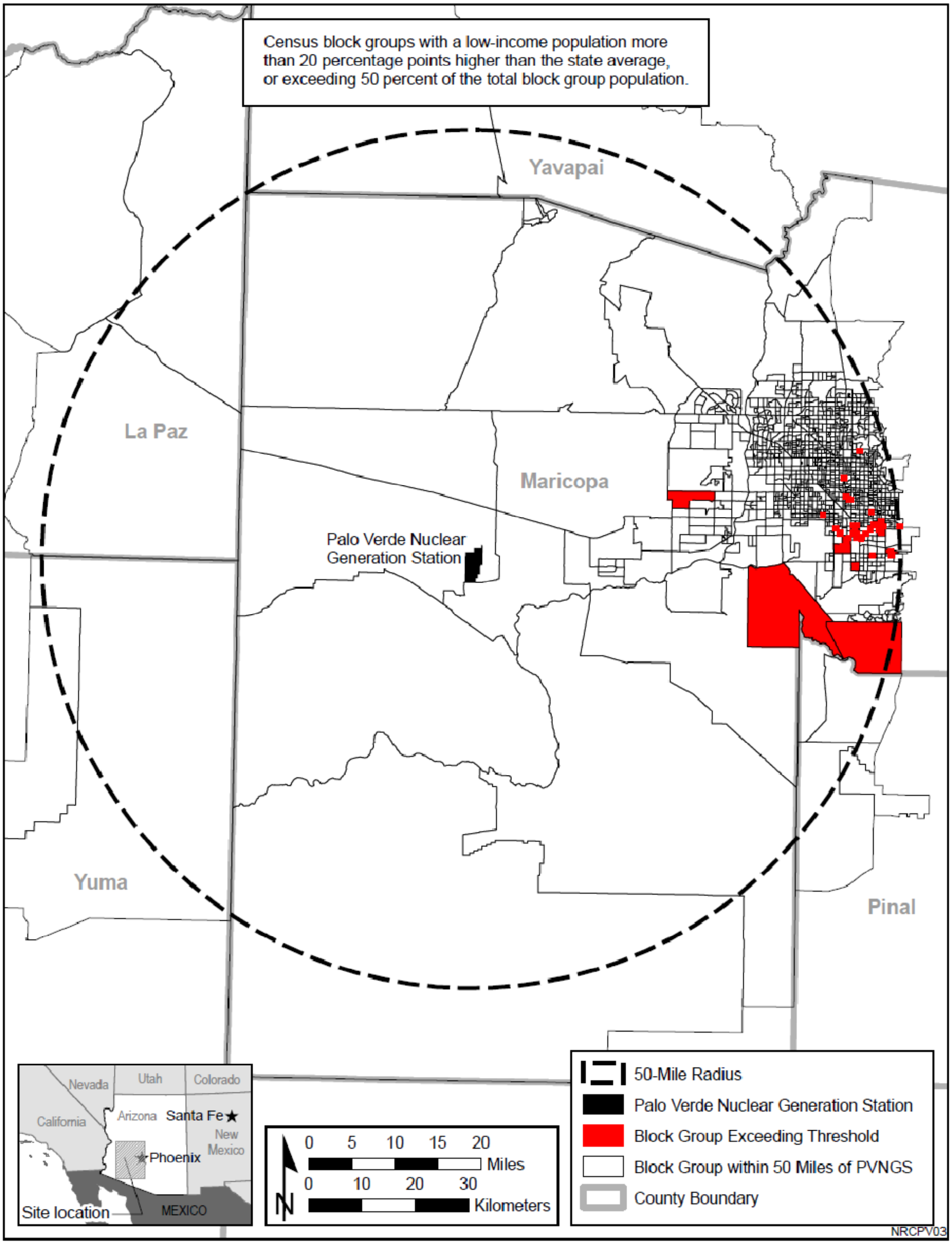


Figure 4.9.7-1. Minority block groups within a 50-mile radius of PVNGS (USCB 2009).

4.9.7.2 Low-Income Population in 2000

According to 2000 census data, 238,112 individuals (14.9 percent) residing within a 50-mile radius of PVNGS were identified as living below the Federal poverty threshold (USCB 2009). The 1999 Federal poverty threshold was $17,029 for a family of four. According to Census Bureau data, the median household income for Arizona in 2007 was $49,923, while 14.1 percent of the state population was determined to be living below the 1999 Federal poverty threshold. Maricopa County had one of the higher median household incomes ($54,733) and a lower percentage (12.9 percent) of individuals living below the poverty level when compared to other counties in Arizona (USCB 2009).

Census block groups were considered low-income block groups if the percentage of households below the Federal poverty threshold exceeded the state average by 20 percent or more. Based on 2000 Census data, there were 108 block groups within the 50-mile (80-km) radius of PVNGS that exceeded the state average for low-income households by 20 percent or more, and 21 block groups that were more than 50 percent low income (APS 2008a). The majority of census block groups with low-income populations were located in Maricopa County, primarily in the city of Phoenix, Arizona. Based on 2000 Census data, Figure 4-2 shows low-income block groups within a 50-mile radius of PVNGS.

1 

2 **Figure 4.9.7-2. Low-income block groups within 50-mile radius of PVNGS (APS 2008a).**

4.9.7.3 Analysis of Impacts

Consistent with the impact analysis for the public and occupational health and safety, the affected populations are defined as minority and low-income populations who reside within a 50-mile (80-km) radius of PVNGS. Based on the analysis of environmental health and safety impacts presented in this document for other resource areas, there would be no high and adverse impacts from the operation of PVNGS during the license renewal period.

NRC also analyzed the risk of radiological exposure through the consumption patterns of special pathway receptors, including subsistence consumption of fish, native vegetation, surface waters, sediments, and local produce; absorption of contaminants in sediments through the skin; and inhalation of plant materials. The special pathway receptors analysis is important to the environmental justice analysis because consumption patterns may reflect the traditional or cultural practices of minority and low-income populations in the area. This analysis is presented below.

4.9.7.4 Subsistence Consumption

Section 4-4 of Executive Order 12898 (1994) directs Federal agencies, whenever practical and appropriate, to collect and analyze information on the consumption patterns of populations who rely principally on fish and/or wildlife for subsistence and to communicate the risks of these consumption patterns to the public. In this document, NRC considered whether there were any means for minority or low-income populations to be disproportionately affected by examining impacts to American Indian, Hispanic, and other traditional lifestyle special pathway receptors. Special pathways that took into account the levels of contaminants in native vegetation, crops, soils and sediments, surface water, fish, and game animals on or near PVNGS were considered.

As described in Section 4.8.1 of this document, APS maintains a comprehensive Radiological Environmental Monitoring Program (REMP) at PVNGS to assess the impact of site operations on the environment. Summarized results of sampling and analyses conducted on air, vegetation, milk, water, sludge and sediment are presented in the following paragraphs (APS 2009f).

Air particulate filters and charcoal cartridges were analyzed for gross beta activity, gamma emitting radionuclides and radioiodine. Gross beta activity is consistent with pre-operational baseline and previous operational results. Gamma and radioiodine analysis observed no detectable levels of Cesium-134, Cesium-137, or Iodine-131 in any of the samples.

Vegetation samples (cabbages) were analyzed for gamma emitting radionuclides. No gamma emitting radionuclides were observed in any of the samples.

Goat and cow milk samples were analyzed for gamma emitting radionuclides. No gamma emitting radionuclides were observed in any of the samples.

Drinking water samples were analyzed for gross beta activity, tritium and gamma emitting radionuclides. No tritium or gamma emitting radionuclides were observed in any samples. Gross beta activity was either less than detectable or low enough to be attributable to natural (background) radioactive materials.

Groundwater samples were analyzed for tritium and gamma emitting radionuclides. No tritium or gamma-emitting radionuclides were observed in any samples.

Although no tritium or gamma-emitting radionuclides were observed in any groundwater samples, tritium was found in subsurface water onsite, within the Radiological Controlled Area (RCA) in 2006. Section 2.1.7.4 of this document discusses the potential sources of tritium and the corrective actions taken including the installation of monitoring wells which are routinely sampled for radiological analyses. APS has not identified any increased health or safety risk to the public or onsite personnel as a result of the tritium discovery.

Surface water samples were analyzed for tritium and gamma emitting radionuclides. The following discussion of surface water sampling and analysis includes the Water Reclamation Facility (WRF) influent, the water storage reservoirs, the evaporation ponds and Sedimentation Basin #2.

As described in Sections 2.2.6 of this document, the main source of cooling water for PVNGS is wastewater effluent from Phoenix-area wastewater treatment plants. This wastewater is pumped to the on-site WRF where it is treated to meet the plant's water quality requirements. Samples of WRF influent were analyzed for tritium and gamma emitting radionuclides.

Iodine-131 was observed routinely in this influent and is due to radiopharmaceutical Iodine-131 use in the Phoenix area ending up in the Phoenix sewage effluent. No tritium was observed in any samples.

After being treated by the WRF, this water is stored in the water storage reservoirs. Reservoir water samples were analyzed for tritium and gamma emitting radionuclides. Iodine-131 was observed in the reservoir samples but tritium was not. These results are consistent with the WRF influent results.

Water from the WRF and water storage reservoirs is used for cooling the reactors. Cooling water that has gone through several cycles of reactor cooling (system blowdown) is discharged to above grade evaporation ponds. Evaporation pond samples were analyzed for tritium and gamma emitting radionuclides. Iodine-131 was observed in the evaporation ponds consistent with the WRF influent and water storage reservoirs. Tritium was also observed in these samples. APS attributes this tritium to permitted gaseous effluent releases and secondary plant liquid discharges.

Sedimentation Basin #2 was sampled and analyzed for tritium and gamma-emitting radionuclides. This basin was dry for most of 2009. No tritium or gamma-emitting radionuclides were observed in any samples.

Sludge samples from the WRF centrifuge were analyzed by gamma spectroscopy. Iodine-131 was present consistent with prior year sample results. Indium-111, a diagnostic radiopharmaceutical, was also identified in the sludge. Sludge and sediment samples from the cooling towers and/or circulating water canals were analyzed for gamma emitting radionuclides, and results are consistent with previous years.

The results of the PVNGS REMP from 2004 through 2008 demonstrate that the only significant or measurable radiological impact on the environment was the tritium discovered in subsurface water onsite in 2006. No elevated radiation levels were detected in the offsite environment as a result of plant operations and the storage of radioactive waste. The results of the REMP continue to demonstrate that the operation of the plant did not result in a significant measurable dose to a member of the general population or adversely impact the environment as a result of radiological effluents. The REMP continues to demonstrate that the dose to a member of the public from the operation of PVNGS remains significantly below the Federally-required dose limits specified in 10 CFR Part 20, 10 CFR 72, and 40 CFR 190 (APS 2009f).

Based on recent monitoring results, concentrations of contaminants in air, vegetation, milk, water, sludge and sediment at and near PVNGS have been at or near the threshold of detection and seldom above background levels (APS 2009f). Consequently, no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations in the region as a result of subsistence consumption.

4.10 EVALUATION OF NEW AND POTENTIALLY SIGNIFICANT INFORMATION

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

In preparing to submit its application to renew the PVNGS operating license, APS developed a process to ensure that information not addressed in or available during the GEIS evaluation regarding the environmental impacts of license renewal for PVNGS would be properly reviewed before submitting the ER, and to ensure that such new and potentially significant information would be identified, reviewed, and assessed during the NRC review period. APS reviewed the Category 1 issues that appear in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, to verify that the conclusions of the GEIS remained valid with respect to PVNGS. This review was performed by personnel from PVNGS and its support organization that were familiar with NEPA issues and the scientific disciplines involved in the preparation of a license renewal ER. NRC also has a process for identifying new and significant information. That process is described in detail in NUREG-1555, Supplement 1, Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan for Operating License Renewal (NRC 2000). The search for new information includes (1) review of an applicant's ER and the process for discovering and evaluating the significance of new information; (2) review of records of public comments; (3) review of environmental quality standards and regulations;

(4) coordination with Federal, State, and local environmental protection and resource agencies; and (5) review of the technical literature. New information discovered by the NRC staff is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues where new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to the assessment of the relevant new and significant information; the scope of the assessment does not include other facets of the issue that are not affected by the new information.

The NRC staff has not identified any new and significant information on environmental issues listed in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, related to the operation of PVNGS during the period of license extension. The NRC staff also determined that information provided during the public comment period did not identify any new issues that require site-specific assessment. The NRC staff reviewed the discussion of environmental impacts in the GEIS (NRC 1996) and conducted its own independent review (including the public scoping meetings held in July 2009) to identify new and significant information.

4.11 CUMULATIVE IMPACTS

The NRC staff considered potential cumulative impacts in the environmental analysis of continued operation of PVNGS. For the purposes of this analysis, past actions are those related to the resources at the time of the power plant licensing and construction. Present actions are those related to the resources at the time of current operation of the power plant, and future actions are considered to be those that are reasonably foreseeable through the end of plant operation including the period of extended operation. Therefore, the analysis considers potential impacts through the end of the current license terms as well as the 20-year renewal license term. The geographic area over which past, present, and future actions would occur is dependent on the type of action considered and is described below for each impact area.

The impacts of the proposed action, as described in Sections 4.1–4.9, are combined with other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

4.11.1 Cumulative Impacts on Water Resources

4.11.1.1 Groundwater Use

PVNGS draws water from three onsite wells completed in the regional aquifer at depths ranging from 340 feet (104 meters) to 1,413 feet (431 meters) (as listed in Table 2.1.7-1). Based on usage from 2001 through 2008, the maximum demand for these wells is about 1,535 gpm (6,978 liters per minute) or 2,476 acre-feet (3.1 million cubic meters) per year (reported for 2006), well below the 3,206 gpm (14,575 liters per minute) authorized by the ADWR as part of the plant's grandfathered nonirrigation groundwater right within the Phoenix AMA. The average annual demand for groundwater in the Phoenix AMA is estimated at 883,000 acre-feet (1.1 billion cubic meters). In comparison, PVNGS operational uses are considered inconsequential, i.e., less than 1 percent of annual demand for groundwater in the Phoenix AMA (ADWR 2008).

Based on the current and planned groundwater pumping rates and the fact that the PVNGS pumps groundwater at rates well below its authorized water right, the NRC staff concludes that the plant's contribution to cumulative impacts on groundwater resources through its water usage would be SMALL, and no additional mitigation is warranted.

4.11.1.2 Surface Water Use

PVNGS annually diverts approximately 53,000 acre-feet (73.1 million cubic meters) of treated effluent that would otherwise be discharged to the Gila River (APS 2008a). This constitutes about 43 percent of the treated effluent generated by the 91st Avenue Wastewater Treatment Plant. Given that the projected annual flow volumes of the treatment plant are expected to increase by as much as 90 percent over the next 20 years, almost double its current capacity, and PVNGS annual usage is not expected to increase the proportion of the treated effluent from the 91st Avenue Wastewater Treatment Plant used by the nuclear plant would be reduced by about half (to about 22 percent by 2030).

Based on its current and planned treated effluent usage rates and the fact that the ADWR's management goal for the Phoenix AMA is to increase the use of renewable (recycled) water supplies (even though such increases would reduce the perennial flow and recharge capacity of the Gila River), the NRC staff concludes that the plant's contribution to cumulative impacts on surface water resources through its water usage would be SMALL, and no additional mitigation is warranted.

4.11.2 Cumulative Impacts of Thermophilic Microbiological Organisms and Electromagnetic Fields

PVNGS does not discharge water to a natural surface water body. Therefore, the NRC staff concludes that the cumulative impacts on public health from thermophilic microbiological organisms from continued operation of PVNGS during the license renewal period would be SMALL.

The NRC staff determined that the PVNGS transmission lines are operating within original design specifications and meet current NESC clearance standards; therefore, the PVNGS transmission lines do not detectably affect the overall potential for electric shock from induced currents within the analysis area. With respect to the chronic effects of electromagnetic fields, although the GEIS finding of “not applicable” is appropriate to PVNGS, the transmission lines associated with PVNGS are not likely to detectably contribute to the regional exposure to extremely low frequency electromagnetic fields. Therefore, the NRC staff concludes that the cumulative impacts of continued operation of the PVNGS transmission lines would be SMALL.

4.11.3 Cumulative Impacts on Aquatic Resources

PVNGS does not draw water from any natural surface water body in the area. Instead, it uses treated wastewater effluent from the Phoenix area.

PVNGS does not release water to any natural surface water body. Instead, water is discharged to man-made lined evaporation ponds with no outlet and no hydraulic connection to any natural water body. The NRC staff concludes that the cumulative impacts of continued operation of PVNGS on aquatic resources would be SMALL.

4.11.4 Cumulative Impacts on Terrestrial Resources

This section addresses past, present, and future actions that could result in adverse cumulative impacts to terrestrial resources, including wildlife populations, desert wash habitats, invasive species, protected species, and land use. For purposes of this analysis, the geographic area considered in the evaluation includes the PVNGS site and in-scope transmission line ROWs.

Approximately 1330 acres of the 4280 acres of PVNGS are developed and maintained for operation of PVNGS (APS 2008a). Developed areas with impervious surfaces have increased precipitation runoff and reduced infiltration into the soil, thus reducing groundwater recharge and increasing soil erosion. Undeveloped portions of the site are composed predominately of desert wash habitat. Before PVNGS was constructed, the site’s land was open desert (NRC 1975).

Construction of the transmission lines maintained by Salt River Project (SRP), Arizona Public Service Company (APS), and Southern California Edison (SCE) for PVNGS resulted in subsequent changes to the wildlife and plant species present within the vicinity of PVNGS. Some fragmentation may have occurred, though because the transmission lines pass through lands that are primarily desert habitat or cultivated farmland, these impacts were likely minimal. ROW maintenance, such as spraying of herbicides, has likely had past impacts and is likely to continue to impact the terrestrial habitat. These impacts may include bioaccumulation of chemicals and prevention of the natural successional stages of the surrounding vegetative communities in and around the ROWs. ROW maintenance has also likely resulted in increases in invasive species, such as saltcedar (*Tamarix* spp.), which are typically more aggressive than native species in colonizing disturbed areas. Within the ROWs, the Saguaro cactus is transplanted or removed because it is a safety threat due to the species' ability to conduct electricity. Cumulatively, this action over time could limit the local recruitment of this species.

Protected terrestrial species, which are discussed in Sections 2.2.7.2 and 4.7.2, are not expected to be adversely affected due to future actions during the renewal term. Numerous wildlife refuges and national parks are located near PVNGS and its associated transmission line ROWs, and these will continue to provide habitat to protected species and other wildlife.

There are no known Federal projects and little industrial development near the immediate vicinity of PVNGS (APS 2008a). Phoenix, the nearest metropolitan area, is 26 miles (42 km) east of the site. Four natural gas-fired power plants are located near PVNGS, which could contribute to cumulative effects on terrestrial resources. The four plants are: Red Hawk Power Station, located 3 miles (5 km) south of the PVNGS site, Mesquite Power Generating Station, also located 3 miles (5 km) south of the site, Arlington Valley Energy Facility just south of the site, and New Harquahala Generating Company, located 17 miles (27 km) northwest of the site (APS 2008a). ROW maintenance of the transmission lines associated with these facilities will have similar cumulative impacts as those discussed above.

The NRC staff examined the cumulative effects of habitat fragmentation, the spread of invasive species, impacts to protected species, and effects of neighboring facilities. The NRC staff concludes that the minimal terrestrial impacts from continued PVNGS operations would not contribute to the overall decline in the condition of terrestrial resources. Furthermore, the NRC staff concludes that the cumulative impacts of other and future actions during the term of license renewal on terrestrial habitat and associated species, when added to past, present, and reasonably foreseeable future actions, would be SMALL.

4.11.5 Cumulative Air Quality Impacts

The analysis below considers potential impacts through the end of the current license term as well as the 20-year renewal license term. As described in Section 2.2.2.2 (Air Quality Impacts), the Phoenix metropolitan area is designated as a nonattainment area for 8-hour ozone and PM_{10}. In support of improved air quality, APS promotes a travel reduction program that includes vanpooling, travel reduction incentives, compressed work weeks, telecommuting, and videoconferencing at PVNGS (APS 2008a). APS has reduced its contributions to air pollutant emissions (including greenhouse gases (GHGs)) and traffic congestion in the area as a result of these efforts.

Operational activities at PVNGS release GHGs (see Table 2.2.2-1), including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Combustion-related GHG emissions (such as CO_2, CH_4 and N_2O) at PVNGS are minor, given the nature of a nuclear facility that is not burning fossil fuels to generate electricity. As discussed in Section 2.2.2.2, GHG stationary emission sources at PVNGS include primarily emergency diesel generators, diesel fire pumps, auxiliary boilers, and miscellaneous portable equipment. These combustion sources are designed for efficiency and operated using good combustion practices on a limited basis throughout the year (often only for testing). Other combustion-related GHG emission sources at PVNGS include commuter, visitor, support, and delivery vehicle traffic within, to, and from PVNGS. In addition, a small amount of CH_4 emissions would be released from biological treatment at the Water

Reclamation Facility. The HFCs and PFCs with higher global warming potential (GWP)[7] are contained in refrigeration systems, while SF_6 with the highest GWP is contained in high-voltage electric equipment; thus, emissions of HFCs and PFCs would be zero, unless these chemicals are mismanaged or mishandled. APS inventories and manages its GHG-containing equipment through its Emergency Planning and Community Right-to-Know Act Section 312 Tier II reporting program and Pollution Prevention Plan reporting program with the Arizona Department of Environmental Quality (ADEQ) (see Section 2.1.3 Nonradioactive Waste Management). In particular, APS's Pollution Prevention Plan (PPP) includes pollution prevention opportunities to eliminate, reduce, reuse or recycle each waste, emission or toxic substance and submits an annual PPP Progress Report to the ADEQ Pollution Prevention Program (ADEQPPP) that tracks the facility operating activities in achieving the Plan goals. Based on the above discussions, release of GHGs should be minor, and the potential impacts of continued operation of PVNGS on climate change are anticipated to be SMALL.

Along with other southwestern states, Arizona is experiencing the ramifications of climate change, such as prolonged drought, degraded forest health, early snowmelts and the attendant severe forest fires, and declining water levels and quality in lakes and reservoirs. In response, Arizona has established two primary objectives in coordination with ADEQ: (1) to prepare an inventory and forecast of GHG emissions in Arizona (ACCAG 2006a); and (2) to develop a Climate Change Action Plan to reduce GHG emissions in Arizona (ACCAG 2006b). In addition, Arizona established a primary Statewide goal of reducing GHG emissions in Arizona to 2000 levels by 2020 and to 50 percent below 2000 levels by 2040.

Recently, the Southwest[8] has experienced rapid population and economic growth. Associated with this growth, it has experienced warming at a rate significantly higher than the global average (GCCRP 2009). The prospect of droughts becomes more severe as a result of environmental warming. Changes in precipitation patterns and projected temperature increases are expected to cause reductions in rain and snowmelt in the spring months, when water is most needed to fill reservoirs to meet summer demands. Record wildfires have also been observed with rising temperatures and associated reductions in spring snowpack and soil moisture. Water, already in great demand, is at the center of many conflicts in the Southwest. Continued rapid population and economic growth will likely exacerbate water conflicts.

Provided below is a brief discussion of the impacts to air quality if fossil-fuel power plant(s) replaced the generating capacity of PVNGS to meet the electricity demands in the region.

A more detailed analysis of alternatives and their associated potential impacts are presented in Chapter 8, including a discussion of the power generation technologies and control equipment likely to be used at the time the PVNGS licenses expire.

Nuclear power generation avoids GHG emissions that would otherwise be released from fossil-fuel power plants, such as coal- or natural gas-fired power plants. GHG emissions at fossil-fuel power plants result primarily from the burning of fossil fuel for power generation.

[7] Various greenhouse gases have different GWP, defined as the cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas, CO_2. As the reference point in this index, CO_2 has a GWP of 1. On the basis of 100-year time horizon, GWPs for other key GHGs are as follows (IPCC 2007): 21 for CH_4, 310 for N_2O, 11,700 for HFC-23, and 23,900 for SF_6.

[8] The Southwest region includes Arizona, California, Nevada, Utah, and western parts of Colorado, New Mexico, and Texas within the Rocky Mountains.

To estimate the amount of CO_2 releases avoided by continued operation of PVNGS, its electricity generation can be compared to an equivalent amount of electricity generation in fossil-fuel power plant(s). For 2005, the composite CO_2 emission factor (representing an average of all operating fossil-fuel power plants) is approximately 1,700 pounds per megawatt hour (lb/MWh) for Arizona (EPA 2009b). PVNGS generates approximately 29,933 gigawatt hours (GWh) per year (assuming a power generating capacity of 4,020 MWe and a capacity factor of 85 percent). Thus, PVNGS generating capacity avoids the release of 23.1 million metric tons of CO_2. This is approximately 20 percent of the projected total gross CO_2 emissions for Arizona in 2010. Considering other GHG emissions, such as N_2O or CH_4, the total GHG emissions being avoided should be slightly higher than those estimated above.

In summary, the NRC staff concludes that potential impacts from the continued operation of PVNGS on GHG emissions and climate change would be SMALL. Replacing PVNGS generating capacity with fossil-fuel generating capacity would result in significant emissions of GHG. Therefore, continued operation of PVNGS contributes to more positive impacts than adverse impacts on environmental warming.

4.11.6 Cumulative Human Health Impacts

The NRC and EPA established radiological dose limits for protection of the public and workers from both acute and long-term exposure to radiation and radioactive materials. These dose limits are codified in 10 CFR Part 20 and 40 CFR Part 190. As discussed in Section 4.8.1, the doses resulting from operation of PVNGS are below regulatory limits, and the impacts of these exposures are SMALL. For the purposes of this analysis, the geographical area considered is the area included within a 50-mile (80-km) radius of the PVNGS site.

EPA regulations in 40 CFR Part 190 limit the dose to members of the public from all sources in the nuclear fuel cycle, including nuclear power plants, fuel fabrication facilities, waste disposal facilities, and transportation of fuel and waste. As discussed in Section 4.8.1, PVNGS has conducted a radiological environmental monitoring program since 1979, well before commercial operation began in 1985. This program measures radiation and radioactive materials in the environment from PVNGS and all other sources. The NRC staff reviewed the radiological environmental monitoring results for the five-year period from 2004-2008 as part of the cumulative impacts assessment. There are no other uranium fuel cycle facilities with a 50-mile (80 km) radius of PVNGS. The NRC and the State of Arizona will regulate any future development or actions near PVNGS that could contribute to cumulative radiological impacts.

Based on the NRC staff's review of PVNGS's radiological environmental monitoring results, the radioactive effluent release data, and the expected continued compliance with Federal radiation protection standards, the cumulative radiological impacts to the public from the operation of PVNGS during the renewal term would be SMALL.

4.11.7 Cumulative Socioeconomic Impacts

As discussed in Section 4.4 of this document, the continued operation of PVNGS during the license renewal term would have no impact on socioeconomic conditions in the region beyond those already being experienced. Since APS has no plans to hire additional non-outage workers during the license renewal term, overall expenditures and employment levels at PVNGS would remain relatively constant with no additional demand for permanent housing and public services. In addition, since employment levels and tax payments would not change, there would be no population and tax revenue-related land use impacts. There would also be no disproportionately high or adverse health or environmental impacts on minority and low-income populations in the region. Based on this and other information presented in Chapter 4 of this document, there would be no cumulative socioeconomic impacts from the continued operation of PVNGS during the license renewal term beyond what is currently being experienced.

It does not appear likely that the proposed license renewal would adversely affect cultural resources at PVNGS. APS has indicated that no refurbishment or replacement activities, including additional land-disturbing activities, at the plant site (or along existing transmission corridors) are planned for the license renewal period (APS 2008a). Absent land-disturbing activities, continued operation of PVNGS would likely protect any cultural resources present within the PVNGS site boundary by protecting those lands from development and providing secured access. Prior to any ground-disturbing activity in an undisturbed area, it is expected the applicant would evaluate the potential for impacts on cultural resources according to APS procedure (91DP-0EN02) and in consultation with the AZ SHPO and appropriate Native American Tribes, as required under Section 106 of the *National Historic Preservation Act*; therefore, the incremental contribution to a cumulative impact on cultural resources by continued operation of PVNGS during the license renewal period would be SMALL.

4.11.8 Summary of Cumulative Impacts

NRC staff considered the potential impacts resulting from the operation of PVNGS during the period of extended operation and other past, present, and future actions in the vicinity of PVNGS. The preliminary determination is that the potential cumulative impacts resulting from PVNGS operation during the period of extended operation would be SMALL.

Table 4-11. Summary of Cumulative Impacts on Resources Areas

Resource Area	Impact	Discussion
Water Resources	SMALL	PVNGS operational uses of groundwater are considered inconsequential, i.e., less than 1 percent of annual demand for groundwater in the Phoenix AMA. PVNGS annual use of treated wastewater effluent from the Phoenix area is expected to decrease as a percentage of available effluent over time, therefore, the plant's contribution to cumulative impacts on surface water resources through its water usage would be SMALL.
Electromagnetic Fields and Thermophilic Microbiological Organisms	SMALL	The NRC staff determined that PVNGS transmission lines are operating within original design specifications and meet current NESC clearance standards; therefore, PVNGS transmission lines do not detectably affect the overall potential for electric shock from induced currents within the analysis area. With respect to the chronic effects of EMFs, although the GEIS finding of "not applicable" is appropriate to PVNGS, the transmission lines associated with PVNGS are not likely to detectably contribute to the regional exposure of extremely low frequency-electromagnetic fields; therefore, the NRC staff has determined that the cumulative impacts of the continued operation of the PVNGS transmission lines would be SMALL. PVNGS does not release cooling water (or cooling water blowdown) effluents to any natural surface water body. The staff concludes that the cumulative impacts on public health from thermophilic microbiological organisms from continued operation of PVNGS during the license renewal period would be SMALL.

Resource Area	Impact	Discussion
Aquatic Resources	SMALL	PVNGS does not draw its cooling (or makeup) water from any natural surface water body in the area. It also does not release cooling water (or cooling water blowdown) effluents to any natural surface water body. Therefore, the cumulative impact on aquatic resources would be SMALL.
Terrestrial Resources	SMALL	Protected terrestrial species are not expected to be adversely affected by future actions during the renewal term. Numerous wildlife refuges and national parks are located near PVNGS and its associated transmission lines, and these will continue to provide habitat for wildlife. Cumulative impacts on terrestrial resources resulting from all past, present, and reasonably foreseeable future actions would be SMALL.
Air Quality	SMALL	No new or significant information was identified during the review of PVNGS ER, the site audit, or the scoping process. Therefore, there are no impacts related to air quality beyond those discussed in the GEIS. NRC staff concludes that the minimal air quality impacts expected from the continued PVNGS operation would not destabilize the air quality in the vicinity of PVNGS; therefore, the NRC staff concludes that the cumulative impacts on the air quality from the continued operation of PVNGS during the license renewal period would be SMALL.
Human Health	SMALL	Cumulative radiological impacts from all uranium fuel cycle facilities within a 50-mile (80-km) radius of PVNGS are limited by the dose limits codified in 10 CFR Part 20 and 40 CFR Part 190. In Section 4.8 of this report, the NRC staff concluded that the impacts of radiation exposure to the public from the operation of PVNGS during the renewal term would be SMALL. NRC and the State of Arizona will regulate any future actions near PVNGS that could contribute to cumulative radiological impacts; therefore, the NRC concludes that the cumulative impacts from continued operations of PVNGS would be SMALL.
Socioeconomics	SMALL	Overall expenditures and employment levels at PVNGS are expected to remain relatively constant during the license renewal period. No refurbishment is planned. APS has no plans to alter the PVNGS site for license renewal. Therefore, there would be no cumulative impacts to socioeconomics and historic and archaeological resources during the license renewal period would be SMALL.

4.12 REFERENCES

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36 CFR Part 800. Code of Federal Regulations, *Title 36*, *Parks, Forests, and Public Property*, Part 800, "Protection of Historic Properties."

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5.0 ENVIRONMENTAL IMPACTS OF POSTULATED ACCIDENTS

This chapter describes the environmental impacts from postulated accidents that Palo Verde Nuclear Generating Station (PVNGS) might experience during the period of extended operation. For a more detailed discussion of this assessment, the reader is referred to Appendix F. The term "accident" refers to any unintentional event outside the normal plant operational envelope that results in a release or the potential for release of radioactive materials into the environment. Two classes of postulated accidents are evaluated in the *Generic Environmental Impact Statements (GEIS) for License Renewal of Nuclear Power Plants* prepared by the U.S. Nuclear Regulatory Commission (NRC), as listed in Table 5-1. These two classes include:

- design-basis accidents (DBAs)
- severe accidents

Table 5-1. Issues Related to Postulated Accidents. *Two issues related to postulated accidents are evaluated under the National Environmental Policy Act (NEPA) in the license renewal review: design-basis accidents and severe accidents.*

Issues	GEIS Section	Category
Design-basis accidents	5.3.2; 5.5.1	1
Severe accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	2

[a] Generic issues (Category 1 issues, see Chapter 1) rely on the analysis provided in the GEIS and are discussed briefly (NRC 1996,1999a).

5.1 DESIGN-BASIS ACCIDENTS

As part of the process for receiving NRC approval to operate a nuclear power facility, an applicant for an initial operating license must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff (staff) reviews the application to determine whether or not the plant design meets the NRC's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the licensee and the staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents, without undue hazard to the health and safety of the public. A number of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in Title 10 of the *Code of Federal Regulations* (CFR) Parts 50 and 100.

The environmental impacts of DBAs are evaluated during the initial licensing process. Before a license renewal is issued, the DBA assessment must demonstrate that the plant can withstand these accidents. The results of these evaluations are found in license documentation such as the applicant's final safety analysis report (FSAR), the safety evaluation report (SER), the final environmental statement (FES), and here in Section 5.1 of this document. A licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual; as such, changes in the plant environment will not affect these evaluations. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for the period of extended operation, the environmental impacts, as calculated for DBAs, should not differ significantly from initial licensing assessments over the life of the plant, including the period of extended operation. Accordingly, the design of the plant relative to DBAs during the period of extended operation is considered to remain acceptable and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission has determined that the significance level of the environmental impacts of DBAs are SMALL for all plants because the plants were designed to successfully withstand these accidents. For the purposes of license renewal, DBAs have been designated as a Category 1 issue. The early resolution of the DBAs makes them a part of the current licensing basis of the plant; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal.

No new and significant information related to DBAs was identified during the review of Arizona Public Service Company's (APS) environmental report (ER) (APS 2008a), site audit, scoping process, or evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS.

5.2 SEVERE ACCIDENTS

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the impacts of severe accidents during the period of extended operation, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the period of extended operation.

Severe accidents initiated by external phenomena such as tornadoes, floods, earthquakes, fires, and sabotage have not traditionally been discussed in quantitative terms in FESs and were not specifically considered for PVNGS in the GEIS. However, the GEIS did evaluate existing impact assessments performed by the staff and by the industry at 44 nuclear plants in the United States and concluded that the risk from beyond design-basis earthquakes at existing nuclear power plants is SMALL. The GEIS for license renewal performed a discretionary analysis of sabotage in connection with license renewal, and concluded that the core damage and radiological release from such acts would be no worse than the damage and release expected from internally-initiated events. In the GEIS, the NRC concludes that the risk from sabotage and beyond design-basis earthquakes at existing nuclear power plants is small, and additionally, that the risks from other external events are adequately addressed by a generic consideration of internally-initiated severe accidents (NRC 1996). A more detailed discussion of severe accidents initiated by terrorism associated with license renewal is provided in Section 5.2.1 of this chapter.

Based on information in the GEIS, the NRC found that:

> The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

The staff identified no new and significant information related to postulated accidents during the review of APS's ER (APS 2008a), the site audit, the scoping process, or evaluation of other available information. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff reviewed severe accident mitigation alternatives (SAMAs) for PVNGS. The results of the review are discussed in Section 5.3.

5.2.1 Severe Accidents Initiated by Sabotage and Terrorism

5.2.1.1 Background

Generic Finding for Sabotage and Terrorism for License Renewal of Nuclear Power Plants

The 1996 GEIS for License Renewal of Nuclear Plants (NUREG-1437) addresses environmental impact of terrorist acts. Section 5.3.3.1 of the GEIS states:

> *Although the threat of sabotage events cannot be accurately quantified, the Commission believes that acts of sabotage are not reasonably expected. Nonetheless, if such events were to occur, the Commission would expect that resultant core damage and radiological releases would be no worse than those expected from internally initiated events.*

Based on this, the Commission concluded in the GEIS that the risk from sabotage at existing nuclear power plants (NPPs) is small.

Implications of 9/11

As a result of the terrorist attacks of September 11, 2001 (9/11), the NRC conducted a comprehensive review of the agency's security program and required significant enhancements to security at a wide range of NRC-regulated facilities. These enhancements included significant reinforcement of the security response capabilities for nuclear facilities, better control of sensitive information, and implementation of mitigating strategies to deal with postulated events potentially causing loss of large areas of the plant due to explosions or fires, including those that an aircraft impact might create. These measures are outlined in greater detail in NUREG/BR-0314 (NRC 2004), NUREG-1850 (NRC 2006a), and Sandia National Laboratory's "Mitigation of Spent Fuel Loss-of-Coolant Inventory Accidents and Extension of Reference Plant Analyses to Other Spent Fuel Pools" (NRC 2006b).

The NRC continues to routinely assess threats and other information provided by a variety of Federal agencies and sources. The NRC also ensures that licensees meet appropriate security-level requirements. The NRC will continue to focus on prevention of terrorist acts for all nuclear facilities and will not focus on site-specific evaluations of speculative environmental impacts resulting from terrorist acts. While these are legitimate matters of concern, the NRC will continue to address them through the ongoing regulatory process as a current and generic regulatory issue that affects all nuclear facilities and many of the activities conducted at nuclear facilities. The issue of security and risk from malevolent acts at nuclear power facilities is not unique to facilities that have requested a renewal of their licenses (NRC 2006a).

Implications of NRC Licensing Actions Located in the Jurisdiction of the US Court of Appeals for the Ninth Circuit

The Commission has stated that licensing actions for facilities subject to the jurisdiction of the United States Court of Appeals for the Ninth Circuit will include an analysis of the environmental impacts of a terrorist attack [*San Luis Obispo Mothers for Peace v. NRC*, 449 F.3d 1016, 1028 (9th Cir. 2006)]. The discussion is limited to the impacts on the nuclear power plant reactor and spent fuel pool. It does not address spent nuclear fuel in the Palo Verde Independent Spent Fuel Storage Installation (ISFSI) since the environmental impacts of the ISFSI have been addressed in a separate licensing process and environmental assessment, including a finding of no significant environmental impact (55 FR 29181, July 18, 1990).

5.2.1.2 Security Requirements and Federal/Industry Actions in Response to 9/11

General Security Considerations

The NRC has historically considered the potential impacts of sabotage and terrorist acts in the development and implementation of its security requirements. NPPs are among the most secure commercial facilities in the country. NPP security is achieved in layers as described below:

- NPPs are inherently secure, robust structures, built to withstand hurricanes, tornadoes and earthquakes. NPPs have redundant safety systems and multiple barriers to protect the reactor and prevent or minimize off-site releases.
- Security measures are in place, including but not limited to trained and armed security officers, physical barriers, intrusion detection and surveillance systems, and access control features. These measures are routinely inspected and evaluated via force-on-force exercises.
- An additional layer of protection involves coordinating threat information and off-site response. The NRC works closely with the Department of Homeland Security (DHS), FBI, intelligence agencies, the Departments of Defense and Energy, states, and local law enforcement. These relationships ensure the NRC can act quickly on any threats that might affect its licensed facilities and allows effective emergency response from "outside the fence" should a terrorist attack occur (NRC 2004).

Federal/Industry Actions in Response to 9/11

Since 9/11, detailed assessments were performed, a spectrum of measures was evaluated to reduce the likelihood or consequences of terrorist attacks, and additional requirements were promulgated to prevent or mitigate the consequences of acts of sabotage/terrorism. The scope of the threats considered, assessments performed, and additional regulatory requirements include: (1) ground-based, water-based, cyber-based, and air-based attacks, (2) reactor, containment, and spent fuel; and, (3) Generic Communications, orders, license conditions, new regulations/rules. A brief discussion of some of the post-9/11 studies conducted, security requirements strengthened and enhanced liaison with Federal, State and local agencies follows.

NRC studies

The NRC conducted detailed site-specific engineering studies of a limited number of NPPs to assess potential vulnerabilities to deliberate attacks involving large commercial aircraft. The NRC also assessed the potential impacts of other types of terrorist attacks. In conducting these studies, the NRC drew on national experts from several Department of Energy laboratories using state-of-the-art experiments, structural analyses, and fire analyses. While the details are classified, the studies confirmed that the plants are robust, and the likelihood of a radioactive release affecting public health and safety is very low (NRC 2006c).

Specific findings included:

- With mitigation strategies and measures in place, the probability of damaging the reactor core and releasing radioactivity that could affect public health and safety is very low;
- Significant releases due to a terrorist attack on a spent fuel pool (SFP) are very unlikely;
- If a radiation release did occur, there would be time to implement mitigating actions and offsite emergency plans at power plants, SFPs, and dry-cask storage installations; and,
- Safety and security studies confirm that NRC's emergency planning bases remain valid (NRC 2006c).

Strengthened Security Requirements

After consideration of terrorist actions, NRC strengthened security requirements at NPPs. NRC major actions included:

- Ordering plant owners to sharply increase physical security programs to defend against a more challenging adversarial threat;
- Requiring more restrictive site access controls for all personnel;
- Enhancing communication and liaison with the Intelligence Community;
- Ordering plant owners to improve their capability to respond to events involving explosions or fires;
- Enhancing readiness of security organizations by strengthening training and qualifications programs for plant security forces;
- Requiring vehicle checks at greater stand-off distances;
- Enhancing force-on-force exercises to provide a more realistic test of plant capabilities to defend against an adversary force; and,
- Improving liaison with Federal, State, and local agencies responsible for protection of the national critical infrastructure through integrated response training (NRC 2006c).

NRC also promulgated additional security-related regulations including:

- A revision of the Design Basis Threat (DBT) rule in 2007 to impose generic security requirements similar to those previously imposed on operating NPPs by the Commission's April 29, 2003 DBT orders (FR 12705, Vol 72, No 52); and,
- Issuance of a new Power Reactor Security Requirements rule in 2009 to establish and update generically applicable security requirements for power reactors similar to those previously imposed by several Commission orders issued after 9/11, including security requirements for ground-based, water-based, cyber-based, and air-based attacks (FR 13926, Vol 74, No 58).

Enhanced Government-to-Government Coordination

The NRC continues to work with other governmental agencies to assure consistency and effectiveness in thwarting a potential attack on a NPP. For example, the NRC has worked with the Transportation Security Administration (TSA) and the Federal Aviation Administration (FAA) to develop guidance for general aviation pilots flying near NPPs. The TSA has initiated a number of other programs to reduce the likelihood an aircraft could attack any type of facility in the U.S. Some of these include:

- Criminal history checks on flight crew members;
- Reinforced cockpit doors;
- Checking of passenger lists against "no-fly" lists;
- Increased control of cargo;
- Random inspections;
- Increased number of Federal Air Marshals;
- Improved screening of passengers and baggage;
- Controls on foreign airlines operating to and from the U.S.;
- Additional requirements for charter aircraft; and,
- Improved coordination and communication between civilian and military authorities (NRC 2008).

Plant-Specific Actions in Response to 9/11

Following the events of 9/11, the NRC issued more robust security requirements as discussed above, and the NRC routinely verifies that PVNGS complies with those requirements. Thus, it is highly unlikely that an adversary force could successfully overcome these security measures and gain entry into the sensitive facilities, and even less likely that they could do this quickly enough to prevent operators from placing the plant's reactors into a safe shutdown mode.

Multiple plant-specific assessments with respect to potential malevolent acts have been and will continue to be completed for PVNGS (APS 2010). An example of an on-going, plant-specific evaluation is the periodic NRC security inspections at PVNGS that occur as part of operating reactor oversight. In response to these evaluations, numerous enhancements were implemented at PVNGS. Examples of resulting enhancements stemming from the various assessments completed include plant hardware changes; improved maintenance, testing and calibration of security equipment; improved training for both security and non-security personnel; and improved procedures in emergency planning and safeguards contingency planning. An example of a post-9/11 industry-wide initiative to enhance NPP security and how it was addressed at PVNGS is provided below (the “B.5.b” mitigation strategies).

Mitigation Strategies for Reactor, Containment, and Spent Fuel Pools (B.5.b)

An Interim Compensatory Measures (ICM) Order was issued February 25, 2002, as part of a comprehensive effort by the NRC, in coordination with other government agencies, to improve the capabilities of commercial nuclear reactor facilities to respond to terrorist threats. Section B.5.b. of the ICM Order required licensees to develop specific guidance and strategies to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities using existing or readily available resources (equipment and personnel) that could be effectively implemented under the circumstances associated with loss of large areas of the plant due to explosions or fire, including those that a large aircraft impact might create. Although it was recognized prior to 9/11 that nuclear reactors already had significant capabilities to withstand a broad range of attacks, implementing these mitigation strategies significantly enhances the plants' capabilities to withstand a broad range of threats (NRC 2007c).

NRC staff conducted inspections of the implementation of the Section B.5.b requirements in 2002 and 2003. Next, engineering studies were conducted by the NRC providing insights into the implementation of mitigation strategies. In 2005, additional guidance was issued by the NRC establishing a phased approach for responding to Section B.5.b of the ICM Order. Determination of the specific strategies required to satisfy the Order was termed Phase 1. Site-specific assessments of SFPs were deemed Phase 2, and site-specific assessments of reactor core and containment were deemed Phase 3. During 2005 and 2006, the NRC staff performed Phase 1 inspections and Phases 2 and 3 assessments (NRC 2007c).

The NRC staff's technical evaluation for PVNGS is described in a publicly-available Safety Evaluation (SE) report (NRC 2007c) The NRC staff concluded that APS's responses to the February 25, 2005, Phase 1 guidance document and the Phases 2 and 3 SFP and reactor core and containment mitigating strategy assessments meet the requirements of Section B.5.b of the February 25, 2002, ICM Order. Additionally, the NRC staff concluded that full implementation of APS's enhancements constitutes satisfactory compliance with Section B.5.b and that they represent reasonable measures to enhance APS's effectiveness in maintaining reactor core and SFP cooling and containment integrity under circumstances involving the loss of large areas of the plant due to fires or explosions.

The requirements for the B.5.b mitigating strategies were incorporated into the Facility Operating Licenses for PVNGS. The effectiveness of APS's actions to implement the mitigative strategies implemented in response to the ICM Order (which were subsequently codified in 10 CFR 50.54 (hh)(2)) is subject to NRC review and inspection.

5.2.1.3 Consideration of Environmental Impacts from Sabotage/Terrorist Acts

In describing the potential for environmental impacts from terrorist activities a description of the relevant terminology is necessary and includes three broad topics: threat, vulnerability, and consequences, as discussed below.

Threat

A threat is considered present when an organization or person has the intent and capability to cause damage to a target.

NRC currently assesses that there is a general, credible threat to NRC-licensed facilities and materials, although there is no specific information available that indicates a specific threat to NPP facilities.

Vulnerability

Vulnerability in this context refers to a weakness in physical protection or mitigation capabilities which can lead to unacceptable consequences. Vulnerabilities are specific to the type of attack.

Frequency of Malevolent Acts

With regard to the frequency of malevolent acts, the NRC has determined that security and mitigation measures the NRC has imposed upon its licensees since 9/11, coupled with national anti-terrorist measures and the robust nature of reactor containments and SFPs, make the probability of a successful terrorist attack, though numerically indeterminate, very low.

The security-related measures and other mitigation measures implemented since 9/11 include actions that would improve the likelihood of identifying/thwarting the attack before it is initiated, mitigating the attack before it results in damage to the plant, and mitigating the impact of the plant damage such that reactor core damage or an SFP fire is avoided. Given the implementation of additional security enhancements and mitigation strategies, as well as further consideration of the factors identified above, the NRC staff concludes that the frequency of large radionuclide releases due to malevolent acts is very low.

Consequences

Consequences relate to the magnitude and type of effect from terrorist actions. A range of consequences can result from sabotage and malevolent acts. NPPs have numerous security measures and protective features that help to prevent or mitigate consequences of potential terrorist attacks. Physical protection was described previously and generally consists of the robust characteristics of the containment and SFP structures; redundant safety systems; and additional security measures in place, including trained and armed security officers, physical barriers, intrusion detection and surveillance systems. Mitigating strategies have also been implemented to deal with postulated events potentially causing loss of large areas of the plant due to explosions or fires, including those that an aircraft impact might create.

Potential consequences are highly dependent on the type of attack or event scenario. Based on the plant-specific probabilistic risk assessment for PVNGS (as summarized in Attachment D to the Environmental Report), the reactor accidents with the highest offsite consequences at PVNGS involve core damage events in which the reactor containment is bypassed or fails to isolate at the onset of the event. These events result in release of a significant fraction of the reactor core radionuclide inventory to the environment within about one hour of event initiation. Accident consequences are described in Table D.3-5 of Attachment D to the Environmental Report.

Although SFP accidents are not specifically addressed in the PVNGS ER, the consequences of the most severe SFP accident, culminating in an SFP fire, were assessed in several previous NRC studies, among others, NUREG-1353, *Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools,"* April 1989, and NUREG-1738, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants*, January 2001. NUREG-1738 did not specifically address PVNGS, however its analysis addressed most power stations. Accident consequence results are provided in Table 4.8.3 of NUREG-1353 for site population densities of 340 persons per square mile (reflective of the mean population density around all NPPs in year 2000) and 860 persons per square mile (reflective of a high population site). Given that the projected 2040 population density within 50 miles of the PVNGS site is approximately 460 persons per square mile (based on a projected population of 3,588,728 reported in Section D.3.1 of Attachment D to the ER), these results are considered reasonably representative of PVNGS.

Potential consequences from malevolent acts against the PVNGS reactor or SFP would not exceed those for a reactor or SFP accident, and would likely be much less due to the need for the adversaries to rapidly defeat physical protection and access controls, as well as the redundant safety system functions. This would be extremely difficult given the significant physical protection (robust containment and SFP structures; redundant safety systems; additional security measures) and the post-9/11 mitigating strategies to deal with postulated events involving loss of large areas of the plant due to explosions or fires. Even if the physical protection and mitigating strategies were only partially effective, these features/measures would delay the time to core damage and radionuclide release, and reduce the consequences of any such release.

In the unlikely event that a terrorist attack did successfully breach the physical and other safeguards at PVNGS resulting in the release of radionuclides, the consequences of such a release are discussed in the 1996 GEIS for license renewal. In the GEIS, the Commission considered sabotage as the potential initiator of a severe accident. The Commission generically determined the risk to be of small significance for all NPPs. The Commission's evaluation of the potential environmental impacts of a terrorist attack, including the GEIS analysis of severe accident consequences, considers the potential consequences that might result from a large scale radiological release, irrespective of the initiating cause.

5.2.1.4 SAMAs for Sabotage/Terrorist Initiated Events

The focus of the Severe Accident Mitigation Alternative (SAMA) evaluation is on plant improvements (e.g., hardware, procedures, and training) that would both substantially reduce plant risk and be cost-beneficial. Given that risk from terrorist events is already reduced by the implementation of post 9/11 existing security enhancements and mitigation strategies, the staff considers it unlikely that there are any additional enhancements that would both substantially reduce plant risk and be cost-beneficial.

5.2.1.5 Consideration of SAMAs for Spent Fuel Pools

GEIS conclusions for Spent Fuel Pool accidents

The GEIS for license renewal provides a generic evaluation of potential SFP accidents, encompassing the potentially most serious accident (a seismically-generated accident causing catastrophic failure of the pool) and concludes that there is no further need for a site-specific SFP accident or mitigation analysis for license renewal. The GEIS concludes, without exception or qualification for any type of SFP accident, that "regulatory requirements already in place provide adequate mitigation incentives for on-site storage of spent fuel," and therefore mitigation alternatives for the SFP need not be considered for the license renewal review. *See* GEIS at 6-86, 6-91 to 6-92.

Risk Associated with Spent Fuel Pool Accidents

Risk is defined as the probability of the occurrence of a given event multiplied by the consequences of that event. The risk of beyond-design-basis accidents in SFPs was first examined as part of the landmark *Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants* (WASH–1400, NUREG–75/014, 1975), and was found to be several orders of magnitude below those involving the reactor core. The risk of an SFP accident was re-examined in the 1980's as Generic Issue 82, "*Beyond Design Basis Accidents in Spent Fuel Pools*," in light of increased use of high-density storage racks and laboratory studies that indicated the possibility of zirconium fire propagation between assemblies in an air-cooled environment. The risk assessment and cost-benefit analyses developed through this effort, NUREG–1353, *Regulatory Analysis for the Resolution of Generic Issue 82, Beyond Design Basis Accidents in Spent Fuel Pools*, Section 6.2, April 1989, concluded that the risk of a severe accident in the SFP was low and ''appear[s] to meet'' the objectives of the Commission's ''Safety Goals for the Operations of Nuclear Power Plants; Policy Statement,'' (August 4, 1986; 51 FR 28044), as amended (August 21, 1986; 51 FR 30028), and that no new regulatory requirements were warranted.

SFP accident risk was re-assessed in the late 1990s to support a risk-informed rulemaking for permanently shutdown, or decommissioned, NPPs. The study, NUREG–1738, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants*, January 2001, conservatively assumed that if the water level in the SFP dropped below the top of the spent fuel, an SFP zirconium fire involving all of the spent fuel would occur, and thereby bounded those conditions associated with air cooling of the fuel (including partial-draindown scenarios) and fire propagation. Even when all events leading to the spent fuel assemblies becoming partially or completely uncovered were assumed to result in an SFP zirconium fire, the study found the risk of an SFP fire to be low and well within the Commission's Safety Goals.

Several analyses conducted by Sandia National Laboratories since 9/11, collectively referred to herein as the ''Sandia studies,'' indicate that the risk of a successful terrorist attack (i.e., one that results in an SFP zirconium fire) is very low. The Sandia studies include sensitive security-related information and are not available to the public. The Sandia studies considered spent fuel loading patterns and other aspects of a pressurized-water reactor SFP and a boiling-water reactor SFP, including the role that the circulation of air plays in the cooling of spent fuel. The Sandia studies indicated that there may be a significant amount of time between the initiating event (i.e., the event that causes the SFP water level to drop) and the spent fuel assemblies becoming partially or completely uncovered. In addition, the Sandia studies indicated that for those hypothetical conditions where air cooling may not be effective in preventing a zirconium fire (i.e., the partial drain down scenario), there is a significant amount of time between the spent fuel becoming uncovered and the possible onset of such a zirconium fire, thereby providing a substantial opportunity for event mitigation. The Sandia studies, which address relevant heat transfer and fluid flow mechanisms, also indicated that air-cooling of spent fuel would be sufficient to prevent SFP zirconium fires at a point much earlier following fuel offload from the reactor than previously considered (e.g., in NUREG–1738). Thus, the fuel would be more easily cooled, and the likelihood of an SFP fire would therefore be reduced (FR 46207, Vol 73, No. 154).

Additional mitigation strategies implemented subsequent to 9/11 enhance spent fuel coolability and the potential to recover SFP water level and cooling prior to a potential SFP zirconium fire. The Sandia studies also confirmed the effectiveness of these additional mitigation strategies to maintain spent fuel cooling in the event the pool is drained and its initial water inventory is reduced or lost entirely. Based on this more recent information, and the implementation of additional strategies following 9/11, the probability and the risk of an SFP zirconium fire initiation is expected to be less than reported in NUREG–1738 and previous studies. In view of the physical robustness of SFPs, the physical security measures, and SFP mitigation measures, and based upon NRC site evaluations of every SFP in the United States, the NRC has determined that the risk of an SFP zirconium fire, whether caused by an accident or a terrorist attack, is very low and less than that for a reactor accident.

The NRC and licensees' efforts to address SFP vulnerabilities through enhancements since 9/11 have focused on "readily available mitigation strategies" which are typically the most cost-effective alternatives. The NRC's ongoing oversight of plant security and safety will continue to include review of SFPs and, in some cases, may require changes associated with SFPs.

5.2.1.6 Conclusions Regarding Sabotage and Terrorism

NRC's efforts to protect against terrorism, including efforts to evaluate potential options or alternatives to reduce the likelihood or severity of a terrorist attack, will continue during the current licensing period and any potential license renewal periods. The NRC staff's consideration of terrorism is a matter of ongoing regulatory oversight, and one that will continue to be dealt with on a daily basis. Based on this and the many actions that have been taken since, the NRC staff maintains the Commission's 1996 finding that although the threat of terrorist or sabotage events cannot be accurately quantified, acts of terrorism or sabotage are not reasonably expected and that even if such events were to occur, the resultant core damage and radiological releases would be no worse than those expected from internally-initiated events.

5.3 SEVERE ACCIDENT MITIGATION ALTERNATIVES

10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedure, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered for PVNGS; therefore, this section addresses those alternatives.

5.3.1 Introduction

The following is a summary of the SAMA evaluation for PVNGS conducted by APS and the NRC staff's review of that evaluation. The NRC staff performed its review with contract assistance from Pacific Northwest Laboratory. The NRC staff's review is available in full in Appendix G; the SAMA evaluation is available in full in APS's ER (APS 2008a).

The SAMA evaluation for PVNGS was conducted with a four-step approach. In the first step, APS quantified the level of risk associated with potential reactor accidents using the plant-specific probabilistic risk assessment (PRA) and other risk models.

In the second step, APS examined the major risk contributors and identified possible ways (SAMAs) of reducing that risk. Common ways of reducing risk are changes to components, systems, procedures, and training. APS identified 23 potential SAMAs for PVNGS. APS performed an initial screening to determine if any SAMAs could be eliminated because they are not applicable at PVNGS due to design differences, have already been implemented at PVNGS, or have estimated implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at PVNGS. This screening reduced the list of potential SAMAs to 13.

In the third step, APS estimated the benefits and the costs associated with each of the remaining SAMAs. Estimates were made of how much each SAMA could reduce risk. Those estimates were developed in terms of dollars in accordance with NRC guidance for performing regulatory analyses (NRC 1997). The cost of implementing the proposed SAMAs was also estimated.

Finally, in the fourth step, the costs and benefits of each of the remaining SAMAs were compared to determine whether the SAMA was cost-beneficial, meaning the benefits of the SAMA were greater than the cost (a positive cost-benefit). APS concluded in its ER that several of the SAMAs evaluated are potentially cost-beneficial (APS 2008a). The potentially cost-beneficial SAMAs do not relate to adequately managing the effects of aging during the period of extended operation; therefore, they need not be implemented as part of license renewal pursuant to 10 CFR Part 54. APS's SAMA analyses and the NRC's review are discussed in more detail below.

5.3.2 Estimate of Risk

APS submitted an assessment of SAMAs for PVNGS as part of the ER (APS 2008a). This assessment was based on the most recent PVNGS PRA available at that time; a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) computer program, and insights from the PVNGS Individual Plant Examination (IPE) (APS 1992) and Individual Plant Examination of External Events (IPEEE) (APS 1995).

The PVNGS core damage frequency (CDF) is approximately 5.07×10^{-6} per year for internal events (not including internal flooding) and 2.72×10^{-6} per year for fire events, as determined from quantification of the Level 1 PRA model. When determined from the sum of the containment event tree sequences, or Level 2 PRA model, the release frequency is approximately 5.24×10^{-6} per year. The latter value was used in the SAMA evaluations. The CDF value is based on the risk assessment for internally-initiated events. APS accounted for the potential risk reduction benefits associated with external events by applying a multiplier to the estimated benefits for internal events. The breakdown of CDF by initiating event is provided in Table 5-3a and 5-3b for internal events and fire events, respectively.

Table 5-3a. PVNGS Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)[a]	% Contribution to CDF
Station Blackout	1.2×10^{-6}	23
Loss of Engineered Safeguard Feature (ESF) Train A or B Bus	8.9×10^{-7}	18
Uncomplicated (Unplanned) Reactor Trips	5.9×10^{-7}	12
Loss of Condensate Feedwater or Vacuum	5.5×10^{-7}	11
Anticipated Transient Without Scram (ATWS)	4.6×10^{-7}	9
Loss of Off-Site Power (LOOP)	3.5×10^{-7}	7
Turbine Trip	2.9×10^{-7}	6
Small Break Loss of Coolant Accident (LOCA)	2.5×10^{-7}	5
Other	1.7×10^{-7}	3
Medium and Large Break LOCAs	1.5×10^{-7}	3
Steam Generator Tube Rupture (SGTR)	1.0×10^{-7}	2
Loss or DC Power	3.5×10^{-8}	1
Interfacing Systems LOCA	1.5×10^{-8}	<1
Loss of Off-Site Power to Train A or B	1.0×10^{-8}	<1
Loss of Vital 120V AC	5.1×10^{-9}	<1
Total CDF (internal events)[b]	$\mathbf{5.07 \times 10^{-6}}$	**100**

(a) Based on percent contribution from response to RAI 1.e (APS 2009, APS 2010) and total CDF.
(b) Column totals may be different due to round off.

As shown in Table 5-3a, events initiated by station blackout, loss of an ESF train, unplanned reactor trips, and loss of condensate feedwater are the dominant contributors to the internal event CDF.

1 **Table 5-3b. Important PVNGS Fire Compartments and their Contribution to Fire CDF**

Fire Compartment	Fire Compartment Description	CDF (per year)	% Contribution to CDF[a]
FZ 17	Main Control Room	7.2×10^{-7}	27
FZ TB9	Main Turbine Bearings Areas	5.7×10^{-7}	21
FZ 5A	Train A Essential Switchgear Room	3.5×10^{-7}	13
FZ COR2A	Corridor Building – 120 foot	2.5×10^{-7}	9
FZ TB1	Turbine Building – 100 foot West	2.3×10^{-7}	8
FZ TB5	Turbine Building – 140 foot West	1.8×10^{-7}	7
FZ TB3B	Feedwater Pumps Area	1.1×10^{-7}	4
FZ TB4B	DC Equipment Room	3.3×10^{-8}	1
FZ 5B	Train B Essential Switchgear Room	3.3×10^{-8}	1
FZ 42A	Electrical Penetration Room – Train A, Channel A	2.9×10^{-8}	1
	Other Fire Compartments[b]	2.1×10^{-7}	8
Total Fire CDF		$\mathbf{2.72 \times 10^{-6}}$	**100**

(c) Based on Fire CDF contribution in ER (APS 2008a) and total Fire CDF.

(d) CDF value derived as the difference between the total Fire CDF and the sum of the fire CDFs reported for the 10 dominant fire compartments.

2 As shown in Table 5-3b, the dominant contributors to fire CDF are fires in the Control Room, the
3 main turbine bearings area, and the Train A Essential Switchgear Room.

4 APS estimated the dose to the population within 50 miles (80 km) of PVNGS to be
5 approximately 13.6 person-rem (0.136 person-sievert [Sv]) per year. The breakdown of the total
6 population dose by containment release mode is summarized in Table 5-4. Late containment
7 over-pressure failures and SGTR-initiated accidents drive the population dose risk at PVNGS.

8 **Table 5-4. Breakdown of Population Dose by Containment Release Mode**

Containment Release Mode	Population Dose (Person-Rem[(a)] Per Year)	Percent Contribution
Containment Over-pressure Failure (Late)	10.5	77
Basemat Melt-Through (Late)	0.5	4
Steam Generator Tube Rupture	2.3	17
Containment Isolation Failure	0.2	1
Interfacing Systems LOCA	0.1	1
Intact Containment	negligible	negligible
Total	**13.6**	**100**

(a) One person-rem = 0.01 person-Sv

9 The NRC staff has reviewed APS's data and evaluation methods and concludes that the quality

of the risk analyses is adequate to support an assessment of the risk reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDFs and offsite doses reported by APS.

5.3.3 Potential Plant Improvements

Once the dominant contributors to plant risk were identified, APS searched for ways to reduce that risk. In identifying and evaluating potential SAMAs, APS considered insights from the plant-specific PRA, and SAMA analyses performed for other operating plants that have submitted license renewal applications. APS identified 23 potential risk-reducing improvements (SAMAs) to plant components, systems, procedures and training.

APS removed all but 13 of the SAMAs from further consideration because they are not applicable at PVNGS due to design differences, have already been implemented at PVNGS, or have estimated implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at PVNGS. A detailed cost-benefit analysis was performed for each of the remaining SAMAs.

The staff concludes that APS used a systematic and comprehensive process for identifying potential plant improvements for PVNGS, and that the set of potential plant improvements identified by APS is reasonably comprehensive and, therefore, acceptable.

5.3.4 Evaluation of Risk Reduction and Costs of Improvements

APS evaluated the risk-reduction potential of the remaining 13 SAMAs. The SAMA evaluations were performed using realistic assumptions with some conservatism.

APS estimated the costs of implementing the candidate SAMAs through the development of site-specific cost estimates and use of other licensee's estimates for similar improvements. The cost estimates conservatively did not include the cost of replacement power during extended outages required to implement the modifications, nor did they account for inflation.

The staff reviewed APS's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the staff based its estimates of averted risk for the various SAMAs on APS's risk reduction estimates.

The staff reviewed the bases for the applicant's cost estimates. For certain improvements, the staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors. The staff found the cost estimates to be reasonable, and generally consistent with estimates provided in support of other plants' analyses.

The staff concludes that the risk reduction and the cost estimates provided by APS are sufficient and appropriate for use in the SAMA evaluation.

5.3.5 Cost-Benefit Comparison

The cost-benefit analysis performed by APS was based primarily on NUREG/BR-0184 (NRC 1997) and was executed consistent with this guidance. NUREG/BR-0058 has recently been revised to reflect the agency's revised policy on discount rates. Revision 4 of NUREG/BR-0058 states that two sets of estimates should be developed: one at 3 percent and one at 7 percent (NRC 2004). APS provided both sets of estimates (APS 2008a).

The cost-benefit analysis, as revised in response to NRC staff RAIs, showed that one of the SAMA candidates was potentially cost-beneficial in the baseline analysis (i.e., SAMA 6). APS performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMA assessment (APS 2009). As a result, two additional SAMAs were identified as potentially cost-beneficial (SAMAs 17 and 23). In response to another NRC staff RAI regarding the method used to assess the fire-related population dose and offsite economic cost reduction for certain SAMAs, APS identified one additional potentially cost-beneficial SAMA (SAMA 8).

The potentially cost-beneficial SAMAs are:

- SAMA 6 – Develop procedures to guide recovery actions for spurious electrical protection faults.
- SAMA 17 – Modify the procedures to preclude reactor coolant pump operations that would clear the water seals in the cold leg after core damage.
- SAMA 23 – Enhance procedures to direct steam generator flooding for release scrubbing.
- SAMA 8 – Add auto start/load capability to the gas turbine generators.

APS has committed to implement the first three SAMAs (SAMA 6, 17, and 23) and also indicated that they will further consider the last SAMA (SAMA 8) for potential implementation (APS 2010).

The staff concludes, with the exception of the potentially cost-beneficial SAMAs discussed above, the costs of the SAMAs evaluated would be higher than the associated benefits.

5.3.6 Conclusions

The staff reviewed APS's analysis and concluded that the methods used and the implementation of those methods was sound. The treatment of SAMA benefits and costs support the general conclusion that the SAMA evaluations performed by APS are reasonable and sufficient for the license renewal submittal.

Based on its review of the SAMA analysis, the staff concurs with APS's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of all or a subset of potentially cost-beneficial SAMAs. Given the potential for cost-beneficial risk reduction, the staff considers that further evaluation of these SAMAs by APS is warranted. However, none of the potentially cost-beneficial SAMAs relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of the license renewal pursuant to 10 CFR Part 54.

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6.0 ENVIRONMENTAL IMPACTS OF THE URANIUM FUEL CYCLE, SOLID WASTE MANAGEMENT, AND GREENHOUSE GAS EMISSIONS

6.1 THE URANIUM FUEL CYCLE AND SOLID WASTE MANAGEMENT

This section addresses issues related to the uranium fuel cycle and solid waste management during the period of extended operation. The uranium cycle includes uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials, and management of low-level wastes and high-level wastes related to uranium fuel cycle activities. The *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996), (NRC 1999) details the potential generic impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes, as listed in Table 6-1 below. The GEIS is based, in part, on the generic impacts provided in Table S-3, "Table of Uranium Fuel Cycle Environmental Data," in Title 10 of the *Code of Federal Regulations* (CFR), Section 51.51(b), and in Table S-4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor," in 10 CFR 51.52(c). The GEIS also addresses the impacts from radon-222 and technetium-99.

The staff of the U.S. Nuclear Regulatory Commission (NRC) did not identify any new and significant information related to the uranium fuel cycle during the review of the Arizona Public Service Company (APS) environmental report (ER) (APS 2008a), the site audit, and the scoping process. Therefore, there are no impacts related to these issues beyond those discussed in the GEIS. For these Category 1 issues, the GEIS concludes that the impacts are designated as SMALL, except for the collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.

Table 6-1. Issues Related to the Uranium Fuel Cycle and Solid Waste Management *Nine generic issues are related to the fuel cycle and solid waste management. There are no site-specific issues.*

Issues	GEIS Section	Category
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level waste)	6.1, 6.2.1, 6.2.2.1, 6.2.2.3, 6.2.3, 6.2.4, 6.6	1
Offsite radiological impacts (collective effects)	6.1, 6.2.2.1, 6.2.3, 6.2.4, 6.6	1
Offsite radiological impacts (spent fuel and high-level waste disposal)	6.1, 6.2.2.1, 6.2.3, 6.2.4, 6.6	1
Nonradiological impacts of the uranium fuel cycle	6.1, 6.2.2.6, 6.2.2.7, 6.2.2.8, 6.2.2.9, 6.2.3, 6.2.4, 6.6	1
Low-level waste storage and disposal	6.1, 6.2.2.2, 6.4.2, 6.4.3, 6.4.3.1, 6.4.3.2, 6.4.3.3, 6.4.4, 6.4.4.1, 6.4.4.2, 6.4.4.3, 6.4.4.4, 6.4.4.5, 6.4.4.5.1, 6.4.4.5.2, 6.4.4.5.3, 6.4.4.5.4, 6.4.4.6, 6.6	1
Mixed waste storage and disposal	6.4.5.1, 6.4.5.2, 6.4.5.3, 6.4.5.4, 6.4.5.5, 6.4.5.6, 6.4.5.6.1, 6.4.5.6.2, 6.4.5.6.3, 6.4.5.6.4, 6.6	1
Onsite spent fuel	6.1, 6.4.6, 6.4.6.1, 6.4.6.2, 6.4.6.3, 6.4.6.4, 6.4.6.5, 6.4.6.6, 6.4.6.7, 6.6	1
Nonradiological waste	6.1, 6.5, 6.5.1, 6.5.2, 6.5.3, 6.6	1
Transportation	6.1, 6.3.1, 6.3.2.3, 6.3.3, 6.3.4, 6.6, Addendum 1	1

6.2 GREENHOUSE GAS EMISSIONS

This section provides a discussion of potential impacts from greenhouse gases (GHGs) emitted during the nuclear fuel cycle. The GEIS does not directly address these emissions, and its discussion is limited to an inference that substantial carbon dioxide (CO2) emissions may occur if coal- or oil-fired alternatives to license renewal are implemented.

6.2.1 Existing Studies

Since the development of the GEIS, the relative volumes of GHGs emitted by nuclear and other electricity generating methods have been widely studied. However, estimates and projections of the carbon footprint of the nuclear power life cycle vary depending on the type of study conducted. Additionally, considerable debate also exists among researchers regarding the relative impacts of nuclear and other forms of electricity generation on GHG emissions. Existing studies on GHG emissions from nuclear power plants generally take two different forms:

(1) Qualitative discussions of the potential to use nuclear power to reduce GHG emissions and mitigate global warming; and

(2) Technical analyses and quantitative estimates of the actual amount of GHGs generated by the nuclear fuel cycle or entire nuclear power plant life cycle and comparisons to the operational or life cycle emissions from other energy generation alternatives.

6.2.1.1 Qualitative Studies

The qualitative studies consist primarily of broad, large-scale public policy or investment evaluations of whether an expansion of nuclear power is likely to be a technically, economically, and/or politically feasible means of achieving global GHG reductions. Examples of the studies identified by the staff during the subsequent literature search include:

- Evaluations to determine whether investments in nuclear power in developing countries should be accepted as a flexibility mechanism to assist industrialized nations in achieving their GHG reduction goals under the Kyoto Protocols (Schneider 2000), (IAEA 2000), (NEA 2002). Ultimately, the parties to the Kyoto Protocol did not approve nuclear power as a component under the Clean Development Mechanism (CDM) due to safety and waste disposal concerns (NEA 2002).
- Analyses developed to assist governments, including the United States, in making long-term investment and public policy decisions in nuclear power (Keepin 1988), (Hagen et al. 2001), (MIT 2003).

Although the qualitative studies sometimes reference and critique the existing quantitative estimates of GHGs produced by the nuclear fuel cycle or life cycle, their conclusions generally rely heavily on discussions of other aspects of nuclear policy decisions and investment such as safety, cost, waste generation, and political acceptability. Therefore, these studies are typically not directly applicable to an evaluation of GHG emissions associated with the proposed license renewal for a given nuclear power plant.

6.2.1.2 Quantitative Studies

A large number of technical studies, including calculations and estimates of the amount of GHGs emitted by nuclear and other power generation options, are available in the literature and were useful to the staff's efforts in addressing relative GHG emission levels. Examples of these studies include—but are not limited to—Mortimer (1990), Andseta et al. (1998), Spadaro et al. (2000), Storm van Leeuwen and Smith (2005), Fritsche (2006), Parliamentary Office of Science and Technology (POST) (2006), Atomic Energy Authority Technology (AEA) (2006), Weisser

(2006), Fthenakis and Kim (2007), and Dones (2007).

Comparing these studies and others like them is difficult because the assumptions and components of the life cycles the authors evaluate vary widely. Examples of areas in which differing assumptions make comparing the studies difficult include:

- energy sources that may be used to mine uranium deposits in the future
- reprocessing or disposal of spent nuclear fuel
- current and potential future processes to enrich uranium and the energy sources that will power them
- estimated grades and quantities of recoverable uranium resources
- estimated grades and quantities of recoverable fossil fuel resources
- estimated GHG emissions other than CO_2, including the conversion to CO_2 equivalents per unit of electric energy produced
- performance of future fossil fuel power systems
- projected capacity factors for alternative means of generation
- current and potential future reactor technologies

In addition, studies may vary with respect to whether all or parts of a power plant's life cycle are analyzed (i.e., a full life cycle analysis will typically address plant construction, operations, resource extraction (for fuel and construction materials), and decommissioning, whereas a partial life cycle analysis primarily focuses on operational differences).

In the case of license renewal, a GHG analysis for that portion of the plant's life cycle (operation for an additional 20 years) would not involve GHG emissions associated with construction because construction activities have already been completed at the time of relicensing. In addition, the proposed action of license renewal would also not involve additional GHG emissions associated with facility decommissioning because that decommissioning must occur whether the facility is relicensed or not. However, in some of the aforementioned studies, the specific contribution of GHG emissions from construction, decommissioning, or other portions of a plant's life cycle cannot be clearly separated from one another. In such cases, an analysis of GHG emissions would overestimate the GHG emissions attributed to a specific portion of a plant's life cycle. Nonetheless, these studies provide some meaningful information with respect to the relative magnitude of the emissions among nuclear power plants and other forms of electric generation, as discussed in the following sections.

In Tables 6-2, 6-3, and 6-4, the staff presents the results of the aforementioned quantitative studies to provide a weight-of-evidence evaluation of the relative GHG emissions that may result from the proposed license renewal as compared to the potential alternative use of coal-fired, natural gas-fired, and renewable generation. Most studies from Mortimer (1990) onward suggest that uranium ore grades and uranium enrichment processes are leading determinants in the ultimate GHG emissions attributable to nuclear power generation.

These studies indicate that at this time when compared to fossil-fueled alternatives, nuclear power emits a relatively lower order of magnitude of GHG emissions. A subset of these studies indicate that this advantage, especially when compared to natural gas, could potentially disappear if available uranium ore grades drop sufficiently while enrichment processes continue to rely on the same technologies.

6.2.1.3 Summary of Nuclear Greenhouse Gas Emissions Compared to Coal

Considering that coal fuels the largest share of electricity generation in the United States and that its burning results in the largest emissions of GHGs for any of the likely alternatives to nuclear power generation, including Palo Verde Nuclear Generating Station (PVNGS), most of the available quantitative studies focused on comparisons of the relative GHG emissions of nuclear to coal-fired generation. The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear life cycle), as compared to an equivalent coal-fired plant, are presented in Table 6-2. The following chart does not include all existing studies but provides an illustrative range of estimates developed by various researchers.

Table 6-2. Nuclear Greenhouse Gas Emissions Compared to Coal

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2 Coal—5,912,000 tons CO_2 Note: Future GHG emissions from nuclear to increase because of declining ore grade, particularly if the ore grade falls to anything less than 0.01% uranium oxide, at which point the nuclear power system could release as much carbon dioxide as fossil fuel-fired power station.
Andseta et al. (1998)	Nuclear energy produces 1.4 percent of the GHG emissions compared to coal. Note: Future reprocessing and use of nuclear-generated electrical power in the mining and enrichment steps are likely to change (lower) the projections of earlier authors, such as Mortimer (1990).
Spadaro et al. (2000)	Nuclear—2.5 to 5.7 g Ceq/kWh Coal—264 to 357 g Ceq/kWh
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g Ceq/kWh Coal—950 g Ceq/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g Ceq/kWh Coal—>1000 g Ceq/kWh Note: Decrease of uranium ore grade to 0.03 percent would raise nuclear to 6.8 g Ceq /kWh. Future improved technology and carbon capture and storage could reduce coal-fired GHG emissions by 90 percent.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8 to 24 g Ceq/kWh Coal—950 to 1250 g Ceq/kWh

6.2.1.4 Summary of Nuclear Greenhouse Gas Emissions Compared to Natural Gas

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle (and, in some cases, the nuclear life cycle), as compared to an equivalent natural gas-fired plant, are presented in Table 6-3. The following chart does not include all existing studies but provides an illustrative range of estimates developed by various researchers.

Table 6-3. Nuclear Greenhouse Gas Emissions Compared to Natural Gas

Source	GHG Emission Results
Spadaro et al. (2000)	Nuclear—2.5 to 5.7 g Ceq/kWh Natural Gas—120 to 188 g Ceq/kWh
Storm van Leeuwen and Smith (2005)	Nuclear fuel cycle produces 20 to 33 percent of the GHG emissions compared to natural gas (at high ore grades). Note: Future nuclear GHG emissions to increase because of declining ore grade.
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g Ceq/kWh Cogeneration Combined-Cycle Natural Gas—150 g Ceq/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g Ceq/kWh Natural Gas—500 g Ceq/kWh Note: Decrease of uranium ore grade to 0.03 percent would raise nuclear to 6.8 g Ceq/kWh. Future improved technology and carbon capture and storage could reduce natural gas GHG emissions by 90 percent.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8 to 24 g Ceq/kWh Natural Gas—440 to 780 g Ceq/kWh
Dones (2007)	Author critiqued methods and assumptions of Storm van Leeuwen and Smith (2005) and concluded that the nuclear fuel cycle produces 15 to 27 percent of the GHG emissions of natural gas.

6.2.1.5 Summary of Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

The quantitative estimates of the GHG emissions associated with the nuclear fuel cycle, as compared to equivalent renewable energy sources, are presented in Table 6-4. Calculation of GHG emissions associated with these sources is more difficult than the calculations for nuclear energy and fossil fuels because of the large variation in efficiencies due to their different sources and locations. For example, the efficiency of solar and wind energy is highly dependent on the location in which the power generation facility is installed. Similarly, the range of GHG emissions estimates for hydropower varies greatly depending on the type of dam or reservoir involved (if used at all). Therefore, the GHG emissions estimates for these energy sources have a greater range of variability than the estimates for nuclear and fossil fuel sources. The following chart does not include all existing studies but provides an illustrative range of estimates developed by various researchers.

Table 6-4. Nuclear Greenhouse Gas Emissions Compared to Renewable Energy Sources

Source	GHG Emission Results
Mortimer (1990)	Nuclear—230,000 tons CO_2 Hydroelectric—78,000 tons CO_2 Wind power—54,000 tons CO_2 Tidal power—52,500 tons CO_2 Note: Future GHG emissions from nuclear to increase because of declining ore grade.
Spadaro et al. (2000)	Nuclear—2.5 to 5.7 g Ceq/kWh Solar photovoltaic (PV)—27.3 to 76.4 g Ceq/kWh Hydroelectric—1.1 to 64.6 g Ceq/kWh Biomass—8.4 to 16.6 g Ceq/kWh Wind—2.5 to 13.1 g Ceq/kWh
Fritsche (2006) (Values estimated from graph in Figure 4)	Nuclear—33 g Ceq/kWh Solar PV—125 g Ceq/kWh Hydroelectric—50 g Ceq/kWh Wind—20 g Ceq/kWh
POST (2006) (Nuclear calculations from AEA, 2006)	Nuclear—5 g Ceq/kWh Biomass—25 to 93 g Ceq/kWh Solar PV—35 to 58 g Ceq/kWh Wave/Tidal—25 to 50 g Ceq/kWh Hydroelectric—5 to 30 g Ceq/kWh Wind—4.64 to 5.25 g Ceq/kWh Note: Decrease of uranium ore grade to 0.03 percent would raise nuclear to 6.8 g Ceq/kWh.
Weisser (2006) (Compilation of results from other studies)	Nuclear—2.8 to 24 g Ceq/kWh Solar PV—43 to 73 g Ceq/kWh Hydroelectric—1 to 34 g Ceq/kWh Biomass—35 to 99 g Ceq/kWh Wind—8 to 30 g Ceq/kWh
Fthenakis and Kim (2007)	Nuclear—16 to 55 g Ceq/kWh Solar PV—17 to 49 g Ceq/kWh

6.2.2 Conclusions: Relative Greenhouse Gas Emissions

The sampling of data presented in Tables 6-2, 6-3, and 6-4 above demonstrates the challenges of any attempt to determine the specific amount of GHG emission attributable to nuclear energy production sources, as different assumptions and calculation methodology will yield differing results. The differences and complexities in these assumptions and analyses will further increase when they are used to project future GHG emissions. Nevertheless, several conclusions can be drawn from the information presented.

First, the various studies indicate a general consensus that nuclear power currently produces fewer GHG emissions than fossil-fuel-based electrical generation, e.g., the GHG emissions from a complete nuclear fuel cycle currently range from 2.5 to 55 g C_{eq}/kWh, as compared to the use of coal plants (264 to 1,250 g C_{eq}/kWh) and natural gas plants (120 to 780 g C_{eq}/kWh). The studies also provide estimates of GHG emissions from five renewable energy sources based on current technology. These estimates included solar-photovoltaic (17 to 125 g C_{eq}/kWh), hydroelectric (1 to 64.6 g C_{eq}/kWh), biomass (8.4 to 99 g C_{eq}/kWh), wind (2.5 to 30 g C_{eq}/kWh), and tidal (25 to 50 g C_{eq}/kWh). The range of these estimates is wide, but the general conclusion is that current GHG emissions from the nuclear fuel cycle are of the same order of magnitude as from these renewable energy sources.

Second, the studies indicate no consensus on future relative GHG emissions from nuclear power and other sources of electricity. There is substantial disagreement among the various authors regarding the GHG emissions associated with declining uranium ore concentrations, future uranium enrichment methods, and other factors, including changes in technology. Similar disagreement exists regarding future GHG emissions associated with coal and natural gas for electricity generation. Even the most conservative studies conclude that the nuclear fuel cycle currently produces fewer GHG emissions than fossil-fuel-based sources and is expected to continue to do so in the near future. The primary difference between the authors is the projected cross-over date (the time at which GHG emissions from the nuclear fuel cycle exceed those of fossil-fuel-based sources) or whether cross-over will occur at all.

Considering the current estimates and future uncertainties, it appears that GHG emissions associated with the proposed PVNGS relicensing action are likely to be lower than those associated with fossil-fuel-based energy sources. The staff based this conclusion on the following rationale:

(1) As shown in Tables 6-2 and 6-3, the current estimates of GHG emissions from the nuclear fuel cycle are far below those for fossil-fuel-based energy sources.

(2) PVNGS license renewal will involve continued GHG emissions due to uranium mining, processing, and enrichment but will not result in increased GHG emissions associated with plant construction or decommissioning (as the plant will have to be decommissioned at some point whether the license is renewed or not).

(3) Few studies predict that nuclear fuel cycle emissions will exceed those of fossil fuels within a timeframe that includes the PVNGS period of extended operation. Several studies suggest that future extraction and enrichment methods, the potential for higher grade resource discovery, and technology improvements could extend this timeframe.

In comparing GHG emissions among the proposed PVNGS license renewal action and renewable energy sources, it appears likely that there will be future technology improvements and changes in mining, processing, and constructing facilities of all types. Currently, the GHG emissions associated with the nuclear fuel cycle and renewable energy sources are within the same order of magnitude. Because nuclear fuel production is the most significant contributor to possible future increases in GHG emissions from nuclear power and because most renewable energy sources lack a fuel component, it is likely that GHG emissions from renewable energy sources would be lower than those associated with PVNGS at some point during the period of extended operation.

The staff provides an additional discussion about the contribution of GHGs to cumulative air quality impacts in Section 4.11.5 of this document.

6.3 REFERENCES

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7.0 ENVIRONMENTAL IMPACTS OF DECOMMISSIONING

Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in the *Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors*, NUREG-0586, Supplement 1 (NRC 2002). The staff's evaluation of the environmental impacts of decommissioning presented in NUREG-0586, Supplement 1, identifies a range of impacts for each environmental issue.

The incremental environmental impacts associated with decommissioning activities resulting from continued plant operation during the renewal term are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).

7.1 DECOMMISSIONING

Category 1 issues in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B that are applicable to Palo Verde Nuclear Generating Station (PVNGS) decommissioning following the renewal term are listed in Table 7-1.

Table 7-1. Category 1 Issues Applicable to the Decommissioning of PVNGS Following the Renewal Term

ISSUE	GEIS Section
Radiation doses	7.3.1
Waste management	7.3.2
Air quality	7.3.3
Water quality	7.3.4
Ecological resources	7.3.5
Socioeconomic impacts	7.3.7

A brief description of the staff's generic review and the conclusions, as stated in Table B-1, 10 CFR Part 51, for each of the issues follows:

- Radiation doses. The GEIS concludes that:

  Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem caused by buildup of long-lived radionuclides during the license renewal term.

- Waste management. The GEIS concludes that:

  Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected.

- Air quality. The GEIS concludes that:

Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term.

- Water quality. The GEIS concludes that:

  The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts.

- Ecological resources. The GEIS concludes that:

  Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.

- Socioeconomic Impacts. The GEIS concludes that:

  Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth.

The NRC staff has not identified any new and significant information during the review of the Arizona Public Service Company (APS) environmental report (ER), the site audit, or the scoping process; therefore, there are no impacts related to these issues beyond those discussed in the GEIS (NRC 1996, 1999). For the issues listed in Table 7-1 above, the GEIS concluded that the impacts are SMALL.

7.2 REFERENCES

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8.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The National Environmental Policy Act (NEPA) mandates that each environmental impact statement (EIS) consider alternatives to any proposed major federal action. NRC regulations implementing NEPA for license renewal require that a supplemental EIS “considers and weighs the environmental effects of the proposed action [license renewal]; the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental effects,” (10 CFR 51.71d). In this case, the proposed Federal action is issuing renewed licenses for Palo Verde Nuclear Generating Station (PVNGS), which will allow the plant to operate for 20 years beyond the license expiration dates of its three reactors. In this chapter, the NRC staff examines the potential environmental impacts of alternatives to license renewal for PVNGS, as well as alternatives that may reduce or avoid adverse environmental impacts from license renewal, when and where these alternatives are applicable.

While the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG-1437 (GEIS; NRC 1996, 1999), reached generic conclusions regarding many environmental issues associated with license renewal, it did not determine which alternatives are reasonable or reach conclusions about site-specific environmental impact levels. As such, NRC staff must evaluate environmental impacts of alternatives on a site-specific basis.

As stated in Chapter 1 of this document, alternatives to the proposed action of license renewal for PVNGS must meet the purpose and need for issuing a renewed license; they must

> “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) decisionmakers.”

The NRC staff ultimately makes no decision as to which alternative (or the proposed action) to implement, since that decision falls to utility, State, or other Federal officials to decide. Comparing the environmental effects of these alternatives will assist the NRC in deciding whether the environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable (10 CFR 51.95(c)(4)). If the NRC acts to issue renewed licenses, all of the alternatives, including the proposed action, will be available to energy planning decisionmakers. If NRC decides not to renew the licenses (or takes no action at all), then energy planning decisionmakers may no longer elect to continue operating PVNGS and will have to resort to another alternative–which may or may not be one of the alternatives considered in this section–to meet the energy needs now being satisfied by PVNGS.

In evaluating alternatives to license renewal, the NRC staff first selects energy technologies or options currently in commercial operation as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current PVNGS operating license expires. The current operating licenses for the three reactors at PVNGS will expire on December 31, 2024, December 9, 2025, and March 25, 2027 and an alternative must be available (constructed, permitted, and connected to the grid), by the time those current PVNGS licenses expire.

Alternatives Evaluated In-Depth:

- Coal-fired (supercritical)
- Natural Gas-fired Combined Cycle (NGCC)
- New Nuclear
- Combination

Other Alternatives Considered:

- Coal-fired IGCC
- Wind power
- Energy Conservation
- Purchased power
- Solar power
  - photovoltaic (PV)
  - concentrating solar power (CSP)
- Wood-fired combustion
- Conventional hydroelectric power
- Wave and ocean energy
- Geothermal power
- Municipal solid waste
- Biofuels
- Methane
- Oil-fired power
- Fuel cells
- Delayed retirement

Secondly, the staff screens the alternatives to remove those that cannot meet future system needs by providing amounts of baseload power equivalent to PVNGS's current generating capacity, including consideration of other options which, if pursued concurrently, might further reduce future system demands, and then screens the remaining options to remove those whose costs or benefits do not justify inclusion in the range of reasonable alternatives. Any alternatives remaining, then, constitute alternatives to the proposed action that NRC staff evaluates in-depth throughout this section. In Section 8.5, the NRC staff will briefly address each alternative that was removed during screening and provide the basis for its removal.

NRC staff initially considered 19 discrete potential alternatives to the proposed action (see text box), and then narrowed the list to the three discrete alternatives and one combination alternative considered in Sections 8.1 through 8.4.

For those technologies undergoing in-depth review, the generic environmental impact evaluations in the Generic Environmental Impact Statement (GEIS) published by NRC in 1996 provides a basic overview of performance and impacts. The NRC staff then augments the information provided in the GEIS with additional evaluation incorporating unique site-specific factors that can influence the feasibility, performance, and environmental impacts of the technologies undergoing review. In addition, since 1996, many energy technologies have evolved significantly in capability and cost, while regulatory structures have changed to either promote or impede development of particular alternatives.

As a result, the NRC staff's analyses start with the GEIS and then include updated information from sources like the Energy Information Administration (EIA), other organizations within the Department of Energy (DOE), the US Environmental Protection Agency (EPA), industry sources and publications, and information submitted in the applicant's Environmental Report (ER) (APS 2008a).

In 2007, electricity generation in Arizona involved the use of nuclear (23.6%), natural gas (33.9%), coal (36.4%), and renewable energy (5.8%) technologies (EIA 2009a, SWEEP 2009). Of the 113,392,528 MWh produced in 2007, 41,275,362 MWh were derived from coal, 38,469,221 MWh came from combustion of natural gas, 26,782,391 MWh from nuclear, 6,597,671 MWh from conventional hydroelectric, 125,411 MWh from other renewables, 49,276

MWh from combustion of petroleum distillate fuels, and 41,639 MWh were derived from pumped storage (EIA 2009a). The NRC staff believes that the mix of electricity generating technologies currently operating in Arizona is representative of the complexion of future power pools and therefore has determined that the technologies represented in the existing mix are examples of reasonable alternatives to the PVNGS reactors.

Consequently, the in-depth alternatives that the staff considered include a supercritical steam pulverized coal-fired plant (section 8.1), a natural gas-fired combined-cycle power plant (Section 8.2), a new nuclear plant (section 8.3), and a reasonable combination of alternatives (Section 8.4), that includes some natural gas-fired capacity, energy conservation, and two concentrated solar power (CSP) facilities. In Section 8.5, the staff explains why it dismissed many other alternatives from in-depth consideration. Finally, in Section 8.6, the staff considers the environmental effects that may occur if NRC takes no action and does not issue a renewed license for PVNGS.

For each in-depth analysis, the staff analyzes environmental impacts across seven impact categories: (1) air quality, (2) groundwater use and quality, (3) surface water use and quality, (4) ecology, (5) human health, (6) socioeconomics, and (7) waste management. As in earlier chapters of this draft supplemental EIS, the staff uses the NRC's three-level standard of significance – SMALL, MODERATE, or LARGE – to indicate the intensity of environmental effects for each alternative undergoing in-depth evaluation.

8.1 SUPERCRITICAL COAL-FIRED GENERATION

The EIA reported that, in 2007, coal accounted for 48.5% of electricity generated nationwide (EIA 2009b). Natural gas, nuclear, and coal remain the three primary electricity generation technologies, with coal being the primary source of baseload electricity generation, generating 2,016 million MWh of the total 4,157 million MWh produced nationwide in 2007. In Arizona, coal accounted for 36.4% of the 41,275,362 MWh of electricity generated in 2007 (EIA 2009a, SWEEP 2009). Coal-fired electricity generation is therefore a reasonable alternative. Units using pulverized coal and producing supercritical steam, known as Super Critical Pulverized Coal (SCPC) boilers, are the most likely variant among current-day coal-fired electricity generation technologies.

Myriad sizes of pulverized coal boilers and steam turbine generators are available; however, the NRC staff recognizes that no single boiler/steam turbine generator (STG) combination could match the 4,020 MWe capacity of PVNGS reactors. Clearly, multiple units would be required. To complete this analysis, the NRC staff has elected not to specify the number or discrete sizes of the coal-fired units that could collectively serve as an alternative, but instead presumes that all units, regardless of size, would have the same features, operate at generally the same conditions, impact the environment in a manner proportional to their power capacity, and be equipped with the same pollution control devices, such that once all parasitic loads are overcome, the net power collectively available will be roughly equal to 4,020 MWe.

The boilers comprising the supercritical coal-fired alternative are presumed to have the following characteristics and be equipped with the following pollution control devices:

- Dual wall-fired, dry bottom boilers, configured to be NSPS-compliant
- Overall thermal efficiency of 38%
- Capacity factor of 85%
- Collective nameplate rating of 4,020 MWe (net)

- Supercritical steam
- Powder River Basin Coal; caloric value 8,820 Btu/lb, ash 6.44%, sulfur 0.48%, pulverized to >70% passing a 200-mesh sieve
- Fabric filter for particulate control, operating at 99% efficiency,
- Wet calcium carbonate sulfur dioxide (SO_2) scrubber operating at 95% efficiency
- Low-NO_x burners with overfire air and selective catalytic reduction for nitrogen oxide controls capable of attaining nitrogen oxides (NO_x) removal of 86% [an emission rate ≤ 2.5 ppmv (dry basis)]

Current regulations would require that these coal-fired generating units be fitted with pollution control equipment to control particulates, sulfur oxide and nitrogen oxide pollutant emissions; future regulations may also require such plants to be outfitted with equipment to control hazardous air pollutants (especially mercury) and to capture and sequester carbon dioxide (CO_2). All such pollution controls will impose parasitic loads such that the net electric power available will be reduced from nameplate values. However, because the required performance of a given pollution control device is dependent on the nature of the coal being burned (and the nature and amounts of pollutants generated and their required levels of control) and because some of the regulations that may require pollution controls in the future have not yet been promulgated in final form, it is difficult to anticipate and quantify parasitic loads with any precision for incorporation into any evaluation of coal-fired alternatives. Despite what is expected to be an increased environmental regulatory burden for coal plants built in the future, the NRC staff still agrees with the EIA projection that coal will continue to be a primary source of baseload power through 2030 (EIA 2009b). Further, because the NRC staff is not aware of any pending developments that would significantly change the complexion of electricity generating technologies in Arizona over the period of the PVNGS license extensions, it is reasonable to conclude that coal-fired generation is a likely alternative.

Supercritical Steam

Supercritical refers to the thermodynamic properties of the steam being produced. Steam whose temperature and pressure is below water's "critical point' (3,200 pounds per square inch absolute [psia] and 705 °F) is subcritical. Subcritical steam forms as water boils and both liquid and gas phases are observable in the steam. The majority of coal boilers currently operating in the U.S. produce subcritical steam with pressures around 2,400 psia and temperatures as high as 1,050 °F. Above the critical point pressure, water expands rather than boils and the liquid and gaseous phases of water are indistinguishable in the supercritical steam that results. More than 150 coal boilers currently operating in the U.S. produce supercritical steam with pressure between 3,300 and 3,500 psia and temperatures between 1,000 and 1,100 °F. Ultrasupercritical boilers produce steam at pressures above 3,600 psia and temperatures exeeding 1,100 °F. There are only a few of these boilers in operation worldwide, and none in the U.S.

In the ER, PVNGS suggests that sufficient space exists on the current PVNGS plant site to accommodate coal-fired alternatives with net generating capacity roughly equivalent to the PVNGS reactors. Locating an alternative generating technology on the existing PVNGS site would minimize overall environmental impacts since much of the infrastructure now in place to support operation of the reactors could be redeployed with minimal modification to support a coal-fired alternative. The NRC staff concurs in that assessment and therefore presumes that to be the case for analysis of the impacts of the coal-fired alternative. Cooling systems, electrical substations and switchyards, and transportation facilities (including rail) are among the existing critical infrastructures on the PVNGS site that would be utilized to support an on-site, coal-fired alternative.

It is reasonable to assume that a coal-fired alternative would utilize supercritical steam (see text box). Supercritical steam technologies are increasingly common in new coal-fired plants. Supercritical plants operate at higher temperatures and pressures than most older subcritical coal-fired plants and therefore can attain higher thermal efficiencies. While supercritical facilities are more expensive to construct, they consume less fuel for a given output, reducing environmental impacts throughout the fuel life cycle. Based on technology forecasts from EIA, the NRC staff expects that a new, supercritical, coal-fired plant beginning operation in 2014 would operate at a heat rate of 9,069 British thermal units/kilowatt hour (Btu/kWh, or approximately 38-39% thermal efficiency (EIA 2009c). However, heat inputs could be less, depending on the coal source and whether fuel blending is practiced in order to remain compliant with emission limitations.

In a supercritical, coal-fired power plant, burning coal heats pressurized water. As the supercritical steam/water mixture moves through plant pipes to a turbine generator, the pressure drops, and the mixture flashes to steam. The heated steam expands across the turbine stages, which then spin and turn the generator to produce electricity. After passing through the turbine, any remaining steam is condensed back to water in the plant's condenser.

In most modern U.S. facilities, condenser cooling water circulates through cooling towers or a cooling pond system (either of which are closed-cycle cooling systems[9]). Older power plants often withdraw cooling water directly from existing rivers or lakes and discharge heated water directly to the same body of water (called open-cycle cooling). However, adequately sized surface water bodies are not present in the vicinity of PVNGS and such open-cycle cooling is not possible at PVNGS. Instead, redeployment of the current closed-cycle cooling system using grey water from local municipalities is the most likely option for cooling. Because nuclear plants require more cooling capacity than comparably-sized, coal-fired plants, the existing cooling towers are expected to be adequate to support a coal-fired alternative without significant amendment or expansion.

Various coal sources exist in northeast Arizona and in the nearby states of New Mexico and Colorado, with over 75% of that total comprised of the sub-bituminous rank. The largest western coal deposits exist within the Powder River Basin (PRB) in Wyoming and Montana. For the purpose of this analysis, the NRC staff presumes that sub-bituminous Powder River Basin coal will be used because of its relatively high BTU content (among sub-bituminous western coals) (8,820 Btu/lb), and low ash (6.44%, as received) and sulfur (0.48%, as received) contents (Stricker and Ellis 1999).

Future environmental regulations may also require utility scale coal-fired units capable of emitting over 250 tons per year of CO_2 to be equipped with various devices capable of removing CO_2 at efficiency as high as 88% (NETL 2007). While such levels of removal are technically feasible, they occur with substantial performance penalties. Because regulations requiring CO_2 control are not now in place, specific control strategies cannot be proposed and the assessment, therefore, disregards the impacts of CO_2 removal requirements on net power availability. (However, some projected impacts are nevertheless provided in the discussion regarding climate change impacts and greenhouse gas (GHG) emissions.)

9 Although they are known as "closed-cycle cooling systems," both mechanical and natural draft cooling towers and all cooling ponds lose a small amount of water to evaporation during operation. The water that evaporates takes heat away from the remaining water in the system, thus lowering its temperature. The water lost to evaporation typically represents as much as 10 to 15% of the system volume and must be continuously replaced.

The overall environmental impacts of a coal-fired alternative as well as the current environmental impacts of the PVNGS reactors are shown in Table 8-1. Additional details on the impacts on individual resources of the coal-fired alternative are provided in subsequent sections.

Table 8-1. Summary of Environmental Impacts of the Supercritical Coal-Fired Alternative Compared to Continued Operation of PVNGS

	Supercritical Coal-Fired Generation	Continued PVNGS Operation
Air Quality	MODERATE	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Waste Management	MODERATE	SMALL

8.1.1 Air Quality

Air quality impacts from coal-fired generation can be substantial, resulting from the emissions of significant quantities of sulfur oxides (SO_x), nitrogen oxides (NO_x), particulates, carbon monoxide (CO), and hazardous air pollutants such as mercury. Coal combustion is also a major source of the GHG gas, CO_2.[10] However, many of these pollutants can be effectively controlled by various technologies, albeit with performance penalties that result in reductions in net power generating capacity.

PVNGS is located in Maricopa County, Arizona. A portion of Maricopa County that includes PVNGS is designated as non-attainment for 8-hour ozone.[11] Another portion of Maricopa County (not including PVNGS), together with the adjacent Pinal County, is designated non-attainment for particulate (PM_{10}) and a portion (not including PVNGS) is designated as CO maintenance. A new coal-fired generating plant would qualify as a new major source of criteria

[10] Depending on the coal source and boiler firing conditions, many other pollutants can be emitted, including acid gases such as hydrogen chloride, various heavy metals besides mercury, a wide array of organic compounds, and various greenhouses gases beside CO_2. However, because the chemical composition of a particular coal source and specific firing conditions cannot be guaranteed with certainty, this assessment does not extend to estimating the amounts of those other pollutants. Emission estimates of CO_2 appearing later are based on average CO_2 emission factors of the presumed coal source (PRB) and no carbon capture or removal capabilities in place.

[11] Areas considered to have air quality as good as or better than National Ambient Air Quality Standards (NAAQS) are designated by EPA as “attainment areas”. Areas where air quality is worse than NAAQS are designated by EPA as “nonattainment areas.” Areas that previously were nonattainment areas but where air quality has since improved to meet the NAAQS are redesignated “maintenance areas” and are subject to an air quality maintenance plan.

pollutants because of its potential to emit (PTE) more than 100 tons/year. It would be subject to Prevention of Significant Deterioration of Air Quality Review under requirements of the Clean Air Act (CAA), and Arizona state regulations. It would also need to comply with the New Source Performance Standards (NSPS) for coal-fired plants set forth in 40 CFR 60 Subpart D. The standards establish limits for particulate matter and opacity (40 CFR 60.42(a)), SO_2 (40 CFR 60.43(a)), and NO_x (40 CFR 60.44(a)). Maricopa County Health Department adopts the EPA's regulations regarding pollutant emission limits.

Section 169A of the CAA (42 USC 7401) establishes a national goal of preventing future, and remedying existing, impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. The Regional Haze Rule, promulgated by EPA in 1999 and last amended in October 2006 (71 FR 60631) requires states to demonstrate reasonable progress towards the national visibility goal established in 1977. Together with the states of Utah, New Mexico and Wyoming, and the City of Albuquerque, NM, Arizona participated in the development of a Regional Haze Plan, as required by Section 309 of the rule. The Arizona Department of Environmental Quality (ADEQ) published the State's Regional Haze Implementation Plan on December 23, 2003 (ADEQ, 2003). A revision was published in December 2004 (ADEQ, 2004)

The visibility protection regulatory requirements, contained in 40 CFR Part 51, Subpart P, include the review of the new sources that would be constructed in the attainment or unclassified areas and may affect visibility in any Federal Class I area (40 CFR Part 51, Subpart P, §51.307). Under the State's plan, coal-fired electric generating units with the potential to emit more than 250 tons/year of SO2, NOx and particulate matter would be evaluated for their potential to affect visibility in Class I areas and, if found to be potentially responsible for Class I visibility impacts, would be required to control emissions of those pollutants to the extent necessary to prevent visibility deterioration. There are 12 Mandatory Class I Federal areas in the state of Arizona, four of which—Grand Canyon National Park, Sycamore Canyon Wilderness Area, Petrified Forest National Park and the Mount Baldy Wilderness Area—are specifically addressed in the Regional Haze State Implementation Plan because their location suggests potential visibility impairment from human activities. None of the Class I areas in Arizona or in surrounding states is located within 62 miles (100 km) of PVNGS, so it is unlikely that additional Regional Haze-specific emission controls would be imposed on an alternative coal-fired unit constructed at PVNGS.

Arizona stationary sources of criteria pollutants are also subject to the Clean Air Interstate Rule (CAIR), which has outlined emissions reduction goals for both SO2 and NOx for the year 2015; however, the rule was vacated by the D.C. Circuit court on February 8, 2008. In December 2008, the U.S. Court of Appeals for the D.C. Circuit reinstated the rule, but required EPA to revise both the rule and its implementation plan. CAIR would require Arizona major sources to reduce SO2 emissions by 7,000 tons (or 5 percent), and NOx emissions by 37,000 tons (or 49%) (EPA 2008b).

In response to the Consolidated Appropriations Action of 2008 (Public Law 110-161), EPA promulgated final mandatory GHG gas reporting regulations on October 30, 2009, that became effective in December 2009 (EPA 2009c) The rules are applicable to major sources of CO_2, defined as those emitting more than 25,000 tons/year. New utility-scale coal-fired power plants would be subject to those regulations. The GHG gases covered by the final rule are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF_6), and other fluorinated gases including nitrogen trifluoride (NF_3) and hydrofluorinated ethers (HFE). Future regulations may require control of CO_2 emissions (i.e., carbon capture and sequestration (CCS)).

8.1.1.1 Sulfur Oxides

The coal-fired alternative at the PVNGS site would likely use wet, limestone-based scrubbers to remove SO_2. The National Energy Technology Laboratory (NETL) indicates that this technology can remove 95 to 98% of SO_2 from flue gases (NETL 2007). SO_2 emissions from a new coal-fired power plant would be subject to the requirements of Title IV of the CAA. Title IV was enacted to reduce emissions of SO_2 and NO_x, the two principal precursors of acid rain, by restricting emissions of these pollutants from power plants. Title IV caps aggregate annual power plant SO_2 emissions and imposes controls on SO_2 emissions through a system of marketable allowances. EPA issues one allowance for each ton of SO_2 that a unit is allowed to emit. New units do not receive allowances, but are required to have secured allowances (or offsets) from existing sources to cover their SO_2 emissions. Owners of new units must therefore purchase allowances from owners of other power plants or reduce SO_2 emissions at other power plants they own. Allowances can be banked for use in future years. Thus, provided a new coal-fired power plant is able to purchase sufficient allowances to operate, it would not add to net regional SO_2 emissions, although it might do so locally.

8.1.1.2 Nitrogen Oxides

A coal-fired alternative at the PVNGS site would most likely employ various available NO_x control technologies, which can be grouped into two main categories: combustion modifications and post-combustion processes. Combustion modifications include low-NO_x burners, over fire air, and operational modifications. Post-combustion processes include selective catalytic reduction and selective non-catalytic reduction. An effective combination of the combustion modifications and post-combustion processes allow the reduction of NO_x emissions by up to 95 percent (EPA 1998). As discussed above, the most likely NO_x control would involve a combination of low-NO_x burners and selective catalytic reduction technologies in order to reduce NO_x emissions from this alternative.

Section 407 of the CAA establishes technology-based emission limitations for NO_x emissions. A new coal-fired power plant would be subject to the new source performance standards for such plants as indicated in 40 CFR 60 44a(d)(1). This regulation, issued on September 16, 1998 (63 FR 49453), limits the discharge of any gases that contain NO_x to 200 nanograms (ng) of NO_x per joule (J) of gross energy output (equivalent to 1.6 lb/MWh), based on a 30-day rolling average.

8.1.1.3 Particulates

The new coal-fired power plant would use fabric filters to remove particulates from flue gases with an expected 99% removal efficiency (NETL 2007). When present, wet SO2 scrubbers further reduce particulate matter emissions (EPA 2008a). Coal-handling equipment would introduce fugitive dust emissions when fuel is being transferred to on-site storage and then reclaimed from storage for use in the plant. During the construction of a coal-fired plant, on-site activities would also generate fugitive dust. Vehicles and motorized equipment would create exhaust emissions during the construction process. These impacts would be intermittent and short-lived, however, and, to minimize dust generation, construction crews would use applicable dust-control measures.

8.1.1.4 Carbon Monoxide

Based on firing conditions and the boiler's overall firing efficiency, SCPC boilers will emit carbon monoxide (CO) in limited quantities. Emission limits for CO will be based on heat input and typically expressed as pounds per million Btu input.

8.1.1.5 Hazardous Air Pollutants

Consistent with the D.C. Circuit Court's February 8, 2008, ruling that vacated its Clean Air Mercury Rule (CAMR), EPA is in the process of developing mercury emissions standards for power plants under the CAA (Section 112) (EPA 2009a). Before CAMR, EPA determined that coal- and oil-fired electric utility steam-generating units are significant emitters of the following hazardous air pollutants (HAPs): arsenic, beryllium, cadmium, chromium, dioxins, hydrogen chloride, hydrogen fluoride, lead, manganese, and mercury (EPA 2000b). EPA concluded that mercury is the HAP of greatest concern and that (1) a link exists between coal combustion and mercury emissions, (2) electric utility steam-generating units are the largest domestic source of mercury emissions, and (3) certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects resulting from mercury exposures caused by the consumption of contaminated fish (EPA 2000b). On February 6, 2009, the Supreme Court denied the EPA's request to review the 2008 Circuit Court's decision, and also denied a similar request by the Utility Air Regulatory Group later that month (EPA 2009a).

8.1.1.6 Carbon Dioxide

A coal-fired plant would also have currently unregulated carbon dioxide (CO_2) emissions during operations as well as during mining, processing, and transportation, which the GEIS indicates could contribute to global warming and connected climate changes. The amount of CO_2 released per unit of power produced would be dependent on the quality of the fuel and the firing conditions and overall firing efficiency of the boiler. Sub-bituminous coal from the Powder River Basin has an average CO_2 emission factor of 212.7 lb/million Btu of heat input (Hong and Slatik 1994). See Section 8.1.8 below for additional discussions regarding climate-related impacts of a coal-fired alternative.

8.1.1.7 Estimated Quantities of Pollutants Emitted

Although the NRC staff has identified the primary features and operating parameters of the supercritical pulverized coal boiler represented in this coal-fired alternative, many more aspects of system design, boiler firing conditions, and operating procedures can influence the amount of criteria pollutants ultimately released to the environment. Consequently, the quantifications of pollutant emissions appearing below should be considered only as estimates. Algorithms and emission coefficients developed by EPA (EPA 1998) were used to estimate the amounts of pollutants that would result from operation of the coal-fired alternative. With a collective net generating capacity of 4020 MWe, the coal-fired alternative, operating at a capacity factor of 85% would produce 29,932,920 MWh of electricity per year or nearly 30 million MWh.[12] With an overall power plant thermal efficiency of 39% and an average caloric value of PRB coal of

[12] For comparison, the total amount of electricity sold at retail in Arizona in 2007 was 77,193,206 MWh (EIA 2009e). Therefore, operating at an average capacity factor of 85%, PVNGS reactors would have accounted for 38.8% of retail electricity sales in the state in 2007.

8,820 Btu/lb, the amount of coal consumed annually will be approximately 29,900 million pounds or (15.0 million T/yr) (13.6 million metric T/yr).

Applying EPA emission factors and reasonable control equipment efficiencies, the resulting estimated annual pollutant releases are shown in Table 8-2.

Table 8-2. Estimated Emissions of Criteria Pollutants and Carbon Dioxide from the Coal-Fired Alternative

Pollutant	Lb/yr (T/yr) Uncontrolled	Tons/yr (MT/yr) Emitted	Notes
SO_2	249.5 million (124,739)	6,237 (5,658)	Assumes 95% efficient limestone scrubber. Emission Factor: 35(% sulfur) lb/Ton of coal
NO_x	109.9 million (54,944)	7,692 (6,978)	Assumes 86% efficient pre- and post-combustion NO_x controls. Emission Factor: 7.4 lb/Ton of coal
CO	7.43 million (3,712)	3,712 (3,368)	Assumes typical NSPS-compliant firing conditions. Emission Factor: 0.5 lb/Ton of coal
Particulates (filterable PM_{10})	956.3 million (478,165)	4,782 (4,338)	Assumes 99% efficient fabric filter control device. Emission Factor: 10(% ash) lb/Ton of coal
CO_2	55,700 million (27.9 million)	27.85 million Tons/yr (25.27 million MT/yr)	Assumes 95% conversion of carbon in coal. Emission Factor: 212.7 lb/MMBtu (for subbituminous coal from Wyoming) (Hong and Slatik, 1994). Value represents uncontrolled emissions of CO_2, i.e., no CCS.

8.1.1.8 Summary of Air Quality

While the GEIS analysis mentions global warming from unregulated CO_2 emissions and acid rain from SO_2 and NO_x emissions as potential impacts, it does not quantify emissions from coal-fired power plants. However, the GEIS analysis does imply that air impacts would be substantial (NRC 1996). The above analysis shows that emissions of air pollutants, including SO_x, NO_x, CO, and particulates, exceed those produced by the existing nuclear power plant plant (provided in Table 2.2.2-1 of this document), as well as those of the other alternatives considered in this section. Operational emissions of CO_2 are also much greater under the coal-fired alternative. Adverse human health effects such as cancer and emphysema have also been associated with air emissions from coal combustion and are discussed further in Section 8.1.5.

The NRC analysis for a coal-fired alternative at the PVNGS site indicates that impacts from the coal-fired alternative would have clearly noticeable effects, but given existing regulatory regimes, permit requirements, and emissions controls, the coal-fired alternative would not destabilize air quality. Therefore, the appropriate characterization of air impacts from a coal-fired plant located at PVNGS would be MODERATE. Existing ambient air quality would dictate the installation of pollution control equipment to meet applicable local requirements and permit conditions and may eventually require participation in emissions trading schemes.

8.1.2 Groundwater Use and Quality

Impacts to groundwater from the coal-fired alternative would be minimal. Except for potable uses, groundwater resources would not be utilized to support operation of the coal-fired plant. Total usage for potable purposes would likely be less under the coal-fired alternative than for continued PVNGS operation because of a smaller operating workforce. No effect on groundwater quality would be apparent.

Construction of a coal-fired plant may have a limited and minor impact on groundwater due to changes to surface drainage patterns during construction and thereafter. The impact to groundwater of the coal-fired alternative would be SMALL.

8.1.3 Surface Water Use and Quality

Minor impacts to surface water would occur during construction of the coal-fired alternative due to ground disturbances, alteration of natural drainage patterns and potential increases in sediment loadings in surface drainage. A site-wide storm water pollution prevention plan would be established for the construction period and would include controls and mitigations that would limit adverse impact to surface water quality. The elements of that plan would be incorporated into a General Stormwater Permit, enforceable under the NPDES program authority. The existing cooling infrastructure is expected to be redeployed to meet the heat rejection demands of the coal-fired alternative. That system currently relies on grey water obtained from nearby municipalities (primarily Phoenix). That arrangement is not expected to change and consequently, the impact to surface water quality during operation would be unchanged from the current conditions. The NRC staff therefore concludes that impacts to surface water quality would be SMALL.

8.1.4 Aquatic and Terrestrial Ecology

8.1.4.1 Aquatic Ecology

Because no surface water bodies are expected to be involved in supporting the operation of the coal-fired alternative, no impacts to aquatic resources are expected; therefore the overall impacts to aquatic resources would be SMALL.

8.1.4.2 Terrestrial Ecology

On-site and offsite land disturbances form the basis for impacts to terrestrial ecology. Because the coal-fired alternative would be built on the PVNGS site, most of the land area involved will have been previously disturbed and currently exists in industrial uses. Thus, terrestrial ecology impacts would have occurred largely during the initial construction of PVNGS. It is possible that some fallow lands on PVNGS would be used for the coal-fired alternative, and terrestrial ecosystems that have re-established on those lands would be impacted by construction and subsequent operation. Construction activities could destroy habitats and affect food supplies, especially for migrating birds. During operation, cooling towers could deposit chemically-treated water on surrounding land areas as drift. However, such impacts would be generally the same as those that are now occurring from the operation of PVNGS. It is further recognized that, because availability of water for cooling is limited at PVNGS, the cooling towers are expected to be operated in a manner that would minimize drift.

Coal-mining operation will also affect terrestrial ecology in offsite coal mining areas, although some of the land is likely already disturbed by mining operations.

Any on-site or offsite waste disposal by landfilling of coal combustion residues (CCR) will also affect terrestrial ecology at least through the period when the disposal area is reclaimed. Deposition of acid rain resulting from NO_x or SO_x emissions, as well as the deposition of other pollutants, can also affect terrestrial ecology. Given the emission controls discussed in Section 8.1.1, air deposition impacts may be noticeable, but are not likely to be destabilizing. Impacts to terrestrial resources from a coal-fired alternative would be SMALL.

8.1.5 Human Health

Coal-fired power plants introduce worker risks from coal and limestone mining, from coal and limestone transportation, and from disposal of coal combustion residues and scrubber wastes. In addition, there are public risks from inhalation of stack emissions (as addressed in Section 8.1.1) and the secondary effects of eating foods grown in areas subject to deposition from plant stacks.

Human health risks of coal-fired power plants are described, in general, in Table 8-2 of the GEIS (NRC 1996). Cancer and emphysema as a result of the inhalation of toxins and particulates are identified as potential health risks to occupational workers and members of the public (NRC 1996). The human health risks of coal-fired power plants, both to occupational workers and to members of the public, are greater than those of the current PVNGS due to exposures to chemicals such as mercury; SOx; NOx; radioactive elements such as uranium and thorium contained in coal and coal ash; and polycyclic aromatic hydrocarbon (PAH) compounds, including benzo(a)pyrene.

Regulations restricting emissions enforced by either EPA or delegated State agencies have reduced potential health effects but have not entirely eliminated them. These agencies also impose site-specific emission limits as needed to protect human health. Even if the coal-fired alternative were located in a nonattainment area, emission controls and trading or offset mechanisms could prevent further regional degradation; however, local effects could be visible. Many of the byproducts of coal combustion responsible for health effects are largely controlled, captured, or converted in modern power plants (as described in Section 8.1.1), although some level of health effects may remain.

Aside from emission impacts, the coal-fired alternative introduces the risk of coal pile fires and for those plants that use coal combustion residue liquid and sludge waste impoundments, the release of the waste due to a failure of the impoundment. Good housekeeping practices to control coal dust greatly reduce the potential for coal dust explosions or coal pile fires. Although there have been several instances in recent years, sludge impoundment failures are still rare. Further, the lack of available space and topography make it unlikely that sludge impoundments would be used for long-term on-site storage or disposal of coal combustion residue liquids or scrubber sludge at PVNGS. Instead, it is reasonable to assume that free water will be recovered from such waste streams and recycled and the solid or semi-solid portions removed to permitted off-site disposal facilities.

Human health issues related to construction would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of best management practices and APS's compliance with application Federal and State worker protection regulations. Both continuous and impulse noise impacts can be expected at off-site locations, including at the closest residences. However, confining noise-producing activities to core hours of the day (7:00 am to 6:00 pm), suspending the use of explosives during certain meteorological conditions, and notifying potentially-affected parties beforehand of such events will control noise impacts to acceptable levels. Noise impacts will be of short duration and will be SMALL.

Overall, given extensive health-based regulation and controls likely to be imposed as permit conditions, the NRC staff expects human health impacts to be SMALL.

8.1.6 Socioeconomics

8.1.6.1 Land Use

The GEIS generically evaluates the impacts of coal-fired power plant operations on land use both on and off a power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a new supercritical coal-fired power plant on the PVNGS site.

PVNGS indicated that approximately 628 acres (254 ha) of land would be needed to support a coal-fired alternative capable of replacing PVNGS (including 495 acres (200 ha) for on-site disposal of CCR and scrubber sludge that is not recycled). However, additional land would be required for coal and limestone storage and possibly coal cleaning or blending. Therefore, CCR and scrubber sludge disposal would more likely occur at off-site locations.

Additional offsite land use impacts would occur from coal mining in addition to land use impacts from the construction and operation of the new power plant. However, most of the land in existing coal-mining areas has already experienced some level of disturbance. This would undoubtedly be the case if the primary source of coal were the PRB mines. The elimination of the need for uranium mining to supply fuel for the PVNGS would partially offset this offsite land use impact. Based on this information and the need for additional land, land use impacts could range from SMALL to MODERATE.

8.1.6.2 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new coal-fired power could affect regional employment, income, and expenditures. Two types of job creation result from this alternative:

(1) construction-related jobs, and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of a new coal-fired power plant were evaluated in order to measure their possible effect on current socioeconomic conditions.

PVNGS projected that a peak construction workforce of 2,580 workers would be required to construct the coal-fired alternative at PVNGS. During construction, the communities surrounding the plant site would experience increased demand for rental housing and public services, with most such demands occurring in the Phoenix metropolitan area, approximately 40 miles east of PVNGS. The relative economic contributions of construction workers to local business and tax revenues would vary over time, but would not likely have a noticeable effect in a metropolitan area as large as Phoenix.

After construction, some local communities may be affected by the loss of construction jobs and associated loss in demand for business services. In addition, the rental housing market could experience increased vacancies and decreased prices. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site, because the workforce would need to relocate closer to the construction site. Although the ER indicates that PVNGS is a rural site, it is located near the Phoenix metropolitan area where most of the socioeconomic impacts would be expected to occur. Therefore, these effects may be somewhat lessened because workers are likely to commute to the site from these areas instead of relocating closer to the construction site. Based on the site's proximity to the Phoenix metropolitan area, construction impacts would be SMALL.

Arizona Public Service Company (APS) estimated an operational workforce of 454 workers for the coal-fired alternative. The APS estimate appears reasonable and is consistent with trends calling for reduced workforces at power generating facilities. Operational impacts would therefore be SMALL.

8.1.6.3 Transportation

During construction, up to 2,580 workers would be commuting daily to the site, primarily from the Phoenix metropolitan area. In addition to commuting workers, trucks would transport construction materials and equipment to the worksite increasing the amount of traffic on local roads, while trains would transport some of the largest components to the plant site. The increase in vehicular traffic on roads would peak during shift changes resulting in temporary levels of service impacts and delays at intersections. Trains would likely be used to deliver large components to PVNGS given its existing rail spur. Although much of the commute from the Phoenix metropolitan area would be by Interstate highway, transportation impacts would likely be MODERATE during construction.

Transportation traffic-related impacts would be greatly reduced after construction, but would not disappear during plant operations. The maximum number of plant operating personnel commuting to PVNGS would be approximately 454 workers. Frequent deliveries of coal and limestone by rail would add to the overall transportation impact by potentially causing frequent and lengthy delays at railroad crossings. Onsite coal storage would make it possible to receive several trains per day. Limestone delivered by rail could also add traffic-related impacts (though considerably less traffic than that generated by coal deliveries). The coal-fired alternative transportation impacts would range from SMALL to MODERATE during plant operations.

8.1.6.4 Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the coal-fired alternative and the surrounding landscape as well as the visibility of the coal plant.

The supercritical coal-fired power plant would be up to 200 ft (61 m) tall with one or more exhaust stacks up to 500 ft (152 m). The facility would likely be visible off site during daylight hours. The coal-fired power plant would be taller than the current PVNGS reactor building, which stands at 140 ft (43 m) with a 328 ft (100 m) offgas stack. The mechanical draft towers would also generate a condensate plume, which would be no more noticeable than the existing PVNGS plumes. The coal-fired alternative may only require the use of one cooling tower, thus minimizing the size of the plume. Noise from plant operations and coal delivery, as well as lighting on plant structures, may be detectable off site.

Overall, aesthetic impacts associated with the supercritical coal-fired alternative would range from SMALL to MODERATE.

8.1.6.5 Historic and Archeological Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for impacts on historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any proposed areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities. Studies would be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where construction would occur (e.g., roads, transmission corridors, rail lines, or other right of ways (ROWs)). Areas with the greatest sensitivity should be avoided. Potential impacts to historic or archeological resources on land located off of PVNGS needed to support the construction and operation of an on-site coal-fired power plant could range from SMALL to MODERATE.

For those portions of the coal-fired alternative that would be located on previously-disturbed lands within the currently-active industrial portion of PVNGS, the potential for adverse impacts to historic and archeological resources is low. Construction of the coal-fired alternative that extends to undisturbed portions of the PVNGS site could impact historic and archeological resources. However, PVNGS performed the necessary surveys in advance of construction to expand the cooling water impoundment infrastructure, and NRC therefore concludes that any such surveys required in connection with construction of the coal-fired alternative would also be completed in a timely manner. The NRC staff therefore further concludes that impacts to historic or archeological resources from pursuit of an on-site coal-fired alternative are likely to be SMALL.

8.1.6.6 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new supercritical coal-fired power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceed the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceeds the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this document. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around PVNGS, and all are exposed to the same hazards generated from constructing and operating a new coal-fired power plant.

Potential impacts to minority and low-income populations from the construction and operation of a new supercritical coal-fired power plant at PVNGS would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. However, minority and low-income populations residing along site access roads could be affected by increased commuter vehicle traffic during shift changes. Increased demand for rental housing during construction in the vicinity of PVNGS could affect low-income populations. However, these effects would be short-term, limited to certain hours of the day, and therefore, not likely to be high and adverse. Given the close proximity to the Phoenix metropolitan area, most construction workers would commute to the site thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this document, the construction and operation of a new supercritical coal-fired power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing near PVNGS.

8.1.7 Waste Management

Coal combustion generates several waste streams including ash (a dry solid recovered from both pollution control devices (fly ash) and from the bottom of the boiler (bottom ash)) and sludge (a semi-solid by-product of emission control system operation, in this case, primarily calcium sulfate from the operation of the wet calcium carbonate SO_2 scrubber). Combustion of 14.85 million T/yr (13.47 million MT/yr) of PRB coal will result in substantial amounts of coal combustion residue (CCR, which includes both fly and bottom ash) recovered from the fabric filter and from the bottom of the boiler. Although recycling options may exist for some of the CCR in such applications as road sub-base, as an admixture in light-weight concrete products, or in embankment stabilization, much of the CCR will require disposal. Although EPA has not declared CCR as hazardous, it does contain hazardous constituents that may leach from improperly designed or operated disposal cells that may threaten surface or groundwater resources. Most sludge may be recycled for use in production of gypsum wallboard for the construction industry. However, temporary holding facilities as well as drying facilities may need to be constructed. Spent catalysts from NO_x catalytic reduction would also be produced. Scrubber sludge and CCR may have beneficial uses, but, in the worst case, all solid wastes resulting from operation would require disposal.

The coal-fired alternative would also include construction impacts such as vegetation removal, excavation, and preparing the site surface before other crews begin actual construction of the plant, as well as modifying existing infrastructure and constructing any additionally required infrastructure. Wastes typical of the construction of large industrial facilities will also be generated. Because this alternative would be constructed at the PVNGS site, it is not likely that new transmission lines or a new rail spur will be necessary.

The NRC staff estimates that 956,331 tons of ash will be generated each year, approximately 473,384 tons/year collected as bottom ash and 478,165 tons/year collected as fly ash in the fabric filter.[13] PVNGS anticipates that as much as 90% of the captured ash can be recycled and be put to beneficial uses[14], with the remainder requiring disposal.[15] Because the recycle potential for CCR relies on both the physical properties of the ash and the leachability of any toxic constituents present, the NRC staff assumes a more conservative estimate of 50% recycled, with the remaining amount, 475,774 tons/yr, requiring disposal. Disposal of this amount of ash annually by landfilling over the expected 40-year lifetime of the coal-fired plants could noticeably affect land use and groundwater quality. Landfill locations would require proper siting in accordance with state solid waste regulations[16] and leachate from the disposal cells would need to be monitored and possibly captured for treatment because of leaching of toxic components (including heavy metals) in the ash. The NRC staff has not determined the location of this ash disposal landfill, but presumes that insufficient area would be available on the PVNGS site. After closure of the waste site and revegetation, the land could be available for other uses.

Combustion of 14.95 million T/yr of PRB coal with 0.48% sulfur will result in the generation of 119,081 T/yr of SO_2, 95% of which will be captured in the wet scrubber and converted to an equimolar amount of calcium sulfate or 253,030 T/yr (dry basis). The NRC staff presumes that as much as 90% of the scrubber sludge can be recycled for such applications as gypsum wallboards and that the remaining 25,303 T/yr can be co-disposed with the CCR that is not recycled.

The NRC staff has not made an estimate of the amount of spent catalysts that will be produced, but presumes that the entire amount will have no recycling opportunities and will require disposal. Depending on the catalysts used, special handling may also be required to address the potential hazardous character of these spent catalysts.

The impacts from waste generated during operation of this coal-fired alternative would be MODERATE to LARGE; the impacts would be clearly visible, but if properly managed the

[13] Some additional fly ash may also be captured in the SO_2 scrubber downstream of the fabric filter. That amount has not been quantified, however.

[14] Beneficial uses might include an admixture to lightweight concrete, road base, and road embankment stabilization.

[15] The American Coal Ash Association reported that 136,073,107 tons of coal combustion residues (fly ash, bottom ash, boiler slag, scrubber sludge, etc.) were produced nationwide in 2008. Of that amount, 60,593,660 tons were put to beneficial uses, reflecting a recycling (or utilization) rate of 44.53% (ACAA 2009).

[16] In May 2000, the EPA issued a "Notice of Regulatory Determination on Wastes from the Combustion of Fossil Fuels" (EPA 2000a) stating that it would issue regulations for disposal of coal combustion waste under Subtitle D of the Resource Conservation and Recovery Act. EPA has not yet issued these regulations. Until such rules are issued at the Federal level, State regulations concerning solid waste disposal are the primary controls.

wastes would not destabilize any important resource. The extent of the impacts of disposal will be dependent on the percentage of the CCR and scrubber sludge that can be recycled.

The impacts from waste generated during construction stage would be short-lived. The amount of the construction waste is small compared to the amount of waste generated during operational stage and most could be recycled. Overall, the impacts from waste generated during construction stage would be SMALL.

Therefore, NRC staff concludes that the overall impacts on wastes from construction and operation of this alternative would be MODERATE to LARGE.

8.1.8 Climate Change-Related Impacts of a Coal-Fired Alternative

The largest anthropogenic source of CO_2 emissions is the combustion of fossil fuels, including coal. After a thorough examination of the scientific evidence and careful consideration of public comments, the U.S. EPA announced on December 7, 2009, that greenhouse gases (GHGs) threaten the public health and welfare of the American people and fit the Clean Air Act definition of air pollutants. Climate change could have potential direct and indirect impacts on the operations of a coal-fired alternative to the PVNGS reactors. The construction and operation of the coal-fired alternative would emit greenhouse gases that likely contribute to climate change.

Impacts to climate change from the construction of a coal-fired alternative would result primarily from the consumption of fossil fuels in reciprocating internal combustion engines (RICE) of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. All such impacts would be temporary, however. Given the relatively small workforce and a relatively short construction period, the overall impact on climate change from the releases of GHGs during construction of a coal-fired alternative would be SMALL.

In 2007, all Arizona electricity generation sources produced an estimated 97 million MT of CO_2. Nationwide, 7,501 million MT were emitted from electricity generating sources (EPA 2009d). The NRC staff estimates that uncontrolled emissions of CO_2, the primary GHG emitted during operation of the coal-fired alternative, would amount to 25.3 MMT/y. This amount represents 0.34% and 26.1%, respectively of 2007 US and Arizona GHG emissions. Although coal combustion would be the primary source, other miscellaneous ancillary sources–as well as truck and rail deliveries of coal, limestone and other materials to the site and removals of CCR and other operational wastes to off-site disposal and/or recycling facilities–would also release GHGs. Precise quantification of GHG releases from these activities is difficult since neither the location of the coal source nor the locations of off-site disposal or recycling facilities is known at this time. Nevertheless, these activities are considered to be relatively minor sources of GHGs.

The National Energy Technology Laboratory (NETL) estimates that technologies currently being perfected will capture and remove as much as 90% of the CO_2 from the exhausts of supercritical pulverized coal-fired boilers. However, NETL anticipates that such equipment will impose a significant parasitic load that will result in a power production capacity decrease of approximately 0.8%, a reduction in overall thermal efficiency from 39.1% to 27.2% and a potential increase in the levelized cost of electricity produced in SCPC units so equipped by as much as 54.9% (NETL 2007). Further, permanent sequestering of the CO_2 would involve removing impurities (including water) and pressurizing it to meet pipeline specifications and transferring the gas by pipeline to acceptable geologic formations. Even when opportunities exist to utilize the CO_2 for enhanced oil recovery (rather than simply dispose of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the SCPC units are far removed from acceptable geologic formations. With carbon capture and sequestration in place, the coal-fired alternative would release 2.53 MMT/yr.

8.2 NATURAL GAS COMBINED-CYCLE GENERATION

In this section, NRC evaluates the environmental impacts of natural gas-fired combined-cycle (NGCC) generation at the PVNGS site.

In 2007, natural gas was responsible for 33.9% of all electricity generation in Arizona, 38,469,221 MWh of the statewide total of 113,392,528 MWh (EIA 2009a, SWEEP 2009). Like coal-fired power plants, natural gas-fired plants may be affected by future regulations that may limit greenhouse gas emissions. A gas-fired power plant, however, produces markedly fewer greenhouse gases per unit of electrical output than a coal-fired plant of the same electrical output. Natural gas-fired power plants are feasible, commercially-available options for providing electrical-generating capacity beyond PVNGS's current license expiration.

Combined-cycle power plants differ significantly from coal-fired and existing nuclear power plants. They derive the majority of their electrical output from a gas-turbine (a Brayton cycle combustion turbine/generator), without the production of steam and then generate additional power by recovering latent heat from gases exiting the combustion turbine (CT) and delivering it to a Heat Recovery Steam Generator (HRSG). The resulting steam subsequently drives a conventional Rankine cycle STG. Power resulting from this secondary cycle is completely pollution-free since it involves no fuel combustion. This "combined-cycle" approach provides significantly greater thermal efficiency than any single-cycle system, with efficiencies routinely attaining 60 percent (as compared to typical thermal efficiencies of coal-fired plants utilizing only Rankine cycle STGs of 39%) (Siemens 2007, NETL 2007). Since the natural-gas-fired alternative derives much of its power from a gas turbine cycle, and because it wastes less heat than either the coal-fired alternative or the existing PVNGS, it requires significantly less cooling.

Typical power trains for large scale combined cycle power generation would involve one, two or three CTs operating simultaneously with the heat extracted from each directed to one HRSG (commonly known as a "1x1", a "2x1" or a "3x1" configuration, respectively). CTs, HRSGs and STGs are all available in a variety of standard sizes. To complete the assessment of a NGCC alternative, the NRC staff presumes that appropriately sized CTs, HRSGs, and STGs could be assembled in appropriate multiple power train configurations to produce net electrical power virtually equivalent to the 4,020 MWe of the PVNGS reactors. The NRC staff further assumes that 75% of the net power produced (3015 MWe) comes from the operation of the CTs with the remainder (1,005 MWe) coming from operation of the HRSG-STG power trains. The CTs are presumed to each be of Advanced F-Class design, equipped with water or steam injection as a pre-combustion control to suppress NO_x formation and selective catalytic reduction (SCR) of the CT exhaust with ammonia for post-combustion control of NO_x emissions. The facility would burn natural gas meeting pipeline specifications, including: chemical composition (volume %): methane-93.9, ethane-3.2, propane-0.7, *n*-butane-0.4, CO_2-1.0, and nitrogen-0.8; and a higher heating value (HHV) of 22,792 Btu/lb (1,040 Btu/standard cubic foot), a lower heating value (LHV) of 20,552 Btu/lb (939 Btu/scf), and an average HV of 1,020 Btu/scf. (Although EIA estimates average heating value of pipeline natural gas to be 1,049 Btu/scf (EIA 2009d), EPA emission factors used in estimating air impacts are based on an average HV of 1,020 Btu/scf). With the entire facility operating at a capacity factor of 85%, CT load factors greater than 80%, a thermal efficiency of 42% for the CTs, and an overall facility thermal efficiency of 60%, the NGCC facility will consume 178.9 Billion ft^3 (4.47 Billion m^3) of natural gas to produce

29,953,422 MWh of power annually.

This gas-fired alternative would produce relatively little solid waste, primarily in the form of spent catalysts used for control of NO_x emissions. The NRC staff presumes that the SCR technology employed would involve introducing ammonia into the exhaust ducts of the CTs where it combines with NO_x in a nickel catalyst bed to form zero-valent nitrogen and water. Referring to data provided by the Institute of Clean Air Companies, EPA acknowledges that typical SCR devices can demonstrate removal efficiencies of between 70 and 90% (EPA 2000c). Because the NRC staff presumes that the NGCC alternative would use the existing PVNGS cooling system, cooling tower blowdown would still occur and waste resulting from the subsequent treatment of that blowdown and of incoming grey water would continue, but at diminished rates of generation.

Environmental impacts from the gas-fired alternative will be greatest during construction. Site crews will clear vegetation from the site, prepare the site surface, and begin excavation before other crews begin actual construction on the plant and any associated infrastructure. A substantial natural gas pipeline infrastructure already exists within what is known as the Palo Verde Hub to support various power plants, including incidental activities at PVNGS, the 1,100 MWe NGCC Harquahala Generating Station 17 miles northwest of PVNGS, the 1,060 MWe NGCC Red Hawk Facility three miles south of PVNGS, the 1,250 MWe Mesquite Power Generating Station immediately west of the Red Hawk plant, and the 550 MWe Arlington Valley Energy Facility directly west of the Mesquite plant. The NGCC alternative would likely require modifications to the natural gas supply line to PVNGS, as well as major changes or capacity upgrades to the pipeline infrastructure serving the Palo Verde Hub, including the installation of one or more additional compressor stations to maintain adequate line pressures. Modifications to existing electricity transmission infrastructure and on-site cooling systems are not expected to be required.

Environmental impacts from the NGCC alternative are summarized in Table 8-3.

Table 8-3. Summary of Environmental Impacts of the Natural Gas Combined-Cycle Generation Alternative Compared to Continued Operation of PVNGS

	Natural Gas Combined-Cycle Generation	Continued PVNGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL	SMALL
Waste Management	SMALL	SMALL

8.2.1 Air Quality

Maricopa County, Arizona is currently a non-attainment area for 8-hour ozone. Portions of the county not including PVNGS are in non-attainment for particulate matter (PM_{10}) and carbon monoxide. A new gas-fired 3,900 MWe (net) generating plant developed at the PVNGS site would qualify as a new major-emitting industrial facility and require a New Source Review

(NSR)/Prevention of Significant Deterioration of Air Quality review under CAA requirements, adopted by ADEQ and the Maricopa County Health Department. The natural gas-fired plant would need to comply with the standards of performance for stationary gas turbines set forth in 40 CFR Part 60, Subpart GG.

40 CFR Part 51, Subpart P contains the visibility protection regulatory requirements, including the review of the new sources that would be constructed in the attainment or unclassified areas and may affect visibility in any Federal Class I area (40 CFR Part 51, Subpart P, §51.307). If a gas-fired alternative were located close to a mandatory Class I area, additional air pollution control requirements would potentially apply. There are 12 Mandatory Class I Federal areas in the state of Arizona, but none within 50 miles of PVNGS, the closest being the Superstition Wilderness Area east of Phoenix.

The NRC staff projects the following emissions for a gas-fired alternative based on data published by the EIA, EPA, and on performance guarantees by the manufacturer of the SCR for this alternative and its emissions controls:

- Sulfur oxides (SO_x) – 310 tons (281 MT) per year;[17]
- Nitrogen oxides (NO_x) – 1,186 tons (1,076 MT) per year;
- Carbon monoxide (CO) – 2,736 tons (2,483 MT) per year;
- Particulate matter (PM) (PM_{10}) – 602 tons (546 MT) per year;
- Carbon dioxide (CO_2) – 10,033,675 tons (9,102,550 MT) per year[18].

A new natural gas-fired plant would have to comply with Title IV of the CAA reduction requirements for SO_2 and NO_x, which are the main precursors of acid rain and the major cause of reduced visibility. Title IV establishes maximum SO_2 and NO_x emission rate from the existing plants and a system of the SO_2 emission allowances that can be used, sold or saved for future use by new plants.

8.2.1.1 Sulfur and Nitrogen Oxides

As stated above, the new natural gas-fired alternative would produce 310 tons (281 MT) per year of SO_x and 1,186 tons (1,076 MT) per year of NO_x based on the use of the dry low NO_x combustion technology and use of the selective catalytic reduction (SCR) in order to significantly reduce NO_x emissions.

The new plant would be subjected to the continuous monitoring requirements of SO_2, NO_x and CO_2 specified in 40 CFR Part 75. The natural gas-fired plant would emit approximately 10.03 million tons (approximately 9.10 million MT) per year of (currently) unregulated CO_2 emissions. In response to the Consolidated Appropriations Action of 2008 (Public Law 110-161), EPA recently promulgated final mandatory greenhouse gas reporting regulations for major

[17] Approximately 99% of this total will be SO_2, with the remainder being SO_3.

[18] Values represent uncontrolled CO_2 emissions. Emission factor for CO_2 released from the combustion of natural gas is 110 lb/MMBtu (EPA 1998), assuming a conversion of 95% of the carbon in the fuel. Note that in its calculations, EIA uses a value of 120.593 lb/1,000 ft^3 or 117.08 lb/MMBtu. (EIA 2009g). Combustion of natural gas also releases other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) so that the total GHG emission is typically represented as CO_2-equivalents (CO_2-e). However, CO_2 predominates and, for simplicity, contributions of CH_4 and N_2O were ignored in the above calculations.

sources (emitting > 25,000 tons/year of all GHGs) in October 2009, effective in December 2009 (EPA 2009c). Regulations appearing in 40 CFR Parts 86, 87 and 89 apply to emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulfur hexafluoride (SF_6), and other fluorinated gases including nitrogen trifluoride (NF_3) and hydrofluorinated ethers (HFE). This new NGCC plant would be subject to those regulations. Future regulations may require control of CO_2 emissions (i.e., CCS).

8.2.1.2 Particulates

The new natural gas-fired alternative would produce 602 tons (546 MT) per year of particulates, all of which would be emitted as PM_{10}. Particulate control would likely not be required.

8.2.1.3 Carbon Monoxide

Based on EPA emission factors (EPA 1998), NRC staff estimates that the total CO emissions would be approximately 2,736 tons (3,483 MT) per year.

8.2.1.4 Hazardous Air Pollutants

The EPA issued in December 2000 regulatory findings (EPA 2000b) on emissions of hazardous air pollutants (HAPs) from electric utility steam-generating units, which identified that natural gas-fired plants emit hazardous air pollutants such as arsenic, formaldehyde and nickel and stated that

> ". . . the impacts due to HAP emissions from natural gas-fired electric utility steam generating units were negligible based on the results of the study. The Administrator finds that regulation of HAP emissions from natural gas-fired electric utility steam generating units is not appropriate or necessary."

8.2.1.5 Construction Impacts

Activities associated with the construction of the new natural gas-fired plant at the PVNGS site would cause some additional air impacts as a result of emissions from construction equipment and fugitive dust from operation of the earth-moving and material handling equipment. Workers' vehicles and motorized construction equipment would generate temporary criteria pollutant emissions. Dust-control practices would reduce fugitive dust, which would be temporary in nature. The NRC staff concludes that the impact of vehicle exhaust emissions and fugitive dust from operation of earth-moving and material handling equipment would be SMALL.

The overall air quality impacts of a new natural gas-fired plant located at the PVNGS site would be SMALL.

8.2.2 Groundwater Use and Quality

No groundwater is expected to be used in the construction or operation of the NGCC alternative.

Some foundation excavations may intrude on the groundwater zone and require dewatering. Otherwise, no impacts on groundwater quality are expected. The impact of the natural gas-fired alternative on groundwater would be SMALL.

8.2.3 Surface Water Use and Quality

The NGCC alternative is expected to utilize the existing cooling system which uses grey water obtained from nearby municipalities. No surface water is expected to be used in the construction or operation of the NGCC. Some impacts to surface water quality may result in increased sediment loading to storm water run-off from active construction zones, however, the NRC staff expects that a stormwater pollution prevention general permit would require best management practices that would prevent or significantly mitigate such impacts. The NRC staff concludes the impact on surface water would be SMALL.

8.2.4 Aquatic and Terrestrial Ecology

8.2.4.1 Aquatic Ecology

No surface water bodies would be used to support the construction or operation of the NGCC alternative. Treated grey water in lined impoundments would provide feedwater for cooling towers. The NRC staff concludes that impacts to aquatic ecology would be SMALL.

8.2.4.2 Terrestrial Ecology

As indicated in previous sections, the NRC staff presumes that an NGCC alternative could be constructed on the existing PVNGS property. While much of the plant is likely to be located on previously-disturbed industrialized portions of the site, some fallow areas may also be involved. Terrestrial ecology in these fallow areas will be affected, primarily resulting in habitat fragmentation and loss of food sources. Off-site impacts will occur at the locations where the existing natural gas pipleine infrastructure needs to be modified or expanded and at the locations where natural gas is extracted to supply the Palo Verde Hub; however, modifications to the existing infrastructure would occur on previously-disturbed areas within existing ROWs, and existing natural gas fields are expected to be used to provide the necessary amount of gas for this facility.

Operation of the cooling towers would produce a visible plume and cause some deposition of dissolved solids on surrounding vegetation and soil from cooling tower drift, however, these impacts will be equal to or less severe than currently-occurring impacts. Based on this information, impacts to terrestrial resources would be SMALL.

8.2.5 Human Health

Like the coal-fired alternative discussed above, a gas-fired plant would emit criteria air pollutants, but in smaller quantities per MW of power produced. None of the criteria pollutants except for NO_x is expected to require control. Human health effects of gas-fired generation are generally low, although in Table 8-2 of the GEIS (NRC 1996), the NRC staff identified cancer and emphysema as potential health risks from gas-fired plants. NO_x emissions contribute to ozone formation, which in turn contributes to human health risks. Emission controls on this gas-fired alternative can be expected to maintain NO_x emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NO_x releases in the region will not increase. Health risks to workers may also result from handling spent catalysts that may contain heavy metals.

Human health issues related to construction would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of best management practices and APS's compliance with application Federal and State worker protection regulations. Both continuous and impulse noise impacts can be expected at off-site locations, including at the closest residences. However, confining noise-producing activities to core hours of the day (7:00 am to 6:00 pm), suspending the use of explosives during certain meteorological conditions, and notifying potentially-affected parties beforehand of such events will control noise impacts to acceptable levels. Noise impacts will be of short duration and will be SMALL.

Overall, human health risks to occupational workers and to members of the public from gas-fired power plant emissions sited at PVNGS would be less than the risks described for coal-fired alternative and therefore, would likely be SMALL.

8.2.6 Socioeconomics

8.2.6.1 Land Use

The GEIS generically evaluates the impacts of natural gas power plant operations on land use both on and off a power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a natural gas-fired combined-cycle power plant at the PVNGS site.

Approximately 154 acres (62.4 ha) of land would be needed to support a natural gas-fired alternative to replace PVNGS. An area of sufficient size in previously-disturbed industrial footprint of the site is expected to be available for the NGCC plant, thus minimizing the amount of disturbance in undeveloped portions of the site. Onsite land use impacts from construction would be SMALL.

In addition to onsite land requirements, land would be required offsite for natural gas wells and collection stations. Land may also be affected by natural gas pipeline modifications. Most of this land requirement would occur on land where gas extraction already occurs.

The elimination of uranium fuel for PVNGS could partially offset off site land requirements. Based on this information and the need for additional land, overall land use impacts from a gas-fired power plant would be SMALL.

8.2.6.2 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new natural gas-fired power plant could affect regional employment, income, and expenditures. Two types of job creation would result:

(1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the natural gas-fired power plant alternative were evaluated in order to measure their possible effect on current socioeconomic conditions.

APS estimated a construction workforce of 946 workers. During construction, the communities surrounding the power plant site would experience increased demand for rental housing and public services. The relative economic effect of construction workers on local economy and tax base would vary over time.

After construction, some local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site, because workers may relocate to rural communities to be closer to the construction site. Although the ER identifies PVNGS as a rural site, it is near the Phoenix metropolitan area. Therefore, workers would likely commute instead of relocating closer to the construction site. Because of PVNGS's proximity to Phoenix, the impact of construction on socioeconomic conditions would be SMALL.

APS estimated an operations workforce of 131 workers. The APS estimate appears reasonable and is consistent with trends toward lowering labor costs by reducing the size of power plant operations workforces. The small number of operations workers is not likely to have a noticeable effect on socioeconomic conditions in the Phoenix metropolitan area. Socioeconomic impacts associated with the operation of a gas-fired power plant at PVNGS would be SMALL.

8.2.6.3 Transportation

Transportation impacts associated with construction and operation of the gas-fired power plant would consist of commuting workers and truck deliveries of construction materials to the PVNGS site. During construction, APS estimates that as many as 946 workers would be commuting daily to the site, most likely from the Phoenix metropolitan area. In addition to commuting workers, trucks would transport construction materials and equipment to the worksite increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes resulting in temporary levels of service impacts and delays at intersections. However, since most of the commute from the Phoenix metropolitan area would occur on interstate highways, increases in vehicular traffic would be easily absorbed without significant adverse impacts. Some plant components are likely to be delivered by train via the existing onsite rail spur. Pipeline construction and modification to existing natural gas pipeline systems could also have a temporary impact on local transportation. Traffic-related transportation impacts during construction would be SMALL.

During plant operations, traffic-related transportation impacts would almost disappear. According to APS, approximately 131 workers would be needed to operate the gas-fired power plant. Because fuel for the plant is transported by pipeline, a new gas-fired plant would have to be supported by the current gas pipeline system. If the required capacity is not available, any upgrades to the current pipeline system could result in additional transportation impacts.

The transportation infrastructure would experience little to no increased traffic from plant operations. Overall, the gas-fired alternative transportation impacts would be SMALL during plant operations.

8.2.6.4 Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the natural gas-fired alternative and the surrounding landscape and the visibility of the natural gas-fired plant.

The power block of the gas-fired units would be approximately 100 foot (30 m) tall, with an exhaust stack up to 500 feet (152 m). The facility would be visible offsite during daylight hours. The gas-fired power plant would be shorter than the current PVNGS reactor buildings, but the exhaust stack would be taller. The mechanical draft towers would also generate a condensate plume, which would be no more noticeable than the existing PVNGS plume. The gas-fired alternative may only require the use of one cooling tower, thus minimizing the size of the plume. Noise from plant operations, as well as lighting on plant structures, may be detectable offsite. Pipelines delivering natural gas fuel could be audible offsite near gas compressors.

In general, aesthetic changes would be limited to the immediate vicinity of the PVNGS and would be SMALL.

8.2.6.5 Historic and Archaeological Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for impacts on historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any proposed areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground-disturbing activities. Studies would be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where construction would occur (e.g., roads, transmission corridors, rail lines, or other ROWs). Areas with the greatest sensitivity should be avoided. Potential impacts to historic or archeological resources on land located off of PVNGS needed to support the construction and operation of an on-site gas-fired power plant could range from SMALL to MODERATE.

For those portions of the gas-fired alternative that would be located on previously-disturbed lands within the currently active industrial portion of the PVNGS site, the potential for adverse impacts to historic and archeological resources is low. Construction of the gas-fired power plant that extends to undisturbed portions of the PVNGS site could impact historic and archeological resources. However, PVNGS performed the necessary surveys in advance of construction to expand the cooling water impoundment infrastructure, and NRC therefore concludes that any such surveys required in connection with construction of the gas-fired alternative would also be completed in a timely manner. Further, NRC expects that the majority of the gas-fired power plant could be constructed on previously-disturbed lands in the active industrial portion of the site. Therefore, impacts to historic and archeological resources from the construction and operation of an on-site gas-fired power plant are likely to be SMALL.

8.2.6.6 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new gas-fired power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceeds the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. Some of these potential effects have been identified in resource areas discussed in this document. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around PVNGS, and all are exposed to the same hazards generated from constructing and operating a new gas-fired power plant.

Potential impacts to minority and low-income populations from the construction and operation of a new gas-fired power plant at PVNGS would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. However, minority and low-income populations residing along site access roads could be affected by increased commuter vehicle traffic during shift changes. Increased demand for rental housing during construction in the vicinity of PVNGS could affect low-income populations. However, these effects would be short-term, limited to certain hours of the day, and therefore, not likely to be high and adverse. Given the close proximity to the Phoenix metropolitan area, most construction workers would commute to the site thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this document, the construction and operation of a new gas-fired power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of PVNGS.

8.2.7 Waste Management

During the construction stage of this alternative, land clearing and other construction activities would generate waste that can be recycled, disposed onsite or shipped to an offsite waste disposal facility. Because the alternative would be constructed on the previously-disturbed PVNGS site, the amounts of wastes produced during land clearing would be minimal.

During the operational stage, spent selective catalytic reduction catalysts used to control NO_x emissions from the natural gas-fired plants would make up the majority of the waste generated by this alternative. PVNGS estimates that approximately 2,440 ft^3 of spent catalysts would be generated during each year of operation of the NGCC alternative. NRC staff concluded in the GEIS (NRC 1996) that a natural gas-fired plant would generate minimal solidwaste and further concludes that the waste impacts would be SMALL for an NGCC alternative located at the PVNGS site.

8.2.8 Climate Change-Related Impacts of a Natural Gas Combined Cycle Alternative

Combustion of fossil fuels, including natural gas, is thought to be the greatest anthropogenic source of GHG emissions. This section presents an assessment of the potential impacts the construction and operation of an NGCC alternative will have on climate change.

Impacts to climate change from the construction of an NGCC alternative would result primarily from the consumption of fossil fuels in reciprocating internal combustion engines (RICE) of construction vehicles and equipment, workforce vehicles used in commuting to and from the work site, and delivery vehicles. Such impacts would be temporary, however. Given the relatively small workforce and a relatively short construction period, the overall impact on climate change from the releases of GHGs during construction of a NGCC alternative would be SMALL.

As noted in Section 8.1.8 of this document, the total amounts of GHGs released in the US and in Arizona in 2007 related to electricity production were 7,501 MMT and 97 MMT of CO_2-equivalents (CO_2-e are explained in a footnote on page 8-11), respectively (EPA 2009d). The NRC staff estimates that uncontrolled emissions of CO_2-e from operation of the NGCC alternative would amount to 9.10 MMT/y. This amount represents 0.12% and 9.38%, respectively of 2007 US and Arizona CO_2-e emissions. Although natural gas combustion in the combustion turbines would be the primary source, other miscellaneous ancillary sources such as truck and rail deliveries of materials to the site and commuting of the workforce would make minor contributions.

NETL estimates that carbon capture and storage technologies (CCS) will capture and remove as much as 90% of the CO_2 from the exhausts of combustion turbines (CTs). However, NETL estimates that such equipment imposes a significant parasitic load that will result in a power production capacity decrease of approximately 14%, a reduction in net overall thermal efficiency of the CTs studied from 50.8% to 43.7% and a potential increase in the levelized cost of electricity produced in NGCC units so equipped by as much as 30% (NETL 2007). Further, permanent sequestering of the CO_2 would involve removing impurities (including water) and pressurizing it to meet pipeline specifications and transferring the gas by pipeline to acceptable geologic formations. Even when opportunities exist to utilize the CO_2 for enhanced oil recovery (rather than simply dispose of the CO_2 in geologic formations), permanent disposal costs could be substantial, especially if the NGCC units are far removed from acceptable geologic formations. With carbon capture and sequestration in place, the NGCC alternative would release 0.91 MMT/yr of CO_2.

If future regulations require the capture and sequestration of CO_2 from NGCC facilities, the impact on climate change from this alternative would be further reduced.

8.3 NEW NUCLEAR GENERATION

In this section, NRC evaluates the environmental impacts of new nuclear generation at the PVNGS site.

In evaluating the new nuclear alternative in its ER, APS presumed that replacement reactors would be installed on the PVNGS site, allowing for the maximum use of existing ancillary facilities such as the cooling system (including the grey water treatment facility that supports it). APS further presumed that the replacement reactors would be light-water reactors such as the Advanced Passive 1000 model Pressurized Water Reactors (PWRs), a reactor design for which

NRC has already issued a certification, and that four such reactors would be required to approximate the power-generating capacity of the existing reactors. To estimate the impacts of these replacement reactors, APS reviewed the NRC's assessment of construction and operating impacts of 2,258 MWe of new electric-generating capacity at the McGuire Nuclear Generating Station through the use of similar reactors and scaled those impacts to the PVNGS rated capacity of 4,020 MWe, amending some parameters as necessary to reflect extant conditions at the PVNGS site. The NRC staff considers the approach taken by APS in evaluating the new nuclear alternative to be appropriate and therefore bases its own assessment on similar assumptions and parameters. APS did not provide estimates of the construction schedule for a new nuclear alternative. However, estimates provided by Southern Nuclear Corporation for the construction of two AP 1000 reactors at the Vogtle Electric Generating Plant (VEGP) in Georgia included 18 months for site preparation, 48 months for construction, and 6 months from fuel loading to initial power generation (SNC 2009). The NRC staff considers these time frames to be reasonable and, although site conditions between VEGP and PVNGS are not the same, and the VEGP construction included construction of a new cooling system dedicated to the two new reactors, the NRC staff presumes that construction of new nuclear alternative at PVNGS would follow generally the same time frames, including simultaneous construction of the multiple reactors required, as was the case in the VEGP example.

Regarding construction impacts, APS estimated that the power block and ancillary facilities (excluding the cooling water system) for the replacement reactors would require approximately 500 acres and that sufficient contiguous fallow acreage was available on the PVNGS site. APS further estimated that the existing cooling system would meet the heat rejection demands of the replacement reactors with only minor modifications.

Environmental impacts from the new nuclear power alternative are summarized in Table 8-4.

Table 8-4. Summary of Environmental Impacts of the New Nuclear Alternative Compared to Continued Operation of PVNGS

	New Nuclear Power Generation	Continued PVNGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL	SMALL
Waste Management	SMALL	SMALL

8.3.1 Air Quality

Air quality would be affected by the release of criteria pollutants from the gasoline- and diesel-fueled RICE of construction vehicles and equipment, workforce commuting vehicles, and material delivery vehicles. Releases of volatile organic compounds can be expected from on-site vehicle and equipment fueling activities and from the use of cleaning agents and corrosion control coatings. Finally, ground disturbances such as ground clearing and cut and fill activities, movement of construction vehicles on unpaved and disturbed land surfaces, and delivery and stockpiling of natural materials used in construction (e.g., sand and gravel) would increase fugitive dust releases. APS would be expected to apply best management practices to control such air quality impacts to acceptable levels. Overall, air impacts during construction would be of relatively short duration and would be SMALL.

8.3.2 Groundwater Use and Quality

Although some groundwater may be used for construction purposes, the amounts are expected to be minimal and would likely be obtained from existing on-site wells. Impacts to groundwater would be SMALL.

8.3.3 Surface Water Use and Quality

Construction would result in minor impacts to surface water due to altered drainage patterns and the potential for increased sediment and construction-related pollutants in run-off from the active construction site. Best management practices, as would be addressed in a General Storm Water Permit for construction, would control such releases so that impacts to surface water from construction would be SMALL.

8.3.4 Aquatic and Terrestrial Ecology

<u>Aquatic Ecology</u>

No surface water bodies would be used to support the construction or operation of the new nuclear alternative. Treated grey water in lined impoundments would provide feedwater for cooling towers. The NRC staff concludes that impacts to aquatic ecology would be SMALL.

<u>Terrestrial Ecology</u>

As indicated in previous sections, the NRC staff presumes that a new nuclear alternative could be constructed on the existing PVNGS property. While much of the plant is likely to be located on previously-disturbed industrialized portions of the site, some fallow areas may also be involved. Terrestrial ecology in these fallow areas will be affected, primarily resulting in habitat fragmentation and loss of food sources.

Operation of the cooling towers would continue to produce a visible plume and cause some deposition of dissolved solids on surrounding vegetation and soil from cooling tower drift, however, these impacts will be equal to or less severe than currently-occurring impacts. Based on this information, impacts to terrestrial resources would be SMALL.

8.3.5 Human Health

Human health effects of a new nuclear power plant would be similar to those of the existing PVNGS. NRC staff expects that operational human health effects would be SMALL. Human health issues related to construction would be equivalent to those associated with the construction of any major complex industrial facility and would be controlled to acceptable levels through the application of best management practices and APS's compliance with application Federal and State worker protection regulations. Human health impacts from operation of the nuclear alternative would be equivalent to those associated with continued operation of the existing reactors under license renewal. Both continuous and impulse noise impacts can be expected at off-site locations, including at the closest residences. However, confining noise-producing activities to core hours of the day (7:00 am to 6:00 pm), suspending the use of explosives during certain meteorological conditions, and notifying potentially-affected parties beforehand of such events will control noise impacts to acceptable levels. Noise impacts will be of short duration and will be SMALL. Overall, human health impacts would be SMALL.

8.3.6 Socioeconomics

8.3.6.5 Land Use

The GIES generically evaluates the impacts that an advanced light-water nuclear reactor would have on land use both on and off a power plant site. The analysis of land use impacts here focuses on the amount of land area that would be affected by the construction and operation of a new nuclear power plant on the PVNGS site.

NRC staff estimates that approximately 154 acres (62.4 ha) of land would be needed to support the construction and operation of a new nuclear power plant at PVNGS. An area of sufficient size in previously-disturbed industrial footprint of the site is expected to be available for the nuclear plant, thus minimizing the amount of disturbance in undeveloped portions of the site. Onsite land use impacts from construction would be SMALL.

Additional off-site land use impacts would occur from uranium mining and fuel fabrication in addition to land use impacts from the construction and operation of the new nuclear power plant. However, most of the land in existing mining areas has already experienced some level of disturbance. Off-site land use impacts would be the same as those currently being experienced for the existing PVNGS reactors and during the license renewal term. Therefore, overall land use impacts from a new nuclear power plant would be SMALL.

8.3.6.6 Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new nuclear power plant could affect regional employment, income, and expenditures. Two types of job creation would result: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for the construction and operation of the new nuclear power plant alternative were evaluated in order to measure their possible effect on current socioeconomic conditions.

APS estimates a peak construction workforce of 3,000, most likely from the Phoenix metropolitan area. During construction, the communities surrounding the power plant site would experience increased demand for rental housing and public services. The relative economic effect of construction workers on local economy and tax base would vary over time.

After construction, some local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site, because workers may relocate to rural communities to be closer to the construction site. Although the ER identifies the PVNGS as a rural site, it is near the Phoenix metropolitan area. Therefore, workers would likely commute instead of relocating closer to the construction site. Because of the PVNGS's proximity to Phoenix, the impact of construction on socioeconomic conditions would be SMALL.

The operations workforce for the new nuclear power plant would be the same size as the current operating workforce at PVNGS. Socioeconomic impacts would therefore be the same as those currently being experienced from the operation of the existing reactors. Socioeconomic impacts associated with the operation of a new nuclear power plant at the PVNGS would therefore be SMALL.

8.3.6.7 Transportation

Transportation impacts associated with construction and operation of the new nuclear power plant would consist of commuting workers and truck and rail deliveries of construction materials to the PVNGS site. During construction, APS estimates that at its peak as many as 3,000 workers would be commuting daily to the construction site, most likely from the Phoenix metropolitan area. In addition to commuting workers, trucks would transport construction materials and equipment to the worksite increasing the amount of traffic on local roads. The increase in vehicular traffic would peak during shift changes resulting in temporary levels of service impacts and delays at intersections. However, since most of the commute from the Phoenix metropolitan area would occur on interstate highways, increases in vehicular traffic would be easily absorbed without significant adverse impacts. Major plant components would be delivered by train via the existing onsite rail spur. Traffic-related transportation impacts during construction would be SMALL.

During plant operations, traffic-related transportation impacts would include commuting by operations workers as well as truck deliveries of equipment and materials including the removal of industrial wastes to offsite disposal and/or recycling facilities.

Since the operations workforce for the new nuclear power plant would be the same size as the current operating workforce at PVNGS, transportation impacts would be the same as those currently being experienced during the operation of the existing reactors. Overall, the new nuclear alternative transportation impacts would be SMALL during plant operations.

8.3.6.8 Aesthetics

The aesthetics impact analysis focuses on the degree of contrast between the new nuclear alternative and the surrounding landscape and the visibility of the new nuclear plant.

Construction of the new nuclear power plant at PVNGS would not contrast greatly from the visual appearance of the existing industrial site. Once completed, the new nuclear power block would be similar to the existing PVNGS power block, including the use of the existing mechanical draft cooling towers . The new nuclear power plant would not change the overall visual impact of PVNGS. Visual impacts during plant operations would therefore be SMALL.

8.3.6.9 Historic and Archaeological Resources

Cultural resources are the indications of human occupation and use of the landscape as defined and protected by a series of Federal laws, regulations, and guidelines. Prehistoric resources are physical remains of human activities that predate written records; they generally consist of artifacts that may alone or collectively yield information about the past. Historic resources consist of physical remains that postdate the emergence of written records; in the United States, they are architectural structures or districts, archaeological objects, and archaeological features dating from 1492 and later. Ordinarily, sites less than 50 years old are not considered historic, but exceptions can be made for such properties if they are of particular importance. American Indian resources are sites, areas, and materials important to American Indians for religious or heritage reasons. Such resources may include geographic features, plants, animals, cemeteries, battlefields, trails, and environmental features. The cultural resource analysis encompassed the power plant site and adjacent areas that could potentially be disturbed by the construction and operation of alternative power plants.

The potential for impacts on historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any proposed areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities. Studies would be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where construction would occur (e.g., roads, transmission corridors, rail lines, or other ROWs). Areas with the greatest sensitivity should be avoided. Potential impacts to historic or archeological resources on land located off of PVNGS needed to support the construction and operation of a new nuclear power plant could range from SMALL to MODERATE.

For those portions of the new nuclear alternative that would be located on previously-disturbed lands within the currently active industrial portion of the PVNGS site, the potential for adverse impacts to historic and archeological resources is low. Construction of the new nuclear power plant that extends to undisturbed portions of the PVNGS site could impact historic and archeological resources. However, PVNGS performed the necessary surveys in advance of construction to expand the cooling water impoundment infrastructure, and NRC staff therefore concludes that any such surveys required in connection with construction of the new nuclear alternative would also be completed in a timely manner. Further, NRC staff expects that the majority of the new nuclear power plant could be constructed on previously-disturbed lands in the active industrial portion of the site. Therefore, impacts to historic and archeological resources from the construction and operation of an on-site new nuclear power plant are likely to be SMALL.

8.3.6.10 Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new nuclear power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. Disproportionately high environmental effects refer to impacts or risk of impact on the natural or physical environment in a minority or low-income community that are significant and appreciably exceeds the environmental impact on the larger community. Such effects may include biological, cultural, economic, or social impacts. For example, increased demand for rental housing during power plant construction could disproportionately affect low-income populations. Minority and low-income populations are subsets of the general public residing around PVNGS, and all are exposed to the same hazards generated from constructing and operating a new nuclear power plant.

Potential impacts to minority and low-income populations from the construction and operation of a new nuclear power plant at PVNGS would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts from construction would be short-term and primarily limited to onsite activities. However, minority and low-income populations residing along site access roads could be affected by increased commuter vehicle traffic during shift changes. Increased demand for rental housing during construction in the vicinity of PVNGS could affect low-income populations. However, these effects would be short-term, limited to certain hours of the day, and therefore, not likely to be high and adverse. Given the close proximity to the Phoenix metropolitan area, most construction workers would commute to the site thereby reducing the potential demand for rental housing.

Based on this information and the analysis of human health and environmental impacts presented in this document, the construction and operation of a new nuclear power plant would not have disproportionately high and adverse human health and environmental effects on minority and low-income populations residing in the vicinity of PVNGS.

8.3.7 Waste Management

During the construction stage of this alternative, land clearing and other construction activities would generate waste that can be recycled, disposed onsite or shipped to an offsite waste disposal facility. Because the alternative would be constructed on the previously-disturbed PVNGS site, the amounts of wastes produced during land clearing would be minimal.

Wastes associated with construction will be similar in nature and amount to wastes from similar industrial construction endeavors and should be easily managed in area landfills and waste treatment facilities. Operating impacts of the replacement reactors with respect to waste generation can also be expected to be virtually equivalent to impacts from the continued operation of the existing reactors. Overall, waste impacts of new reactors at the PVNGS would be SMALL.

8.3.8 Climate Change-Related Impacts of a New Nuclear Alternative

Operation of a new nuclear alternative would have essentially identical effects on climate change as operating the current PVNGS. These effects are discussed in Chapter 6 of this document. Construction activities would increase these impacts from RICE and commuting workers, though these effects would be short-lived.

8.4 COMBINATION ALTERNATIVE

In this section, the NRC staff evaluates the environmental impacts of a combination of alternatives. Myriad combinations are possible. However, the combination the staff selected for evaluation represents what NRC believes to be both a technically feasible and practicable technology combination alternative to continuing the operation of the PVNGS reactors. This combination will include an NGCC power plant located on the PVNGS site with 3,120 MWe capacity, a demand side management (DSM) equivalent to a peak load reduction of 100 MWe, annually, and two Concentrated Solar Power (CSP) facilities constructed somewhere in southwest Arizona within the APS service area each with a 400 MWe nameplate capacity and each equipped with thermal storage capabilities. Table 8-5 contains a summary of environmental impacts of the combination alternative compared to continued operation of PVNGS.

Table 8-5. Summary of Environmental Impacts of the Combination Alternative Compared to Continued Operation of PVNGS

	Combination Alternative (NGCC, 2 CSPs, DSM)	Continued PVNGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	MODERATE to LARGE [a]	SMALL
Aquatic and Terrestrial Resources	SMALL (for Aquatic) SMALL to LARGE (for terrestrial)	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL
Waste Management	SMALL	SMALL

(a) Treats the water in the existing PVNGS cooling system as surface water. MODERATE impact if only NGCC is supported by the cooling system, LARGE if NGCC and both CSPs are supported by the cooling system.

8.4.1 Impacts of the Natural Gas Combined Cycle Facility Portion of the Combination Alternative

The environmental resource demands and environmental footprint of a 3,120 MWe NGCC plant are generally proportional to the requirements and impacts of the 4,020 MWe facility evaluated in Section 8.2 above. The hypothetical facility would consist of appropriately sized CTs, HRSGs, and STGs arranged in multiple power trains and capable of producing 3,120 MWe (net) amounts of power. The NRC staff further assumes that 75% of the power generated, 2,340 MW, comes from the operation of the CTs, with the remainder resulting from operation of the HRSG-STG power trains. As with the alternative described in Section 8.2, this alternative would be built on PVNGS site and utilize existing infrastructures. It would consume pipeline specification natural gas and operate at a thermal efficiency of 60% and a capacity factor of 85%. The NGCC portion of this combination alternative would consume 138.8 billion ft^3 (3.89 billion m^3) of natural gas each year to generate 23,231,520 MWh of electricity annually. Its impacts would be proportional to the impacts of the alternative assessed in Section 8.2. The NRC staff projects the air quality impacts as follows:

- Sulfur oxides (SO_x) – 241 tons (218 MT) per year;[19]
- Nitrogen oxides (NO_x) – 920.3 tons (834.9 MT) per year;
- Carbon monoxide (CO) – 2,124 tons (1,927 MT) per year;
- Particulate matter (PM) (PM_{10}) – 467 tons (424 MT) per year;
- Carbon dioxide (CO_2) – 7,787,330 tons (7,064,666 MT) per year.

Most other impacts of the 4,020 MWe NGCC facility identified in Section 8.2 would similarly be reduced by roughly 20%. The footprint of this reduced-capacity facility would be only incrementally smaller than the NGCC alternative assessed above so most site-specific impacts would undergo only incremental reductions in severity or extent. However, some impacts may experience a greater reduction or be eliminated entirely. For example, the lesser amount of natural gas required to support this NGCC facility may obviate the need to modify or upgrade the existing natural gas pipeline (or, especially, to add another compressor station). The GHG emissions from the construction of the 3,120 MW NGCC portion of this combination alternative

[19] Approximately 99% of this total will be SO_2, with the remainder being SO_3.

would be virtually the same as for construction of the NGCC alternative discussed in Section 8.2. Finally, because the 3,120 MW NGCC portion of this combination alternative would consume less natural gas than the NGCC alternative (138.8 billion ft^3 *vs*. 178.9 billion ft^3), GHG emissions from its operation would be proportionally reduced from that of the NGCC alternative (7.06 MMT/y of CO_2, as compared to 9.10 MMT/yr of CO_2).

8.4.2 Impacts of the Conservation Portion of the Combination Alternative

The combination alternative would include activities aimed at reducing the load that is now being satisfied by the PVNGS reactors. For the purpose of this assessment, "conservation" would include a variety of programs and initiatives generally described as "Demand Side Management" (DSM). DSM programs fall into two broad categories: improving the energy efficiency of facilities and equipment comprising the electrical load supplied by PVNGS reactors, and demand response programs. Energy conservation programs will result in a reduction in the overall quantity of electricity consumed over the year, but may not result in reduction in electricity demand during peak periods.[20] Demand response programs are actions and initiatives aimed at encouraging customers to reduce usage during peak times, or to shift that usage to off-peak times. Unlike energy generation initiatives discussed in this chapter, DSM programs focus on the behavior of the energy end user. DSM can include measures that shift energy consumption to different times of the day to reduce peak loads, measures that can interrupt certain large customers during periods of high demand or measures that interrupt certain appliances during high demand periods, and measures like replacing older, less efficient appliances, lighting, or control systems. While DSM can also include measures that utilities use to boost sales, such as encouraging customers to switch from gas to electricity for water heating, the staff is not evaluating such load-building activities as part of this alternative, as it would result in the need for more energy generation capacity.

In a 2008 staff report, the Federal Energy Regulatory Commission (FERC) outlined the results of the 2008 FERC Demand Response and Advanced Metering Survey (FERC, 2008). Nationwide, approximately 8% of retail electricity customers are enrolled in some type of demand response program. The potential demand response resource contribution from all US demand response programs is estimated to be close to 41,000 MW, or about 5.8% of US peak demand. A national assessment of Demand Response Potential required of FERC by Section 529 of the Energy Independence and Security Act of 2007 was published by FERC in June 2009 (FERC 2009). The survey evaluated potential energy savings in five- and ten-year horizons for four development scenarios: Business As Usual, Expanded Business As Usual, Achievable Participation, and Full Participation, each representing successively greater demand response program opportunities and successively increasing levels of customer participation. The greatest savings would be realized under the Full Participation scenario with peak demand reductions of 188 GW by the year 2019, a 20% reduction of the anticipated peak load without any demand response programs in place. Under the Achievable Participation scenario, reflecting a more realizable voluntary customer participation level of 60%, peak demand would be reduced by 138 GW by 2019, a 14% reduction.

In Arizona, the retail electricity customer profile is made up of relatively large percentages of residential customers and small commercial and industrial customers (54% and 26%, respectively). Much of their demand is spent on central air conditioning. Under the Achievable

[20] In Arizona, peak loads are generally experienced during the hottest part of the day and are dispropoortionally the result of air conditioner usage by residential and commercial customers.

Participation and Full Participation scenarios, residential customer participation could reduce peak loads by 3,082 MW and 4,755 MW, respectively by 2019, whereas small commercial and industrial participation could reduce peak loads by 273 and 606 MW, respectively, by 2019. With all retail electricity customers enrolled in the Full Participation scenario, Arizona has the potential to reduce the projected 2019 statewide peak demand of 22.4 GW by 6,200 MW, or 27.7% of the peak demand.

APS already offers a number of demand response program opportunities to its retail customers, including rebates for installing distributed solar energy systems and high efficiency air conditioning equipment, election of the percentage of power to be generated by renewable energy technologies, voluntary load interruptions during peak times, time-differentiated rates to encourage off-peak energy usage, and a variety of cash incentives, training, and energy information services offered to business customers. Overviews of these programs are available on the APS website: http://www.aps.com/main/services/default.html.

In 2008 testimony before the Arizona Corporation Commission, David Pickles, speaking on behalf of APS, outlined the APS demand response programs and provided an estimation of potential expansion (Pickles 2008). The collective impact of all of APS's currently approved DSM Programs through December 2007 has resulted in a peak load reduction of 64.2 MW. Given a reasonable set of assumptions regarding incentive levels and customer acceptance, APS concluded that cost-effective demand response programs could be responsible for peak demand reductions of between 2,600 and 3,900 GWh by 2020. Thus, APS would need to increase the reach of its DSM programs by slightly more than 50% to meet the capacity demands of this hypothetical technology combination alternative to continued operation of the PVNGS reactors.

Although it is impossible to predict with precision which specific DSM programs would be expanded (or started) to meet the 100 MW capacity requirement of this Combination Alternative, it is safe to suggest that conservation programs, by their very nature, represent little to no adverse environmental impacts relative to the conventional electricity generation technology they would replace. The NRC staff concludes, therefore, that the impacts of the conservation portion of the combination alternative will by SMALL for all categories.

Land use impacts of an energy efficiency alternative would be SMALL. Rapid replacement and disposal of old energy inefficient appliances and other equipment would generate waste material and could potentially increase the size of landfills. However, given time for program development and implementation, the cost of replacements, and the average life of appliances and other equipment, the replacement process would probably be gradual. Older energy inefficient appliances and equipment would likely be replaced by more efficient appliances and equipment as they fail (especially frequently-replaced items, like light bulbs). In addition, many items (like home appliances or industrial equipment) have substantial recycling value and would likely not be disposed of in landfills.

Low-income families could benefit from weatherization and insulation programs. This effect would be greater than the effect for the general population because (according to the Office of Management and Budget [OMB]) low-income households experience home energy burdens more than four times larger than the average household (OMB 2007). Weatherization programs could target low-income residents as a cost-effective energy efficiency option since low-income populations tend to spend a larger proportion of their incomes paying utility bills (OMB 2007). Overall impacts to minority and low-income populations from energy efficiency programs would be nominal, depending on program design and enrollment.

8.4.3 Impacts of the Concentrated Solar Power (CSP) Portion of the Combination Alternative

In recent years, solar power has enjoyed explosive growth, especially in portions of six southwestern states (California, Nevada, Utah, Colorado, New Mexico, and Arizona). Although both photovoltaic (PV) solar power and concentrated solar power (CSP) technologies have enjoyed growth, the NRC staff considers CSP to have a greater potential to serve as baseload power, primarily because of currently-existing opportunities to store thermal energy for delayed production of electricity over time periods coincident with peak loads.[21]

EIA reports that total statewide electricity capacity in 2007 was 25,579 MW, 2,736 MW of which was from all renewable energy sources, and 9 MW of which was from grid-connected solar, with all solar energy facilities in the state producing 9,000 MWh of electricity in 2007 (EIA 2009e).

Three CSP technologies have been developed for utility-scale power production: parabolic trough, power tower, and Stirling heat engine. The parabolic trough and power tower both concentrate the sun's heat by reflecting it onto a container of heat transfer fluids that is circulated to a conventional tube-type heat exchanger to make steam to drive a conventional STG. The Stirling heat engine concentrates the sun's heat on a closed container of hydrogen gas which expands to drive a piston whose motion is converted to angular momentum to drive a generator. Both parabolic trough and power tower facilities are operational at utility scale. The first utility-scale Stirling heat engine facility is expected to become operational in California in the near future.

Although having substantially less impact on air quality than any conventional fossil fuel power generating technology, CSP is not entirely without impact. Substantial amounts of land are required for utility-scale CSP facilities. CSP facilities are thermoelectric technologies whose steam cycles must be supported by heat rejection capabilities at least equivalent in capacity to similarly-sized fossil fuel plants. Most utility-scale CSP facilities have nameplate ratings of no more than 400 MW. At the current stage of CSP development, both parabolic trough and power tower CSP facilities require approximately 5 acres for every MW of capacity, without accounting for the increased capacity necessary for thermal storage capabilities. CSP facilities can use molten salt to store heat for steam production when the sun is not shining, but to do so and to still maintain their nameplate capacities, such CSP facilities must increase the size of their solar field. A CSP facility with 6 hours of thermal storage (considered at this stage of development to be the practical limit) and operating at a capacity factor of approximately 48% would require a solar field over 3.5 times as large as the field size required to generate power at the facility's nameplate rating, or a "solar multiple" of 3.5 (SDRREG 2005). Thus, a 400 MWe CSP plant with 6 hours of thermal storage operating at a capacity factor of 48% would have a solar field of roughly 7,000 acres.

Both parabolic trough and power tower facilities utilize conventional steam cycles and thus have cooling demands similar to equivalently-sized fossil fuel power plants with the same overall

[21] Work is proceeding to equip PV systems with battery storage or fuel cell storage capabilities, thus improving the dispatchability of power, however, these technologies are in their infancy and not currently being deployed at utility scale in the United States. PV technologies continue to improve and are excellent options for distributed systems as well as for low-power-demand activities such as water heating and structure heating and cooling and a variety of remote, off-grid applications, where their widespread use could substantially reduce peak loads.

thermal efficiency. CSP facilities using closed loop cooling (e.g., a mechanical or natural draft cooling tower) can consume as much as 15 acre-ft/yr/MW, or approximately 4.89 million gallons/yr for every MW of capacity (DOE 2009). Because water is a scarce commodity in the desert southwest where solar resources are greatest, dry cooling alternatives that simply pass ambient air across a tube heat exchanger containing the steam condensate or a secondary heat transfer fluid have been explored. Such dry cooling can be feasible, albeit with some performance penalties (a reduction in net power production of 10% or more). Further, such dry cooling alternatives exhibit their worst performance during the hottest part of the day, typically the time when APS experiences load peaks due primarily to air conditioning demands of its residential and small commercial/industrial customers. Hybrid wet/dry cooling introduces a small stream of water into the ambient air stream which flash evaporates (due to low relative humidity in the southwest) by extracting heat from the air stream. Such hybrid systems result in significant reductions in water demands over wet recirculating closed loop cooling systems with less severe losses in performance than the dry cooling alternative. The NRC staff concludes that two 400 MWe CSP facilities utilizing either parabolic trough or power tower technologies and with adequate thermal storage to meet baseload demands would have a SMALL impact on air quality, and a SMALL to MODERATE impact on land use. The NRC staff presumes that the cooling system currently in place for the reactors would be more than adequate to provide cooling support to the two 400 MWe CSP plants. However, because the extant cooling system is also expected to provide heat rejection for the 3,120 MWe NGCC portion of this combination alternative,[22] the available amount of water may not be sufficient to support all three power plant units simultaneously and such a configuration could result in a MODERATE to LARGE impact on water.

An area of sufficient size in previously-disturbed industrial footprint of the site is expected to be available for the CSP facility, thus minimizing the amount of disturbance to undeveloped land. The elimination of uranium fuel for PVNGS could partially offset land requirements. Based on this information and the need for additional land, overall land use impacts from a concentrated solar power plant would be SMALL.

During construction, the communities surrounding the power plant site would experience increased demand for rental housing and public services. Using modified cost data extracted from a model developed by NREL (NREL 2010) and incorporating relevant parametric data from economic impact analyses of representative CSP facilities (Stoddard 2008, Schwer 2004), the NRC staff estimates that construction of trough technologies would produce between 1,218 and 1,744 jobs. The relative economic effect of construction workers on local economy and tax base would vary over time.

After construction, some local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. Employment impacts during a single year of operation would vary from 91 to 252 jobs. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site,

[22] In a 2009 Report to Congress, DOE estimated that a typical NGCC facility would consume approximately 200 gallons of water per MWh of power produced while a water-cooled parabolic trough plant would consume 800 gal/MWh and a Power Tower facility would consume 600 gal/MWh, as compared to 500 gal/MWh consumed by a typical nuclear reactor. Dish engine facilities utilize a closed cycle cooling system comparable to an automobile's radiator cooling system and therefore consume only approximately 20 gal/MWh (DOE 2009).

because workers may relocate to rural communities to be closer to the construction site. Workers would likely commute instead of relocating closer to the construction site if the CSP facility is located near a metropolitan area. Depending on the size of the workforce, the impact of construction on socioeconomic conditions would be SMALL to MODERATE.

The small number of operations workers is not likely to have a noticeable effect on socioeconomic conditions in most areas. Socioeconomic impacts associated with the operation of a concentrated solar power plant would be SMALL.

Transportation impacts associated with construction and operation of the concentrated solar power plant would consist of commuting workers and truck deliveries of construction materials. The increase in vehicular traffic would peak during shift changes resulting in temporary levels of service impacts and delays at intersections. Some plant components could be delivered by train. Traffic-related transportation impacts during construction would be SMALL to MODERATE.

During plant operations, traffic-related transportation impacts would be reduced. Overall, the transportation impacts would likely be SMALL during plant operations.

The power block of the concentrated solar power plant would be visible offsite during daylight hours. Mechanical draft towers would generate a condensate plume, which would be no more noticeable than the existing PVNGS plume. Noise from plant operations, as well as lighting on plant structures, may be detectable offsite. In general, if located at an existing industrial site, aesthetic impacts would be SMALL.

The potential for impacts on historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any proposed areas would need to be surveyed to identify and record historic and archaeological resources, identify cultural resources (e.g., traditional cultural properties), and develop possible mitigation measures to address any adverse effects from ground disturbing activities. Studies would be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where construction would occur (e.g., roads, transmission corridors, rail lines, or other ROWs). Potential impacts to historic or archeological resources on land needed to support the construction and operation of a concentrated solar power plant would range from SMALL to MODERATE.

Potential impacts to minority and low-income populations from the construction and operation of a concentrated solar power plant would mostly consist of environmental and socioeconomic effects (e.g., noise, dust, traffic, employment, and housing impacts). Noise and dust impacts would be short-term and primarily limited to onsite activities during construction. Minority and low-income populations residing along site access roads would be affected by increased commuter vehicle traffic during shift changes. Increased demand for rental housing during construction could also affect low-income populations. These effects would occur during the construction of the power plant and during certain hours of the day. However, if the construction site is located near a metropolitan area, most construction workers would commute to the site from their homes thereby reducing the potential demand for rental housing.

Based on this information, the construction and operation of a concentrated solar power plant could have a disproportionate effect on minority and low-income populations residing in the vicinity of the concentrated solar power plant.

8.4.4 Summary of Impacts of the Combination Alternative

Despite the intrinsic limitations of CSP for production of baseload power, the NRC staff believes that it is nevertheless feasible to identify an area of adequate size within the APS service area in which to construct two 400 MWe facilities to serve in combination with an NGCC facility and DSM programs to constitute a combination alternative in replacement of the PVNGS reactors. The impacts of the combination alternative are shown in Table 8-5.

Although the majority of power in the combination alternative is expected to come from the operation of an NGCC plant (3,120 MWe of a total 4,020 MWe), many of the impacts of the three thermoelectric portions of the combination are additive. The NRC staff concludes that air quality, groundwater, aquatic resources, human health and waste impacts are largely the consequence only of the operation of the NGCC portion of this combination alternative and generally the same as for the NGCC alternative discussed in Section 8.2, i.e., SMALL. However, overall impacts from the combination alternative would result in a MODERATE to LARGE impact for surface water and SMALL to MODERATE for other resource areas.

8.5 ALTERNATIVES CONSIDERED BUT DISMISSED

In this section, the NRC staff presents the alternatives it initially considered for analysis as alternatives to license renewal of PVNGS, but later dismissed due to technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the existing PVNGS license expires. Under each of the following technology headings, the NRC staff indicates why it dismissed each alternative from further consideration.

8.5.1 Offsite Coal-Fired, Gas-Fired, and Nuclear Capacity

While it is possible that coal-fired, gas-fired, and nuclear alternatives like those considered in Sections 8.1, 8.2, and 8.3, respectively, could be constructed at sites other than PVNGS, the NRC staff determined that they would result in greater impacts than alternatives constructed at the PVNGS site. Greater impacts would occur primarily as a result of the need to construct necessary supporting infrastructure, like transmission lines, roads, and railway spurs, all of which are already present on the PVNGS site. Further, the community around PVNGS is already familiar with the appearance of a power facility, and it is an established part of the region’s aesthetic character. The next most feasible alternatives to the PVNGS site would be formerly used industrial sites where some of the required infrastructure may also exist; however, remediation of past contamination may be necessary in order to make the site ready for redevelopment. The greatest impacts would occur if the alternative were to be constructed at a “greenfield” site. In short, an existing power plant site with supporting transmission and cooling infrastructures sufficient to support the production of 4,020 MWe would present the best location for a new power facility.

8.5.2 Coal-Fired Integrated Gasification Combined-Cycle (IGCC)

IGCC is an emerging technology for generating electricity with coal that combines modern coal gasification technology with both gas turbine and steam turbine power generation. In general, gasifiers use heat pressure and steam to change solid fuels such as petroleum residuals, petroleum coke, coal and other solid carbonaceous fuels to produce synthesis gases (generically referred to as Syngas) typically composed of carbon monoxide, hydrogen, and other flammable constituents. At the same time, the inorganic fractions of the fuels are vitrified into a glassy, chemically inert slag that can be disposed, typically without adverse environmental consequence. Reactions of the Syngas with water (the Water-Gas Shift Reaction) convert the carbon monoxide to CO_2 and H_2. The Syngas is then further processed to remove contaminants and produce various liquid chemicals and subsequently combusted in a combustion turbine to produce electric power. Separating the CO_2 from the Syngas prior to combustion is also possible. Latent heat is recovered both from the Syngas as it exits the gasifier and from the combustion gases exiting the combustion turbine and directed to a Heat Recovery Steam Generator (HRSG) feeding a conventional Rankine cycle STG to produce additional amounts of electricity. Only a few IGCC plants are operating at utility scale.

IGCC systems operate at high thermal efficiencies and are capable of producing electrical power that is cleaner and cheaper than the older, conventional fossil fuel power producing technologies such as pulverized coal boilers. The technology is cleaner than conventional pulverized coal plants because major pollutants can be removed from the gas stream before combustion. The IGCC alternative also generates less solid waste than the pulverized coal-fired alternative. The largest solid waste stream produced by IGCC installations is slag, a black, glassy, sand-like material that is also potentially a marketable by-product as inert, non-compressible fill material. The other large-volume by-product produced by IGCC plants is sulfur, which is extracted during the gasification process and can be marketed rather than placed in a landfill. IGCC units do not produce ash or scrubber wastes.

To date, however, IGCC technologies have had limited application and have been plagued with operational problems such that their effective, long-term capacity factors are often not high enough for them to reliably serve as baseload units. Emissions of criteria pollutants would likely be slightly less than those from the NGCC alternative, but significantly lower than those from the coal-fired alternative. In addition, an IGCC alternative, especially one equipped with an air separation unit for production of a pure oxygen feedstream to the gasifier and with carbon capture and sequestration capabilities, would require slightly more onsite space than the coal-fired alternative in Section 8.1 and operate at a higher thermal efficiency. Depending on gasification technology employed, IGCC would use less water than PC units but slightly more than NGCC.[23] Long-term maintenance costs of this relatively complex technology would likely be greater than that for a similarly-sized coal-fired plant of NGCC plant.

EIA indicates that IGCC and other advanced coal plants may become increasingly common in coming years (EIA 2009f), though uncertainties about construction time periods and commercial viability in the near future leads NRC staff to believe that IGCC is an unlikely alternative to PVNGS license renewal at this time.

[23] In a study completed in 2007, DOE's National Energy Technology Laboratory (NETL) compared various hypothetical IGCC, PC, and NGCC technologies, each equipped to meet current and expected pollution limits, and operating with capacity factors of 0.80, 0.85, and 0.85, respectively, on the basis of resource demands, environmental footprints, and reliability. The study found that overall efficiencies of IGCC facilities using three different gasifier designs ranged from 38.2 to 41% without CCS and from 31.7 to 32% when CCS was included. Without CCS, the relative normalized raw water use ratios for PC:IGCC:NGCC technologies was 2.4:1.4:1.0. The normalized environmental performance with respect to criteria pollutant emissions for PC:IGCC:NGCC included: for SO_2 (lb/MMBtu) 0.085:0.0128:negligible, for NO_x 0.070 lb/MMBtu:15 ppmv (dry @ 15% O_2):2.5 ppmv (dry@ 15% O_2), and for PM (lb/MMBtu) 0.013:0.0071:negligible.

8.5.3 Energy Conservation/Energy Efficiency

As discussed above in Section 8.3.2, conservation programs and initiatives can play an important role in meeting future energy needs. However, testimony provided to the Arizona Corporation Commission by Pickles suggests that opportunities to further expand conservation programs beyond their current levels would not yield a demand savings equivalent to the baseload power currently represented by PVNGS's nuclear reactors, regardless of how aggressively such conservation programs are pursued (Pickles 2008). As shown in the assessment in Section 8.3 above, however, the NRC nevertheless believes that, when combined with other more conventional baseload technologies, including with certain renewable technologies, conservation programs can help define a technically feasible and practicable alternative to the PVNGS reactors.

8.5.4 Purchased Power

Purchased electrical power is not likely to be an alternative to PVNGS license renewal. The NRC staff recognizes the potential for purchased power to offset a portion of the electricity generated by PVNGS, however, for the timeframe of PVNGS renewal, there are no guaranteed available power sources to replace the 4,020 MWe that PVNGS provides. Because of the lack of assured available purchased electrical power, NRC staff has not evaluated purchased power as an alternative to license renewal.

8.5.5 Solar Power

Solar technologies use the sun's energy to produce electricity. Solar power technologies include photovoltaic (PV) and concentrated solar power (CSP). In PV systems, sunlight incident on special photovoltaic materials results in the direct production of direct current electricity. Two types of CSP technology that have enjoyed the greatest development are the parabolic trough and the power tower. Both involve capturing the sun's heat and converting it to steam which powers a conventional Rankine cycle STG.

Currently, the PVNGS site receives more than 6.8 kWh of solar insolation per square meter per day (kWh/m^2/day), for PV solar collectors oriented at an angle equal to the installation's latitude and more than 8.3 kWh/m2/day Direct Normal Insolation (DNI) for CSP (NREL 2008). This is a relatively high-value solar resource, sufficient for cost-effective generation of power given the current state of PV technology development. Since flat-plate photovoltaics tend to be roughly 25% efficient (although that is expected to rapidly improve with the development of inexpensive, more efficient photocells), a PV alternative will require at least 20,000 acres (8,134 ha) of collectors to provide an amount of electricity equivalent to that generated by PVNGS. Space between collectors for maintenance purposes and associated infrastructure and areas allowed to remain fallow to avoid drainage swales, sensitive habitats, and unacceptable topography grades further increase this land requirement. This amount of land, while large, is consistent with the land required for coal and natural gas-fired plants when the entire fuel cycles are considered. In the GEIS, the NRC staff noted that, by its nature, PV solar power is intermittent (i.e., it does not work at night and cannot satisfy baseload power demands when the sun is not shining), and the efficiency of collectors varies greatly with weather conditions. The PV alternative will require energy storage or backup power supply to provide electric power at night. While development of battery storage options is ongoing, none are currently available that would provide baseload amounts of power. Given the challenges in meeting baseload requirements, the NRC staff does not believe that PV solar power can serve as an alternative to license renewal of PVNGS.

Concentrated solar power (CSP) which has the potential to store the sun's energy as heat for delayed production of electricity has the potential to overcome PV's inherent intermittency, and therefore, is better suited to offer the reliability and availability of baseload power. At its current state of technology development, CSP requires approximately 5 acres of land for every MW of power produced and, if wet closed loop cooling is used, an amount of water equal to or greater than the amount now required to support PVNGS reactors (as much as 15 acre-ft/yr/MW, or approximately 4.89 million gallons/yr/MW). Although CSP alone cannot match the power or capacity factor of the PVNGS reactors, the NRC has determined that CSP, in combination with other conventional thermoelectric technologies, may provide a technically feasible and practical alternative. One such combination of alternatives involving CSP is discussed in detail in Section 8.4.

8.5.6 Wind

The American Wind Energy Association (AWEA) reports that a total of 25,369 MW of wind energy capacity was installed at the end of 2008, with 8,545 MW installed just in 2008 (AWEA 2009). Texas is by far the leader in installed capacity with 2,671.3 MW, followed by Iowa (1,599.8 MW), Minnesota (455.65 MW), Kansas (450.3 MW), and New York (407 MW). There are no utility-scale wind farms in Arizona. As with solar, the feasibility of wind resources serving as alternative baseload power in the APS service area is dependent on the location, value, accessibility, and constancy of the resource. Wind energy must be converted to electricity at or near the point where it is extracted, and there are limited energy storage opportunities available to overcome the intermittency and variability of wind resource availability.

At the current stage of wind energy technology development, wind resources of Category 3 or better[24] are required to produce utility-scale amounts of electricity. Notwithstanding mountain ridges where installation of a wind farm would present significant logistical constraints, there are very few locations within Arizona where wind resources meet or exceed that value (NREL 2002). Land-based wind turbines have individual capacities as high as 3 MW, with the 1.67 MW turbine being the most popular size to have been installed in 2008 (offshore wind turbines have capacities as high as 5 MW). The capacity factors of wind farms are primarily dependent on the constancy of the wind resource and while off-shore wind farms can have relatively high capacity factors due to high-quality winds throughout much of the day (resulting primarily from differential heating of land and sea areas), land-based wind farms typically have capacity factors less than 40%. Notwithstanding capacity factors much lower than desirable for baseload power, many hundreds of turbines would be required to meet the baseload capacity of PVNGS reactors. Further, to avoid inter-turbine interferences to wind flow through the wind farm, turbines must be located well separated from each other, resulting in utility-scale wind farms requiring substantial amounts of land.[25] The limited availability of adequately-sized and constantly-available wind

[24] By industry convention, wind resource values are categorized on the basis of the power density and speed of the prevailing wind at an elevation of 50 meters, from Category 1 with wind power densities of 200-300 W/m^2 (typically existing with constant wind speeds between 12.5-14.3 mph (5.8-6.4 m/s) through Category 7 with power densities of 800-1800 W/m^2 (wind speeds of 19.7-24.8 mph (8.8-11.1 m/s)). Category 3 wind has a power density of 300-400 W/m^2 with wind speeds of 15.7-16.8 mph (7.0-7.5 m/s).

[25] However, the permanent components of wind farms, the individual turbines, electrical substations and maintenance/control/storage buildings occupy roughly 5% of the area of a typical wind farm with the remaining land areas available for most other non-intrusive land uses once construction is completed.

resources in Arizona, low-capacity factors, and the substantial land requirements combine to allow the NRC staff to conclude that utility-scale wind farms in the APS service area would not be reasonable alternatives to PVNGS reactors.

8.5.7 Wood Waste

As noted in the GEIS (NRC 1996), the use of wood waste to generate utility scale baseload power is limited to those locations where wood waste is plentiful. Wastes from pulp, paper, and paperboard industries and for forest management activities in those areas can be expected to provide sufficient, reliable supplies that are feedstocks for energy generation. Beside the fuel source, the technological aspects of a wood-fired generation facility are virtually identical to those of a coal-fired alternative and, given constancy of fuel source, can be expected to operate at equivalent efficiencies and reliabilities. Walsh, et. al. (2000) have determined that forest waste, urban wood waste, and primary mill waste are all produced in Arizona, all in relatively modest quantities. The availability of each was determined for delivery prices ranging from < $30/dry ton to < $50/dry ton. Facilities to convert wood waste to electricity are typically less than 50 MW in size, although co-firing biomass with coal can take place in boilers as large as 300 MW (EPA 2010). Processing the wood waste into pellets can improve the overall efficiency of such co-fired units. Although co-fired units can have capacity factors similar to coal-fired units, such levels of performance are dependent on the continued availability of the wood waste fuel. Given the typically small size of biomass facilities for electricity production and the limited availability of wood resources in Arizona at economical delivery prices, the NRC staff has determined that production of electricity from biomass at levels equivalent to PVNGS would not be a reasonable alternative to the PVNGS reactors.

8.5.8 Hydroelectric Power

Three technology variants of hydroelectric power exist: dam and release, run-of-the-river, and pumped storage. Dam and release facilities affect large amounts of land behind the dam to create reservoirs, but can provide substantial amounts of power at capacity factors greater than 90%. Power generating capacities of run-of-the-river dams fluctuate with the flow of water in the river and the operation of such dams is typically constrained so as not to create undue stress on the aquatic ecosystems present. Pumped storage facilities pump water from flowing water courses to higher elevations during off-peak load periods, in order to release the water during peak load periods through turbines to generate electricity. A comprehensive survey of hydropower resources in Arizona was completed in 1997 by DOE's Idaho National Environmental Engineering Laboratory (INEEL 1997)[26]. At that time, statewide hydroelectric potential was approximately 1,809 MW, distributed across 21 dams. More recently, as much as 37,000 MW of potential installed capacity has been identified for the state, including 22 sites where pumped storage hydroelectric facilities could be built (Arizona Solar Center 2009). Although Arizona appears to have substantial untapped hydroelectric potential, competing demands for water, together with the potential substantial environmental impacts of constructing and operating a utility-scale hydroelectric facility have resulted in no large-scale dams being approved in recent years. The NRC staff concludes that relying on new hydroelectric power facilities as an alternative to PVNGS reactors is not a reasonable alternative to license renewal.

[26] Located outside of Idaho Falls, ID, this DOE laboratory is now known as Idaho National Laboratory.

8.5.9 Wave and Ocean Energy

Wave and ocean energy has generated considerable interest in recent years. Ocean waves, currents, and tides are often predictable and reliable. Ocean currents flow consistently, while tides can be predicted months and years in advance with well-known behavior in most coastal areas. Most of these technologies are in relatively early stages of development, and while some results have been promising, they are not likely to be able to replace the capacity of PVNGS by the time its license expires. Even if a suitably-large facility is built, the PVNGS site is not located near an ocean, though a portion of its generating capacity is sold to consumers in California. Given the state of technology, scale of likely projects, and distance from an ocean, the NRC staff did not consider wave and ocean energy as an alternative to PVNGS license renewal.

8.5.10 Geothermal Power

As with most renewable energy sources, value, accessibility, and availability within a geographic area determines the feasibility of geothermal energy's use for baseload power generation. Two technology variants for geothermal energy have been developed. "Hydrothermal technology" involves extracting heat from hot, pressurized groundwater located in readily accessible formations readily close to the surface. The heated water is either pumped to the surface where the sharp reduction in pressure allows it to flash into steam that is directed to an STG, or a heat transfer fluid is pumped into the formation in a closed loop system where it is heated by the groundwater before being returned to the surface and its latent heat used to produce steam. The water must be at least 150 °C (302 °F) for such systems to run efficiently. A second technology variant, hot dry rock (HDR), also known as enhanced geothermal systems (EGS), extracts heat from dry, hot formations, first by fracturing those formations and then by circulating water in open loop systems in formations where it passes through the just created fractures and extracts heat (Duchane 2005).

Geothermal energy has an average capacity factor of 90% and can be used for baseload power where available. However, geothermal electric generation is limited by the geographical availability of geothermal resources (NRC 1996). Three areas of the state have low-grade geothermal resources: Buckthorn Baths in Apache Junction, Castle Hot Springs in the Bradshaw Mountains, and Childs on the Verde River (ASC 2009). No geothermal energy generation is currently occurring in Arizona.[27] Given the low quality of these resources and their relative distances from the APS service area and the primary load center of the Phoenix metropolitan area, the NRC staff has concluded that none of these locations can support utility scale electricity development using hydrothermal technology.

Investigations into HDR technology began in 1974 and focused on fracturing the bedrock in a HDR formation in order to inject, and later recover water that had been heated. Areas in the White Mountains east of Phoenix have also been recently explored for their ability to support HDR technologies, but remoteness of the area and lack of a convenient water source make such areas infeasible for development. The NRC staff has therefore concluded that utility scale electricity generation from geothermal resources in Arizona is not a reasonable alternative to PVNGS license renewal.

[27] However, geothermal resources of adequate quality and accessibility exist in areas west of Yuma, Arizona, in the Imperial Valley of California.

8.5.11 Municipal Solid Waste

Municipal solid waste (MSW) combustors use three types of technologies—mass burn, modular, and refuse-derived fuel. Mass burning is currently the method used most frequently in the United States and involves no (or little) sorting, shredding, or separation. Consequently, toxic or hazardous components present in the waste stream are combusted, and toxic constituents are exhausted to the air or become part of the resulting solid wastes. Currently, approximately 87 waste-to-energy plants operate in 25 states (none in Arizona), processing 28.7 million tons of trash annually and operate at capacity factors greater than 90% to generate approximately 2,720 MWe, or an average of 31.3 MWe per plant (Integrated Waste Services Association 2007). More than 128 average-sized plants would be necessary to provide the same level of output as the PVNGS reactors. EPA estimates that, on average, air impacts from MSW-to-Energy plants are: 3,685 lb/MWh of CO_2, 1.2 lb/MWh of SO_2, and 6.7 lb/MWh of NO_x.[28] Depending on the composition of the municipal waste stream, air emissions can vary greatly, and the ash produced may exhibit hazardous character and require special treatment and handling (EPA 2009e).

Estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant would be approximately the same as that for a coal-fired power plant. Additionally, waste-fired plants have the same or greater operational impacts than coal-fired technologies (including impacts on the aquatic environment, air, and waste disposal). The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at coal-fired facilities or at wood-waste facilities because of the need for specialized waste separation and handling equipment (NRC 1996).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term as energy prices increase (and especially since such landfills, of sufficient size and maturity, can be sources of easily recoverable methane fuel); however, it is possible that municipal waste combustion facilities may become attractive again.

Regulatory structures that once supported municipal solid waste incineration no longer exist. For example, the Tax Reform Act of 1986 made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal alternatives such as landfills. Also, the Supreme Court's 1994 decision in *C&A Carbone, Inc. v. Town of Clarkstown*, 511 U.S. 383 (1994), limits the ability of local governments to mandate that waste be delivered to specific waste combustion facilities, thus adding uncertainty to fuel and revenue streams and casting doubt on the financial feasibility of such projects. In addition, environmental regulations have increased the capital cost necessary to construct and maintain municipal waste combustion facilities.

Given the small average installed size of municipal solid waste plants and the unfavorable regulatory environment, the NRC staff does not consider municipal solid waste combustion to be a reasonable alternative to PVNGS license renewal.

[28] These estimates assume 0.535 MWh/ton of MSW feed combusted, based on EPA emission factors contained in "Compilation of Air Pollutant Emission Factors (AP-42) (EPA 1998).

8.5.12 Biofuels

In addition to wood and municipal solid waste fuels, there are other concepts for biomass-fired electric generators, including direct burning of energy crops, conversion to liquid biofuels, and biomass gasification. In the GEIS, the NRC staff indicated that none of these technologies had progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as PVNGS. No electricity was generated in Arizona in 2007 using biomass technology (EIA 2009e). After reevaluating current technologies, the NRC staff finds other biomass-fired alternatives are still unable to reliably replace the PVNGS capacity. For this reason, the NRC staff does not consider other biomass-derived fuels to be feasible alternatives to PVNGS license renewal.

8.5.13 Oil-Fired Power

In Arizona in 2007, oil-fired electricity generation accounted for only 46,137 MWh of the statewide total of 88,825,573 MWh produced by all electric utilities (EIA 2009a). EIA projects that oil-fired plants will account for very little of the new generation capacity constructed in the United States during the 2008 to 2030 time period. Further, EIA does not project that oil-fired power will account for any significant additions to capacity (EIA 2009f).

The variable costs of oil-fired generation tend to be greater than those of the nuclear or coal-fired operations, and oil-fired generation tends to have greater environmental impacts than natural gas-fired generation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive (EIA 2009f). The high cost of oil has prompted a steady decline in its use for electricity generation. Thus, the NRC staff does not consider oil-fired generation as a reasonable alternative to PVNGS license renewal.

8.5.14 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air (or oxygen) over a cathode and separating the two by an electrolyte. The only byproducts (depending on fuel characteristics) are heat, water, and CO_2. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Natural gas is typically used as the source of hydrogen.

At the present time, fuel cells are not economically or technologically competitive with other alternatives for electricity generation. EIA projects that fuel cells may cost $5,374 per installed kW (total overnight costs) (EIA 2009f), or 3.5 times the construction cost of new coal-fired capacity and 7.5 times the cost of new, advanced gas-fired, combined-cycle capacity. In addition, fuel cell units are likely to be small in size (the EIA reference plant is 10 MWe). While it may be possible to use a distributed array of fuel cells to provide an alternative to PVNGS, it would be extremely costly to do so and would require many units and wholesale modifications to the existing transmission system. Accordingly, the NRC staff does not consider fuel cells to be a reasonable alternative to PVNGS license renewal.

8.5.15 Delayed Retirement

APS indicated in the ER that it has no knowledge of any plans to retire any Arizona coal-fired plants with capacities equivalent to PVNGS prior to expiration of PVNGS licenses. As a result, delayed retirement is not a viable alternative to license renewal. Other generation capacity may be retired prior to the expiration of the PVNGS license, but this capacity is likely to be older, less efficient, and without modern emissions controls.

8.6 NO-ACTION ALTERNATIVE

This section will examine the environmental effects that occur if NRC takes no action. No action in this case means that NRC does not issue renewed operating licenses for any of the three reactors at PVNGS and the licenses expire at the end of the current license terms (December 31, 2024, December 9, 2025, and March 25, 2027). If NRC takes no action to renew the licenses, each reactor will shut down at or before the expiration of its current license. After shutdown, plant operators will initiate decommissioning according to 10 CFR 50.82. Table 8-6 provides a summary of environmental impacts of no action compared to continued operation of the PVNGS reactors.

The NRC staff notes that no action is the only alternative that is considered in-depth that does not satisfy the purpose and need for this draft Supplemental Environmental Impact Statement (SEIS), since it does not provide power generation capacity to meet the needs currently satisfied by PVNGS reactors. Assuming that a need currently exists for the power generated by PVNGS, the no-action alternative would require that the appropriate energy planning decisionmakers rely on an alternative to replace the capacity of PVNGS or otherwise reduce the need for power by an amount equivalent to PVNGS's current contribution to the grid. Overall impacts as a result of taking no action could therefore ultimately vary widely and may, in some cases, be much larger than the immediate impacts of plant shutdown considered in this section.

This section addresses only those impacts that arise directly as a result of plant shutdown. The environmental impacts from decommissioning and related activities have already been addressed in several other documents, including the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG-0586, Supplement 1 (NRC 2002); the license renewal GEIS (chapter 7; NRC 1996); and Chapter 7 of this SEIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever APS ceases operation of PVNGS.

The NRC staff notes that, even with renewed operating licenses, PVNGS will eventually shut down, and the environmental effects addressed in this section will occur at that time. Those impacts will be addressed in this section. As with decommissioning effects, shutdown effects are expected to be similar whether they occur at the end of the current license or at the end of a renewed license period.

Table 8-6. Summary of Environmental Impacts of No Action Compared to Continued Operation of PVNGS

	No Action	Continued PVNGS Operation
Air Quality	SMALL	SMALL
Groundwater	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL	SMALL
Waste Management	SMALL	SMALL

8.6.1 Air Quality

When the plant stops operating, there would be a reduction in emissions from activities related to plant operation such as use of diesel generators and employees' vehicles. In Chapter 4, NRC staff determined that these emissions would have a SMALL impact on air quality during the renewal term. Therefore, if the emissions decrease, the impact to air quality would also decrease and would be SMALL.

8.6.2 Groundwater Use and Quality

The current use of groundwater to support facility operation is limited and impacts have been evaluated as SMALL. Plant closure would further reduce groundwater usage so the impacts would still be SMALL.

8.6.3 Surface Water Use and Quality

PVNGS cooling requirements as well as most industrial demands are satisfied by treated grey water. No surface water is used, and, consequently, the impacts of operation on surface water are SMALL. Likewise, the impact of plant shutdown on surface water would also be SMALL. However, it should be noted that PVNGS currently supplies cooling water to the Red Hawk Plant. If that support continues, stoppage of the operation of the PVNGS reactors will not result in a complete shutdown of the cooling water management system.

8.6.4 Aquatic and Terrestrial Resources

8.6.4.1 Aquatic Ecology

The impacts to aquatic ecology from plant operation are SMALL. Consequently, the impact of plant shutdown will also be SMALL.

8.6.4.2 Terrestrial Ecology

Terrestrial ecology impacts would be SMALL. No additional land disturbances on or offsite would occur.

8.6.5 Human Health

Human health risks would be smaller following plant shutdown. The plant, which is currently operating within regulatory limits, would emit less gaseous and liquid radioactive material to the environment. In addition, following shutdown, the variety of potential accidents at the plant (radiological or industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. In Chapter 4 of this draft SEIS, the NRC staff concluded that the impacts of continued plant operation on human health would be SMALL. In Chapter 5, the NRC staff concluded that the impacts of accidents during operation were SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood and variety of accidents decrease following shutdown, the NRC staff concludes that the risks to human health following plant shutdown would be SMALL.

8.6.6 Socioeconomics

8.6.6.1 Land Use

Plant shutdown would not affect onsite land use. Plant structures and other facilities would remain in place until decommissioning, and the cooling water management system would remain operational, albeit at a reduced level of activity. Most transmission lines connected to PVNGS would remain in service after the plant stops operating (and portions of the electricity generation and management infrastructure may remain operational to provide amounts of reactive power necessary to maintain grid stability). Maintenance of most existing transmission lines would continue as before. Impacts on land use from plant shutdown would be SMALL.

8.6.6.2 Socioeconomics

Plant shutdown would have an impact on socioeconomic conditions in the region around PVNGS. The PVNGS workforce includes 2,200 permanent employees and 620 long-term contract employees, with 98% of the workforce living in Maricopa County. Plant shutdown would eliminate the great majority of these jobs and would reduce tax revenue in the region. Given the size of the workforce pool in Maricopa County, the loss of these contributions, which may not entirely cease until after decommissioning, would have a SMALL impact. See Appendix J to NUREG-0586, Supplement 1 (NRC 2002), for additional discussion of the potential socioeconomic impacts of plant decommissioning.

8.6.6.3 Transportation

Traffic volumes on the roads in the vicinity of PVNGS would be reduced after plant shutdown. Most of the reduction in traffic volume would be associated with the loss of jobs at the plant. Deliveries of materials to the plant would be reduced, as would removals of waste materials related to plant operation until decommissioning commences. Transportation impacts would be SMALL as a result of plant shutdown.

8.6.6.4 Aesthetics

Plant structures and other facilities would remain in place until decommissioning. Noise caused by plant operation would cease. Aesthetic impacts of plant closure would be SMALL.

8.6.6.5 Historic and Archaeological Resources

Impacts from the no-action alternative would be SMALL, since PVNGS would ultimately be decommissioned. A separate environmental review would be conducted for decommissioning. That assessment will address the protection of historic and archaeological resources.

8.6.6.6 Environmental Justice

Termination of power plant operations would not disproportionately affect minority and low-income populations outside of the immediate vicinity of PVNGS. Impacts to all other resource areas would be SMALL. Therefore, because there are no high or adverse impacts, by definition, there is also no disproportionate impact upon low income or minority populations. See Appendix J of NUREG-0586, Supplement 1 (NRC 2002), for additional discussion of these impacts.

8.6.7 Waste Management

If the no-action alternative were implemented the generation of high-level waste would stop and generation of low-level and mixed waste would decrease. There may be a temporary increase in wastes resulting from the purging and cleaning of various systems as they are placed into stable long-term storage modes. Impacts from implementation of no-action alternative are expected to be SMALL.

8.7 ALTERNATIVES SUMMARY

In this chapter, the NRC staff considered the following alternatives to PVNGS license renewal: supercritical coal-fired generation; natural gas combined-cycle (NGCC) generation; new nuclear generation; and a combination alternative involving NGCC, concentrated solar power (CSP) and demand side management (DSM). No action by the NRC and the effects it would have were also considered. The impacts for all alternatives are summarized in Table 8-7 on the following page.

The environmental impacts of the proposed action (issuing renewed PVNGS operating licenses) would be SMALL for all impact categories, except for the Category 1 issue of collective offsite radiological impacts from the fuel cycle, high level waste (HLW), and spent fuel disposal. The NRC staff did not determine a single significant level for these impacts, but the Commission determined them to be Category 1 issues nonetheless.

The NRC staff concludes that the coal-fired alternative would have the greatest overall adverse environmental impact. This alternative would result in MODERATE waste management and air quality from nitrogen oxides, sulfur oxides, particulate matter, polycyclic aromatic hydrocarbons, carbon monoxide, carbon dioxide, and mercury (and the corresponding human health impacts). Its impacts upon socioeconomic and biological resources would result in SMALL impacts.

The NGCC alternative would result in SMALL impacts in all areas. This alternative would result in substantially lower air emissions, and lesser amounts of operational wastes than the coal-fired alternative. However, the NGCC alternative could result in off-site local, short-term impacts if major modifications and expansions of the natural gas pipeline infrastructure were required. Further, although the overall impact to air quality from NGCC operation would be SMALL, NGCC operation would release greenhouse gases, albeit in lesser quantities per unit of power produced than the coal-fired alternative, but in significantly greater quantities than would result from continued operation of the PVNGS reactors.

Although impacts of installing and operating new nuclear-generating capacity on the PVNGS would be SMALL for all impact categories, there would be impacts during construction that would not occur if operation of the existing reactors were to continue under license renewal.

The combination alternative would have lower air emissions and waste management impacts than both the NGCC and coal-fired alternatives, however it would have relatively higher construction impacts in terms of land use and terrestrial resources, and potential disruption to historic and archaeological resources, mainly as a result of construction of the solar portions of the combination alternative which is likely to occur in areas off the PVNGS site.

Under the No Action Alternative, plant shutdown would eliminate approximately 2200 jobs and would reduce tax revenue in the region. The loss of these contributions, which may not entirely cease until after decommissioning, would have a SMALL impact. However, the no-action alternative does not meet the purpose and need stated in this draft SEIS.

Of the alternatives that meet the purpose and need for this draft SEIS, the natural gas-fired alternative, the new nuclear alternative, and the continued operation of PVNGS all have SMALL environmental impacts. Given the need to construct new facilities for gas-fired and new nuclear alternatives, however, NRC staff concludes that continued operation of the existing PVNGS is the environmentally-preferred alternative.

Table 8-7. Summary of Environmental Impacts of Proposed Action and Alternatives

Alternative	Impact Area						
	Air Quality	**Groundwater**	**Surface Water**	**Aquatic and Terrestrial Resources**	**Human Health**	**Socioeconomics**	**Waste Management**
License Renewal	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL[a]
Supercritical Coal-fired Alternative	MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	MODERATE
NGCC Alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
New Nuclear	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Combination Alternative	SMALL	SMALL	MODERATE to LARGE	SMALL	SMALL	SMALL to MODERATE	SMALL
No Action Alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL

[a] For the PVNGS license renewal alternative, waste management was evaluated in Chapter 6. Consistent with the findings in the generic environmental impact statement (GEIS), these impacts were determined to be SMALL with the exception of collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal.

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9.0 CONCLUSION

This draft supplemental environmental impact statement (DSEIS) contains the environmental review of the Arizona Public Service Company (APS) application for a renewed operating license for Palo Verde Nuclear Generating Station (PVNGS), as required by the *Code of Federal Regulations* (CFR), Part 51 of Title 10 (10 CFR Part 51) and the U.S. Nuclear Regulatory Commission's (NRC) regulations that implement the National Environmental Policy Act (NEPA). This chapter presents conclusions and recommendations from the site-specific environmental review of PVNGS and summarizes site-specific environmental issues of license renewal that were identified during the review. The environmental impacts of license renewal are summarized in Section 9.1; a comparison of the environmental impacts of license renewal and energy alternatives is presented in Section 9.2; unavoidable impacts of license renewal, energy alternatives, and resource commitments are discussed in Section 9.3; and conclusions and NRC staff recommendations are presented in Section 9.4.

9.1 ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL

The NRC staff's (staff) review of site-specific environmental issues in this SEIS leads to the conclusion that issuing a renewed license would have SMALL impacts for the Category 2 issues applicable to license renewal at PVNGS, as well as environmental justice and chronic effects of electromagnetic fields (EMF). No impacts beyond those discussed in the GEIS were identified for the site-specific environmental issue applicable at PVNGS.

Mitigation measures were considered for each Category 2 issue, as applicable. The staff identified several measures that could mitigate potential acute EMF impacts resulting from continued operation of the PVNGS transmission lines, including erecting barriers along the length of the transmission line to prevent unauthorized access to the ground beneath the conductors and installing road signs at road crossings. These mitigation measures could reduce human health impacts by minimizing public exposures to electric shock hazard. Additionally, one measure the staff identified that could mitigate potential impacts to threatened or endangered species would be for APS to report existence of any Federally- or State-listed endangered or threatened species within or near the transmission line rights-of-way to the Arizona Game and Fish Department (AGFD), California Department of Fish and Game (CDFG) and/or U. S. Fish and Wildlife Service (USFWS) if any such species are identified during the renewal term. In particular, if any evidence of injury or mortality of migratory birds, State-listed species, or Federally-listed threatened or endangered species is observed within the corridor during the renewal period, coordination with the appropriate State or Federal agency would minimize impacts to the species and, in the case of Federally-listed species, ensure compliance with the Endangered Species Act.

The NRC staff also considered cumulative impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes them. The staff concluded that cumulative impacts of PVNGS's license renewal would be SMALL for potentially-affected resources.

9.2 COMPARISON OF ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL AND ALTERNATIVES

In the conclusion to Chapter 8, the NRC staff considered the following alternatives to PVNGS license renewal: supercritical coal-fired generation; natural gas combined-cycle (NGCC) generation; new nuclear generation; and a combination alternative involving NGCC, concentrated solar power (CSP) and demand side management (DSM). The NRC staff concluded that the coal-fired alternative and the combination alternative would have a greater overall adverse environmental impact than NGCC or new nuclear generation. The NGCC alternative, the new nuclear alternative, and the continued operation of PVNGS all have SMALL environmental impacts. Given the need to construct new facilities for NGCC and new nuclear alternatives, however, NRC staff concluded that continued operation of the existing PVNGS is the environmentally preferred alternative.

9.3 RESOURCE COMMITMENTS

9.3.1 Unavoidable Adverse Environmental Impacts

Unavoidable adverse environmental impacts are impacts that would occur after implementation of all feasible mitigation measures. Implementing any of the energy alternatives considered in this SEIS, including the proposed action, would result in some unavoidable adverse environmental impacts.

Minor unavoidable adverse impacts on air quality would occur due to emission and release of various chemical and radiological constituents from power plant operations. Nonradiological emissions resulting from power plant operations are expected to comply with Environmental Protection Agency (EPA) emissions standards, though the alternative of operating a fossil-fueled power plant in some areas may worsen existing attainment issues. Chemical and radiological emissions would not exceed the National Emission Standards for Hazardous Air Pollutants.

During nuclear power plant operations, workers and members of the public would face unavoidable exposure to radiation and hazardous and toxic chemicals. Workers would be exposed to radiation and chemicals associated with routine plant operations and the handling of nuclear fuel and waste material. Workers would have higher levels of exposure than members of the public, but doses would be administratively controlled and would not exceed standards or administrative control limits. In comparison, the alternatives involving the construction and operation of a non-nuclear power generating facility would also result in unavoidable exposure to hazardous and toxic chemicals to workers and the general public.

The generation of spent nuclear fuel and waste material, including low-level radioactive waste, hazardous waste, and nonhazardous waste would also be unavoidable. In comparison, hazardous and nonhazardous wastes would also be generated at non-nuclear power generating facilities. Wastes generated during plant operations would be collected, stored, and shipped for suitable treatment, recycling, or disposal in accordance with applicable Federal and State regulations. Due to the costs of handling these materials, power plant operators would be expected to conduct all activities and optimize all operations in a way that generates the smallest amount of waste possible.

9.3.2 The Relationship between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The operation of power generating facilities would result in short-term uses of the environment as described in Chapters 4, 5, 6, 7, and 8. “Short-term” is the period of time that continued power generating activities take place.

Power plant operations require short-term use of the environment and commitment of resources, and also commit certain resources (e.g., land and energy) indefinitely or permanently. Certain short-term resource commitments are substantially greater under most energy alternatives, including license renewal, than under the no-action alternative because of the continued generation of electrical power and the continued use of generating sites and associated infrastructure. During operations, all energy alternatives require similar relationships between local short-term uses of the environment and the maintenance and enhancement of long-term productivity.

Air emissions from power plant operations introduce small amounts of radiological and nonradiological constituents to the region around the plant site. Over time, these emissions would result in increased concentrations and exposure, but are not expected to impact air quality or radiation exposure to the extent that public health and long-term productivity of the environment would be impaired.

Continued employment, expenditures, and tax revenues generated during power plant operations directly benefit local, regional, and State economies over the short term. Local governments investing project-generated tax revenues into infrastructure and other required services could enhance economic productivity over the long term.

The management and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste requires an increase in energy and consumes space at treatment, storage, or disposal facilities. Regardless of the location, the use of land to meet waste disposal needs would reduce the long-term productivity of the land.

Power plant facilities are committed to electricity production over the short term. After decommissioning these facilities and restoring the area, the land could be available for other future productive uses.

9.3.3 Irreversible and Irretrievable Commitments of Resources

This section describes the irreversible and irretrievable commitment of resources that have been identified in this SEIS. Resources are irreversible when primary or secondary impacts limit the future options for a resource. An irretrievable commitment refers to the use or consumption of resources that are neither renewable nor recoverable for future use. Irreversible and irretrievable commitment of resources for electrical power generation include the commitment of land, water, energy, raw materials, and other natural and man-made resources required for power plant operations. In general, the commitment of capital, energy, labor, and material resources are also irreversible.

The implementation of any of the energy alternatives considered in this SEIS would entail the irreversible and irretrievable commitment of energy, water, chemicals, and in some cases, fossil fuels. These resources would be committed during the license renewal term and over the entire life cycle of the power plant and would be unrecoverable.

Energy expended would be in the form of fuel for equipment, vehicles, and power plant operations and electricity for equipment and facility operations. Electricity and fuel would be purchased from offsite commercial sources. Water would be obtained from existing water supply systems. These resources are readily available, and the amounts required are not expected to deplete available supplies or exceed available system capacities.

The irreversible and irretrievable commitment of material resources includes materials that cannot be recovered or recycled, materials that are rendered radioactive and cannot be decontaminated, and materials consumed or reduced to unrecoverable forms of waste. None of the resources used by these power generating facilities, however, are in short supply, and for the most part are readily available.

Various materials and chemicals derived from chemical vendors, including acids and caustics, are required to support the operation's activities. Their consumption is not expected to affect local, regional, or national supplies.

The treatment, storage, and disposal of spent nuclear fuel, low-level radioactive waste, hazardous waste, and nonhazardous waste require the irretrievable commitment of energy and fuel and will result in the irreversible commitment of space in disposal facilities.

9.4 RECOMMENDATION

The NRC's preliminary recommendation is the adverse environmental impacts of license renewal for PVNGS are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by APS; (3) consultation with Federal, State, and local agencies; (4) the NRC staff's own independent review; and (5) the NRC staff's consideration of public comments received during the scoping process.

10.0 LIST OF PREPARERS

This draft supplemental environmental impact statement (SEIS) was prepared by members of the Office of Nuclear Reactor Regulation, with assistance from other U.S. Nuclear Regulatory Commission (NRC) organizations and with contract support from Argonne National Laboratory and Pacific Northwest National Laboratory.

Table 10-1 provides a list of NRC staff that participated in the development of the draft SEIS. Argonne National Laboratory provided contract support for air quality, hydrology, historic and archaeological resources, and alternatives, presented primarily in Chapters 2, 4, and 8. Pacific Northwest National Laboratory provided contract support for the severe accident mitigation alternatives (SAMAs) analysis, presented in Chapter 5 and Appendix F.

Table 10-1. List of Preparers

Name	Affiliation	Function or Expertise
Jay Robinson	Nuclear Reactor Regulation	Branch Chief
Andrew Imboden	Nuclear Reactor Regulation	Branch Chief
Lisa Regner	Nuclear Reactor Regulation	Project Manager
David Drucker	Nuclear Reactor Regulation	Project Manager
Dennis Beissel	Nuclear Reactor Regulation	Hydrology
Dennis Logan	Nuclear Reactor Regulation	Aquatic Ecology; Terrestrial Ecology
Stephen Klementowicz	Nuclear Reactor Regulation	Radiation Protection; Human Health
Allison Travers	Nuclear Reactor Regulation	Historic and Archaeological Resources
Briana Balsam	Nuclear Reactor Regulation	Terrestrial Ecology
George Bacuta	Nuclear Reactor Regulation	Air Quality
Ekaterina Lenning	Nuclear Reactor Regulation	Electromagnetic Fields
Robert Palla	Nuclear Reactor Regulation	Severe Accident Mitigation Alternatives
Jeffrey Rikhoff	Nuclear Reactor Regulation	Socioeconomics; Land Use; Environmental Justice; Historic and Archaeological Resources
Andrew Stuyvenburg	Nuclear Reactor Regulation	Alternatives

Name	Affiliation	Function or Expertise
Ron Kolpa	Argonne National Laboratory[(a)]	Alternatives
Konnie Wescott	Argonne National Laboratory	Historic and Archaeological Resources
Young-Soo Chang	Argonne National Laboratory	Air Quality
Terri L. Patton	Argonne National Laboratory	Hydrology
Steve Short	Pacific Northwest National Laboratory[(b)]	Severe Accident Mitigation Alternatives
Bruce Schmitt	Pacific Northwest National Laboratory	Severe Accident Mitigation Alternatives
Jon Young	Pacific Northwest National Laboratory	Severe Accident Mitigation Alternatives

(a) Argonne National Laboratory is operated by UChicago Argonne, LLC for the U.S. Department of Energy.
(b) Pacific Northwest National Laboratory is operated by Batelle for the U.S. Department of Energy.

11.0 INDEX

12.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT ARE SENT

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Mr. Joseph Manual Lt. Governor	Gila River Indian Community Council P.O. Box 97 Sacaton, AZ 85247
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APPENDIX A.
COMMENTS RECEIVED ON THE PALO VERDE NUCLEAR GENERATING STATION, ENVIRONMENTAL REVIEW

A. COMMENTS RECEIVED ON THE PALO VERDE NUCLEAR GENERATING STATION, ENVIRONMENTAL REVIEW

A.1 COMMENTS RECEIVED DURING SCOPING

The scoping process began on May 26, 2009 with the publication of the U.S. Nuclear Regulatory Commission's (NRC's) Notice of Intent to conduct scoping in the *Federal Register* (74 FR 24884). The scoping process included two public scoping meetings held in Tonopah and Avondale, Arizona on June 25, 2009. Approximately 60 people attended the meetings. After the NRC's prepared statements pertaining to the license renewal process, the meetings were open for public comments. Twelve (12) attendees provided oral comments that were recorded and transcribed by a certified court reporter, written statements or both. Transcripts for the afternoon and evening meetings were made publicly available at the NRC Public Document Room (PDR) and from the NRC's Agencywide Documents Access and Management System (ADAMS) listed under Accession Nos. ML092040121 and ML092040125, respectively. A summary of the meeting, which was issued on August 4, 2009, is listed under Accession No. ML091900138.

At the conclusion of the scoping period, the NRC staff reviewed the transcripts and all written material received, and identified individual comments. Twenty-two (22) letters, emails, or documents containing comments were also received during the scoping period. All comments and suggestions received orally during the scoping meetings or in writing were considered.

Each set of comments from a given commenter was given a unique alpha identifier (Commenter ID letter), allowing each set of comments to be traced back to the transcript, letter, or email in which the comments were submitted. The Commenter ID letter is preceded by PV (short for Palo Verde Nuclear Generating Station). The Commenter ID letter is followed by a number for submissions that contained multiple comments. Table A-1 identifies the individuals providing comments and the Commenter ID letter associated with each person's set(s) of comments. For oral comments, the individuals are listed in the order in which they spoke at the public meeting. Accession numbers indicate the location of the written comments in ADAMS.

The comments received are grouped by category. The categories are as follows:

1. Comments Regarding License Renewal and Its Processes
2. Comments Concerning Water Quality and Use
3. Comments Concerning Air Quality
4. Comments Concerning Human Health
5. Comments Concerning Alternatives
6. Comments Concerning Issues Outside the Scope of License Renewal: Support for License Renewal, Security and Terrorism, Emergency Response and Preparedness, Plant Performance, Energy Costs, and Other Out of Scope Issues

TABLE A-1. Individuals Providing Comments During Scoping Comment Period

Commenter ID	Commenter	Affiliation (If Stated)	ADAMS Accession Number [a]
		Afternoon Public Meeting	
PV-A	Mary Widner	Local resident	ML092040121
PV-B	Mr. Armiger	Local resident	ML092040121
PV-C	Mr. Herring	Local resident	ML092040121
		Evening Public Meeting	
PV-D	Steve Brittle	President, Don't Waste Arizona	ML092040125
PV-E	Darah Mann	Director of Marketing, Western Maricopa Coalition	ML092040125
PV-F	Ms. Hohmu	Southwest Valley Chamber of Commerce	ML092040125
PV-G	Adolfo Gamez	Mayor of Tolleson, AZ	ML092040125
PV-H	John Findley	Local resident	ML092040125
PV-I	Glenn Hamer	Pres., & CEO, AZ Chamber of Commerce and Industry	ML092040125
PV-J	Felipe Zubia	DMB Associates, developer of Verrado, a community 30 miles east	ML092040125
PV-K	Armando Contreras	Pres., & CEO, AZ Hispanic Chamber of Commerce	ML092040125
PV-L	Jackie Meck	Mayor, Buckeye, AZ	ML092040125
		Written Comments	
PV-M	James Cavanaugh	Mayor, Goodyear, AZ	ML092110634
PV-N	Bas Aja	Executive Vice President, Arizona Cattle Feeders' Association	ML092110635
PV-O	Jack Harper	Senator, AZ Legislative District 4	ML092110636
PV-P	Connie Wilhelm	Pres., & Exec Dir, Home Builders Association of Central Arizona	ML092110637
PV-Q	Mary Peters	Former U.S. Secretary of Transportation 2006-2009	ML092180409
PV-R	Louis J. Manuel Jr.	Chairman, Ak-Chin Indian Community	ML092180427
PV-S	Phil Gordon	Mayor, Phoenix, AZ	ML092180666
PV-T	Tom Boone	Representative, AZ Legislative District 4	ML092180428

Commenter ID	Commenter	Affiliation (If Stated)	ADAMS Accession Number [(a)]
PV-U	Tom Kelly	U.S. EPA, Region IX, Envr Review Office, Communities and Ecosystems Division	ML092180429
PV-V	Deanna K. Kupcik	President/CEO, Buckeye Valley, Chamber of Commerce	ML092180430
PV-W	Patricia Fleming	AZ State Representative, District 25	ML092180431
PV-X	Judy Burges	Representative, AZ Legislative District 4	ML092220044
PV-Y	Todd Sanders	Pres., & CEO Greater Phoenix Chamber of Commerce	ML092370065
PV-Z	Chris Horyza	Planning and Environmental Coordinator, Bureau of Land Management, Arizona State Office	ML091730377
PV-AA	Steve Brittle	President, Don’t Waste Arizona	ML092720530
PV-AB	Steve Brittle	President, Don’t Waste Arizona	ML092720533
PV-AC	Steve Brittle	President, Don’t Waste Arizona	ML092160241
PV-AD	Steve Brittle	President, Don’t Waste Arizona	ML092160239
PV-AE	Steve Brittle	President, Don’t Waste Arizona	ML092160232

[(a)] The accession number for the afternoon transcript is ML0920401210.
The accession number for the evening transcript is ML092041250.

The comments and suggestions received as part of the scoping process are discussed below. Comments can be tracked to the commenter and the source document through the ID letter and comment listed in Table A-1.

A.1.1. Comments Regarding License Renewal and Its Processes

Comment PV-H: My name is John Findley. I'm here tonight representing myself as a member of the public. I want to thank the NRC for coming to Arizona from their home in Rockville, which we know is next to paradise. And I just wish at this point to express my concern about some of the issues that have been brought up tonight and express my hopes that the NRC will examine this in a thorough and extensive process that you have set out in the table that you laid out.

Concerns involve the uneven performance of Palo Verde in the past, along with the uncertain future of long-term storage for nuclear waste; I think that's a really important issue that has to be taken into consideration. And probably most of all and as has been pointed out, the aging infrastructure that we're dealing with.

The implications of this are basically unknown. We've had incidents in the past in other locations where corrosion and the effects of radiation on the physical infrastructure have gone unnoticed in spite of continued surveillance and this has to be something that is taken into consideration.

Comment PV-U-2: With regard to the existing Palo Verde facility, we recommend the DEIS include: an evaluation of environmental justice concerns, based on CEQ guidance[1]; a summary of routine releases and a description of any non-routine releases; a discussion of the capacity and adequacy of nuclear waste storage for an additional twenty years or more; an updated estimate to decommission the facility; and financial assurance mechanisms in place to ensure proper decommissioning in the event of bankruptcy on the part of the owner.

[1]Environmental Justice Guidance under 'the National Environmental Policy Act; Appendix A (Guidance for Federal Agencies on Key Term is in Executive Order 12898), CEQ, December 10, 1997.

Response: *The comments, in general, express concern with the thoroughness of the license renewal process. Overall, NRC has developed a comprehensive license renewal process to evaluate applications for extended periods of operation.*

In 1982, the NRC established a comprehensive program for Nuclear Plant Aging Research as the result of a widely attended workshop on nuclear power plant aging. Based on the results of that research, a technical review group concluded that many aging phenomena were readily manageable and did not pose technical issues that would preclude life extension for nuclear power plants.

The NRC also concluded that the existing regulatory requirements governing a nuclear reactor facility would offer reasonable assurance of adequate protection if the license were renewed, provided that the current licensing basis was modified to account for age-related safety issues. In 1991, the Commission approved a rule on the technical requirements for license renewal and published the rule in the Code of Federal Regulations, 10 CFR Part 54. The NRC then undertook a demonstration program to apply the rule to pilot plants and to develop experience to establish implementation guidance. The rule defined the scope as age-related degradation unique to license renewal. However, during the demonstration program, the NRC found that many aging effects are managed adequately during the initial license period. In addition, the NRC found that the review did not allow sufficient credit for existing programs, particularly the maintenance rule, which also helps manage plant-aging phenomena.

As a result, in 1995, following the rulemaking process, the NRC amended the license renewal rule. The amended rule in 10 CFR Part 54 established a regulatory process that is more effective, stable and predictable than the previous license renewal rule. In particular, Part 54 was clarified to focus on managing the adverse effects of aging. The rule changes were intended to ensure that important systems, structures, and components would continue to perform their intended function during the 20-year period of extended operation.

The comments, in specific, express concern with the following topics:

History of plant performance - The NRC will ensure that the safety of a currently operating power plant will continue to be maintained before renewing the license by ensuring that aging effects will be adequately managed and that the licensing basis related to the present plant design and operation will be maintained. Before a new license is issued, the NRC will ensure that there is a technically credible and legally sufficient basis for granting a new license for an extended 20 years as reflected in the NRC's safety evaluation report (SER), final SEIS, and the proposed new license.

Nuclear waste storage - The staff notes that on March 3, 2010, DOE submitted a motion to the

Atomic Safety and Licensing Board to withdraw with prejudice its application for a permanent geologic repository at Yucca Mountain, Nevada. Nevertheless, the safety and environmental effects of spent fuel storage have been evaluated by the NRC and, as set forth in the Waste Confidence Rule (10 CFR 51.23), the NRC generically determined that such storage could be accomplished without significant environmental impacts. In the Waste Confidence Rule, the Commission determined that spent fuel can be safely stored onsite for at least 30 years beyond the plant's life, including license renewal. In 10 CFR Part 51, on-site spent fuel storage is classified as a Category 1 issue that is applicable to all nuclear power plant sites. While the Commission did not assign a single level of significance (i.e., Small, Moderate, or Large) in Table B-1 of Appendix B to Subpart A to Part 51 for the impacts associated with spent fuel and high level waste disposal, it did conclude that the impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated.

The GEIS for license renewal (NUREG-1437) evaluated a variety of spent fuel and waste storage scenarios, including on-site storage of these materials for up to 30 years following expiration of the operating license, transfer of these materials to a different plant, and transfer of these materials to an Independent Spent Fuel Storage Installation (ISFSI). During dry cask storage and transportation, spent nuclear fuel must be "encased" in NRC-approved casks. An NRC-approved cask is one that has undergone a technical review of its safety aspects and been found to meet all of the NRC's requirements. These requirements are specified in 10 CFR Part 72 for storage casks and 10 CFR Part 71 for transportation casks. For each potential scenario involving spent fuel, the GEIS determined that existing regulatory requirements, operating practices, and radiological monitoring programs were sufficient to ensure that impacts resulting from spent fuel and waste storage practices during the term of a renewed operating license would be small, and is a Category 1 issue.

Aging Infrastructure – The principle safety concerns associated with license renewal are related to the aging of structures, systems and components important to the continued safe operation of the facility. When the plants were designed, certain assumptions were made about the length of time each plant would be operated. During the safety review for license renewal, the NRC must determine whether aging effects will be adequately managed so that the original design assumptions will continue to be valid throughout the period of extended operation or verify that any aging effects will be adequately managed. For all aspects of operation, other than the aging management during the period of extended operation, there are existing regulatory requirements governing a plant that offer reasonable assurance of adequate protection if its license were renewed. The NRC's environmental review is confined to environmental matters relevant to the extended period of operation requested by the applicant. Safety matters related to aging are outside of the scope of this review. An NRC safety review for the license renewal period is conducted separately. The comment provides no new information and will not be evaluated further in the context of the environmental review.

Environmental Justice - Environmental Justice will be addressed in Chapters 2 and 4 of the PVNGS SEIS.

Routine and non-routine releases - The comment regarding a summary of routine releases and a description of any non-routine releases is noted. The NRC staff will evaluate the applicant's routine and non-routine releases in Chapters 2 and 4 of the PVNGS SEIS.

Financial assurance of decommissioning - The comment regarding financial assurance of decommissioning is noted. Decommissioning funding assurance is outside the scope of license *renewal. Decommissioning funding assurance is addressed pursuant to the requirements of 10 CFR 50.75(f)(1). Arizona Public Service Company (APS) submitted the 2008 Decommissioning Funding Status Report for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (ML091030418, dated March 31, 2009). NRC staff reviewed this document and found APS to be providing decommissioning funding assurance.*

A.1.2. Comments Concerning Water Quality and Use

Comment PV-D-8: Another issue I call "Water." With global warming projections indicating a hotter, drier southwest, we must be reminded that the vast majority of wastewater from the Phoenix metro area, mainly the discharge from the 91st Avenue Wastewater Treatment Plant in west Phoenix, goes to cool Palo Verde.

With hotter temperatures expected, even more water will be needed and nuclear power already uses more power per megawatt of power generated than any other form of electrical power generation.

Is this sustainable? Is this water supply for Palo Verde really reliable and sufficient? Is this projected Palo Verde water usage a severe economic disincentive to overall economic growth and even population growth in this part of Arizona? Are the water needs of Palo Verde a type of opportunity cost and opportunity loss brought about by a lack of affordable water for industrial and residential uses?

Comment PV-AB-1: The Maricopa Association of Governments (MAG) is the regional planning organization of local government in Maricopa County. MAG's Transportation Policy Committee has "Interstates 8 and 10-Hidden Valley Transportation Framework Study" as one of its upcoming agenda items. This is an early attempt at planning for the transportation needs of a projected population of 2.5 million people in the western part of Maricopa County. That population is almost the size of the Phoenix metro area now.

The NRC needs to fully examine the planned population growth in that area near Palo Verde, and especially in the context of planned or needed groundwater pumping and the potential land subsidence and fissuring, again especially in the area near and including Palo Verde. Some areas of Arizona are especially prone to subsidence and fissuring.

Response: *The comments, in general, pertain to the plant's consumptive use of waste water from the Phoenix metro area, groundwater resources in the vicinity of PVNGS, and the plant's potential impact on subsidence and fissuring. Groundwater use and water quality issues are Category 2 issues and will be addressed in Chapters 2 and 4 of the PVNGS SEIS.*

A.1.3. Comments Concerning Air Quality

Comment PV-D-9: Next topic, carbon impacts. If uranium demand rises as projected, the carbon cost of developing less rich ores nullifies any presumed carbon savings from keeping their reactors online. Isn't it likely that the true lifecycle carbon emissions of nuclear power generation will be officially recognized by the EPA and the U.S. Congress, and carbon cap and trade or carbon tax strategies will make nuclear power even more unprofitable?

Nuclear power is not at all free from carbon emissions. A number of recent studies have found out that when mining, processing, and extensive transportation of uranium in order to make nuclear fuel is considered, the release of carbon dioxide as a result of making electricity from uranium is comparable to converting natural gas into electric power.

Additional energy required for decommissioning and disposition of the wastes generated increases this carbon dioxide output substantially.

Comment PV-AB-7: In addition to radiological pollution, nuclear power also contributes massive thermal pollution to both our air and water. It has been estimated that every nuclear reactor daily releases thermal energy –heat-- that is in excess of the heat released by the detonation of a 15 kiloton nuclear bomb blast. Nuclear power contributes significantly to the thermal energy inside Earth's atmosphere, making it contraindicated at this time of rapid global warming.

Nuclear power is not at all free from carbon emissions. A number of recent studies have found that when mining, processing, and extensive transportation of uranium in order to make nuclear fuel is considered, the release of carbon dioxide (CO2) as the result of making electricity from uranium is comparable to burning natural gas to make electric power. Additional energy required for decommissioning and disposition of the wastes generated increases this CO2 output substantially. What if the national and worldwide economic downturn causes a downgrade of the economic viability of funds set aside for decommissioning of Palo Verde? Putting decommissioning off even further increases uncertainty, in light of massive resource depletion and environmental deterioration aspects like global warming. All of these issues need to be analyzed and mitigated.

Response: *The comments are noted, and pertain to impacts to air quality from carbon emissions. Impacts to air quality from carbon emissions associated with the uranium fuel cycle will be evaluated in Chapter 6 of the PVNGS SEIS.*

A.1.4. Comments Concerning Human Health

Comment PV-D-1: My name is Stephen Brittle, I'm the president of Don't Waste Arizona, a nonprofit environmental organization, 501(c)(3)(7) here in Arizona. On behalf of the organization and its effect of their concerns are these comments on the record:

Thank you for the opportunity to submit concerns and questions about the wisdom of renewing the license of an aging, severely-troubled, nuclear power plant complex that has caused significant economic hardship for a financially troubled company that just asked for a rate increase to forestall an even worse credit rating.

The first concern I have is that in April, there was a meeting and you let them off the hook for their closer scrutiny. I was frankly disappointed that NRC representatives seemed unaware of the plume of tritium under the nuclear plant; something I found out about by looking through the facility's file at the Arizona Department of Environmental Quality. And the fact that they didn't seem to know about it raised real questions about NRC's oversight.

I understand that the plume was caused by the monsoon rains knocking the normal radioactive air emissions from Palo Verde onto the roof of the facility that then drained into an unpaved area where it soaked into the ground. Levels of tritium in the ground seemed likely to increase.

I remind everyone that the National Academy of Sciences agrees there is no safe dose. According to the National Academy of Sciences in 2005, there is no threshold dose below which ionizing radiation is safe.

And years before that, it stated there is no safer level of exposure, there is no dose of ionizing radiation so low that the risk of a malignancy is zero; that's from Dr. Karl Morgan, the father of health physics.

Historically, the significance of internal dosage from fission products has not been appreciated. There is something that is called "Reference Man" and these standards ignore those most at risk.

Women are 52 percent more likely to get cancer from the same amount of radiation dose compared to men. Children are at greater risk, of course, than adults.

A female infant has about a seven times greater chance of getting cancer than a 30—year old male with the same radiation exposure. Pregnant women and the developing fetus are particularly vulnerable to radiation exposure; however, non-cancer reproductive effects are not part of the U.S. Regulatory framework for radiation protection.

U.S. radiation exposure regulations and compliance methods often fail women, children, and other more radiosensitive groups because they are based on the reference man; a hypothetical 20 to 30 year old Caucasian male.

At least three federal agencies, the Environmental Protection Agency, the NRC, and the Department of Energy, still use reference man in radiation dose regulations and compliance assessment including the Clean Air Act and safe drinking water rules despite evidence that the standard is not adequate to protect many groups.

In both France and the U.S., for nearly 30 years after the first reactors went on line, no studies of cancer near reactors were done. Neither utilities nor the NRC conducts health studies; neither monitor local cancer rates near reactors, yet both strongly criticize any studies that suggest harm. One is left wondering who to trust.

Look at the French. Official French statistics, among 39 European nations the 2006 cancer incidence rate is the third highest for men and 13th highest for women. The incidence rates rose 39 percent from 1980 to 2005 compared to 10 percent in the United States.

Perhaps most telling, the thyroid cancer rate in France rose a staggering 433 percent for males and 186 percent for females, far more than in the U.S. A clue and indicator, if not a smoking gun. Doctors know of no other clear cut cause of thyroid cancer other than radiation exposure. The thyroid cancer rates in the four counties closest to Indian Point, for example, are nearly double the U.S. average, and that childhood cancer in these counties is also above the national rate.

Something called the Mother's Milk Project, also this year; of 30 milk samples from breastfeeding mothers and goats within 50 miles of Indian Point, nearly all revealed levels of strontium-90 with the highest results occurring closest to the Indian Point reactors.

Of great concern, the presence of both strontium-90 and a related fission product strontium-89, which has a short half life. Its presence provides strong evidence radioactivity was recently produced from a nearby source.

Comment PV-AE: While analyzing and determining the additional risks posed by relicensure of aging nuclear power plants like Palo Verde's, please consider the attached article, "Push For New Nuclear Power Sputters, But Old Reactors Still Pose Cancer Risks".

A recent energy bill sponsored by Congressional Republicans proposed building 100 new nuclear reactors across the United States in the next 20 years.

The proposal, which would double the current U.S. total of 104 operating nuclear reactors, would amount to a nuclear renaissance, as no new reactors have been ordered since 1978.

Concerns about global warming gave utilities the idea for this revival since reactors don't emit greenhouse gases while generating power, and utilities have stopped closing old reactors while proposing 33 new ones to be sited in New England, throughout the South and Southeast, and in Texas, Utah and Idaho.

(For a list of applications to the Nuclear Regulatory Commission for approval of new reactors click here. http://www.nrc.gov/reactors/new-reactors/new-licensingfiles/expected-new-rx-applications.pdf)

But this month, two Swedish scientists published an article concluding that a large increase in nuclear reactors will not solve global warming.

The utilities, of course, fail to report that greenhouse gases are emitted throughout the entire nuclear fuel cycle, and operating the reactor itself is the only exception. Both the nuclear reactor industry and its support industries spew radioactive materials into local air and water, posing a serious health hazard, warns Dr. Samuel S. Epstein, chairman of the Cancer Prevention Coalition and Professor emeritus Environmental & Occupational Medicine at the University of Illinois at Chicago School of Public Health.

In the 1970s, Wall Street investors stopped funding new reactor projects due to cost and safety concerns. Today, these issues are unchanged, and private investors again gave a thumbs-down to nuclear power. A 2005 law authorizing $18.5 billion in federal loan guarantees would only cover two reactors.

The Bush administration was a willing partner in the nuclear revival. George W. Bush became the first sitting U.S. president to visit a nuclear plant since a grim-faced President James Carter toured the damaged Three Mile Island reactor on April 1, 1979.

President Barack Obama has poured cold water on the renaissance. He rejected a request for $50 billion in loan guarantees in the stimulus package. Additionally, he rejected further funding for developing the nuclear waste dump at Yucca Mountain Nevada, leaving utilities with no place to permanently store their highly radioactive nuclear waste. It is now being held temporarily at 55 storage sites licensed by the Nuclear Regulatory Commission and at Department of Defense sites and national laboratories across the country.

The major threat posed by nuclear reactors is not the addition of new reactors, but continuing to operate old and corroding ones, says Dr. Epstein. U.S. reactors are granted licenses for 40 years, and many are approaching that mark. Many utilities have asked regulators to extend their licenses for an additional 20 years.

"Each of the first 52 requests has been given a rubber-stamp approval, even though operating a 60 year old reactor would be a huge risk to human health," says Joseph Mangano, MPH, MBA, executive director of the Radiation and Public Health Project. Notable exceptions are state government officials in New York and New Jersey, who are opposing the attempts to extend licenses for reactors in their states.

About 80 million Americans in 37 states live within 40 miles of a nuclear reactor, including residents of New York City, Chicago, Philadelphia, Detroit, Miami, Phoenix, Cleveland, and Boston. "If a meltdown were to occur, safe evacuation would be impossible and many thousands would suffer from radiation poisoning or cancer," warns Dr. Epstein. "The horrifying specter of Chernobyl, or of terrorists attacking a nuclear plant, is not lost on concerned Americans."

Reactors are a real health threat, not just a potential one, a fact largely ignored by mainstream media, he declares.

To generate electricity, over 100 radioactive chemicals are created – among the most dangerous chemicals on Earth, and the same toxic mix in atomic bomb test fallout. These gases and particles, including Strontium-90, Cesium-137, and Plutonium-239, are mostly stored as waste. But some must be routinely released into air and water. Humans breathe, eat, and drink them - just as they did bomb fallout - raising the cancer risk, especially to children.

Industry and government officials argue that reactor emissions are too small to cause harm. But for years, scientists have produced study after study documenting high cancer rates near reactors. For example, a 2007 review of the scientific literature by researchers from the University of South Carolina found elevated rates of childhood cancers, particularly leukemia and brain cancers, in nearly all 17 studies examined. A 2008 study of German reactors was one of the largest ever done, and it also found high local rates of child cancer.

Mangano and colleagues published a January 2002 article in the journal "Archives of Environmental Health," showing that local infant deaths and child cancer cases plunged dramatically right after shut down whenever a U.S. reactor closed. Because the very young suffer most from radiation exposures, they benefit most when exposures are removed. This research indicated that there would be approximately 18,000 fewer infant deaths and 6,000 fewer child cancer cases over the next 20 years if all nuclear reactors were closed.

Over half the states in the United States, 31, currently host nuclear power plants.

Illinois has the most with 11, Pennsylvania has nine, New Jersey has four. While waiting for the federal government to phase out nuclear power in favor of safer alternatives, state governments should act to warn and protect their citizens, urges the Cancer Prevention Coalition.

Governors have responsibilities to take whatever political action they can to phase-out nuclear plants. In the first instance, governors should tell their citizens of the danger.

In 1954, Atomic Energy Chairman Lewis Strauss declared nuclear power “too cheap to meter.” President Richard Nixon envisioned that the nation would have 1,000 reactors by this time. But the dreams of people like Strauss and Nixon were dashed by staggering costs and built-in dangers.

The attempt to revive this Cold War-era dream has been, and still is, largely talk. While the talk goes on, the nation is fast developing technologies like solar and wind power, which never run out and don’t pollute. Putting millions of Americans at risk of cancer by hanging on to old reactors – that produce only 19% of America's electricity and 8% of the country's total energy – is a reckless gamble. Nuclear reactors in the U.S. should be phased out, and replaced by options that don’t threaten public health.

Response: *The NRC staff will address the radiological impacts to human health during its evaluation of the Palo Verde license renewal application. However, the radiological impact to human health is a Category 1 issue. This means that technical issues classified as Category 1 in Table B-1 of 10 CFR Part 51 have been generically evaluated in the Generic Environmental Impact Statement (GEIS) for license renewal and are not specifically reevaluated in the site-specific supplemental environmental impact statement (SEIS) unless new and significant information is identified. During the environmental review, the NRC staff will make a concerted effort to determine whether any new and significant information exists at Palo Verde that would change the generic conclusion for a Category 1 issue into a Category 2 issue. Category 2 issues are site specific issues which must be thoroughly analyzed by the applicant as part of its submittal and included in detail in its environmental report. The NRC staff would then independently evaluate the issue as part of its SEIS.*

The NRC's primary mission is to protect the public health and safety and the environment from the effects of radiation from nuclear reactors, materials, and waste facilities. The NRC's regulatory limits for radiological protection are set to protect workers and the public from the harmful health effects (i.e., cancer and other biological impacts) of radiation on humans. The limits are based on the recommendations of standards-setting organizations. Radiation standards reflect extensive scientific study by national and international organizations. The NRC actively participates and monitors the work of these organizations to keep current on the latest trends in radiation protection. If the NRC determines that there is a need to revise its radiation protection regulations, it will initiate a rulemaking. The models recognized by the NRC for use by nuclear power reactors to calculate dose incorporate conservative assumptions and do account for differences in gender and age to ensure that workers and members of the public are adequately protected from radiation.

Although radiation may cause cancers at high doses and high dose rates, currently there are no reputable scientifically conclusive data that unequivocally establish the occurrence of cancer following exposure to low doses, below about 10 rem (0.1 Sv). However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model probably over-estimates those risks. Based on this theory, the NRC conservatively establishes limits for radioactive effluents and radiation exposures for workers and members of the public. While the public dose limit in 10 CFR Part 20 is 100 mrem (1 mSv) for all facilities licensed by the NRC, the NRC has imposed additional constraints on nuclear power reactors. Each nuclear power reactor, including Palo Verde, has enforceable license conditions that limit the total annual whole body dose to a member of the public outside the facility to 25 mrem (0.25 mSv). In addition, there are license conditions to limit the dose to a member of the public from radioactive material in gaseous effluents to an annual dose of 15 mrem (0.15 mSv) to any organ and for radioactive liquid effluents, a dose of 3 mrem (0.03 mSv) to the whole body and 10 mrem (0.1 mSv) to any organ.

The amount of radioactive material released from nuclear power facilities is well measured, well monitored, and known to be very small. The doses of radiation that are received by members of the public as a result of exposure to nuclear power facilities are so low (i.e., less than a few millirem) that resulting cancers attributed to the radiation have not been observed and would not be expected. To put this in perspective, each person in this country receives a total annual *dose of about 300 millirems (3 mSv) from natural sources of radiation (i.e., radon, 200 mrem; cosmic rays, 27 mrem; terrestrial (soil and rocks), 28 mrem; and radiation within our body, 39 mrem) and about 63 mrem (0.63 mSv) from man-made sources (i.e., medical x-rays, 39 mrem; nuclear medicine, 14 mrem; consumer products, 10 mrem; occupational, 0.9 mrem; nuclear fuel cycle, <1 mrem; and fallout, <1 mrem).*

Although a number of studies of cancer incidence in the vicinity of nuclear power facilities have been conducted, there are no studies to date that are accepted by the scientific community that show a correlation between radiation dose from nuclear power facilities and cancer incidence in the general public.

- *In 1990, at the request of Congress, the National Cancer Institute conducted a study of cancer mortality rates around 52 nuclear power plants and 10 other nuclear facilities. The study covered the period from 1950 to 1984, and evaluated the change in mortality rates before and during facility operations. The study concluded there was no evidence that nuclear facilities may be linked causally with excess deaths from leukemia or from other cancers in populations living nearby.*

- *In June 2000, investigators from the University of Pittsburgh found no link between radiation released during the 1979 accident at Three Mile Island power plant and cancer deaths among nearby residents. Their study followed 32,000 people who lived within five miles of the plant at the time of the accident.*

- *The Connecticut Academy of Sciences and Engineering, in January 2001, issued a report on a study around the Haddam Neck nuclear power plant in Connecticut and concluded radiation emissions were so low as to be negligible and found no meaningful associations to the cancers studied.*

- *The American Cancer Society in 2000 concluded that although reports about cancer clusters in some communities have raised public concern, studies show that clusters do not occur more often near nuclear plants than they do by chance elsewhere in the population. Likewise, there is no evidence that links strontium-90 with increases in breast cancer, prostate cancer, or childhood cancer rates. Radiation emissions from nuclear power plants are closely controlled and involve negligible levels of exposure for nearby communities.*

- *Also in 2001, the Florida Bureau of Environmental Epidemiology reviewed claims that there are striking increases in cancer rates in southeastern Florida counties caused by increased radiation exposures from nuclear power plants. However, using the same data to reconstruct the calculations, on which the claims were based, Florida officials were not able to identify unusually high rates of cancers in these counties compared with the rest of the state of Florida and the nation.*

- *In 2000, the Illinois Public Health Department compared childhood cancer statistics for counties with nuclear power plants to similar counties without nuclear plants and found no statistically significant difference.*

There are three sources of strontium-90 in the environment: fallout from nuclear weapons testing, releases from the Chernobyl accident in the Ukraine, and releases from nuclear power reactors. The largest source of strontium-90 is from weapons testing fallout as a result of *above-ground explosions of nuclear weapons (approximately 16.9 million curies of strontium-90). The Chernobyl accident released 216,000 curies of strontium-90. The total annual release of strontium-90 into the atmosphere from all U.S. nuclear power plants is typically 1/1,000th of 1 curie, which is so low that the only chance of detecting strontium-90 is sampling the nuclear power plant effluents themselves. Radioactive effluent releases are monitored at all nuclear power plants, and the results of the monitoring are reported annually to the NRC and are publicly available on the NRC's website.*

To ensure that U.S. nuclear power plants are operated safely, the NRC licenses the nuclear power plants to operate, licenses the plant operators, and establishes license conditions for the safe operation of each plant. The NRC provides continuous oversight of plants through its Reactor Oversight Process (ROP) to verify that they are being operated in accordance with NRC regulations. The NRC has full authority to take whatever action is necessary to protect public health and safety, and the environment and may demand immediate licensee actions, up to and including a plant shutdown.

In conclusion, the NRC staff will address the radiological impacts to human health during its evaluation of the Palo Verde license renewal application. The information will be contained in Chapter 4 of the Palo Verde draft SEIS. The public will be offered the opportunity to comment on the NRC staff's findings in the SEIS.

A.1.5. Comments Concerning Alternatives

Comment PV-U-1: The U.S. Environmental Protection Agency (EPA) has reviewed the Federal Register Notice published on May 26, 2009, requesting comments on the Nuclear Regulatory Commission's (NRC's) Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process for Palo Verde Nuclear Generating Station, Units 1, 2. and 3 (Palo Verde). Our comments are provided pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality regulations (40 CFR Parts 1500-1508) and our NEPA review authority under Section 309 of the Clean Air Act.

EPA recognizes the difficulty of finding a viable alternative to an existing facility, such as Palo Verde, but we encourage you to consider a full range of alternatives. We recommend that NRC examine the most recent information available on renewable energy generation. The Bureau of Land Management and Department of Energy have prepared many documents that may be helpful, and are currently working on a Solar Energy Programmatic Environmental Impact Statement (http://solareis.anl.gov/). This effort is intended to facilitate utility scale solar energy development in selected solar energy zones in six western states, including Arizona. We also recommend the Draft Environmental Impact Statement (DEIS) discuss the feasibility of using residential and wholesale distributed renewable energy generation, in conjunction with increased energy efficiency, as a viable alternative in your analysis.

Comment PV-AB-8: Another aspect to renewable energy is that it lends itself to something that nuclear power cannot: decentralized power production. Therefore, the NRC needs to fully examine and analyze the economic impacts and reliability aspects of decentralized power vs. nuclear power when examining the relicensure of Palo Verde.

Response: *NRC Staff will consider a wide variety of potential energy alternatives in Chapter 8 of the PVNGS SEIS.*

A.1.6. Comments Concerning Issues Outside the Scope of License Renewal: Support for

License Renewal, Security and Terrorism, Emergency Response and Preparedness, Plant Performance, Energy Costs, and Other Out of Scope Issues

Comment PV-B: Not much other than that I appreciate that Palo Verde is here and I want to keep it here. But then you said we won't get into a situation like they did out on Avondale where they built the plant and then they couldn't license it because of the evaluation maps were -- had the population blown at them and then the traffic passed the plant to get out. So we don't have that. And just that Palo Verde has had problems in the past, you know with safety compliance, but they've come up again with the help of the NRC and they changed management and they're doing great. So we'd just like to keep it that way. Thank you, very much.

Comment PV-C: I'm Jack Herring and I've been in the area since the 1940s. I've seen a lot of changes here. And as far as the plant goes, they've been a good neighbor. And anytime there was ever anything going on out there that we needed to know, they always called us or let us know in some way. So with that I think it should remain here.

Comment PV-E: Good evening. My name is Darah Mann and I'm the director of marketing and communications for WESTMARC. WESTMARC is an acronym for Western Maricopa Coalition, which is a broad-based coalition of the 15 communities in western Maricopa County which represent more than 35 percent of the county's population. Our membership consists of business, industry, government, education, human services, arts, and cultural organizations, chambers of commerce, and community leaders. Thank you for the opportunity to participate this evening.

WESTMARC would like to publicly recognize the multiple significant areas of impact that Palo Verde has on our State. On our economy, by providing thousands of well paying jobs, by generating low-cost electricity, and by their status of being Arizona's largest taxpayer. On our environment, by generating clean energy for a metropolitan area that struggles to meet air quality standards. On our quality of life, by powering an unprecedented period of growth, by committing to safe and efficient operations.

Arizonans and others throughout the southwest would not enjoy such a high quality of life without the reliable electricity Palo Verde provides to power our businesses, our homes, and especially our air conditioners.

On behalf of WESTMARC, thank you for allowing me to express our continued appreciation for the valued contributions Palo Verde continues to provide our community.

Comment PV-F: It's my new toy [referring to wheel chair]. Thank you for letting me speak tonight. I find Palo Verde especially poignant for me. I came to Goodyear in 1980, when we were in the throes of building Palo Verde and saw the economic contribution that just the building of the plant created. I've subsequently moved to a position with the Southwest Valley Chamber of Commerce. The Southwest Valley Chamber of Commerce is an organization that focuses on the business communities of Avondale, Goodyear, Litchfield Park, and Tolleson. We're a family proximately invested in the organization representing about 15 thousand employees.

I've been with the Chamber since 1984, so I indeed have had the opportunity to see the results of the operation of the plant.

And for those of you who have not been here, did not see the tremendous growth, you have to realize, I too, since 1984 did not expect to have the thousands of buildings and people living not in just this area, which of course Palo Verde supplies the perfect stage, but we need the energy, obviously (indiscernible). It is only when operations such as the power plant that we can supply our needs, especially in our peak season which you have the pleasure of joining us in.

I want to also recognize the Arizona Public Services for their responsible agent managing with this particular plant. Their 25 hundred employees do make a significant impact economically. But I think more importantly is the contribution that the energy makes to the economic growth of our area. Without energy we could not continue our growth.

So I thank you very much for allowing me to address the issues and I thank you for being in our community tonight so that we can.

Comment PV-G: Good evening. Welcome to the west valley. My name is Adolfo Gamez, I'm the Mayor of the city of Tolleson. And for the record, the city of Tolleson supports the license renewal of Palo Verde and we're a member of WESTMARC, and so the statements that they made on behalf of WESTMARC we echo.

Comment PV-I: Good evening. My name is Glenn Hamer, I'm the president and CEO of the Arizona Chamber of Commerce and Industry. We're a statewide advocacy organization representing hundreds of companies across Arizona who employ about 250 thousand Arizonans. We're also served as the home to the Arizona Manufacturer's Council, which is -- we are the statewide affiliate for manufacturers for the National Association of Manufacturers.

I just wanted to say that we strongly support this application. Nuclear power, in fact, in our 2009 business agenda we've identified nuclear power generation as a key goal. In fact, we've talked about the importance of removing obstacles to expanding nuclear power generation.

We strongly believe, for the State’s economic health, that nuclear power must continue to play a major role in Arizona's energy net. That becomes all the more important given a number of the proposals closer to your home in Washington, DC concerning climate change. It's unimaginable for us to think of a world where we didn't have a -- the very important State asset of Palo Verde.

Again, the Arizona Chamber of Commerce and Industry, we strongly support continuation and this application and it's absolutely vital to the state's economic health.

Thank you for the chance to speak this evening.

Comment PV-J: Good evening, Felipe Zubia. For the record, I'm here representing DMB Associates, developer and master plan developer for a community called Verrado, which is about 30 miles east of the facility.

And a little bit of history here. About ten years ago we embarked on the investment of this community, which is about 10 thousand acres, over 3000 homes.

And at the time, the property was being used as a Caterpillar proving ground, of course an appropriate use for the area at the time. However, we saw the area as much more than that, in fact partnered with Caterpillar to bring a master planned community that really is unrivaled in the west valley and frankly I'd put it up against any other community here in the State.

With that in mind, as we went through that process we reached out to all of our constituents in the area. Not only the Town of Buckeye and the surrounding communities but Luke Air force Base as well as Palo Verde.

At the time, we certainly wanted to assure all of our partners and constituents that we would be good neighbors; and in doing so, we received recommendations of support. We believe that we've upheld our commitment to be good neighbors. And in that same regard, we're here today to support APS, Pinnacle West, and the extension of the Palo Verde licensing process.

They have been tremendously good neighbors. They have been a foundation of support and economic support for the area. And most importantly, they've been very responsive and reliable managers of the facility.

In fact, as the master plan developer of the community, we have a substantial investment not only in the built environment but in the cultural environment, and the natural environment that we have built up out there.

And we too hope that you look at the application very closely. We have a lot of people out there that certainly want to make sure that the process is done right.

But with that in mind we think that you'll find up and down the line from Palo Verde managers to APS to Pinnacle West; that you'll have responsive, reliable, and responsible management of the facility. So we look forward to the renewal process and the successful completion.

Thank you, very much.

Comment PV-K: Good evening. Thank you for the opportunity to say a few words. Armando Contreras, the new president and CEO of the Arizona Hispanic Chamber of Commerce. The Chamber of Commerce certainly encourage and supports the relicensing process.

We -- here in the State, there are approximately 35 thousand Hispanic-owned businesses just in Phoenix. We're encouraged with the continued development and safety that Palo Verde has offered to the community.

And we're also encouraged at the participation and embracement of the Hispanic minority women business and economic development that's been going on here. That has been really supported by Palo Verde and we want to continue that partnership and we hope that you continue towards these procuring opportunities that are out there for Hispanic businesses and all minority businesses in the State of Arizona.

Thank you, very much.

Comment PV-L: Thank you. I apologize for being late, but I had another meeting that ended just now. My name is Jackie Meck and I reside at 225012 West Walcott, Buckeye, Arizona.

Nuclear Regulatory Commission Members, thank you for allowing me to speak on behalf of the Palo Verde Nuclear Power Plant.

I am the Mayor of the Town of Buckeye with a population of around 45 thousand. We are located approximately 20 miles east of the power plant. In the 1970's I was on the Town Council for a period of nine years. The final three years, as Mayor, the Arizona Public Service managing partner of Palo Verde asked me, among others, to be on a community advisory committee. The committee functioned for approximately 10 to 12 years as I recall.

During that time, we as committee members, were updated regularly as to the ongoing construction and any problems that would arise from traffic, dust, or equipment. We were always kept up to date and made aware of any and all situations.

Since the beginning, they have provided funding for various community clubs, charities, and activities. Currently, as a member of the large area fund committee, which was funded by Arizona Public Service Palo Verde, the committee meets annually and it supports funding various groups such as schools and other opportunities to better our community. They have been partners and excellent neighbors to the Town of Buckeye for the past 30 years.

In closing, they are committed to the community, not only with contributions in real dollars, but in employee volunteer service. They operate the plan efficiently, faithfully and continue to help Arizonans in inexpensive power. Palo Verde is Arizona's largest tax payer and a major employer. I would support them anywhere, anytime, especially at this point in time to continue their development of the next phase of the Palo Verde Nuclear Power Plant.

Thank you for allowing me to speak. And again I apologize for being late to my appointment. Thank you.

Comment PV-M: I am writing to request your board to uphold the standings of the Palo Verde Nuclear Generating Station in the review of all its units. Palo Verde matters greatly to the citizens of Goodyear. The plant provides the energy that fuels many homes in my city. Further, it provides clean, reliable energy to over four million people in the Southwest region. Arizona Public Service has worked diligently, along with NRC supervision, to ensure Palo Verde is a safe and efficient plant, and a model of America's nuclear energy team as the nation's largest energy provider. The plant employs over 2,500 people, many of those from Goodyear, and is Arizona's largest taxpayer. It makes economic sense to efficiently continue to run Palo Verde.

As the Mayor of Goodyear, I strongly encourage you to renew the license for Palo Verde, to keep clean and reliable power coming to our homes, and to allow this fine example of America's nuclear power to function for years to come.

Comment PV-N: I am writing to your board to support the renewal application for the Palo Verde Nuclear Generating Station. As the largest nuclear power plant in America, Palo Verde is a symbol of Arizona's energy leadership and a welcome contributor to our energy infrastructure.

Palo Verde supplies the clean and efficient power that keeps so many of our state's businesses in operation and homes well lit. With recent improvement made to the safety and management of the plant, I am confident in APS's ability to continue running Palo Verde reliably for many years more. As a major contributor to Phoenix and Southern California's power structure, Palo Verde holds a firm place in our two region's economies. Palo Verde is the baseline standard for pricing of energy here and helps keep costs low so that business owners can concentrate more on expanding and growing and less on the costs of operation like an expensive utility bill.

I can recall few times where the power has been out that it has not been swiftly restored. Thanks to the reliability of APS and Palo Verde, I have rarely had to worry about such a concern. As Arizona is facing one of the toughest economic climates in decades, losing the lower costs Palo Verde provides would be yet one more blow to business owners all over the region. I hope you will take my letter into consideration and find that renewing the license application for Palo Verde is a smart decision for businessmen, homeowners and our entire state's economy.

Comment PV-O: I am writing this letter to express my support for the renewal application of the Palo Verde Nuclear Generating Station. Palo Verde creates the clean, reliable and cost effective energy that my constituents in Legislative District 4 can rely on. The continued future of this generating station is important to all of us.

Benefits of the energy produced by Palo Verde directly impact the citizens I represent. An unwavering and low cost for energy can ease the strain experienced due to the current economic climate. Beyond the cost of energy consumption, my constituents expect the power coming to their homes to stay on throughout summer heat waves and desert monsoons. Palo Verde has been a part of that dependable service provided by APS.

APS has shown a long-term commitment to the development of the Palo Verde's location and wide range of service areas. The generating station is a major employer with more than 2,500 jobs and is one of Arizona's largest taxpayers. Support of Palo Verde makes strong economic sense, especially as it is the nation's largest power provider.

APS has shown its ability to safely and efficiently operate the generating station. With Palo Verde, the utility company has kept power bills low while ensuring environmental benefits such as clean air. I ask that you take my letter of support into consideration when reviewing the renewal of Palo Verde. I have confidence in APS and the plant to continue delivering clean, reliable and cost effective energy to my constituents' homes, for a very long time.

Comment PV-P: I am writing in support of the renewal application for the Palo Verde Nuclear Generating Station. Palo Verde's contribution to the State of Arizona with clean, reliable, and cost effective energy is of great importance to members of the Home Builders Association of Central Arizona (HBACA).

As President and Executive Director of the HBACA, I am intimately familiar with the need for a steady and low cost energy supply to support Arizona's economic growth, which has been largely spurred by housing. Our homeowners expect reliable power that can be swiftly repaired when storms knock down lines, blow transformers or otherwise cause an interruption in service. APS and the power it provides with Palo Verde have always ensured this.

As the state's largest power provider, APS's ability to continue to operate the existing Units at Palo Verde makes strong economic sense. It makes sense for homeowners and for homebuilders. Losing the low-cost reliable energy provided by Palo Verde, in addition to the number of jobs it creates, would be a damaging blow to an already weak housing market in Arizona.

APS's strong management team has led the state in efforts to keep energy efficiency a major goal for customers, while continuing to provide energy that balances environmental and development concerns. The Palo Verde Station is an important part of the Arizona economy and a symbol of Arizona's commitment to delivering clean, reliable, and cost effective energy to Arizona homeowners for decades to come. I urge your strong consideration in renewing Palo Verde's application.

Comment PV-Q: Palo Verde Nuclear Generating Station provides the power that keeps Arizona homes, businesses, our transportation system and our economy moving. When I learned of Palo Verde's renewal application, I wanted to take the opportunity to write in support of that application to the Nuclear Regulatory Commission. Arizona would simply not run as efficiently without this important power plant.

Palo Verde provides the clean, inexpensive and reliable energy that ensures not only homes around Arizona are powered, but the street lights and signs of their neighborhoods as well. As the former U.S. Secretary of Transportation and Director of the Arizona Department of Transportation, I know how crucial it is for our transportation systems to be efficient and dependable. Whether it is a school street sign or the Valley's newest light rail, power provided by Palo Verde ensures Arizona's transportation continues to operate smoothly.

Within recent years APS has renewed their efforts to make Palo Verde the safe and reliable plant it is today. One of the most important factors in powering any transportation system is reliability. Our transportation systems must be working at all times. I have confidence in APS to maintain that reliability with Palo Verde for decades to come and continue providing the low cost, efficient and reliable power that runs our systems.

It is both a strong economic and infrastructure decision to renew the license for Palo Verde Nuclear Generating Station. Losing the power provided by Palo Verde would be devastating for the state's infrastructure and cost a great deal of money in building additional plants to supplant the need. If you would like to speak with me further on why I believe Palo Verde is right for Arizona, please do not hesitate to contact me.

Comment PV-S: I am very pleased to highly recommend the renewal of the license for the Palo Verde Nuclear Power Facility which is situated just west of Phoenix. I am even more pleased to provide comments in support, of Arizona Public Service (APS) and its parent and affiliates who are the primary operators of this incredible facility, the largest nuclear power plant in the United States.

The facility itself appears to meet or exceed standards of safety, environmental regulations, security, operations, communications, and community integration. It has a history of operational excellence by a company and partnership that truly cares about: its employees and the community in which it serves. As with any community near a nuclear facility, we want to ensure that such an operation is the safest and most efficient of its kind. As the 5^{th} largest city in the nation, that concern is manifold. That is why the most crucial element of the facility is the open and frequent communications that exists between its main operator, APS, and our city. APS is quick, meticulous, and thorough in responding to any questions or concerns which ever arise. They initiate contact with our authorities whenever any incident occurs or if there is even the appearance of any incident. That outstanding two-way communications is responsible for ensuring that facts are distinguished quickly from rumors and that -all pertinent parties are kept regularly informed of any situation occurring at or near the plant.

In addition, Palo Verde was an active member of our statewide Domestic Preparedness Task Force which was in place years before the tragedy of 9-11**.** APS had the foresight, since its inception, to form public-private partnerships with our city's and state's leaders and managers including our vital public safety entities. That partnership has ensured that communications flows to all stakeholders and potentially affected persons/organizations on a regular basis and during any times of crisis. That joint effort includes training drills with police, fire, and other first responders, and there is a cooperative spirit that is second to none.

That partnership exists with the other productive operations of APS. As a geographic area which has peak energy demands in our summer months, APS has been responsive and aggressive in ensuring that power is preserved and available for the homes and businesses of our residents which is crucial for our economic, educational, public safety, and business climate.

APS is a company of which you can be very proud. We certainly are. I have known the top leaders of this company over the past 20 years. Each one has understood the tremendous responsibilities of the company and the nuclear power facility and have lived up to the obligations for producing a safe environment for both employees and residents.

APS is very involved in our community in more ways than providing power and energy. The company's contributions have been essential to our social and economic well-being. It is hard to find a cause or an element of quality of life in our Valley in which APS has not been involved. Its personnel have been leaders in improving elements of transportation, education, the environment, health care, and public safety. Its employees serve on numerous non-profit and civic organizations and serve as valuable appointees on various public boards and commissions which affect public policy. The awards received by the company and its employees are too numerous to mention. They are true community partners, and this Mayor is very grateful for their endless contributions to our city, our Valley, our state, and our nation. If there is any additional information you need or if you have any questions, please do not hesitate to contact me.

Comment PV-T: I am writing to express my support for Palo Verde Nuclear Generating Station during its upcoming review by the U.S. Nuclear Regulatory Commission (NRC). For roughly 20 years Palo Verde has been operating safely and efficiently as the largest station of its kind.

Many of my constituents in Arizona, Legislative District 4 have always relied on the trustworthy service provided by APS. Palo Verde has secured its reputation as an area point of pride, in part because of the effort by APS and yourselves, the NRC, to ensure Palo Verde runs safely under national rules and regulations. The safety and efficiency of the plant stands out and has created a model which nuclear energy can be judged.

Electricity costs are certainly a consideration for many businesses and homeowners relocating all over Arizona, including LD4. Palo Verde has been an important generator of low and steady energy costs in Arizona. My constituents and their potential new neighbors care about the clean efforts of APS with plants such as Palo Verde, which keep the bottom lines on their electric bills low.

Palo Verde provides energy around the southwest and can continue to support Arizona economically and safely. I strongly believe APS will continue to run Palo Verde to the highest standards and provide Arizona with clean, reliable energy for years more to come.

Comment PV-V: I would like to advise you about how important the Palo Verde Nuclear Generating Station is to Buckeye and to Arizona. Palo Verde's contribution to the state of Arizona, with clean, reliable and cost effective energy is well appreciated by everyone at the Buckeye Valley Chamber of Commerce. It is a vital resource not only for its energy supply, but on a broader scale. Palo Verde affects Arizona's entire economy.

As the President/CEO of the Buckeye Valley Chamber of Commerce, I understand the benefits of a steady and lower cost energy supply. It is always a chief concern economically and, often times affects how businesses and families in Buckeye spend their money, especially in the hot summers. In accordance, APS and the power it provides with Palo Verde have always striven to create clean, cost- sensitive energy, while continuing to provide important environmental benefits.

Continuing the operation of Palo Verde makes strong economic sense for Buckeye, for Arizona and for other locations across the Southwest. Losing the low-cost reliable energy provided to over four million people by Palo Verde, in addition to the over 2,500 jobs it creates would be another damaging blow to Arizona's economic standing.

Palo Verde is a local point of pride for all of us in Buckeye and our neighbors. My request is simple, that you take my letter of support into consideration when reviewing the re-licensing of Palo Verde and its current units. I hope you will come to the same conclusion I have.

Comment PV-W: I write to you in full support of the renewal application of the Palo Verde Nuclear Generating Station. Arizona Public Service (APS) has safely and efficiently operated the plant for years, allowing PV to make long-term contributions to local area development. My constituents in Arizona Legislative District, 25 are some of those persons directly benefitting from Palo Verde's presence. The generating station is a major area business, employing more than 2,500 individuals.

Clean, reliable and cost effective energy is important now more than ever. The electricity generated by Palo Verde is something which my constituents in Legislative District 25 and our fellow citizens nationwide can rely on. Benefits of the energy produced by Palo Verde directly impact more than four million people throughout the Southwest. More than half of those live in the state of Arizona.

Not only does Palo Verde provide for millions, it ensures the light will turn on when our fellow citizens flip the switch. APS stands for dependable service, while at the same time keeping power bills low and taking important environmental considerations. I believe APS and Palo Verde will continue to deliver, clean, reliable and cost effective, energy to Arizona homes for decades, and I ask you to keep Palo Verde in operation.

Comment PV-X: I am contacting you to lend my support to the Palo Verde Nuclear Generating Station and the review for continued operation. Palo Verde has a tremendous positive impact for my constituents in Arizona Legislative District 4 by providing clean, reliable and low-cost energy.

In these troubling economic times, that low-cost energy is especially important for my constituents. Families around the Valley are pinching pennies wherever they can and simply struggling to get by. Where they might once have been wondering what expenditures they could afford, now they are troubled simply trying to keep the lights on. Palo Verde keeps their energy costs lower than alternative measures, and helps ensure they are able to light their homes.

That reliable and low cost energy is just as important to businesses as it is to homeowners. With larger utility expense costs, the difference Palo Verde makes for many businesses can be great. In addition, the reliability of the power supplied by APS ensures that businesses are never closed due to a failing energy infrastructure. This is extremely attractive for new businesses looking to locate to Arizona.

I am proud to have Palo Verde, the largest nuclear generating station in America, right here in Arizona. It is a symbol of Arizona's growing potential within the U.S. market and a welcome addition to our family. It is my sincere wish that you approve Palo Verde's request for continued operation.

Comment PV-Y: The Greater Phoenix Chamber of Commerce has been following with great interest the Nuclear Regulatory Commission's license renewal process for the Palo Verde Nuclear Generating Station. Palo Verde plays an important role in meeting the tremendous energy requirements of a fast growing state. For decades, it has done so in a safe and efficient manner, while also reducing our dependence on foreign oil and the production of green house gasses.

In my role as President and CEO of the Greater Phoenix Chamber of Commerce, I understand how much our economy depends on the reliable delivery of power to keep Arizona working. As you most certainly are aware, losing power, even for a short period of time, can result in the loss of millions of dollars for our businesses large and small. APS and Palo Verde have a strong track record of delivering the consistent, reliable and cost effective energy that Arizona businesses need to succeed.

Palo Verde is also Arizona's biggest single tax payer. At a time when our state faces the largest budget deficit in the country (as a percentage of the total budget) losing such a major contributor will result in the loss of millions to the state's General Fund, local communities and our schools. From an economic development perspective, a significant number of businesses in the Phoenix metropolitan area operate around the direct or indirect needs of the plant, and would suffer greatly in the event of a non-renewal.

The Greater Phoenix Chamber of Commerce stands squarely behind APS in its license renewal bid. I hope you will consider my letter in your review and strongly take into account the contributions Palo Verde makes to our economy and our state.

Response: *The comments are noted. The comments are supportive of APS and license renewal at PVNGS, and are general in nature. The comments provide no new information and will not be evaluated further.*

Comment PV-D-2: The second large issue, Arizona's nuclear dump. With Yucca Mountain apparently out of the picture, Palo Verde is really a huge defacto nuclear waste dump.

And in 20 more years increases its waste on site by 50 percent even if they're in dry casks, while continuing the added risk of cooling pools for a total of 60 years. The question is, can this facility handle this securely and reliably?

Comment PV-D-10: And wasn't it unrealistic, if not the height of arrogance, for a species that has only a few thousand years of recorded history to plan on safely managing radioactive waste for a minimum of 100 thousand years?

Thank you.

Response: *The staff notes that on March 3, 2010, DOE submitted a motion to the Atomic Safety and Licensing Board to withdraw with prejudice its application for a permanent geologic repository at Yucca Mountain, Nevada. Nevertheless, the safety and environmental effects of spent fuel storage have been evaluated by the NRC and, as set forth in the Waste Confidence Rule (10 CFR 51.23), the NRC generically determined that such storage could be accomplished without significant environmental impacts. In the Waste Confidence Rule, the Commission* *determined that spent fuel can be safely stored onsite for at least 30 years beyond the plants life, including license renewal. In 10 CFR Part 51, on site spent fuel storage is classified as a Category 1 issue that is applicable to all nuclear power plant sites. While the Commission did not assign a single level of significance (i.e., Small, Moderate, or Large) in Table B-1 of Appendix B to Subpart A to Part 51 for the impacts associated with spent fuel and high level waste disposal, it did conclude that the impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated.*

The GEIS for license renewal (NUREG-1437) evaluated a variety of spent fuel and waste storage scenarios, including on site storage of these materials for up to 30 years following expiration of the operating license, transfer of these materials to a different plant, and transfer of these materials to an Independent Spent Fuel Storage Installation (ISFSI). During dry cask storage and transportation, spent nuclear fuel must be "encased" in NRC-approved casks. An NRC-approved cask is one that has undergone a technical review of its safety aspects and been found to meet all of the NRC's requirements. These requirements are specified in 10 CFR Part 72 for storage casks and 10 CFR Part 71 for transportation casks. For each potential scenario involving spent fuel, the GEIS determined that existing regulatory requirements, operating practices, and radiological monitoring programs were sufficient to ensure that impacts resulting from spent fuel and waste storage practices during the term of a renewed operating license would be small, and is a Category 1 issue.

The comments provide no new and significant information and, therefore, will not be evaluated further.

Comment PV-D-3: If we want a dump at this site, off-site from Palo Verde for the dump, it raises other questions. If a waste disposal site actually becomes available, will that put shipments of highly radioactive wastes on the Interstate 10 near the facility? And what are the potential impacts to transportation and other economic costs associated with such a contingency?

As a person with over a decade of emergency planning experience, I'm aware of the many disaster drills at Palo Verde, but I don't believe there has ever been an exercise or plan involving a worst case scenario of a spill of nuclear waste from Palo Verde or a terror attack on a shipment that causes the release of nuclear waste into the environment.

I did see information about a worst case scenario of a nuclear waste spill along Interstate 40. I attended that State Emergency Response Initiative where we discussed it.

According to their estimates it would take about 15 months to decontaminate to safe levels. Further, if the roads to or from Palo Verde are closed for an extended period of time due to a radioactive spill; would that give terrorists an advantage? Would such a scenario impede response and/or defense?

Comment PV-AB-2: The number one concern of American citizens about nuclear power plants is the threat of a terrorist attack on a nuclear power plant, whether by foreign or domestic terrorists. All possible terrorist scenarios regarding Palo Verde need to be examined, along with potential impacts and mitigation, including scenarios where there is a significant population residing near Palo Verde (within ten miles), per NEPA requirements. There have been train derailments caused by someone unknown tampering with the rail lines, a form of domestic terrorism, in western Maricopa County, that still have never been solved. So there is already a history of suspicious actions and concerns about the ability of authorities to prevent these incidents, monitor for them, or prevent them. These incidents indicate a continuing vulnerability to terrorist acts, and should be reviewed as part of the terrorism analysis performed under NEPA.

Response: *A discussion of the environmental impacts of a terrorist attack is provided in Chapter 5 of the SEIS.*

Comment PV-AB-4: Please consider and address the following questions: What would the torque be for a full Boeing 747 hitting the generator building at different points of the building, such as the middle point of the generator building, at the point that is connected to the reactor containment building RCB, at the point 25% of the way from the RCB toward the end of the generator building, at the 75% point, all assuming a maximum speed for the aircraft and at a perpendicular strike directly against the generator building?

Is the generator building and the heat transfer area around the primary coolant loops and secondary generator loops strong enough to withstand this impact without a coolant breach?

We know that the RCB is not strong enough for the most powerful strike, as this has been admitted in NRC proceedings. What is the likelihood of a full impact strike causing a meltdown?

Please consider the attached Greenpeace study, *New Nukes and Old Radioactive Waste* in these deliberations and analysis. (P_@_SEJ_2006_Final_Draft).

Response: *A discussion of the environmental impacts of a terrorist attack, including attacks involving large commercial aircraft, is provided in Chapter 5 of the SEIS.*

Comment PV-D-4: Next issue, population growth and contingency issues. There are plans for a large development near Palo Verde bringing in at this point about 140 thousand people. The current contingency plan is to evacuate within a ten mile radius and then wait for federal assistance. A footnote, we might want to ask the people of New Orleans what they think about the folly of that plan.

To move such a large population away from the ten mile radius in a timely manner, when time would be so much of the essence in a situation like that, would require enormous resources including legions of buses that would in themselves become contaminated during the evacuation and would need, of course, much more detailed decontamination afterwards if they were ever going to be put back into service. It's doubtful that anyone would ever want to ride them nonetheless.

It's also doubtful that buses pulled from normal service for such an evaluation would be able to arrive here in a timely manner. I don't think there are enough buses in the Phoenix metro area that could move those -- that could move that number of people and of course it's easily more than an hour away. Again, time is of the essence.

It would seem to me that in order to be properly prepared the requisite number of buses would have to be ready and in the immediate vicinity of Palo Verde. Where will they be stored? Who will maintain them? Who will be ready to drive them in the case of something happening?

Comment PV-AB-3: The current contingency plan is to evacuate people within a ten mile radius and then wait for federal assistance. The strategy for moving hundreds of thousands of people away quickly and perhaps permanently needs to be examined and laid out, as well as any mitigation that could be implemented.

Response: *The Commission considered the need for a review of emergency planning issues in the context of license renewal during its rulemaking proceedings on 10 CFR Part 54, which included public notice and comment. As discussed in the Statement of Considerations of a 1991 rulemaking (56 FR 64943 at 64966-7) and reaffirmed in a 1995 rulemaking (60 FR 22461 at 22468), the programs for emergency preparedness at nuclear plants apply to all nuclear power plant licensees and require the specified levels of protection for each licensee regardless of plant design, construction, or license date. Requirements related to emergency planning are in the regulations at 10 CFR 50.47 and Appendix E to 10 CFR Part 50. These requirements apply to all operating licenses and will continue to apply to plants with renewed licenses. Through its standards and required exercises, the Commission reviews existing emergency preparedness plans throughout the life of any plant, keeping up with changing demographics and other site-related factors. Therefore, the Commission has determined that there is no need for a special review of emergency planning issues in the context of an environmental review for license renewal.*

Comment PV-D-5: The next issue I call "Trust Us." The Palo Verde reactors are only now, after an unprecedented length of time, being moved off of the multiple repetitive degraded corner stone column, an extreme level of NRC oversight. Can these people really be trusted?

The NRC decided for years that the culture of management at Palo Verde was such a huge problem that it closely scrutinized the plant and was on the brink of closing the facility.

Suddenly, after five years the NRC decided everything is suddenly okay. That sounds much more like a political decision than something that's reality based. And we are left wondering if Palo Verde operators might have just straightened up their act just long enough to get their license reviewed with plans to backslide or did they really, finally get their act together? What assurances do we have that future violations and noncompliance will be detected and dealt with early enough? The nuclear industry is admittedly only one big accident away from a total collapse. So this makes us wonder, is it time to double down at this facility?

Comment PV-D-6: The next issue is what they call the "Bathtub Curve." Complex engineering projects have most problems at the beginning and the ends of their lifecycle.

The bathtub curve is widely used in reliability engineering, although the general concept is also applicable to humans, it describes a particular form of the hazard function, which comprises three parts: The first part is a decreasing failure rate, known as early failures. The second part is a constant failure rate, known as random failures. And the third part is an increasing failure rate, known as wear-out failures. The name is derived from the cross-sectional shape of the eponymous device.

The bathtub curve is generated by mapping the rate of early infant mortality failures. When first introduced the rate of random failures with constant failure rate during its useful life, and finally the rate of wear-out failures as the product exceeds its design.

It is especially concerning as there are plant aging and radiation embrittlement issues for reactors and their associated equipment. My bet is that nobody really knows a lot of what will be happening to the metals after 30 to 40 to 60 years of radioactive bombardment.

Considering the previous and serious problems at Palo Verde already with leaking pipes and all the other issues there, will NRC require and monitor the requisite inspections to prevent another problem and outage?

Comment PV-D-7: The next issue I call "New Crew." As reactors get older the crews that run them didn't build them and likely haven't looked at the original plans even once in their lives. How good is the institutional memory of Palo Verde, given that they've had such significant problems in the past? We'll have a new generation of employees. What training programs will be in place to assure that this doesn't cause problems? There is already a critical shortage of trained workers for the nuclear technology.

Response: *Plant performance is part of the current operating license. To ensure that U.S. nuclear power plants are operated safely, the NRC licenses the nuclear power plants to operate, licenses the plant operators, and establishes license conditions for the safe operation of each plant. The NRC provides continuous oversight of plants through its Reactor Oversight Process (ROP) to verify that they are being operated in accordance with NRC regulations.*

The NRC has full authority to take whatever action is necessary to protect public health and safety, and the environment and may demand immediate licensee actions, up to and including a plant shutdown.

The NRC's environmental review is confined to environmental matters relevant to the extended period of operation requested by the applicant. The NRC will ensure that the safety of a currently operating power plant will continue to be maintained before renewing the license by ensuring that aging effects will be adequately managed and that the licensing basis related to the present plant design and operation will be maintained. Before a new license is issued, the NRC will ensure that there is a technically credible and legally sufficient basis for granting a new license for an extended 20 years as reflected in the NRC's safety evaluation report (SER), final SEIS, and the proposed new license. The comment provides no new information, and does not pertain to the scope of license renewal under 10 CFR Part 51 and Part 54. Therefore, it will not be evaluated further.

Comment PV-AD: Below are DWAZ's questions, with an article of Moody's downgrading SC Electric and Gas due to their participation in a nuke. Moody's has said that it would be downgrading utilities participating in nuclear energy projects. Moody's study and a recent follow-up are attached for inclusion and reference. Fitch also downgraded this utility a while back, and the article is below the first one.

DWAZ includes the attached by reference: "Special Comment, Moody's Corporate Finance--New Nuclear Generating Capacity: Potential Credit Implications for U. S. Investor Owned Utilities," May 2008, at http://massimobray. italianieuropei. it/080527MoodysNewNukeGen Capacit y.pdf

DWAZ's questions include:

In relation to the "Special Comment, Moody's Global Infrastructure Finance--New Nuclear Generation: Ratings Pressure Increasing," June 2009.

Q: This report says, "History gives us reason to be concerned about possible balance-sheet challenges, the lack of tangible efforts today to defend the existing ratings, and the substantial execution risk involved in building new nuclear power facilities."

While this report largely deals with new reactors, it is true that older reactors are having major components replaced, like heat exchangers, plumbing and electrical infrastructure, generators, and condensers, etc. Some of these are beyond "variable operating cost" and are capital investments, capitalized on the balance sheet. Similar to when an old company truck gets too old and the repairs and capital improvements outweigh the cost of payments on a new one, when reactors get older, this at some point will happen. When that does happen, what are the risks that could down-grade APS/PVNGS ratings with firms like Moody's Standard and Poor's and Fitch ratings companies?

Q: What are the major component and infrastructure replacements that PVNGS has had so far that have been capitalized?

Q: Are is the NRC learning from the collective experience of other reactors in the U.S. and their major component and infrastructure replacements?

Q: What are the costs of capitalized major component and infrastructure replacements for other reactors in the U.S., and how does PVNGS compare?

Q: One of the Browns Ferry reactors had a fire many years ago, and this fire knocked out the reactor from producing electricity for decades. When the reactor was refurbished, the total cost was about $1.5 billion. Does APS see how this kind of repair/renovation could have a significant impact on corporate risk levels and on ratings by credit ratings agencies like Moody's? Could APS financially handle such a contingency and survive without bankruptcy, or would APS just stick ratepayers with the bill again?

Q: In another case, at the Davis-Besse in Ohio, the reactor came a few months away from a corrosion-caused breach of containment. Does APS or ANPP realize that there are possible major repairs that may make an old plant a large previously un-booked liability?

Q: What are the costs of increased variable operation and maintenance of U.S. reactors as reactors have aged, for reactors, per reactor, over 15 years old, over 20 years old, over 25 years old, over 30 years old and over 35 years old?

Q: What are the costs of capitalized major component and infrastructure replacements of all U.S. reactors, per reactor, as reactors have aged, for reactors over 15 years old, over 20 years old, over 25 years old, over 30 years old and over 35 years old?

Q: What depreciation duration was used for these capitalization schedules for income tax purposes for each U.S. reactor per incident of capitalization?

Q: This reports says, "We also believe companies will ultimately revise their corporate-finance policies to begin materially strengthening balance sheets and bolstering available liquidity capacity at the start of the construction cycle." To the degree that there can be breakdowns and capitalized major component and infrastructure replacements with significant economic value at any time, what are Arizona Public Service and other members of the Arizona Nuclear Power Project doing in terms of "strengthening their balance sheets and bolstering available liquidity capacity"?

Q: What are APS and ANPP target reserve margins, by year, for 2009 and for future years through the proposed extended lifespan of PVNGS?

Q: What have the target reserve margins been for the years since PVNGS Unit 1 has been in operation?

Q: What have the actual reserve margins been for APS and ANPP for the low point of each year since PVNGS Unit 1 has been in operation?

Q: To what degree are APS and the other partners of ANPP counting on PVNGS in its total relied- upon capacity and as part of the calculate reserve capacity?

Q: As PVNGS reactors go down because of increased interruptions in service due to age, is APS and ANPP increasing its reserve margin to cover this decrease in reliability?

Q: If so, by what megawattage and percentage of total power design electrical rating plant capacity, for APS and ANPP?

Q: The report says, "Historical rating actions have been unfavorable for issuers seeing to build new nuclear generation. Of the 48 issuers that we evaluated during the last nuclear building cycle (roughly 1965-1995), two received ratings upgrades, six went unchanged, and 40 had downgrades. Moreover, the average downgraded issuer fell four notches. All these ratings were evaluated on the senior secured or first mortgage bond ratings." While these are for new builds, major capitalization may be required numerous times for aging reactors during their last 2-3 decades of operation. Have APS and ANPP members prepared for the possibility of downgrades by the ratings agencies due to large capital outlays?

Q: The report says, "We view new nuclear generation plans as a 'bet the farm' endeavor for most companies. . ." While they are referring to long construction timelines, there may be lengthy repair timelines at PVNGS. What are APS and ANPP doing to brace for possible extended capital repairs of PVNGS Units 1-3, in terms of bolstering financial health and in terms of increasing reserve margins?

Q: Please provide a list of all capitalized component and infrastructure investments for PVNGS year by year and component by component and infrastructure investment by investment, since the initial power-up at each reactor.

Q: Please give projections for what the cost of similar investments will be, item by item, in the future. For example, for a generator replacement done in the past, what is the projection on cost to do replace a generator in the future, year by year through the proposed license extension period?

Q: The report says that APS moved down 4 notches from 1981-1993, with a beginning rating of A2 FMB with the lowest rating at Baa3. If there is to be an extended period of repair/construction in the future for any of the Units 1-3, say for 1, 2, 3, or 4 years, what ratings downgrade might happen?

Q: If there is a Moody's rating downgrade of 1, 2, 3 or 4 levels, what impact on interest rates for new plant construction and major capitalized repair debt will occur, in percentage increases?

Q: What are APS and ANPP doing to improve their respective credit ratios in anticipation of such component replacements or capitalized infrastructure repair possibilities?

Q: The reports says, "The likelihood that Moody's will take a more negative rating position for most issuers actively seeking to build new nuclear generation is increasing. With only about 24 months remaining before the NRC begins issuing licenses for new projects and major investment begins, few of the issuers we currently rate have taken any meaningful steps to strengthen their balance sheets. Considering these new projects tend to raise an issuer's business and operating risk profiles, the utility's overall credit profile appears weaker." Again, with increases in major repairs as reactors get older, and with increasing dollar amounts for repairs, what are APS and ANPP doing to minimize their risks and to keep from getting down-graded by the ratings agencies?

SCANA feels rating bite on nuclear plant

Wednesday, July 15, 2009

Moody's Investor Services lowered SCANA Corp.'s bond rating this week and listed the outlook as negative because of the S.C. utility's joint ownership of a $12 billion nuclear project under construction. Moody's warned investors two weeks ago that it was likely to take a negative view on nuclear development by power companies. Some in the nuclear industry have taken issue with that policy. But Moody's stood by it when explaining its decision on SCANA.

"We remain concerned with the … risks associated with a project of this magnitude for a company of this size," said Moody's Senior Vice President Jim Hempstead.

SCANA subsidiary S.C. Electric & Gas is expanding the V.C. Summer Nuclear Station with Santee Cooper. The power companies are adding two AP100 nuclear reactors at the existing nuclear plant.

Comment PV-AB-6: The life cycle of nuclear power is not only dependent upon fossil fuels for the production of uranium fuel, decommissioning, and the disposition of wastes generated: it is also dependent upon a grid that is powered by other sources of energy, typically coal. This is due to the simple fact that nuclear reactors cannot "black start"– in other words, they depend on electric power from the external power grid to be able to come on-line. Transition away from the combustion of fossil fuels cannot be accomplished solely by the expansion of nuclear power since it depends on the grid being powered up before reactors can come on-line.

Other studies on the economics of nuclear power generation that should be reviewed and considered in the NEPA analysis are at: http://www.greenpeace.org/raw/ content/usa/ press-center/ reports4/ the-economics- of-nuclear- power.pdf

http://www.earth- policy.org/ Updates/2008/ Update78 _ printable. htm

Amory Lovins:
http://www.rmi. org/sitepages/ pid467.php

http://www.arizonap irg.org/uploads/ ee/qD/eeqDk _ cKZXyH5yuhZduZTA /The-High- Cost-of-Nuclear- Power.pdf

http://www.stanford.edu/group/efmh/jacobson/EnergyEnvRev0908.pdf

Also see the attached file, the copy of SEA Energy Costs.

Comment PV-AC: The attached study says on page 296, that a 2000 study says every $1.4 million yields 11.3 to 13.5 full-time equivalent jobs. This study should be used in the economic analysis comparing the economic benefits of the relicensure of Palo Verde vs. expending resources to get an equivalent amount of generating power from solar, wind, and other renewables. The total number of jobs (FTE) at Palo Verde Nuclear Generating Station (PVNGS) and the total revenue is for PVNGS' electricity should be determined, and dividing the latter by the former will yield dollars/job at PVNGS. The attached study will provide much useful information re the dollars/job of renewable energy options.

Comment PV-AB-5: A recent study by an economic analyst at the University of Vermont finds that building 100 new reactors would cost from $1.9 to $4.1 trillion more than getting our electricity from clean renewable energy sources. (See http://www.nirs.org/neconomics/cooperreport_neconomics062009.pdf)

All costs and impacts of energy efficiency programs, alternative and renewable energy sources should be examined against the costs and impacts of relicensing Palo Verde. This analysis should also include water usage, air pollution impacts (Palo Verde has been fined significantly by the Maricopa County Air Quality Department for exceedances of its particulate matter (PM) emissions limits, specifically for excess PM emissions from its cooling towers.), wastes, radioactive emissions, mining impacts and groundwater impacts of uranium mining, sustainability, and the costs in terms of money and of carbon of developing less rich ores for reactor fuel, including the rising costs of the electricity used in the process of making fuel rods, which includes enrichment and fuel processing. The uranium enrichment plant at Paducah, Kentucky is the largest U.S. emitter of CFCs, which destroy the ozone layer.

The average energy efficiency cost for State programs across the U.S. is 3-4 cents per KWH. The average cost of just nuclear fuel, O&M (fixed and variable) is at least 3.7 cents and at most 4.9 cents per KWH, according to the Keystone report. (See page 42 of referenced Keystone report http://www.ne.doe.gov/pdfFiles /rpt_KeystoneReportNuclearPowerJointFact Finding_2007.pdf.) The Keystone report was hailed by Nuclear Engineering International and it was a multidisciplinary report. This averages higher than the average efficiency cost.

A fundamental element in finding that nuclear power is a false solution to climate change is that the economics of nuclear power are not sound – in open markets nuclear cannot compete. Since splitting atoms is not a cost-effective source of electric power, it is even less cost-effective in preventing greenhouse gas emissions. Life cycle costs for nuclear power generation (in the USA) have been estimated at 12 cents a kilowatt hour; whereas life cycle costs for wind power in the same analysis is estimated at 4 cents a kilowatt hour. Others find that expanding nuclear generating capacity is about twice as expensive as expanding generating capacity through investment in wind power. Since the same money will buy 2 – 3 times more electric power when used to purchase wind generated electric power, it is clear that prevention of greenhouse emissions will also be 2 – 3 times greater when buying wind generated electricity than nuclear generated electricity (as opposed to nuclear generating capacity). CO2 production per dollar is not constant. According to the Sovacool study, the average study which passed the test for quality projects that nuclear power will produce 66 grams of CO2/kilowatt- hour, and that wind's life cycle will produce 10 grams. CO2 output is related to KWH, not cost per kilowatt- hour, partly because cost is a fluctuating value, but a KWH is a fixed scientific measurement. Therefore, nuclear power will produce 66 grams CO2/KWH and wind 10 grams, which is 6.6 times the pollution output of CO2. If we can assume that wind is half the price per KWH, then the output becomes 13.2 times the CO2 output per nuclear power compared to wind. However, it is important to note that all the studies reviewed by Sovacool only assume the current ore grade of uranium to continue into the future. We know that ore grades will decline, as they have already halved over the last 30 years from 3000 ppm to 1500 ppm. The Sovacool report also does not assume any CO2 for long-term waste management and remediation, including unintentional and intentional terrorist environmental breaches.

The average cost should include all costs, including transmission & distribution. DWAZ estimates that the cost of new nuke energy will be about 24 cents/KWH (18 cents for generation plus 7 cents for T&D), wind with T&D is 15 cents on average, and energy efficiency is 3.5. The Cooper and other reports are in the same ballpark on nuclear power.

Comment PV-AA: The following was provided as an attachment to an email.

Solar Photovoltaic Costs for Life of System

Spreadsheet by Russell Lowes, www.SafeEnergyAnalyst.org, 3/5/09 DRAFT

Energy Production Assumptions			**Utility**	
Residential	**Residential**	**Residential**	**Industrial**	
Based on Construction Cost Given By Solon at 2/12 Tour	Based on Typical Construction Cost Locally	Based on 50% rebate from Gov't & Utilities	Based on Lower Cost Industrial w/ Higher 12% Charge Rate	
1	1	1	1	Kilowatt
8766	8766	8766	8766	hours per year
30.0%	30.0%	30.0%	30.0%	capacity factor (percentage of maximum nameplate rating realized in kilowatt-hours)
25	25	25	25	Lifespan; years of production of electricity
65745	65745	65745	65745	Subtotal
10.0%	10.0%	10.0%	10.0%	average degradation over 25 year lifespan, based on Solon guarantee of
59170.5	59170.5	59170.5	59170.5	kilowatt-hours production for lifespan

Cost Assumptions				
$4,000.00	$12,000.00	$6,000.00	$4,000.00	Dollars per kilowatt of e capacity, A/C
$1,000.00	$1,000.00	$1,000.00	$1,000.00	Repairs and Maintenance over 25 year lifespan (GENERAL ESTIMATE)
$5,000.00	$13,000.00	$7,000.00	$5,000.00	Total investment over lifespan

Simple cost per Kilowatt-hour, without finance charges				
$0.085	$0.220	$0.118	$0.085	dollars per kilowatt-hour

To calculate the finance charges:				
$4,000.00	$12,000.00	$6,000.00	$4,000.00	Capital investment, construction cost
25	25	25	25	Years of loan
8.25%	8.25%	8.25%	12.00%	Interest rate of loan / FIXED CHARGE RATE FOR INDUSTRIAL OPTION
$386.52	$1,159.56	$579.78	$480.00	Mortgage payment for loan per year (hand-entered from loan amortization program for Residential, Calc'd for Industrial)

$9,663.00	$28,989.00	$14,494.50	$12,000.00	Total repayment for loan over lifespan (line above times lifespan years)

Total lifespan costs with mortgage payments

$9,663.00	$28,989.00	$14,494.50	$12,000.00	Capital costs (mortgage) over lifespan
$5,000.00	$5,000.00	$5,000.00	$5,000.00	Repairs and maintenance over lifespan
$14,663.00	$33,989.00	$19,494.50	$17,000.00	Total cost over lifespan
$0.25	$0.57	$0.33	$0.29	Final cost per kilowatt-hour with interest
			$0.06	For Utilities, add 6 cents for Transmission and Distribution
			$0.35	End cost for average retail price.

Note that profit for investors, insurance & property taxes are included in the 12% levelized fixed charge rate, in the Industrial example. 12% is used by Standard and Poor's for utilities (non-nuclear).

Other factors:
For residential non-utility examples, insurance and property costs are not included.
The maintenance costs need to be better grounded in experience, for all examples.

Deterioration Rate of Solar PV at 0.5% per year

1	1	Initial kilowatt of capacity
2	0.995	
3	0.990025	
4	0.985075	
5	0.98015	
6	0.975249	
7	0.970373	
8	0.965521	
9	0.960693	
10	0.95589	
11	0.95111	
12	0.946355	
13	0.941623	
14	0.936915	
15	0.93223	
16	0.927569	
17	0.922931	
18	0.918316	
19	0.913725	
20	0.909156	
21	0.90461	
22	0.900087	
23	0.895587	
24	0.891109	
25	0.886654	
	0.942238	Average delivery of electricity per initial kilowatt of capacity

Electricity Costs for Pima County Residents					
Now and in the Future					
Spreadsheet by Russell Lowes, www.SafeEnergyAnalyst.org, 3/17/09 DRAFT					
	Reduction In				
Typical	**Electricity With**				
Residential	**Different Mix of**	**Prior Column**			
Consumption	**Consumption**	**over**		**CO2**	**. . .See**
KWH/Mo	**KWH/Mo**	**25 years**		**Output. . .**	**Below**
750	750	225000	Current consumption for a typical residence		
$ 0.105	$ 0.105		Cost per kilowatt-hour of electricity		
$ 78.75	$ 78.75		TOTAL ROUGH CURRENT COST		
0.00%	25.00%		Assumed % reduction in consumption of KWH		
750	563	168,750	New consumption level after energy efficiency program		
0	188	56,250	Energy saved per month in KWH		
Projected Blend of Energy in %					
0.00%	10.00%		New Solar PV		
70.00%	50.00%		Old Coal		
30.00%	25.00%		Old natural gas plants		
0.00%	5.00%		New natural gas plants		
0.00%	0.00%		New Nuclear		
0.00%	10.00%		Wind		
0.00%	0.00%		Hydro		
100.00%	100.00%				
				Initial	**New Mix**
				CO2	**CO2**
Energy efficiency with new mix of solar/coal/natural gas				**Output**	**Output**
			Cost for Electricity for Each Source	**grams/KWH**	**Output**
$ -	$ 13.50	$ 4,050.00	New Solar PV	0	1,800
$ 52.50	$ 28.13	$ 8,437.50	Old Coal	504,000	270,000
$ 26.25	$ 16.41	$ 4,922.44	Old natural gas plants	112,500	70,313
$ -	$ 4.22	$ 1,265.63	New natural gas plants	0	12,459
$ -	$ -	$ -	New Nuclear	0	0
$ -	$ 8.44	$ 2,531.25	Wind	0	506
$ -	$ -	$ -	Hydro	0	0
$ 0.03	**$ 0.03**	**$ 0.03**	**Energy efficiency cost per KWH**	616,500	354,572
$ -	$ 5.63	$ 1,687.50	Energy efficiency cost per month		

$ 78.75	**$ 67.88**	**$20,363.06**	Total new cost of electricity		
$ (0.00)	**$ 10.87**	**$ 3,261.94**	**Savings/total bill**		
0.0%	1.4%	1.4%	Savings as % of original bill **Savings in Total CO2:**		42%
			Average CO2 per Kilowatt-Hour	822	630
			Savings per KWH CO2:		23%
				Initial	**New Mix**
				CO2	**CO2**
				Output	**Output**
Cost per Kilowatt-Hour			Resulting KWH Used	**grams/KWH**	**Output**
$0.240	$0.240		New Solar PV	32	32
$0.100	$0.100		Old Coal	960	960
$0.117	$0.117		Old natural gas plants	500	500
$0.150	$0.150		New natural gas plants	443	443
$0.240	$0.240		New Nuclear	400	400
$0.150	$0.150		Wind	9	9
$0.100	$0.100		Old Hydro	10	10
$0.035	$0.035		Energy Efficiency	5	5
KWH Consumption breakdown by source					
0	56	16,875	New Solar PV		
525	281	84,375	Old Coal		
225	141	42,188	Old natural gas plants		
0	28	8,438	New natural gas plants		
0	0		New Nuclear		
0	56		Wind		
0	0		Hydro		
750	563	168,750	Total KWH/Mo		
$ 0.105	$ 0.121		Total Cost Per KWH		

Cost for a Nuclear Reactor and Cost Per Person for Nuclear Energy, Capital Portion Only

A Worksheet by Russell J. Lowes, updated 3/5/09

I have seen nuclear industry estimates have run from $1,000-2,000 per kilowatt of installed electrical capacity to $4,000, over the 2000-2006 period. When 2006 arrived, cost estimates increased dramatically.

Recently, some spokespersons for the industry have begun to face reality and have increased their projections dramatically, two estimates as high as $8,200 and $10,000 per kilowatt.

However, reactors in the late 1980s were finishing at just over $3000, in 1980s dollars.

(See Brice Smith, Insurmountable Risks: The Dangers of Using Nuclear Power to Combat Global Climate Change at www.ieer.org/)

This $3000 does not count all the reactors that were canceled due to cost overruns, so this figure is low. Running a $3000 price out from 1988 to 2008 with simple inflation yields (at the http://data.bls.gov/cgi-bin/cpicalc.pl) $5500, rounded to the nearest $100.
This $5500 figure is low due to construction costs outpacing general inflation, particularly with the price of copper, steel and cement going up with increased world demand.
On top of the $5500 in 2008, projecting out to 2020 as a completion year for a reactor at a 4% annual cost escalation rate yields $8500.

However, more robust reactor designs with two decades worth of lessons of safety improvements has its costs. The industry is going to be required to build structures capable of withstanding large jet impacts, per post-911 rules. This will substantially increase the cost of building nukes. Additionally, "passive" cooling systems will require substantial cost increases, as massive reservoirs will be built to hold water for ECCS backup.

What will the nuclear program cost per person in the U.S. if the industry builds 1000 reactors, each averaging 1000 megawatts, in this nation?

The following table assumes that the 100 reactors are built the same year, and run for 30 or 40 years. However, no reactor has run for this long of a period at an average 85% capacity factor, so this 40-year estimate is giving the nuclear industry the benefit of the doubt.

1,350	average size reactor, megawatts		
$9,000	average cost per kilowatt of electrical capacity installed (for 2020 completion)		
$12,150,000,000	cost per plant		
100	number of plants under the Bush and McCain plans		
$1,215,000,000,000	total construction cost		
14.0%	levelized fixed charge rate for 30 year payback schedule		
$170,100,000,000	annual rate paid per year		
$5,103,000,000,000	total capital payback over 30 years		
350,000,000	people in the U.S. on average over the 30-year payback period	Keystone Report/Nuclear Power Joint Fact-Finding	
486	costs per person per year for loan payback		
		Low Cost	High Cost
If the above scenario is realized, what will the cost of nuclear power be per kilowatt-hour, for just the capital portion?		40Yr90%	30Yr75%
$9,000	Cost per kWe installed	**$2,950**	**$2,950**
14.0%	Capital payback per year/Fixed Charge Rate	12.3%	13.8%
$1,260	Annual payback per KW, first 30 years	$363	$408

	30	**Reactor Life in years**	**40**	**30**
	30	**Capital Payback Period**	**30**	**30**
			10,887	12,229
	$37,800	Capital payback over 30 years Capital Payback per kW installed	$14,516	$12,229
	85.0%	Capacity factor	**90.0%**	**75.0%**
	223,533	kWhe generated per kWe installed, for years in Reactor Life	315,576	197,235
$ 0.1691		$/kWhe	**0.046**	**0.062**
		compared with the calculations on the left:	**0.127**	**0.169**
	40	**Extended 40-year reactor life in years**		
	298,044	kWhe generated per kWe installed		
$ 0.1268		Capital cost/kWhe		

If the reactors ran at the fantasy industry figure of $2000 per kWhe, lasted 40 years and had a 85% capacity factor:

280	Annual Payback per KW, first 30 years
$8,400	Capital payback over Reactor Life per kilowatt installed
$ 0.0376	Capital cost/kWhe

Fuel, and Operation and Maintenance Costs are Projected Differently by the Following Sources

	From the Keystone Report/"Nuclear Power Joint Fact-Finding," page 42.
0.015	Fuel
0.023	Fixed Operating and Maintenance Cost
0.005	Variable O&M
$ 0.0430	Total Fuel and O&M
$ 0.1698	Total All Costs/kWhe

	From IEER January 2008 Science for Democratic Action newsletter:
$ 0.0430	per kilowatt-hour, average projection by the Keystone Report, 2007 $
$ 0.0230	PacifiCorp, a Western states utility company 2007 $

		From Report submitted to the California Public Utilities Commission,
		Energy & Environmental Economics, Inc.
		www.ethree.com/cpuc_ghg_model.html
		Fixed O&M is estimated at $83/kW-yr, this would be
$	**0.0111**	Fixed O&M
$	**0.0012**	Variable O&M
		Fuel is listed as $.78/MMBtu, with Heat Rate @10,400 btu/kwh
$	0.7800	/MMBtu (million btu)
	293	kilowatts = 1 MMBtu At 3413 btu/kWh 1MMBtu
$	**0.0027**	Cost of fuel
$	**0.0150**	Cost of Fuel and O&M

		From Standard & Poor's "Which Power Generation Technologies Will Take the Lead In Response to Carbon Controls," May 11, 2007
$	**0.0134**	per kW/yr
		$/kWhe @ 85% Capacity factor

*The Keystone report is considered the most accurate and up-to-date for future reactors, and will be used in the cost of calculating nuclear energy. It should be noted that there is a predicted shortage of uranium for fueling reactors, starting around 2018, with resource depletion problems getting worse over the subsequent years. Keystone does not take into account the more dire projections.
Keystone was an interdisciplinary process involving teams of researchers and writers from the nuclear industry, NGOs, etc.

Nuclear and Other Energy Options

Cost Recap

		Projected Nuclear Costs per Kilowatt-Hour of Electricity Delivered
$	0.1268	Capital costs
$	0.0150	Fuel Costs
$	0.0230	Fixed Operation and Maintenance
$	0.0050	Variable Operation and Maintenance
$	0.1698	Total Generating Cost for Nuclear Electricity Per Kilowatt-Hour
$	0.0700	Transmission and Distribution
$	0.2398	Total Cost of Electricity for Delivered Nuclear Electricity

$	0.1000	**Current Coal Technology Electricity Generation Cost**
$	0.0700	Transmission and Distribution
$	0.1700	Total Cost of Electricity for Delivered Coal Electricity

$	0.0800	**Current Natural Gas Technology Electricity Generation Cost**
$	0.0700	Transmission and Distribution
$	0.1500	Total Cost of Electricity for Delivered Gas Electricity

$	0.1200	**Solar Thermal Electricity Generation Cost**
$	0.0700	Transmission and Distribution
$	0.1900	Total Cost of Electricity for Delivered Solar Thermal Electricity

$	0.15-0.40	**Solar Photovoltaic Electricity Generation, including On-Site T&D**

$	0.0800	**Wind Generation Cost of Electricity**
$	0.0700	Transmission and Distribution
$	0.1500	Total Cost of Electricity for Delivered Wind Electricity

$	0.0350	**Cost of Energy Efficiency Per Kilowatt-Hour Saved, if Implemented On Large Scale**

KWH/Household for nukes and coal	2	2
capacity factor for nukes and coal	75	75
capacity factor for wind and PV	35	30
Renewable CF fraction of Nuke/Coal CF	0.466667	0.4
KWH/Household for wind and PV solar	4.285714	5
Households per kilowatt of nukes & coal	0.5	0.5
Households per kilowatt of wind & solar	0.233333	0.2

Decommissioning and Waste Cost of Surveillance System Over One Million and Ten Thousand Years

	The total number of megawatt-hours put out by a 1000 1000-MW nuclear plants over 40 years at 85% capacity factor
1000	number of reactors
1000	Megawatts of electricity per reactor, Design Electrical Rating
40	Number of years
8766	Hours per year
85.0%	Capacity Factor/Load Factor

298,044,000,000	Megawatt-hours of electricity for reactors
298,044,000,000,000	Kilowatt-hours of electricity for reactors

The federal court system has ruled that the Environmental Protection Agency can no longer use 10,000 years as a guideline for nuclear waste planning – they must now use 1 million years.

See: U.S. News & World Report, "Mired in Yucca Muck, Nuclear power is trendy again, but what about the waste?" by Bret Schulte, at
http://www.usnews.com/usnews/news/articles/061022/30nukes.htm

Under the old 10,000 year guideline, the amount of kilowatt-hours the plants produce divided by 10,000 would
equal what?

298,044,000,000,000	Kilowatt-hours of electricity for reactors
10,000	years of waste management
29,804,400,000	Kilowatt-hours of electricity for waste management.
30.0%	Reduced by the 30%, for example of energy input at the front end: mining, milling, conversion, enrichment, re-conversion, fabrication, building the plant, running the plant, short-term waste storage
30.0%	Reduced by say another 30%, with the goal of having a 40% net energy gain.
11,921,760,000	Hours per year to devote to waste management.

If the new 1,000,000 year guideline is used, the amount of kilowatt-hours for waste storage per year:

298,044,000,000,000	Kilowatt-hours of electricity for waste management.
1,000,000	years of waste management
298,044,000	Kilowatt-hours of electricity for waste management.
30.0%	Reduced by the 30%, for example of energy input at the front end: mining, milling, conversion, enrichment, re-conversion, fabrication, building the plant, running the plant, short-term waste storage
30.0%	Reduced by say another 30%, with the goal of having a 40% net energy gain.
119,217,600	Kilowatt-hours per year to devote to waste management.

How does this waste cost compare to other industrial management processes?
If the waste is kept at the reactor sites, as may be the case in the future, then there will be 104 reactor sites (if you count each reactor as a site – many reactors are at multiple-reactor sites).

10,000-Year Plan:

11,921,760,000	Kilowatt-hours per year to devote to waste management.
1,000	reactors
11,921,760	Kilowatt-hours per year to devote to waste management.

Million-Year Plan:

119,217,600	Kilowatt-hours per year to devote to waste management.
1,000	reactors
119,218	Kilowatt-hours per year to devote to waste management.

What would this value be in today's dollars at, for example, 10 cents per kWhe?
10,000-Year Plan:

11,921,760	Kilowatt-hours per year to devote to waste management.
$0.10	
$1,192,176	Electricity cost per year in today's dollars.

Million-Year Plan:

119,218	Kilowatt-hours per year to devote to waste management.
$0.10	
$11,922	Electricity cost per year in today's dollars.

Response: *The need for power and the economic costs and benefits of the proposed action are inquires that are, generally, outside of the scope of the environmental review. 10 CFR 51.95(c)(2). While the comment is noted, it provides no new information and, therefore, will not be evaluated further.*

Comment PV-R: The Ak-Chin Indian Community did receive your letter regarding the scoping comments for the Palo Verde Nuclear Generating Station license renewal application review. Based on the location of this project, the Ak-Chin Indian Community will defer comments to the Lead Tribe for Land Management area - the Gila River Indian Community.

We are still interested in being informed on the SEIS when it is completed and further development on the progress of the License Renewal Application.

Thank you for informing the Ak-Chin Indian Community about this project. If you should have any questions, please contact Mrs. Caroline Antone, Cultural Resources Manager at (520) 568-1372 or Mr. Gary Gilbert, Technician II at (520) 568-1369.

Response: *The comments are noted. The Ak-Chin Indian Community and the Gila River Indian Community were added to the expanded service list (those that receive the draft SEIS and the final SEIS).*

Comment PV-Z: The Bureau of Land Management appreciates the opportunity to review and provide comment regarding the subject ER 09/549. However, the BLM has no jurisdiction or authority with respect to the project, the agency does not have expertise or information relevant to the project, nor does the agency intend to submit comments regarding the project.

Response: *The comment is noted.*

Comment PV-A: My name is Mary Widner, I live in the community. I was wondering, on the impact study, does the future growth the developers have planned for this area affect this in any way or can the NRC back them off some?

What affect does the amount of people that they are planning on putting out here how does that affect this?

Is there any type of system set up that they have to be so far away from Palo Verde in their building? You know, like two miles, five miles.

Because, you know, Luke here they built right up to almost the boundaries. And they've caused so much problems trying to shut Luke down. We don't want that to happen out here.

Well, you know, I would like to be sure that Palo Verde is going to be here. And that this is not –

just because we have development that's been brought in and planning development of people out there in this local valley doesn't affect Palo Verde. No. Palo Verde has not encroached on anybody. I'm just concerned that like Luke where the developers have come out, planted homes and subdivisions and developments and now they're complaining. Well, they knew that air base was there, they know Palo Verde's here. But they -- that doesn't slow them down. I mean, they plan on planting close to a little over a million people in this Valley inside a ten mile radius. We would like to know, can NRC slow that down and keep them to some type of bay so that Palo Verde does exist and continue to operate without their interference?

Response: *The NRC has no role in land development planning in the area near PVNGS.*

Comment PV-AB-9: The startling revelation that the NRC is proposing to allow an exemption to the regulation requiring the written and operations test for the SRO at Palo Verde by a FONSI brings forward the question of NRC honesty and integrity. There is a question now whether the NRC is acting in a criminal manner in these regards. This must be examined fully and openly. The NRC should examine fully in the EIS the probability and likelihood that the NRC has exhibited now that it has "unclean hands" and that it is evidently a corrupt agency and not capable of regulating Palo Verde. In the course of this investigation and analysis, the NRC should examine whether the decision to lift the scrutiny of Palo Verde in spring 2009 was merely a cynical move to assist with the relicensure process and if it was the agency yielding to political pressure, or if the NRC really did determine, after four to five years of extra scrutiny and concern, that suddenly the operators of Palo Verde had indeed changed their corporate culture and were worthy of less scrutiny. Included with this analysis is the likelihood or increased probability that the NRC's actions will help cause a serious problem at Palo Verde leading to extra charges for ratepayers, at a minimum, or the worst, an incident releasing radiation in unpermitted amounts.

Response: *The NRC mission is to enable the nation to safely use radioactive materials for beneficial civilian purposes while ensuring that people and the environment are protected. We take our responsibilities very seriously and are committed to performing our duties with honesty and integrity. The NRC staff followed its regulatory process in addressing the subject exemption request. That discussion can be found in NRC Exemption number NRC-2009-0316 at ML091540950. The concern described in this comment has been referred to the NRC's independent Office of the Inspector General for evaluation.*

APPENDIX B.
NATIONAL ENVIRONMENTAL POLICY ACT ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS

B. NATIONAL ENVIRONMENTAL POLICY ACT ISSUES FOR LICENSE RENEWAL OF NUCLEAR POWER PLANTS

NUREG-1437, *Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants* (referred to as the GEIS), documents the results of the NRC staff's systematic approach to evaluating the environmental impacts of renewing the licenses of individual nuclear power plants. Of the 92 total environmental issues the NRC staff identified in the GEIS, the staff determined that 69 are generic to all plants (Category 1), while 21 issues must be discussed on a site-specific basis (Category 2). Two other issues, environmental justice and the chronic effects of electromagnetic fields, are uncategorized and must be evaluated on a site-specific basis.

The table below is a listing of all 92 environmental issues, including the possible environmental significance (SMALL, MODERATE, LARGE, or uncategorized) as appropriate. This table is provided in Chapter 9 of the GEIS, is codified in the NRC regulations as Table B-1 in Appendix B, Subpart A, to Title 10 of the *Code of Federal Regulations* (CFR) Part 51, and is provided here for convenience.

Table B-1. Summary of Issues and Findings

Issue	Type of Issue	Finding
Surface Water Quality, Hydrology, and Use		
Impacts of refurbishment on surface water quality	Generic	SMALL. Impacts are expected to be negligible during refurbishment because best management practices are expected to be employed to control soil erosion and spills.
Impacts of refurbishment on surface water use	Generic	SMALL. Water use during refurbishment will not increase appreciably or will be reduced during plant outage.
Altered current patterns at intake and discharge structures	Generic	SMALL. Altered current patterns have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Altered salinity gradients	Generic	SMALL. Salinity gradients have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Altered thermal stratification of lakes	Generic	SMALL. Generally, lake stratification has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Temperature effects on sediment transport capacity	Generic	SMALL. These effects have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Scouring caused by discharged cooling water	Generic	SMALL. Scouring has not been found to be a problem at most operating nuclear power plants and has caused only localized effects at a few plants. It is not expected to be a problem during the license renewal term.
Eutrophication	Generic	SMALL. Eutrophication has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Discharge of chlorine or other biocides	Generic	SMALL. Effects are not a concern among regulatory and resource agencies, and are not expected to be a problem during the license renewal term.

Issue	Type of Issue	Finding
Discharge of sanitary wastes and minor chemical spills	Generic	SMALL. Effects are readily controlled through National Pollutant Discharge Elimination System (NPDES) permit and periodic modifications, if needed, and are not expected to be a problem during the license renewal term.
Discharge of other metals in wastewater	Generic	SMALL. These discharges have not been found to be a problem at operating nuclear power plants with cooling-tower-based heat dissipation systems and have been satisfactorily mitigated at other plants. They are not expected to be a problem during the license renewal term.
Water use conflicts (plants with once-through cooling systems)	Generic	SMALL. These conflicts have not been found to be a problem at operating nuclear power plants with once-through heat dissipation systems.
Water use conflicts (plants with cooling ponds or cooling towers using make-up water from a small river with low flow)	Site-specific	SMALL OR MODERATE. 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. See § 51.53(c)(3)(ii)(A).
		Aquatic Ecology
Refurbishment	Generic	SMALL. During plant shutdown and refurbishment there will be negligible effects on aquatic biota because of a reduction of entrainment and impingement of organisms or a reduced release of chemicals.
Accumulation of contaminants in sediments or biota	Generic	SMALL. Accumulation of contaminants has been a concern at a few nuclear power plants but has been satisfactorily mitigated by replacing copper alloy condenser tubes with those of another metal. It is not expected to be a problem during the license renewal term.
Entrainment of phytoplankton and zooplankton	Generic	SMALL. Entrainment of phytoplankton and zooplankton has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.
Cold shock	Generic	SMALL. Cold shock has been satisfactorily mitigated at operating nuclear plants with once-through cooling systems, has not endangered fish populations or been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds, and is not expected to be a problem during the license renewal term.
Thermal plume barrier to migrating fish	Generic	SMALL. Thermal plumes have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Distribution of aquatic organisms	Generic	SMALL. Thermal discharge may have localized effects but is not expected to affect the larger geographical distribution of aquatic organisms.
Premature emergence of aquatic insects	Generic	SMALL. Premature emergence has been found to be a localized effect at some operating nuclear power plants but has not been a problem and is not expected to be a problem during the license renewal term.

Issue	Type of Issue	Finding
Gas supersaturation (gas bubble disease)	Generic	SMALL. Gas supersaturation was a concern at a small number of operating nuclear power plants with once-through cooling systems but has been satisfactorily mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Low dissolved oxygen in the discharge	Generic	SMALL. Low dissolved oxygen has been a concern at one nuclear power plant with a once-through cooling system but has been effectively mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	Generic	SMALL. These types of losses have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Stimulation of nuisance organisms (e.g., shipworms)	Generic	SMALL. Stimulation of nuisance organisms has been satisfactorily mitigated at the single nuclear power plant with a once-through cooling system where previously it was a problem. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.
Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)		
Entrainment of fish and shellfish in early life stages	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(B).
Impingement of fish and shellfish	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(B).
Heat shock	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(B).
Aquatic Ecology (for plants with cooling-tower-based heat dissipation systems)		
Entrainment of fish and shellfish in early life stages	Generic	SMALL. Entrainment of fish has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Impingement of fish and shellfish	Generic	SMALL. The impingement has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.
Heat shock	Generic	SMALL. Heat shock has not been found to be a problem at operating nuclear power plants with this type of cooling system and is not expected to be a problem during the license renewal term.

Issue	Type of Issue	Finding
Groundwater Use and Quality		
Impacts of refurbishment on groundwater use and quality	Generic	SMALL. Extensive dewatering during the original construction on some sites will not be repeated during refurbishment on any sites. Any plant wastes produced during refurbishment will be handled in the same manner as in current operating practices and are not expected to be a problem during the license renewal term.
Groundwater use conflicts (potable and service water; plants that use <100 gpm)	Generic	SMALL. Plants using less than 100 gallons per minute (gpm) are not expected to cause any ground-water use conflicts.
Groundwater use conflicts (potable and service water, and dewatering plants that use >100 gpm)	Site-specific	SMALL, MODERATE, OR LARGE. Plants that use more than 100 gpm may cause ground-water use conflicts with nearby ground-water users. See § 51.53(c)(3)(ii)(C).
Groundwater use conflicts (plants using cooling towers withdrawing makeup water from a small river)	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(A).
Groundwater use conflicts (Ranney wells)	Site-specific	SMALL, MODERATE, OR LARGE. Ranney wells can result in potential ground-water depression beyond the site boundary. Impacts of large ground-water withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal. See § 51.53(c)(3)(ii)(C).
Groundwater quality degradation (Ranney wells)	Generic	SMALL. Ground-water quality at river sites may be degraded by induced infiltration of poor-quality river water into an aquifer that supplies large quantities of reactor cooling water. However, the lower quality infiltrating water would not preclude the current uses of groundwater and is not expected to be a problem during the license renewal term.
Groundwater quality degradation (saltwater intrusion)	Generic	SMALL. Nuclear power plants do not contribute significantly to saltwater intrusion.
Groundwater quality degradation (cooling ponds in salt marshes)	Generic	SMALL. Sites with closed-cycle cooling ponds may degrade ground-water quality. Because water in salt marshes is brackish, this is not a concern for plants located in salt marshes.
Groundwater quality degradation (cooling ponds at inland sites)	Site-specific	SMALL, MODERATE, OR LARGE. Sites with closed-cycle cooling ponds may degrade ground-water 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. See § 51.53(c)(3)(ii)(D).

Terrestrial Ecology		
Refurbishment impacts	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(E).
Cooling tower impacts on crops and ornamental vegetation	Generic	SMALL. Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Cooling tower impacts on native plants	Generic	SMALL. Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Bird collisions with cooling towers	Generic	SMALL. These collisions have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.
Cooling pond impacts on terrestrial resources	Generic	SMALL. Impacts of cooling ponds on terrestrial ecological resources are considered to be of small significance at all sites.
Power line right-of-way management (cutting and herbicide application)	Generic	SMALL. The impacts of right-of-way (ROW) maintenance on wildlife are expected to be of small significance at all sites.
Bird collisions with power lines	Generic	SMALL. Impacts are expected to be of small significance at all sites.
Impacts of electromagnetic fields on flora and fauna	Generic	SMALL. No significant impacts of electromagnetic fields on terrestrial flora and fauna have been identified. Such effects are not expected to be a problem during the license renewal term.
Floodplains and wetland on power line ROW	Generic	SMALL. Periodic vegetation control is necessary in forested wetlands underneath power lines and can be achieved with minimal damage to the wetland. No significant impact is expected at any nuclear power plant during the license renewal term.
Threatened and Endangered Species		
Threatened or endangered species	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(E).
Air Quality		
Air quality during refurbishment (nonattainment and maintenance areas)	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(F).
Air quality effects of transmission lines	Generic	SMALL. Production of ozone and oxides of nitrogen is insignificant and does not contribute measurably to ambient levels of these gases.
Land Use		

Onsite land use	Generic	SMALL. Projected onsite land use changes required during refurbishment and the renewal period would be a small fraction of any nuclear power plant site and would involve land that is controlled by the applicant.
Power line ROW	Generic	SMALL. Ongoing use of power line ROWs would continue with no change in restrictions. The effects of these restrictions are of small significance.
	Human Health	
Radiation exposures to the public during refurbishment	Generic	SMALL. During refurbishment, the gaseous effluents would result in doses that are similar to those from current operation. Applicable regulatory dose limits to the public are not expected to be exceeded.
Occupational radiation exposures during refurbishment	Generic	SMALL. Occupational doses from refurbishment are expected to be within the range of annual average collective doses experienced for pressurized-water reactors and boiling-water reactors. Occupational mortality risk from all causes including radiation is in the mid-range for industrial settings.
Microbiological organisms (occupational health)	Generic	SMALL. Occupational health impacts are expected to be controlled by continued application of accepted industrial hygiene practices to minimize worker exposures.
Microbiological organisms (public health)(plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(G).
Noise	Generic	SMALL. Noise has not been found to be a problem at operating plants and is not expected to be a problem at any plant during the license renewal term.
Electromagnetic fields—acute effects (electric shock)	Site-specific	SMALL, MODERATE, OR LARGE. 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. See § 51.53(c)(3)(ii)(H).
Electromagnetic fields—chronic effects	Uncategorized	UNCERTAIN. Biological and physical studies of 60-Hz electromagnetic fields have not found consistent evidence linking harmful effects with field exposures. However, research is continuing in this area and a consensus scientific view has not been reached.
Radiation exposures to public (license renewal term)	Generic	SMALL. Radiation doses to the public will continue at current levels associated with normal operations.
Occupational radiation exposures (license renewal term)	Generic	SMALL. Projected maximum occupational doses during the license renewal term are within the range of doses experienced during normal operations and normal maintenance outages, and would be well below regulatory limits.
	Socioeconomic Impacts	

Housing impacts	Site-specific	SMALL, MODERATE, OR LARGE. 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 in areas with growth control measures that limit housing development. See § 51.53(c)(3)(ii)(I).
Public services: public safety, social services, and tourism, and recreation	Generic	SMALL. Impacts to public safety, social services, and tourism and recreation are expected to be of small significance at all sites.
Public services: public utilities	Site-specific	SMALL OR MODERATE. An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability. See § 51.53(c)(3)(ii)(I).
Public services: education (refurbishment)	Site-specific	SMALL, MODERATE, OR LARGE. Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors. See § 51.53(c)(3)(ii)(I).
Public services: education (license renewal term)	Generic	SMALL. Only impacts of small significance are expected
Offsite land use (refurbishment)	Site-specific	SMALL OR MODERATE. Impacts may be of moderate significance at plants in low population areas. See § 51.53(c)(3)(ii)(I).
Offsite land use (license renewal term)	Site-specific	SMALL, MODERATE, OR LARGE. Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal. See § 51.53(c)(3)(ii)(I).
Public services: transportation	Site-specific	SMALL, MODERATE, OR LARGE. Transportation impacts (level of service) of highway traffic generated during plant refurbishment and during the term of the renewed license are generally expected to be of small significance. However, the increase in traffic associated with the additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites. See § 51.53(c)(3)(ii)(J).
Historic and archaeological resources	Site-specific	SMALL, MODERATE, OR LARGE. Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archaeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection. See § 51.53(c)(3)(ii)(K).
Aesthetic impacts (refurbishment)	Generic	SMALL. No significant impacts are expected during refurbishment.
Aesthetic impacts (license renewal term)	Generic	SMALL. No significant impacts are expected during the license renewal term.
Aesthetic impacts of transmission lines (license renewal term)	Generic	SMALL. No significant impacts are expected during the license renewal term.

Postulated Accidents		
Design basis accidents	Generic	SMALL. The Nuclear Regulatory Commission (NRC) staff has concluded that the environmental impacts of design basis accidents are of small significance for all plants.
Severe accidents	Site-specific	SMALL. 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. See § 51.53(c)(3)(ii)(L).
Uranium Fuel Cycle and Waste Management		
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high level waste)	Generic	SMALL. Off-site impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 of this part. Based on information in the Generic Environmental Impact Statement (GEIS), impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small.
Offsite radiological impacts (collective effects)	Generic	The 100-year environmental dose commitment to the U.S. population from the fuel cycle, high level waste and spent fuel disposal excepted, is calculated to be about 14,800 person roentgen equivalent man (rem), or 12 cancer fatalities, for each additional 20-year power reactor operating term. Much of this, especially the contribution of radon releases from mines and tailing piles, consists of tiny doses summed over large populations. This same dose calculation can theoretically be extended to include many tiny doses over additional thousands of years as well as doses outside the U.S. The result of such a calculation would be thousands of cancer fatalities from the fuel cycle, but this result assumes that even tiny doses have some statistical adverse health effect, which will not ever be mitigated (for example no cancer cure in the next thousand years), and that these doses projected over thousands of years are meaningful. However, these assumptions are questionable. In particular, science cannot rule out the possibility that there will be no cancer fatalities from these tiny doses. For perspective, the doses are very small fractions of regulatory limits, and even smaller fractions of natural background exposure to the same populations. Nevertheless, despite all the uncertainty, some judgment as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgment in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the commission has not assigned a single level of significance for the collective effects of the fuel cycle, this issue is considered Category 1 [Generic].

Offsite radiological impacts (spent fuel and high level waste disposal)	Generic	For the high level waste and spent fuel disposal component of the fuel cycle, there are no current regulatory limits for offsite releases of radionuclides for the current candidate repository site. However, if we assume that limits are developed along the lines of the 1995 National Academy of Sciences (NAS) report, "Technical Bases for Yucca Mountain Standards," and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository can and likely will be developed at some site, which will comply with such limits, peak doses to virtually all individuals will be 100 millirem per year or less. However, while the Commission has reasonable confidence that these assumptions will prove correct, there is considerable uncertainty since the limits are yet to be developed, no repository application has been completed or reviewed, and uncertainty is inherent in the models used to evaluate possible pathways to the human environment. The NAS report indicated that 100 millirem per year should be considered as a starting point for limits for individual doses, but notes that some measure of consensus exists among national and international bodies that the limits should be a fraction of the 100 millirem per year. The lifetime individual risk from 100 millirem annual dose limit is about 3 x 10-3. Estimating cumulative doses to populations over thousands of years is more problematic. The likelihood and consequences of events that could seriously compromise the integrity of a deep geologic repository were evaluated by the Department of Energy in the "Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste," October 1980. The evaluation estimated the 70-year whole-body dose commitment to the maximum individual and to the regional population resulting from several modes of breaching a reference repository in the year of closure, after 1,000 years, after 100,000 years and after 100,000,000 years. Subsequently, the NRC and other Federal agencies have expended considerable effort to develop models for the design and for the licensing of a high level waste repository, especially for the candidate repository at Yucca Mountain. More meaningful estimates of doses to population may be possible in the future as more is understood about the performance of the proposed Yucca Mountain repository. Such estimates would involve very great uncertainty, especially with respect to cumulative population doses over thousands of years. The standard proposed by the NAS is a limit on maximum individual dose. The relationship of potential new regulatory requirements, based on the NAS report, and cumulative population impacts has not been determined, although the report articulates the view that protection of individuals will adequately protect the population for a repository at Yucca Mountain. However, EPA's generic repository standards in 40 CFR Part 191 generally provide an indication of the order of magnitude of cumulative risk to population that could result from the licensing of a Yucca Mountain repository, assuming the ultimate standards will be within the range of standards now under consideration. The standards in 40 CFR Part 191 protect the population by imposing amount of radioactive material released over 10,000 years. (continued)

Offsite radiological impacts (spent fuel and high level waste disposal) (continued)	Generic	The cumulative release limits are based on EPA's population impact goal of 1,000 premature cancer deaths worldwide for a 100,000 metric ton (MTHM) repository. Nevertheless, despite all the uncertainty, some judgment as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgment in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the impacts of spent fuel and high level waste disposal, this issue is considered in Category 1 [Generic].
Nonradiological impacts of the uranium fuel cycle	Generic	SMALL. The nonradiological impacts of the uranium fuel cycle resulting from the renewal of an operating license for any plant are found to be small.
Low-level waste storage and disposal	Generic	SMALL. The comprehensive regulatory controls that are in place and the low public doses being achieved at reactors ensure that the radiological impacts to the environment will remain small during the term of a renewed license. The maximum additional onsite land that may be required for low-level waste storage during the term of a renewed license and associated impacts will be small. Nonradiological impacts on air and water will be negligible. The radiological and nonradiological environmental impacts of long-term disposal of low-level waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient low-level waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.
Mixed waste storage and disposal	Generic	SMALL. The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.
Onsite spent fuel	Generic	SMALL. The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated onsite with small environmental effects through dry or pool storage at all plants. if a permanent repository or monitored retrievable storage is not available.
Nonradiological waste	Generic	SMALL. No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants.

Transportation	Generic	SMALL. The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC up to 62,000 megawatt days per metric ton of uranium (MWd/MTU) and the cumulative impacts of transporting high-level waste to a single repository, such as Yucca Mountain, Nevada, are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S–4 – Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in § 51.52.
Decommissioning		
Radiation doses	Generic	SMALL. Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem caused by buildup of long-lived radionuclides during the license renewal term.
Waste management	Generic	SMALL. Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected.
Air quality	Generic	SMALL. Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term.
Water quality	Generic	SMALL. The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts.
Ecological resources	Generic	SMALL. Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.
Socioeconomic impacts	Generic	SMALL. Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth.
Environmental Justice		
Environmental Justice	Uncategorized	NONE. The need for and the content of an analysis of environmental justice will be addressed in plant-specific reviews.

B.1 REFERENCES

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

Department of Energy (DOE). 1980. "Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste," October 1980.

National Academy of Sciences (NAS). 1995. "Technical Bases for Yucca Mountain Standards.

APPENDIX C.
APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS

C. APPLICABLE REGULATIONS, LAWS, AND AGREEMENTS

The Atomic Energy Act (42 USC § 2021) authorizes the U.S. Nuclear Regulatory Commission (NRC) to enter into agreement with any State to assume regulatory authority for certain activities. For example, through the Agreement State Program, Arizona assumed regulatory responsibility over industrial x-rays and the disposal of water reclamation facility sludge contaminated by nuclear material. This Arizona Agreement State Program is administered by the Arizona Radiation Regulatory Agency.

In addition to implementing some Federal programs, State legislatures develop their own laws. State statutes supplement as well as implement Federal laws for protection of air, water quality, and groundwater. State legislation may address solid waste management programs, locally rare or endangered species, and historic and cultural resources.

The Arizona Department of Environmental Quality, Arizona Department of Health Services, and the Arizona Department of Water Resources address issues from operation of the Palo Verde Nuclear Generating Station (PVNGS) related to groundwater impacts and environmental compliance.

Federal and State Environmental Requirements

PVNGS is subject to Federal and State requirements regarding its environmental program. Those requirements are briefly described below. See Section 1.9 for PVNGS's compliance status with these requirements.

Table C-1 provides a list of the principal Federal and State environmental regulations and laws that are applicable to the review of the environmental resources that could be affected by this project that may affect license renewal applications for nuclear power plants.

Table C-1. Federal and State Environmental Requirements

Law/Regulation	Requirements
	Current Operating License and License Renewal
10 CFR Part 51. *Code of Federal Regulations* (CFR), Title 10, Energy, Part 51	"Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." This part contains environmental protection regulations applicable to NRC's domestic licensing and related regulatory functions.
10 CFR Part 54	10 CFR Part 54. "Requirements for Renewal of Operating Licenses for Nuclear Power Plants." Part 54 of 10 CFR focuses on managing adverse effects of aging, rather than identification of all aging mechanisms. The rule is intended to ensure that important systems, structures, and components will continue to perform their intended function in the period of extended operation.
10 CFR Part 50	Regulations promulgated by the NRC pursuant to the Atomic Energy Act of 1954, as amended (68 Stat. 919), and Title II of the Energy Reorganization Act of 1974 (88 Stat. 1242), provide for the licensing of production and utilization facilities. This part also gives notice to all persons who knowingly provide to any licensee, applicant, contractor, or subcontractor, components, equipment, materials, or other goods or services, that relate to a licensee's or applicant's activities subject to this part, that they may be individually subject to NRC enforcement action for violation of § 50.5.

Air Quality Protection	
Clean Air Act (CAA) (42 U.S.C. §7401 et seq.)	The CAA is a comprehensive Federal law that regulates air emissions. Under the CAA, Federal actions cannot thwart State and local efforts to remedy long-standing air quality problems that threaten public health issues associated with the six criteria air pollutants (i.e., ozone, nitrogen dioxide, sulfur dioxide, particulate matter, carbon monoxide, and lead).
Water Resources Protection	
Arizona Water Quality Control (A.R.S. 49-2); A.A.C. R-18-9 Article 7	The Arizona Department of Environmental Quality has issued Aquifer Protection permits to PVNGS to protect against potential impacts to groundwater.
A.A.C. R-12-15-1214; A.R.S. Title 45, Chapter 2	The Arizona Department of Water Resources has issued permits for PVNGS to operate evaporation ponds and permits for groundwater withdrawal.
Waste Management and Pollution Prevention	
Resource Conservation and Recovery Act (RCRA) (42 USC § 6901et seq.)	Before a material can be classified as a hazardous waste, it must first be a solid waste as defined under the RCRA. Hazardous waste is classified under Subtitle C of the RCRA. Parts 261 and 262 of Title 40 CFR contain all applicable generators of hazardous waste regulations. Part 261.5 (a) and (e) contains requirements for Conditionally Exempt Small Quantity Generators (CESQGs). Part 262.34(d) contains requirements for Small Quantity Generators (SQGs). Parts 262 and 261.5(e) contain requirements for Large Quantity Generators (LQGs)
Pollution Prevention Act (42 U.S.C. § 13101 et seq.)	Formally established a national policy to prevent or reduce pollution at its source whenever feasible. The Act provides funds for State and local pollution prevention programs through a grant program to promote the use of pollution prevention techniques by business.
Endangered Species	
Endangered Species Act (ESA) (16 U.S.C. § 1531 et seq.)	Forbids any government agency, corporation, or citizen from taking (harming or killing) endangered animals without an Endangered Species Permit.
Historic Preservation	
National Historic Preservation Act (NHPA) (16 U.S.C. § 470 et seq.)	Directs Federal agencies to consider the impact of their actions on historic properties. NHPA also encourages state and local preservation societies.

APPENDIX D.
CONSULTATION CORRESPONDENCES

D. CONSULTATION CORRESPONDENCES

The Endangered Species Act of 1973, as amended, the Magnuson-Stevens Fisheries Management Act of 1996, as amended; and the National Historic Preservation Act of 1966 require that Federal agencies consult with applicable State and Federal agencies and groups prior to taking action that may affect threatened and endangered species, essential fish habitat, or historic and archaeological resources, respectively. This appendix contains consultation documentation.

Table D-1 provides a list of the consultation documents sent between the U.S. Nuclear Regulatory Commission (NRC) and other agencies. The NRC staff is required to consult with these agencies based on the National Environmental Policy Act of 1969 (NEPA) requirements.

Table D-1. Consultation Correspondences

Author	Recipient	Date of Letter
U.S. Nuclear Regulatory Commission (D. Wrona)	Office of Historic Preservation Arizona State Parks (J. Garrison)	May 21, 2009 (ML091070394)
U.S. Nuclear Regulatory Commission (D. Wrona)	Fort McDowell Yavapai Tribal Council (Dr. Clinton M. Pattea)	June 1, 2009[(a)] (ML091390581)
U.S. Nuclear Regulatory Commission (D. Wrona)	Arizona Ecological Services Field Office U.S. Fish and Wildlife Service (S. Spangle)	June 12, 2009 (ML091600427)
U.S. Nuclear Regulatory Commission (D. Wrona)	Arizona Game and Fish Department (R. Davidson)	June 12, 2009 (ML091600441)
Arizona Ecological Services Field Office U.S. Fish and Wildlife Service (S. Spangle)	U.S. Nuclear Regulatory Commission (D. Wrona)	July 15, 2009 (ML101100631)
Arizona Game and Fish Department (G. Ritter)	U.S. Nuclear Regulatory Commission (D. Wrona)	July 16, 2009 (ML093100184)

(a) Similar letters went to twelve other Native American Tribes listed in Section 1.8.

D.1 CONSULTATION CORRESPONDENCE

The following pages contain copies of the letters listed in Table D-1

May 21, 2009

Mr. James W. Garrison
State Historic Preservation Officer
Office of Historic Preservation
Arizona State Parks
1300 West Washington Street
Phoenix, AZ 85007

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION LICENSE RENEWAL APPLICATION REVIEW (SHPO NO. 2007-1713)

Dear Mr. Garrison:

The U.S. Nuclear Regulatory Commission (NRC or the staff) is reviewing an application to renew the operating licenses for Palo Verde Nuclear Generating Station Units 1, 2, and 3 (Palo Verde), which are located in Maricopa County, Arizona, approximately 26 miles west of the Phoenix metropolitan area boundary. Palo Verde is operated by Arizona Public Service Company (APS). The application for renewal was submitted by APS in a letter dated December 11, 2008, as supplemented by letter dated April 14, 2009, pursuant to Title 10 of the *Code of Federal Regulations* Part 54 (10 CFR Part 54).

The NRC has established that, as part of the staff's review of any nuclear power plant license renewal action, a site-specific Supplemental Environmental Impact Statement (SEIS) to its "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," NUREG-1437, will be prepared under the provisions of 10 CFR Part 51, the NRC's regulation that implements the National Environmental Policy Act of 1969 (NEPA). In accordance with 36 CFR 800.8(c), the SEIS will include analyses of potential impacts to historic and cultural resources.

In the context of the National Historic Preservation Act of 1966, as amended, the NRC staff has determined that the area of potential effect (APE) for a license renewal action is the area at the power plant site and its immediate environs that may be impacted by post-license renewal land-disturbing operations or projected refurbishment activities associated with the proposed action. The APE may extend beyond the immediate environs in those instances where post-license renewal land-disturbing operations or projected refurbishment activities specifically related to license renewal may potentially have an effect on known or proposed historic sites. This determination is made irrespective of ownership or control of the lands of interest.

Mr. Garrison -2-

The NRC staff plans to hold two public license renewal and environmental scoping meetings on June 25, 2009. The first session will be held in the afternoon and an identical session will be held later that evening. The afternoon session will be held at the Tonopah Valley High School, 38201 West Indian School Road, Tonopah, Arizona 85354, from 2:00 p.m. until 5:00 p.m., as necessary. The evening session will be held at the Estrella Mountain Community College, 3000 North Dysart Road, Avondale, Arizona 85392, from 7:00 p.m. until 10:00 p.m., as necessary. In addition, the NRC plans to hold a one hour Open House prior to each meeting to answer public questions. You and your staff are invited to attend the public meetings and Open House. Your office will receive a copy of the draft SEIS along with a request for comments. The anticipated publication date for the draft SEIS is May 2010.

The Palo Verde license renewal application is available on the internet at http://www.nrc.gov/reactors/operating/licensing/renewal/applications/palo-verde.html. If you have any questions or require additional information, please contact Mrs. Lisa Regner, License Renewal Project Manager, by phone at 301-415-1906 or by email at Lisa.Regner@nrc.gov.

Sincerely,

\ ***RA*** \

David J. Wrona, Chief
Projects Branch 2
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket Nos. 50-528, 50-529, and 50-530

cc: See next page

June 1, 2009

Dr. Clinton M. Pattea, President
Fort McDowell Yavapai Tribal Council
P.O. Box 17779
Fountain Hills, AZ 85268

SUBJECT: REQUEST FOR SCOPING COMMENTS CONCERNING THE PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3, LICENSE RENEWAL APPLICATION REVIEW

Dear Dr. Pattea:

The U.S. Nuclear Regulatory Commission (NRC or the staff) has recently received an application from the Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde) for the renewal of operating licenses NPF-41, NPF-51, and NPF-74. Palo Verde is located in Maricopa County, Arizona, approximately 26 miles west of the Phoenix metropolitan area boundary. The NRC is in the initial stages of developing a Supplemental Environmental Impact Statement (SEIS) to the Generic Environmental Impact Statement (GEIS), which will document the potential environmental impacts associated with the proposed license renewal of Palo Verde.

We would like your assistance in our review by your participation in the NRC's environmental review scoping process. The NRC's process includes an opportunity for public and inter-governmental participation in the environmental review. We want to ensure that you are aware of our efforts and pursuant to Title 10 of the *Code of Federal Regulations* Part 51, Section 51.28(b), the NRC invites your tribe to provide input relating to the NRC's environmental review of the application. In addition, as outlined in 36 CFR 800.8(c), the NRC plans to coordinate compliance with Section 106 of the National Historic Preservation Act of 1966 through the requirements of the National Environmental Policy Act of 1969.

The NRC has sent copies of this letter to the tribal contacts for the following Federally-recognized tribes: Fort McDowell Yavapai Tribal Council, Salt River Pima-Maricopa Indian Community Council, San Carlos Tribal Council, Tohono O'odham Nation, White Mountain Apache Tribe, Yavapai-Apache Nation Tribal Council, Gila River Indian Community Council, Ak Chin Indian Community Council, Yavapai-Prescott Board of Directors, Tonto Apache Tribe, and Pascua Yaqui Tribe.

Under NRC regulations, the original operating license for a nuclear power plant is issued for up to 40 years. The license may be renewed for up to an additional 20 years if NRC requirements are met. The current operating licenses for Palo Verde will expire for Unit 1 on June 1, 2025; for Unit 2 on April 24, 2026; and for Unit 3 on November 25, 2027.

Provided for your information is the Palo Verde Site Layout (Enclosure 1) and Transmission Line Map (Enclosure 2). Additionally, attached you will find a compact disk containing copies of the license renewal application (LRA) and the GEIS.

The GEIS considered the environmental impacts of renewing nuclear power plant operating licenses for a 20-year period on all currently operating sites. In the GEIS, the NRC staff identified 92 environmental issues and developed generic conclusions related to environmental impacts for 69 of these issues that apply to all plants or to plants with specific design or site characteristics. For the remaining 23 issues, plant-specific analyses will be documented in a supplement to the GEIS.

A SEIS will be prepared for Palo Verde to document the staff's review of environmental impacts related to terrestrial ecology, aquatic ecology, hydrology, cultural resources, and socioeconomic issues (among others), and will contain a recommendation regarding the environmental acceptability of the license renewal action.

Please submit any comments that you may have to offer on the scope of the environmental review by July 27, 2009. Written comments should be submitted by mail to the Chief, Rulemaking and Directives Branch, Division of Administrative Services, Mail Stop TWB-05-B01M, U.S. Nuclear Regulatory Commission, Washington DC 20555-0001. Electronic comments may be submitted to the NRC by e-mail at PaloVerde.EIS@nrc.gov. At the conclusion of the scoping process, the NRC staff will prepare a summary of the significant issues identified and the conclusions reached, and mail a copy to you.

To accommodate interested members of the public, the NRC will hold two public scoping meetings for the Palo Verde license renewal supplement to the GEIS on June 25, 2009. The afternoon session will be held from 2:00 p.m. until 5:00 p.m. at the Tonopah Valley High School, 38201 West Indian School Road, Tonopah, AZ 85354. The evening session will be held from 7:00 p.m. until 10:00 p.m. at the Estrella Mountain Community College, 3000 North Dysart Road, Avondale, AZ 85392. Additionally, the NRC staff will host informal discussions one hour before the start of each session.

The Palo Verde LRA and the GEIS are available on the internet at http://www.nrc.gov/reactors/operating/licensing/renewal/applications/palo-verde.html. In addition, the Litchfield Park Branch Library, 101 West Wigwam Boulevard, Litchfield Park, Arizona 85340, has agreed to make the LRA and the GEIS available for public inspection.

The staff expects to publish the draft SEIS in May of 2010. A copy of the document will be sent to you for your review and comment. The NRC will hold another set of public meetings in the site vicinity to solicit comments on the draft SEIS. After consideration of public comments received, the NRC will prepare a final SEIS, which is scheduled to be issued in November of 2010.

C. Pattea - 3 -

If you have any questions or require additional information, please contact Mrs. Lisa Regner, License Renewal Project Manager, by phone at 301-415-1906 or by email at Lisa.Regner@nrc.gov.

Sincerely,

/RA/

David J. Wrona, Chief
Projects Branch 2
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket Nos. 50-528, 50-529, and 50-530

Enclosures:
As stated

cc w/encls.: See next page

June 12, 2009

Mr. Steven Spangle
Arizona Ecological Services Field Office
U.S. Fish and Wildlife Service
2321 West Royal Palm Road, Suite 103
Phoenix, AZ 85021

SUBJECT: REQUEST FOR LIST OF FEDERAL PROTECTED SPECIES WITHIN THE AREA UNDER EVALUATION FOR THE PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3, LICENSE RENEWAL APPLICATION REVIEW

Dear Mr. Spangle:

The U.S. Nuclear Regulatory Commission (NRC or the staff) is reviewing an application submitted by Arizona Public Service Company (APS) for the renewal of the operating licenses for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde). Palo Verde is located in Maricopa County, Arizona, approximately 26 miles west of the Phoenix metropolitan area. As part of the review of the license renewal application (LRA), the NRC is preparing a supplemental environmental impact statement (SEIS) under the provisions of Title 10 of the *Code of Federal Regulations* Part 51 (10 CFR Part 51), which is the NRC's regulation that implements the National Environmental Policy Act of 1969. The SEIS includes an analysis of pertinent environmental issues, including endangered or threatened species and impacts to fish and wildlife. This letter is being submitted under the provisions of the Endangered Species Act of 1973, as amended, and the Fish and Wildlife Coordination Act of 1934, as amended.

The proposed action would include the use and continued maintenance of existing plant facilities and transmission lines. The Palo Verde site covers approximately 4,280 acres, of which approximately 720 acres are developed. Approximately 605 surface acres of water occur on the site in various large ponds. Facilities on the property include the three reactor containment buildings, three turbine buildings, nine cooling towers, plus various auxiliary buildings, small ponds and retention tanks, an outdoor firing range, various landfills, and the water reclamation facility, which is vital to the plant's operation.

The area surrounding the plant is in the Sonoran Desert of the Basin and Range Physiographic Province. This area is characterized by long hot summers, cool winters, and warm springs. The Palo Verde site is mostly flat, with some small hills and buttes in the area. Elevations in the surrounding area range from 900 to 1,000 feet above mean sea level. Approximately, six miles northwest of the site, the Palo Verde Hills rise rapidly to 2,200 feet. Buckeye Valley, where the Gila River flows, is east and southeast of the site. Aside from the Palo Verde site, little industrial or commercial activity exists in the area.

The owner, APS, stated that it has no plans to alter current operations over the license renewal period. Further, Palo Verde would use existing plant facilities and transmission lines and would not require additional construction or disturbance of new areas if issued a renewed operating license. APS would limit any maintenance activities to previously disturbed areas.

The circulating water system for the Palo Verde plant employs a heat dissipation system that removes waste heat from the condensers and rejects it to the atmosphere using round mechanical draft cooling towers. The circulating water system consists of a main condenser, mechanical draft cooling towers, circulating water pumps, a chemical injection system, and makeup and blowdown systems for each unit. The circulating water pumps take water from the cooling tower basins, provide a continuous flow of water to the main condensers, and discharge back to the cooling towers. The plant has two sources of makeup water for the cooling systems. The primary source is wastewater effluent from sewage treatment plants in the Phoenix area. The secondary source is on-site groundwater wells. Makeup water reservoirs hold and supply makeup water to compensate for blowdown, evaporation, and other losses. Two lined ponds receive and evaporate blowdown and all liquid waste that is not recycled for cooling.

Approximately 530 miles of transmission line corridors that occupy about 13,000 acres of land connect Palo Verde to the transmission system. The corridors pass through agricultural land, open range, and desert. The areas are mostly remote with low population densities, but the lines cross numerous counties and State and U.S. highways. Much of the land crossed is Federal property. The 235-mile-long Palo Verde-to-Devers transmission line passes through relatively undisturbed habitats including the Kofa National Wildlife Refuge in La Paz County, Arizona and the Coachella Valley National Wildlife Refuge in Riverside County, California.

The following transmission lines are owned by Salt River Project except for Devers, which is owned by Southern California Edison, and Rudd, which is jointly owned by APS and Salt River Project:

- Westwing #1 and #2 – two 525-kilovolt lines extending east and north for 45 miles in a 330-foot wide corridor to the Westwing Substation northwest of Phoenix.

- Rudd – one 525-kilovolt line that shares a common corridor with Westwing and runs for 37 miles to the Rudd Substation in Phoenix. After leaving the Westwing corridor, the Rudd corridor is 160 feet wide.

- Hassayampa #1 (or Kyrene) – one 525-kilovolt line that runs south to the Hassayampa Substation for 3 miles, then turning to the southeast for 20 miles to the Jojoba Substation, then runs another 52 miles to the Kyrene Generating Station south of Tempe, Arizona. Other than the 3-mile common corridor it shares with Hassayampa #2 (330 feet wide) the width of the corridor varies from 75 feet to 200 feet.

- Hassayampa #2 – one 525-kilovolt line running in the same corridor with the Hassayampa #1 for 3 miles to the Hassayampa Substation. The combined corridor width is 330 feet.

- Hassayampa #3 – one 525-kilovolt line that parallels the Hassayampa #1 and #2 to the Hassayampa Substation, but has a separate corridor. The line runs south and west in a corridor that is 200 feet wide to the North Gila Substation near Yuma, Arizona.

- Devers – one 525-kilovolt 235-mile line running west from the plant to the Devers Substation north of Palm Springs, California. The corridor width is typically 200 feet.

APS, Salt River Project, and Southern California Edison plan to maintain these transmission lines indefinitely. These transmission lines are to remain a permanent part of the transmission system even after Palo Verde is decommissioned. These transmission line corridors are included in the SEIS process. The enclosed transmission line map shows the transmission system included in the SEIS.

To support the SEIS preparation process and to ensure compliance with Section 7 of the Endangered Species Act, the NRC requests information on federally-listed, proposed, and candidate species and critical habitat that may be in the vicinity of Palo Verde and its associated transmission line rights-of-way. In addition, please provide any information you consider appropriate under the provisions of the Fish and Wildlife Coordination Act.

The NRC staff plans to hold two public license renewal and environmental scoping meetings on June 25, 2009. We will hold the first session in the afternoon and an identical session later that evening. The afternoon session will be held at the Tonopah Valley High School, 38201 West Indian School Road, Tonopah, Arizona 85354, from 2:00 p.m. until 5:00 p.m., as necessary. The evening session will be held at the Estrella Mountain Community College, 3000 North Dysart Road, Avondale, Arizona 85392, from 7:00 p.m. until 10:00 p.m., as necessary. In addition, the NRC plans to hold a one hour open house prior to each meeting to answer public questions. NRC invites you and your staff to attend the public meetings and open house. Your office will receive a copy of the draft SEIS along with a request for comments. We anticipate a publication date for the draft SEIS in May 2010.

The Palo Verde LRA is available on the internet at http://www.nrc.gov/reactors/operating/licensing/renewal/applications/palo-verde.html. If you have any questions concerning the NRC staff's review of this LRA, please contact Ms. Lisa Regner, Project Manager, at 301-415-1906 or by e-mail at Lisa.Regner@nrc.gov.

Sincerely,

/RA by Bo M. Pham Acting For/

David J. Wrona, Chief
Projects Branch 2
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket Nos. 50-528, 50-529, and 50-530

Enclosures:
1. Palo Verde Site Layout
2. Palo Verde Transmission Systems

cc w/encls: See next page

June 12, 2009

Ms. Rebecca Davidson
Project Evaluation Supervisor
Arizona Game and Fish Department
WMHB-Project Evaluation Program
2221 West Greenway Road
Phoenix, AZ 85023

SUBJECT: REQUEST FOR LIST OF STATE PROTECTED SPECIES WITHIN THE AREA UNDER EVALUATION FOR THE PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3, LICENSE RENEWAL APPLICATION REVIEW

Dear Ms. Davidson:

The U.S. Nuclear Regulatory Commission (NRC or the staff) is reviewing an application submitted by Arizona Public Service Company (APS) for the renewal of the operating licenses for Palo Verde Nuclear Generating Station, Units 1, 2, and 3 (Palo Verde). Palo Verde is located in Maricopa County, Arizona, approximately 26 miles west of the Phoenix metropolitan area. As part of the review of the license renewal application (LRA), the NRC is preparing a supplemental environmental impact statement (SEIS) under the provisions of Title 10 of the *Code of Federal Regulations* Part 51 (10 CFR Part 51), which is the NRC's regulation that implements the National Environmental Policy Act of 1969. The SEIS includes an analysis of pertinent environmental issues, including endangered or threatened species and impacts to fish and wildlife.

The proposed action would include the use and continued maintenance of existing plant facilities and transmission lines. The Palo Verde site covers approximately 4,280 acres, of which approximately 720 acres are developed. Approximately 605 surface acres of water occur on the site in various large ponds. Facilities on the property include the three reactor containment buildings, three turbine buildings, nine cooling towers, plus various auxiliary buildings, small ponds and retention tanks, an outdoor firing range, various landfills, and the water reclamation facility, which is vital to the plant's operation.

The area surrounding the plant is in the Sonoran Desert of the Basin and Range Physiographic Province. This area is characterized by long hot summers, cool winters, and warm springs. The Palo Verde site is mostly flat, with some small hills and buttes in the area. Elevations in the surrounding area range from 900 to 1,000 feet above mean sea level. Approximately, six miles northwest of the site, the Palo Verde Hills rise rapidly to 2,200 feet. Buckeye Valley, where the Gila River flows, is east and southeast of the site. Aside from the Palo Verde site, little industrial or commercial activity exists in the area.

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Approximately 530 miles of transmission line corridors that occupy about 13,000 acres of land connect Palo Verde to the transmission system. The corridors pass through agricultural land, open range, and desert. The areas are mostly remote with low population densities, but the lines cross numerous counties and State and U.S. highways. Much of the land crossed is Federal property. The 235-mile-long Palo Verde-to-Devers transmission line passes through relatively undisturbed habitats including the Kofa National Wildlife Refuge in La Paz County, Arizona and the Coachella Valley National Wildlife Refuge in Riverside County, California.

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R. Davidson - 3 -

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To support the SEIS preparation process, the NRC requests information on state-listed, proposed, and candidate species and critical habitat that may be in the vicinity of Palo Verde and its associated transmission line rights-of-way. In addition, please provide any information you consider appropriate under the provisions of the Fish and Wildlife Coordination Act.

The NRC staff plans to hold two public license renewal and environmental scoping meetings on June 25, 2009. We will hold the first session in the afternoon and an identical session later that evening. The afternoon session will be held at the Tonopah Valley High School, 38201 West Indian School Road, Tonopah, Arizona 85354, from 2:00 p.m. until 5:00 p.m., as necessary. The evening session will be held at the Estrella Mountain Community College, 3000 North Dysart Road, Avondale, Arizona 85392, from 7:00 p.m. until 10:00 p.m., as necessary. In addition, the NRC plans to hold a one hour open house prior to each meeting to answer public questions. NRC invites you and your staff to attend the public meetings and open house. Your office will receive a copy of the draft SEIS along with a request for comments. We anticipate a publication date for the draft SEIS in May 2010.

The Palo Verde LRA is available on the internet at http://www.nrc.gov/reactors/operating/licensing/renewal/applications/palo-verde.html. If you have any questions concerning the NRC staff's review of this LRA, please contact Ms. Lisa Regner, Project Manager, at 301-415-1906 or by e-mail at Lisa.Regner@nrc.gov.

Sincerely,

/RA by Bo M. Pham Acting For/

David J. Wrona, Chief
Projects Branch 2
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket Nos. 50-528, 50-529, and 50-530

Enclosures:
1. Palo Verde Site Layout
2. Palo Verde Transmission Systems

cc w/encls: See next page

United States Department of the Interior
U.S. Fish and Wildlife Service
Arizona Ecological Services Field Office
2321 West Royal Palm Road, Suite 103
Phoenix, Arizona 85021-4951
Telephone: (602) 242-0210 Fax: (602) 242-2513

In Reply Refer to:
AESO/SE
22410-2008-SL-0091

July 15, 2009

Mr. David J. Wrona, Chief
U.S. Nuclear Regulatory Commission
Attn: Division of License Renewal
Washington D.C 20555-0001

RE: Palo Verde Nuclear Generating Station (PVNGS) Located Approximately 26 Miles West of the Phoenix Metropolitan Area, Which Includes Maricopa County and Yuma County in Arizona (Operating License Renewal for Units 1, 2 and 3)

Dear Mr. Wrona:

Thank you for your recent request for information on threatened or endangered species, or those that are proposed to be listed as such under the Endangered Species Act of 1973, as amended (Act), which may occur in your project area. The Arizona Ecological Service Field Office has posted lists of the endangered, threatened, proposed, and candidate species occurring in each of Arizona's 15 counties on the Internet. Please refer to the following web page for species information in the county where your project occurs: **http://www.fws.gov/southwest/es/arizona**

If you do not have access to the Internet or have difficulty obtaining a list, please contact our office and we will mail or fax you a list as soon as possible.

After opening the web page, find County Species Lists on the main page. Then click on the county of interest. The arrows on the left will guide you through information on species that are listed, proposed, candidates, or have conservation agreements. Here you will find information on the species' status, a physical description, all counties where the species occurs, habitat, elevation, and some general comments. Additional information can be obtained by going back to the main page. On the left side of the screen, click on Document Library, then click on Documents by Species, then click on the name of the species of interest to obtain General Species Information, or other documents that may be available. Click on the "Cactus" icon to view the desired document.

Please note that your project area may not necessarily include all or any of these species. The information provided includes general descriptions, habitat requirements, and other information for each species on the list. Under the General Species Information, citations for the Federal Register (FR) are included for each listed and proposed species. The FR is available at most Federal depository libraries. This information should assist you in determining which species may or may not occur within your project area. Site-specific surveys could also be helpful and may be needed to verify the presence or absence of a species or its habitat as required for the evaluation of proposed project-related impacts.

Endangered and threatened species are protected by Federal law and must be considered prior to project development. If the action agency determines that listed species or critical habitat may be adversely affected by a federally funded, permitted, or authorized activity, the action agency will need to request formal consultation with us. If the action agency determines that the planned action may jeopardize a proposed species or destroy or adversely modify proposed critical habitat, the action agency will need to enter into a section 7 conference. The county list may also contain candidate or conservation agreement species. Candidate species are those for which there is sufficient information to support a proposal for listing; conservation agreement species are those for which we have entered into an agreement to protect the species and its habitat. Although candidate and conservation agreement species have no legal protection under the Act, we recommend that they be considered in the planning process in the event that they become listed or proposed for listing prior to project completion.

If any proposed action occurs in or near areas with trees and shrubs growing along watercourses, known as riparian habitat, we recommend the protection of these areas. Riparian areas are critical to biological community diversity and provide linear corridors important to migratory species. In addition, if the project will result in the deposition of dredged or fill materials into waterways, we recommend you contact the Army Corps of Engineers which regulates these activities under Section 404 of the Clean Water Act.

The State of Arizona and some of the Native American Tribes protect some plant and animal species not protected by Federal law. We recommend you contact the Arizona Game and Fish Department and the Arizona Department of Agriculture for State-listed or sensitive species, or contact the appropriate Native American Tribe to determine if sensitive species are protected by Tribal governments in your project area. We further recommend that you invite the Arizona Game and Fish Department and any Native American Tribes in or near your project area to participate in your informal or formal Section 7 Consultation process.

For additional communications regarding this project, please refer to consultation number 22410-2008-SL-0091. We appreciate your efforts to identify and avoid impacts to listed and sensitive species in your project area. If we may be of further assistance, please feel free to contact Brenda Smith (928) 226-0614 (x101) for projects in Northern Arizona, Debra Bills (602) 242-0210 (x239) for projects in central Arizona and along the Lower Colorado River, and Sherry Barrett (520) 670-6150 (x223) for projects in southern Arizona.

Sincerely,

Debra T. Bills

for Steven L. Spangle
Field Supervisor

cc: Josh Avey, Chief, Habitat Branch, Arizona Game and Fish Department, Phoenix, AZ

W:\Cathy Gordon\administration\species ltrs\complete\US Nuclear Reg Commission Palo Verde Nuclear Gen Station Units 1 2 and 3.docx:cgg

JAN-08-1996 02:12 P.02/03

THE STATE OF ARIZONA
GAME AND FISH DEPARTMENT
5000 W. CAREFREE HIGHWAY
PHOENIX, AZ 85086-5000
(602) 942-3000 • WWW.AZGFD.GOV

July 16, 2009

Mr. David J. Wrona
Division of License Renewal
Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Re: Special Status Species Information for **Palo Verde Nuclear Facility and Transmission Line License Renewal Review.**

Dear Mr. Wrona:

The Arizona Game and Fish Department (Department) has reviewed your request, dated June 12, 2009, regarding special status species information associated with the above-referenced project area. The Department's Heritage Data Management System (HDMS) has been accessed and current records show that the special status species listed on the attachment have been documented as occurring in the project vicinity. The Department's HDMS data are not intended to include potential distribution of special status species. Arizona is large and diverse with plants, animals, and environmental conditions that are ever changing. Consequently, many areas may contain species that biologists do not know about or species previously noted in a particular area may no longer occur there. Not all of Arizona has been surveyed for special status species, and surveys that have been conducted have varied greatly in scope and intensity.

If you have any questions regarding this letter, please contact me at (623) 236-7606. General status information, county and watershed distribution lists and abstracts for some special status species are also available on our web site at http://www.azgfd.gov/hdms.

Sincerely,

Ginger Ritter

Ginger Ritter
Project Evaluation Program Specialist

cc: Laura Canaca, Project Evaluation Program Supervisor
Russ Haughey, Habitat Program Manager, Region VI

AGFD #M09-06181622

Special Status Species within 5 Miles of Palo Verde Nuclear Plant Facility

NAME	COMMON NAME	ESA	USFS	BLM	STATE
Opuntia echinocarpa	Straw-top Cholla				SR

Special Status Species within 3 Miles of Palo Verde Transmission Lines

NAME	COMMON NAME	ESA	USFS	BLM	STATE
Ardea alba	Great Egret				WSC
Athene cunicularia hypugaea	Western Burrowing Owl	SC		S	
Bat Colony					
CH for Xyrauchen texanus	Designated Critical Habitat for razorback sucker				
Charina trivirgata gracia	Desert Rosy Boa	SC	S	S	
Coccyzus americanus	Yellow-billed Cuckoo (Western U.S. DPS)	C			WSC
Colorado River Indian Reservation	Colorado River Indian Reservation				
Dendrocygna autumnalis	Black-bellied Whistling-Duck				WSC
Empidonax traillii extimus	Southwestern Willow Flycatcher	LE	S		WSC
Gila Bend - Sierra Estrella Linkage Design	Wildlife Corridor				
Gila River Indian Reservation	Gila River Indian Reservation				
Gopherus agassizii (Sonoran Population)	Sonoran Desert Tortoise	SC			WSC
Haliaeetus leucocephalus (wintering pop.)	Bald Eagle - Winter Population	SC	S		WSC
Ixobrychus exilis	Least Bittern				WSC
Lasiurus blossevillii	Western Red Bat				WSC
Macrotus californicus	California Leaf-nosed Bat	SC			WSC
Myotis velifer	Cave Myotis	SC		S	
Opuntia echinocarpa	Straw-top Cholla				SR
Rallus longirostris yumanensis	Yuma Clapper Rail	LE			WSC
Xyrauchen texanus	Razorback Sucker	LE	S		WSC

AGFD #M09-06181622. Palo Verde License Renewal Application Review.

Arizona Game and Fish Department, Heritage Data Management System, July 16, 2009.

APPENDIX E.
CHRONOLOGY OF ENVIRONMENTAL REVIEW

E. CHRONOLOGY OF ENVIRONMENTAL REVIEW

This appendix contains a chronological listing of correspondence between the U.S. Nuclear Regulatory Commission (NRC) and external parties as part of its environmental review for Palo Verde Nuclear Generating Station. All documents, with the exception of those containing proprietary information are available electronically from the NRC's Public Electronic Reading Room found on the Internet at the following Web address: http://www.nrc.gov/reading-rm.html. From this site, the public can gain access to the NRC's Agency-wide Document Access and Management System (ADAMS), which provides text and image files of NRC's public documents in ADAMS. The ADAMS accession number for each document is included below.

E.1 ENVIRONMENTAL REVIEW CORRESPONDENCE

December 11, 2008	Letter from APS forwarding the application for renewal of operating license for Palo Verde Nuclear Generating Station, Units 1, 2 and 3., requesting an extension of operating license for an additional 20 years (ADAMS Accession Nos. ML083510611, 12, 14, 15).
January 12, 2009	Letter to APS, "Receipt and Availability of the License Renewal Application for the Palo Verde Nuclear Generating Station Units 1, 2 and 3" (ADAMS Accession No. ML083530426).
February 13, 2009	Letter to APS, "Review Status of the License Renewal Application for the Palo Verde Nuclear Generating Station" (ADAMS Accession No. ML090360279).
February 25, 2009	Letter from APS providing a plan to resolve a deficiency in the License Renewal Application for the Palo Verde Nuclear Generating Station (ADAMS Accession No. ML090750614).
April 14, 2009	Letter from APS forwarding Supplement 1 to the application for renewal of operating license for Palo Verde Nuclear Generating Station, Units 1, 2 and 3 (ADAMS Accession No ML091130221).
May 18, 2009	Letter to APS, "Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process Receipt for License Renewal for the Palo Verde Nuclear Generating Station Units 1, 2 and 3 (TAC NOS. ME0261, ME0262, ME0263)" (ADAMS Accession No. ML091100086).
May 21, 2009	Letter to Mr. James W. Garrison, State Historic Preservation Officer, Office of Historic Preservation, Arizona State Parks, "Palo Verde Nuclear Generating Station License Renewal Application Review (SHPO NO. 2007-1713)" (ADAMS Accession No. ML091070394).
June 1, 2009	Letter to Dr. Clinton M. Pattea, President, Fort McDowell Yavapai Tribal Council, "Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review" (ADAMS Accession No. ML091390581).

June 1, 2009	Letter to Ms. Diane Enos, President, Salt River Pima-Maricopa Indian Community Council, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Ms. Wendsler Noise, Sr., Chairperson, San Carlos Tribal Council, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Mr. Ned Norris, Jr., Chairperson, Tohono O’odham Nation, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Mr. Ronnie Lupe, Chairman, White Mountain Apache Tribe, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Mr. Thomas Beauty, Chairman, Yavapai-Apache Nation Tribal Council, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Mr. Peter Yucupicio, Chairman, Pascua Yaqui Tribe, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Mr. Ivan Smith, Chairman, Tonto Apache Tribe, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Mr. Ernest Jones, Sr., President, Yavapai-Prescott Board of Directors, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter to Ms. Delia M. Carlyle, President, Ak Chin Indian Community Council, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 1, 2009	Letter Mr. William R. Rhodes, Governor, Gila River Indian Community Council, “Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review” (ADAMS Accession No. ML091390581).
June 3, 2009	Memo to David Wrona, NRC, “Forthcoming Meeting to Discuss the

	License Renewal Process and Environmental Scoping for Palo Verde Nuclear Generating Station, Units 1, 2 and 3, License Renewal Application Review" (ADAMS Accession No. ML091480348).
June 12, 2009	Letter to Mr. Steven Spangle, Arizona Ecological Services Field Office, U.S. Fish and Wildlife Service, "Request for List of Federal Protected Species within the Area under Evaluation for the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review" (ADAMS Accession No. ML091600427).
June 12, 2009	Letter to Ms. Rebecca Davidson, Project Evaluation Supervisor, Arizona Game and Fish Department, "Request for List of State Protected Species within the Area under Evaluation for the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review" (ADAMS Accession No. ML091600441).
July 15, 2009	Letter from Arizona Game Ecological Services Field Office, U.S. Fish and Wildlife Service, U.S. Department of the Interior, response to request for list of State Protected Species within the area under evaluation for Palo Verde Nuclear Generating Facility License Renewal Application Review" (ADAMS Accession No. ML101100631).
July 16, 2009	Letter from Arizona Game and Fish Department, "Special Status Species Information for Palo Verde Nuclear Facility and Transmission Line License Renewal Review" (ADAMS Accession No. ML093100184).
August 4, 2009	Memo from L. Regner, "Summary of Public Environmental Scoping Meetings Related to the review of the Palo Verde License Renewal Application (TAC NOS. ME0261, ME0262, ME0263)" (ADAMS Accession No. ML091900138).
August 7, 2009	Letter to APS, "Palo Verde Nuclear Generating Station, Units 1, 2 and 3 License Renewal Application Online Reference Portal (TAC NOS. ME0261, ME0262, ME0263)" (ADAMS Accession No. ML091900244).
September 22, 2009	Letter to Mr. Richard Milanovich, Chairperson, Agua Caliente Tribal Council, "Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review" (ADAMS Accession No. ML092570673).
September 22, 2009	Letter to Mr. Eldred Enas, Chairperson, Colorado River Tribal Council, "Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review" (ADAMS Accession No. ML092570673).
September 22, 2009	Letter to Mr. Mike Jackson Sr., President, Fort Yuma-Quechan, "Request for Scoping Comments Concerning the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Renewal Application Review" (ADAMS Accession No. ML092570673).

September 29, 2009	Letter to APS, “Environmental Site Audit Regarding Palo Verde Nuclear Generating Station Units 1, 2 and 3” (ADAMS Accession No. ML073310128).
September 30, 2009	Letter to APS, “Request for Additional Information for the Environmental Review of the Palo Verde Nuclear Generating Station License Renewal Application (ME0261, ME0262, ME0263)” (ADAMS Accession No. ML092470551).
September 30, 2009	Memo, “Summary of Telephone Conference Call Held on September 3, 2009, between the U.S. Nuclear Regulatory Commission and Arizona Public Service Company Pertaining to the Palo Verde Nuclear Generating Station, Units 1, 2 and 3, License Renewal Application Review” (ADAMS Accession No. ML092470463).
October 14, 2009	Letter from APS forwarding Amendment 1 to the application for renewal of operating license for Palo Verde Nuclear Generating Station, Units 1, 2 and 3., providing a revised Environmental Report Figure 3-2 and Table 4-2 for the Hassayampa No. 3 Transmission Line (ADAMS Accession No. ML092950484).
November 10, 2010	Letter from APS forwarding response to September 30, 2009 Request for Additional Information regarding severe accident mitigation alternatives for the review of the license renewal application for Palo Verde Nuclear Generating Station, Units 1, 2 and 3 Amendment #2 (ADAMS Accession No. ML093230225).
November 17, 2009	Letter to APS, “Environmental Project Manager Change for the License Renewal Project for Palo Verde Nuclear Generating Station Units 1, 2 and 3 (TAC NOS. ME0261, ME0262, ME0263)” (ADAMS Accession No. ML0793140009).
December 23, 2009	Letter from APS providing environmental documents for NRC review of the license renewal application for Palo Verde Nuclear Generating Station, Units 1, 2 and 3 (ADAMS Accession No. ML101110129).
January 13, 2010	Letter from APS forwarding follow-up clarification to the response to September 2009 Request for Additional Information regarding severe accident mitigation alternatives for the review of the license renewal application for Palo Verde Nuclear Generating Station, Units 1, 2 and 3 (ADAMS Accession No. ML100270290).
April 8, 2010	Letter to APS, “Request for Additional Information for the review of the Palo Verde Nuclear Generating Station Units 1, 2 and 3, License Renewal Application” (TAC NOS. ME0261, ME0262, ME0263)” (ADAMS Accession No. ML1009603672).
April 26, 2010	Letter to APS, “Issuance of Environmental Scoping Summary Report associated with the Staff’s review of Application by Arizona Public Service Company for Renewal of the Operating License for Palo Verde Nuclear Generating Station, Units 1, 2, and 3, (TAC NOS.

	ME0261, ME0262, ME0263)" (ADAMS Accession No. ML100820451).
April 29, 2010	Letter from APS responding to "Request for Additional Information for the review of the Palo Verde Nuclear Generating Station Units 1, 2 and 3, License Renewal Application" (TAC NOS. ME0261, ME0262, ME0263)" (ADAMS Accession No. ML101310227).

APPENDIX F.
U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR PALO VERDE NUCLEAR GENERATING STATION IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW

F. U.S. NUCLEAR REGULATORY COMMISSION STAFF EVALUATION OF SEVERE ACCIDENT MITIGATION ALTERNATIVES FOR PALO VERDE NUCLEAR GENERATING STATION IN SUPPORT OF LICENSE RENEWAL APPLICATION REVIEW

F.1 INTRODUCTION

Arizona Public Service Company (APS) submitted an assessment of severe accident mitigation alternatives (SAMAs) for the Palo Verde Nuclear Generating Station (PVNGS) as part of the environmental report (ER) (APS 2008a). Supplemental information on the SAMA assessment was provided in Supplement 1 to the license renewal application (APS 2009a). This assessment was based on the most recent PVNGS probabilistic risk assessment (PRA) available at that time, a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) computer code (NRC 1998a), and insights from the PVNGS Individual Plant Examination (IPE) (APS 1992) and Individual Plant Examination of External Events (IPEEE) (APS 1995). In identifying and evaluating potential SAMAs, APS considered SAMA candidates that addressed the major contributors to core damage frequency (CDF) and population dose at PVNGS, as well as SAMA candidates for other operating plants which have submitted license renewal applications. APS identified 23 potential SAMA candidates. This list was reduced to 13 SAMA candidates by eliminating SAMAs that are not applicable to APS due to design differences or have already been implemented at APS, or have estimated implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at PVNGS. APS assessed the costs and benefits associated with each of the potential SAMAs, and concluded in the ER that several of the candidate SAMAs evaluated are potentially cost-beneficial.

Based on a review of the SAMA assessment, the U.S. Nuclear Regulatory Commission (NRC) issued a request for additional information (RAI) to APS by letter dated September 30, 2009 (NRC 2009). Key questions concerned: changes to the PRA model since the IPE, and internal and external reviews of the updated model; the process used to map Level 1 results into the Level 2 analysis and to group containment event tree (CET) end states into release categories; source term and release category assignment assumptions; justification for the multiplier used for external events; population assumptions used in the Level 3 analysis; and further information on the cost benefit analysis of several specific candidate SAMAs and low cost alternatives. APS submitted additional information by letters dated November 10, 2009 (APS 2009b), and January 13, 2010 (APS 2010). In response to the RAIs, APS provided a description of the major changes to the PRA model since the IPE and the internal and external review comments on the updated model; a description of the process for mapping Level 1 results into the Level 2 analysis and for assigning CET sequences to release categories; a description of how fission product release fractions were developed for each release category; a revised SAMA analysis reflecting a higher external events multiplier; further details on the development of the population estimates used in the Level 3 analysis; and additional information regarding several specific SAMAs. APS's responses addressed the NRC staff's concerns, and resulted in the identification of additional potentially cost-beneficial SAMAs.

An assessment of SAMAs for PVNGS is presented below.

F.2 ESTIMATE OF RISK FOR PVNGS

APS's estimates of offsite risk at PVNGS are summarized in Section F.2.1. The summary is followed by the NRC staff's review of APS's risk estimates in Section F.2.2.

F.2.1 APS's Risk Estimates

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the PVNGS Level 1 and 2 PRA model, which is an updated version of the IPE (APS 1992), and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMA analysis. The SAMA analysis is based on the most recent PVNGS Level 1 and Level 2 PRA model available at the time of the ER, referred to as the PVNGS PRA (Revision 15, September 2007 model). The scope of the Level 1 model includes both internal and external (fire) initiating events; the PVNGS Fire PRA model is integrated with the internal events Level 1 model. The scope of the Level 2 model does not include external events.

The PVNGS CDF is approximately 5.07×10^{-6} per year for internal events (not including internal flooding) and 2.72×10^{-6} per year for fire events, as determined from quantification of the Level 1 PRA model. When determined from the sum of the containment event tree (CET) sequences, or Level 2 PRA model, the release frequency is approximately 5.24×10^{-6} per year for internal events. The latter value was used in the SAMA evaluations (APS 2008a). The total release frequency is greater than the internal events CDF in part because the Level 2 model uses a truncation value of 1.0×10^{-13} per year while the Level 1 model uses a truncation value of 1.0×10^{-12} per year. APS accounted for the potential risk reduction benefits associated with external events by applying a multiplier to the estimated benefits for internal events. A different approach was used in the Phase I and Phase II analyses. In the Phase I analysis reported in the ER, APS applied a multiplier of 2.0 to the estimated dollar value associated with completely eliminating all internal events at PVNGS (referred to as the maximum averted cost risk or MACR) and used this modified MACR value in the Phase I SAMA screening process. This effectively assumes that the risk from external events at PVNGS (and the external event risk reduction potential of the candidate SAMAs) is equal to that from internal events. In the Phase II analysis reported in the ER, APS separately quantified the benefits using the internal event and fire event models. For internal event-related SAMAs, APS accounted for the potential additional risk reduction benefits associated with non-fire external events (e.g., seismic, high wind, and other events) by multiplying the estimated benefits for internal events by a factor of 0.464. The factor of 0.464 derives from an assumption that the external events CDF is equal to the internal events CDF and that fire events account for 53.6 percent of the external events CDF (with the remaining 46.4 percent from non-fire external events). For fire-related SAMAs, APS separately estimated the risk reduction benefits using the PVNGS Fire PRA model. The estimated SAMA benefits for internal events, fire events, and non-fire external events were then summed to provide an overall benefit. This is discussed further in Sections F.2.2 and F.6.2.

The breakdown of CDF by initiating event is provided in Table F-1a and F-1b for internal events and fire events, respectively. As shown in Table F-1a, events initiated by station blackout, loss of an engineered safeguard feature (ESF) train, unplanned reactor trips, and loss of condensate feedwater are the dominant contributors to the internal event CDF. As shown in Table F-1b, the dominant contributors to fire CDF are fires in the Control Room, the main turbine bearings area, and the Train A Essential Switchgear Room.

Table F-1a. PVNGS Core Damage Frequency for Internal Events

Initiating Event	CDF (per year)[a]	% Contribution to CDF
Station Blackout	1.2×10^{-6}	23
Loss of Engineered Safeguard Feature (ESF) Train A or B Bus	8.9×10^{-7}	18
Uncomplicated (Unplanned) Reactor Trips	5.9×10^{-7}	12
Loss of Condensate Feedwater or Vacuum	5.5×10^{-7}	11
Anticipated Transient Without Scram (ATWS)	4.6×10^{-7}	9
Loss of Off-Site Power (LOOP)	3.5×10^{-7}	7
Turbine Trip	2.9×10^{-7}	6
Small Break Loss of Coolant Accident (LOCA)	2.5×10^{-7}	5
Other	1.7×10^{-7}	3
Medium and Large Break LOCAs	1.5×10^{-7}	3
Steam Generator Tube Rupture (SGTR)	1.0×10^{-7}	2
Loss or DC Power	3.5×10^{-8}	1
Interfacing Systems LOCA	1.5×10^{-8}	<1
Loss of Off-Site Power to Train A or B	1.0×10^{-8}	<1
Loss of Vital 120V AC	5.1×10^{-9}	<1
Total CDF (internal events)[b]	**5.07×10^{-6}**	**100**

(a) Based on percent contribution from response to RAI 1.e (APS 2009b, APS 2010) and total CDF.
(b) Column totals may be different due to round off.

Based on the response to an NRC staff RAI, the Level 2 PRA model that forms the basis for the SAMA evaluation represents a revision of the original IPE Level 2 model (APS 2009b). The current Level 2 model utilizes two containment event trees (CETs) containing both phenomenological and systemic events. The Level 1 core damage sequences are binned into one of five Plant Damage State (PDS) bins which provide the interface between the Level 1 analysis and Level 2 CET analysis. The CET probabilistically evaluates the progression of the damaged core with respect to release to the environment. CET nodes are evaluated using supporting fault trees and logic rules. The CET end states then are examined for considerations of timing and magnitude of release and assigned to release categories.

The result of the Level 2 PRA is a set of 12 release categories, also referred to as source term categories, with their respective frequency and release characteristics. The results of this analysis for PVNGS are provided in Table 2.E.III-1 of the RAI responses (APS 2009b). The frequency of each release category was obtained by summing the frequency of the individual accident progression CET endpoints binned into the release category. Source terms were developed for each of the 12 release categories using the results of Modular Accident Analysis Program (MAAP) computer code calculations for a representative sequence in each release category. In response to an NRC staff RAI, APS stated that MAAP Version 4.0.5 was used in the PVNGS analysis (APS 2009b).

Table F-1b. Important PVNGS Fire Compartments and their Contribution to Fire CDF

Fire Compartment	Fire Compartment Description	CDF (per year)	% Contribution to CDF[a]
FZ 17	Main Control Room	7.2×10^{-7}	27
FZ TB9	Main Turbine Bearings Areas	5.7×10^{-7}	21
FZ 5A	Train A Essential Switchgear Room	3.5×10^{-7}	13
FZ COR2A	Corridor Building – 120 foot	2.5×10^{-7}	9
FZ TB1	Turbine Building – 100 foot West	2.3×10^{-7}	8
FZ TB5	Turbine Building – 140 foot West	1.8×10^{-7}	7
FZ TB3B	Feedwater Pumps Area	1.1×10^{-7}	4
FZ TB4B	DC Equipment Room	3.3×10^{-8}	1
FZ 5B	Train B Essential Switchgear Room	3.3×10^{-8}	1
FZ 42A	Electrical Penetration Room – Train A, Channel A	2.9×10^{-8}	1
	Other Fire Compartments[b]	2.1×10^{-7}	8
Total Fire CDF		$\mathbf{2.72 \times 10^{-6}}$	**100**

(a) Based on Fire CDF contribution in ER (APS 2008a) and total Fire CDF.

(b) CDF value derived as the difference between the total Fire CDF and the sum of the fire CDFs reported for the 10 dominant fire compartments.

The offsite consequences and economic impact analyses use the MACCS2 code to determine the offsite risk impacts on the surrounding environment and public. Inputs for these analyses include plant-specific and site-specific input values for core radionuclide inventory, source term and release characteristics, site meteorological data, projected population distribution (within an 80-kilometer (50-mile) radius) for the year 2040, emergency response evacuation modeling, and economic data. The core radionuclide inventory corresponds to long-term operation of a single PVNGS unit operating at 3990 megawatt-thermal (MWt). The magnitude of the onsite impacts (in terms of clean-up and decontamination costs and occupational dose) is based on information provided in NUREG/BR-0184 (NRC 1997a).

In the ER, APS estimated the dose to the population within 80 kilometers (50 miles) of the PVNGS site to be approximately 0.136 person-Sievert (Sv) (13.6 person-rem) per year. The breakdown of the total population dose by containment release mode is summarized in Table F-2. Late containment over-pressure failures and SGTR-initiated accidents dominate the population dose risk at PVNGS.

Table F-2. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode	Population Dose (Person-Rem[a] Per Year)	Percent Contribution
Containment Over-pressure Failure (Late)	10.5	77
Basemat Melt-Through (Late)	0.5	4
Steam Generator Tube Rupture	2.3	17
Containment Isolation Failure	0.2	1
Interfacing Systems LOCA	0.1	1
Intact Containment	negligible	negligible
Total	**13.6**	**100**

(a) One person-rem = 0.01 person-Sv

F.2.2 Review of APS's Risk Estimates

APS 's determination of offsite risk at PVNGS is based on the following three major elements of analysis:

- the Level 1 and 2 risk models that form the bases for the 1992 IPE submittal (APS 1992) and the external event analyses of the 1995 IPEEE submittal (APS 1995),
- the major modifications to the IPE model that have been incorporated in the APS PRA, and
- the MACCS2 analyses performed to translate fission product source terms and release frequencies from the Level 2 PRA model into offsite consequence measures.

Each of these analyses was reviewed to determine the acceptability of the PVNGS risk estimates for the SAMA analysis, as summarized below.

The NRC staff's review of the APS IPE is described in an NRC report dated July 1, 1994 (NRC 1994). Based on a review of the original IPE submittal and responses to RAIs, the NRC staff concluded that the IPE submittal met the intent of Generic Letter 88-20, “Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10CFR 50.54(f)” (NRC 1988); that is, the licensee’s IPE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities. Although no vulnerabilities were identified in the IPE, improvements to the plant or procedures were identified and implemented. These improvements are discussed in Section F.3.2.

There have been 17 revisions to the PRA model since the 1992 IPE submittal. A listing of the major changes in each revision of the PRA was provided by APS in the ER (APS 2008a) and in response to an NRC staff RAI (APS 2009b, APS 2010) and is summarized in Table F-3. A comparison of the internal events CDF between the 1992 IPE and Revision 15 of the PVNGS PRA model used for the SAMA evaluation indicates a decrease of over 90 percent (from 8.6×10^{-5} per year to 5.07×10^{-6} per year).

The CDF value from the 1992 PNGNS IPE (8.6×10^{-5} per year) is in the middle of the range of the CDF values reported in the IPEs for CE plants. Figure 11.6 of NUREG-1560 shows that the IPE based internal events CDF for CE plants range from about 1×10^{-5} per year to 3×10^{-4} per year, with an average CDF for the group of about 7×10^{-5} per year (NRC 1997b). It is recognized that other plants have updated the values for CDF subsequent to the IPE submittals to reflect modeling and hardware changes. The internal events CDF result for PVNGS used for the SAMA analysis (5.07×10^{-6} per year) is at the lower end of the range of internal event CDF for other plants of similar vintage and characteristics.

APS explained in the ER that the PVNGS PRA model is representative of Unit 1 design and operation but that it is essentially representative of all three PVNGS units since the units are nearly identical and that differences between the units are primarily due to the phased implementation of the same modifications at all three units during succeeding outages (APS 2008a). The one exception to this is that the PVNGS PRA model includes automatic static transfer switches for the Vital AC, which have been installed on Units 2 and 3 but not on Unit 1. APS explained that this difference has no material impact on the SAMA evaluation since the probability of failure of the automatic static transfer switch is of the same order of magnitude as the human error probability associated with the manual static transfer switch. In response to an NRC staff RAI, APS further clarified that the automatic static transfer switch has an estimated failure probability of 3.0E-3 per demand, while the probability that the operator fails to perform the transfer of a manual switch is estimated to be 5.6E-03 based on the results of a human reliability assessment (APS 2009b). The human error probability for the operator action is based on an action that is in PVNGS procedures, is practiced by the plant operators, and is a relatively simple action that does not involve performance shaping factors that would diminish operator success at performing the action. Based on this clarification, the NRC staff concurs that the design difference between Unit 1 and Units 2 and 3 is not likely to impact the results of the SAMA evaluation and that use of Revision 15 of the PVNGS PRA model to represent all three units is reasonable.

Table F-3. PVNGS PRA Historical Summary

PRA Version	Summary of Changes from Prior Model	CDF (per year)
1992	IPE Submittal	8.6×10^{-5}
Revision 0 1/1999	- Revised Level 1 model to model specific plant maintenance configurations and correct modeling errors	3.9×10^{-5}
Revision 1 2/1999	- Updated mean values of basic events used in the importance analysis and corrected an error in an initiating event frequency	3.9×10^{-5}
Revision 2 5/1999	- Corrected modeling errors including the incorrect application of a human reliability analysis (HRA)	4.2×10^{-5}
Revision 3 8/1999	- Added downcomer block valve to the model - Updated station blackout initiating event frequency - Incorporated change in test intervals associated with engineered safety features actuation system	5.8×10^{-5}
Revision 4 3/2000	- Revised Level 1 model to model equipment taken out of service while still maintaining correct cutsets and recoveries - Removed credit for 125 VDC power when the bus battery is failed - Updated initiating event data	7.0×10^{-5}
Revision 5 9/2000	- Updated documentation	7.0×10^{-5}
Revision 6 1/2001	- Updated the revision numbers of various references used by the PRA model	7.0×10^{-5}
Revision 7 7/2001	- Added recovery rules - Added modeling of the back-up power supplies for the new digital feedwater control system - Corrected modeling of several plant systems - Added credit for a check valve in the charging system flow path	2.1×10^{-5}
Revision 8 10/2001	- Updated documentation	2.1×10^{-5}
Revision 9 3/2002	- Addressed internal and Combustion Engineering Owners Group (CEOG) peer review comments - Added credit for alternate paths to carry power to the mitigating systems	1.8×10^{-5}
Revision 10 2/2003	- Corrected modeling of Loss of Offsite Power (LOOP) non-recovery probabilities - Incorporated new Loss of Coolant Accident (LOCA) success criteria - Updated unavailability data	1.8×10^{-5}
Revision 11 4/2003	- Incorporated changes to LOOP non-recovery probabilities - Removed LOOP events having two recovery actions	1.8×10^{-5}
Revision 12 5/2003	- Incorporated changes for new Rudd Transmission Line installation	1.4×10^{-5}

Table F-3. PVNGS PRA Historical Summary

Revision 13 6/2004	- Corrected modeling of several plant systems - Removed credit for atmospheric dump valves in an Steam Generator Tube Rupture (SGTR) event - Updated test intervals for auxiliary feedwater valves and relays - Updated turbine bypass modeling logic - Added potential for an ATWS in an SGTR and small LOCA event - Updated the human reliability probability for containment spray header flange fail-to-restore - Credited use of the reactor makeup water tank as a water source for the auxiliary feedwater - Added turbine cooling water isolation valves for instrument air (IA) compressor coolers - Updated values for feedwater isolation valve recovery actions - Updated dependence of the steam bypass control and reactor power cutback systems on non-vital AC and station DC	1.3×10^{-5}
Revision 14 1/2006	- Updated failure data - Updated common-cause methodology	1.4×10^{-5}
Revision 15[a] 9/2007	- Revised modeling of diesel-generator (DG) and pump control faults - Added credit for feeding either steam generator (SG) after SGTR and removed alternate feedwater - Revised SGTR top logic for cooldown and depressurization - Made occurrence of main steam isolation signal (MSIS) with SGTR conditional upon operator failure to control SG level - Revised failure data for the condensate storage tank (CST) and refueling water tank (RWT) - Removed the reactor water makeup tank (RWMT) as a back-up to the CST - Revised instrument failure probabilities - Removed engineered safeguard feature (ESF) pump room dependency on HVAC - Removed HRAs for overriding MSIS in order to use non-safety FW pump and to open an MSIV to provide steam to the condenser - Revised HRAs for auxiliary feedwater (AFW) and alternate feedwater	5.1×10^{-6}
Revision 16[b] 12/2008	- Revised the station blackout event tree - Revised the DG failure modes to align with the mitigating systems performance index (MSPI) program - Updated recovery rules for AFW, alternative feedwater, and DG failure modes - Added credit for providing main feedwater (MFW) for the full 24-hour mission time and for recovering loss of all feedwater with restarting MFW - Updated MSPI system unavailability parameters	5.0×10^{-6}

(a) PVNGS PRA version used as the basis for the SAMA analysis.

(b) CDF reported in the RAI response (APS 2010) is the sum of CDF for internal events and internal fire events.

The NRC staff considered the peer reviews performed for the PVNGS PRA and the potential impact of the review findings on the SAMA evaluation. In the ER and in response to an NRC staff RAI (APS 2009b), APS described the Combustion Engineering Owner's Group (CEOG) peer review conducted on Revision 3 of the PVNGS PRA model in 1999. The peer review identified 8 Level A (important and necessary to address before the next regular PRA update) and 26 Level B (important and necessary to address, but disposition may be deferred until the next PRA update) Facts and Observations (F&Os). APS stated in the ER that all Level A and Level B F&Os have been subsequently addressed and all but one Level B F&O are considered closed, with all final disposition of comments incorporated in Revision 15 of the PVNGS PRA model.

The one Level B F&O still open is that the PVNGS PRA model does not address internal flooding events. APS explained that incorporating an internal flood model into the PVNGS PRA model has been a low priority because of the low internal flooding CDF estimated in the PVNGS IPE. For the purposes of the SAMA evaluation, APS reviewed the IPE internal flooding analysis for PVNGS. The IPE internal flooding analyses employed a two step process as follows:

(1) screen out PVNGS plant flood zones determined to contribute negligibly to overall PVNGS CDF and (2) quantify the contribution to CDF of all unscreened zones deemed to have a significant impact on total CDF (APS 1992). All 144 flood zones were screened from further analysis based on the following criteria: (1) the zone is not susceptible to a flood or spray event because it does not contain any “critical” equipment and contains no flood source (82 zones screened out), (2) the maximum postulated flood or spray event for the zone does not cause an initiating event and does not degrade the ability to shut the plant down (49 zones screened out), or (3) the estimated flood frequency for the zone is less than 1×10^{-4} per year and loss of equipment does not have a significant impact on plant risk (13 zones screened out). Of the 13 zones for which a frequency estimate was developed, all contributed less than 1×10^{-8} per year to CDF. APS’s evaluation of potential SAMAs to address internal flooding events is discussed in Section F.3.2.

The NRC staff asked APS to identify and describe the results of any other more recent internal or external reviews that have been conducted on the PVNGS PRA model (NRC 2009). In response to the RAI, APS described the following additional reviews: (1) a February/March 2001 external review of Revision 6 of the PRA model by ERIN Engineering that evaluated and prioritized the technical issues identified in the CEOG peer review, evaluated the actions taken and responses to the peer review issues, and evaluated the PVNGS PRA update procedures and process, (2) an August 2001 external review of Revision 7 of the PRA model by RELCON-AB that evaluated certain model attributes, including common cause modeling, event and fault trees, boundary conditions, reliability models, success criteria, and others identified in the RAI response, (3) a February 2003 external review of the Fire PRA associated with Revision 10 of the PRA model by ERIN Engineering that assessed the transparency of the documentation, assessed the use of acceptable methodology, and identify obvious errors, misapplications, and deficiencies, and (4) a September 2008 internal self-assessment of Revision 15 of the PRA model against NRC Regulatory Guide 1.200, Revision 1, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment (PRA) Results for Risk-Informed Activities," and its capability category II supporting requirements (NRC 2007). APS stated that there are no open items from the first three reviews (APS 2009b). For the September 2008 internal self-assessment, APS provided a summary of the supporting requirements determined to not meet capability category II and the results of an assessment of their impact on the SAMA analysis, which are summarized as follows:

- Lack of internal flood model. This deficiency was addressed separately in the SAMA evaluation as discussed above.

- No evidence of cross-comparison of plant initiating events with other similar plants. APS explained that PVNGS initiating events are consistent with NRC and Electric Power

Research Institute (EPRI) publications and that there are no open items from either the 1999 CEOG peer review or the CEOG cross-comparison of PWR initiating events to other plants.

- No credit taken in the Large Early Release Frequency (LERF) analysis for post-core damage repairs or human actions. APS explained that the SAMA analysis results are conservative relative to this deficiency since taking credit for equipment repairs and for human actions not already credited would result in a decrease in LERF as compared to the LERF used in the SAMA evaluation.

- Insufficient uncertainty analyses in the CDF and LERF analyses. APS explained that the uncertainty analysis performed for the SAMA evaluation, which used the 95th percentile CDF as discussed in Section F.6.2, addresses this deficiency.

- Documentation issues. APS explained that no numerical deficiencies in the CDF or LERF analyses were identified from this deficiency.

The NRC staff considers APS's explanation for each deficiency reasonable and concludes that final resolution of the deficiencies is not likely to impact the results of the SAMA analysis.

The NRC staff asked APS to identify any changes to the plant, including physical and procedural modifications, since Revision 15 of the PVNGS PRA model that could have a significant impact on the results of the SAMA analysis (NRC 2009). In response to the RAI, APS described the major changes to the PRA model since Revision 15, which are summarized in Table G-3 for Revision 16 of the PVNGS PRA model (APS 2009b). The CDF for Revision 16 reported in Table G-3 of 5.0×10^{-6} per year, which includes internal fire events, is a decrease from Revision 15 and is primarily due to additional credit being taken for longer operation of main feedwater following a transient. APS also compared the Revision 16 and Revision 15 Level 1 importance lists and found that use of PRA Revision 16 in the SAMA identification process would not have resulted in addition of any new basic events or SAMAs. APS further stated that there have been no plant modifications since Revision 16 that would have significantly impacted CDF or LERF. Based on the fact that CDF has decreased since Revision 15 of the PVNGS PRA model used for the SAMA analysis, that Revision 16 of the PRA model does not result in additional basic events on the Level 1 importance list, and that there have been no major plant changes since Revision 16, the NRC staff concurs with APS's conclusion that changes to the PVNGS PRA model since Revision 15 of the model are not likely to impact the results of the SAMA analysis.

In the ER, APS described the quality control process in use at PVNGS (APS 2008a). The model is updated typically every 2 years to incorporate plant changes. The entire process of monitoring potential plant changes, tracking items that may lead to model changes, making model changes, documenting the changes, software quality control, independent reviews, and qualification of PRA staff are governed by APS procedures and programs.

Given that the PVNGS internal events PRA model has been peer reviewed and the peer review findings were all addressed, and that APS has satisfactorily addressed NRC staff questions regarding the PRA, the NRC staff concludes that the internal events Level 1 PRA model is of sufficient quality to support the SAMA evaluation.

As indicated above, APS maintains a current PVNGS external events PRA model that explicitly models fire-initiated core damage accidents but does not include non-fire external events. The

PVNGS Fire PRA model is described in the ER. In the absence of an analysis of non-fire external events, APS used the PVNGS IPEEE to identify the highest risk accident sequences and the potential means of reducing the risk posed by those sequences, as discussed below and in Section F.3.2.

The PVNGS IPEEE was submitted in June 1995 (APS 1995) in response to Supplement 4 of Generic Letter 88-20 (NRC 1991). This submittal included a seismic margins analysis, an internal fire PRA, and a screening analysis for other external events. While no fundamental weaknesses or vulnerabilities to severe accident risk in regard to the external events were identified, a number of opportunities for risk reduction were identified as discussed below. In a letter dated July 2, 1999, the NRC staff concluded that the submittal met the intent of Supplement 4 to Generic Letter 88-20, and that the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe accident vulnerabilities (NRC 1999).

The seismic portion of the IPEEE consisted of a full-scope seismic evaluation using the Electric Power Research Institute (EPRI) methodology for Seismic Margins Assessment (SMA) (EPRI 1991). This method is qualitative and does not provide numerical estimates of the CDF contributions from seismic initiators. For this assessment, plant walkdowns were performed in which components and structures were screened against the review level earthquake (RLE) of 0.3g based on the EPRI guidelines, and specific high confidence low probability of failure (HCLPF) capacities were calculated for components required to perform following a seismic event. The PVNGS IPEEE seismic evaluation identified no significant changes to plant design that were required to mitigate the RLE. However, the IPEEE walkdown identified one enhancement to improve plant seismic capacity, which is to improve the anchorage on the bookshelves located behind the Unit 3 control cabinets. This enhancement has been implemented (APS 2008a).

For purposes of the SAMA evaluation, APS assumed a seismic CDF of 1.0×10^{-6} per year in the development of the external events multiplier (APS 2008a). The NRC staff noted that in a risk-informed license amendment request for an extended containment integrated leak rate test (ILRT) interval, APS estimated a seismic CDF for PVNGS of 7.49×10^{-6} per year (APS 2008b). The APS estimate was based on the simplified-hybrid approximation method described in a paper by Robert P. Kennedy, entitled "Overview of Methods for Seismic PRA and Margin Analysis Including Recent Innovations" (Kennedy 1999) and seismic hazard data specific to PVNGS. The NRC staff requested APS to provide justification for not using the APS estimated seismic CDF in the SAMA evaluation (NRC 2009). In response to the RAI, APS re-calculated the seismic CDF to be 4.75×10^{-6} per year by performing a more realistic interpolation between data points on the PVNGS seismic hazard curve and provided a revised SAMA evaluation using this seismic CDF, which is discussed further below. The NRC staff finds the APS approach to estimating the PVNGS seismic CDF acceptable and concludes that the revised seismic CDF of 4.75×10^{-6} per year is reasonable for the SAMA analysis.

The APS IPEEE fire analysis employed EPRI's fire-induced vulnerability evaluation (FIVE) methodology (EPRI 1993) to perform a qualitative screening of fire areas and compartments not important from a fire impact standpoint followed by a progressive probabilistic evaluation of unscreened fire compartments that considers the sequence of events necessary for a fire to result in a complete loss of a safe shutdown function. This evaluation determined ignition sources and frequency for each unscreened fire compartment and redundant/alternate shutdown system unavailability, and, if necessary, considered fire growth and propagation, component damage, and fire detection and suppression effectiveness. A fire compartment was screened from further analysis once the fire-induced core damage frequency dropped below 1×10^{-6} per year. Lastly, a plant walkdown and verification process was employed to verify that all assumptions and calculations were supported by the physical condition of the plant. Several additions and improvements to plant administrative controls, procedures, and training were identified and implemented. The total fire CDF, found by summing the values for all compartments in Table 4-6 of the IPEEE, is 8.7×10^{-5} per year.

While no physical plant changes were found to be necessary as a result of the IPEEE fire analysis, the analysis did credit three plant design changes that had not been implemented at that time. The enhancements credited were (1) installation of a switch to remotely disconnect the essential air cooling unit (ACU) for the Train B DC equipment rooms from the main control room (MCR), (2) modification to reconfigure the fire damper control panels to provide separation between the fire panel control circuits for the Train A and Train B essential switchgear rooms, and (3) installation of additional fuses to eliminate common fuses for certain safe shutdown and non-safe shutdown control circuits. These plant modifications have all been implemented (APS 2008a).

Subsequent to the IPEEE, APS created a fire PRA that was used in the SAMA evaluation. The fire CDF by PVNGS fire compartment is provided in Table F-1b. The total fire CDF, found by summing the values for all compartments in Table F-1b, is 2.72×10^{-6} per year. The ER describes the fire PRA model as being integrated with, and having many of the same characteristics of, the internal events PRA model. In response to an NRC staff RAI (NRC 2009), APS provided additional information on the fire PRA model. The model is a substantial update to the IPEEE fire PRA model and was originally incorporated into Revision 7 of the PVNGS internal events PRA model (APS 2009b). The NRC notes that while the internal events and fire PRA models are integrated, APS reports the CDF contribution from internal events and fire events separately in the ER and in responses to the RAIs. The fire PRA model was developed using the EPRI fire PRA methodology (EPRI 1995) and fire events database, and its development was subject to the staff qualification and independent verification requirements of PVNGS administrative controls as described above. The updated model results in fire CDF values that are substantially reduced from those reported for the IPEEE fire PRA model. APS explained that, while the changes to the fire PRA model since the IPEEE are too numerous to list, the model was peer reviewed in 2003 because of the substantial changes made since the IPEEE and that all Level A or B F&Os from this peer review were subsequently resolved in later revisions of the fire PRA model. APS clarified that no internal or external reviews of the fire PRA have been made since the 2003 peer review (APS 2010). However, APS identified a number of conservatisms in the fire PRA model, as summarized below (APS 2008a):

- A revised NRC fire events database indicates a trend toward lower frequency and less severe fires than assumed in the PVNGS fire PRA model.

- Crediting of manual fire suppression is limited outside the MCR.

- Bounding fire modeling is generally used to assess the immediate effects of a fire and fire propagation. For example, failure of a suppression system in a fire compartment is generally assumed to result in the loss of all equipment in the fire compartment.

- Because of a lack of industry experience with regard to crew performance during the types of fires modeled in the fire PRA, the characterization of crew actions in the fire PRA is generally conservative.

Considering that the PVNGS fire PRA model has been peer reviewed and the peer review findings were all addressed, that the model contains some conservatisms, and that APS has satisfactorily addressed NRC staff RAIs regarding the fire PRA, the NRC staff concludes that the fire PRA model is of sufficient quality to support the SAMA evaluation.

The APS IPEEE analysis of high winds, tornadoes, external floods, and other external events followed the screening and evaluation approaches specified in Supplement 4 to GL 88-20 (NRC 1991). For high winds, external floods, and accidents at nearby facilities, the IPEEE concluded that APS meets the 1975 Standard Review Plan criteria (NRC 1975) and therefore the contribution from these hazards to CDF is less than the 1.0×10^{-6} per year criterion (APS 1995). For lightning, sandstorms, and extreme heat hazards, the IPEEE concluded that none posed a threat to the plant.

In the ER, APS noted that the review of the IPEEE analysis of tornado events revealed that the PVNGS design basis tornado was assumed to have a maximum wind speed of 360 miles per hour (mph) while the APS Updated Final Safety Analysis Report (UFSAR) describes the design basis tornado to have a maximum wind speed of 300 mph. APS re-assessed the frequency of a Category F5 tornado, defined as having wind speeds between 260 and 318 mph, and developed a beyond-design-basis-tornado CDF of 5.75×10^{-9} per year. APS further explained that while there may potentially be tornadoes having wind speeds greater than 318 mph, the majority of the F5 tornado wind speed spectrum is below 300 mph and that, therefore, use of the F5 tornado frequency includes a significant wind speed spectrum that does not pose a threat to the PVNGS structures. The NRC staff finds the APS approach to estimating the PVNGS beyond design-basis-tornado CDF acceptable.

As previously discussed, in the Phase I analysis reported in the ER, APS multiplied the estimated benefits for internal events by a factor of 2.0 to account for external events, and in the Phase II analysis separately quantified the internal event and fire event benefits and estimated the benefits in non-fire external events by applying a multiplier of 0.464 to the internal events benefits. Based on the aforementioned results, however, the external events CDF is approximately 1.5 times the internal events CDF (based on a seismic CDF of 4.75×10^{-6} per year, a fire CDF of 2.72×10^{-6} per year, a negligible contribution from other external events, and an internal events CDF of 5.07×10^{-6} per year). This would suggest that the external event multiplier used in the Phase I screening should be 2.5 rather than 2.0. Similarly, given the higher seismic CDF discussed above, the non-fire external events multiplier should be about 0.95 rather than 0.464 (based on a seismic CDF of 4.75×10^{-6} per year, a negligible contribution from other external events, and an internal events CDF of 5.07×10^{-6} per year). In response to an NRC staff RAI, APS provided a revised SAMA evaluation using a Phase I multiplier of 2.5 and a Phase II multiplier of 0.955 to account for external events (APS 2009b). This is discussed further in Section F.6.2.

The NRC staff reviewed the general process used by APS to translate the results of the Level 1 PRA into containment releases, as well as the results of the Level 2 analysis, as described in the ER and in response to NRC staff requests for additional information (APS 2009b). The current Level 2 model is completely revised from the model used in the IPE and utilizes two CETs based on WCAP-16341-P (Westinghouse 2005), containing both phenomenological and systemic events, which are linked to the Level 1 event trees. WCAP-16341-P was developed with the intent that Level 2 models developed using its methodology would meet the Capability Category II supporting requirements in Regulatory Guide 1.200, Revisions 1 and 2 for PRAs (NRC 2007). Each Level 1 core damage sequence was, based on a set of boundary conditions, evaluated using three attributes: (1) is there a station blackout, (2) is the containment bypassed, and (3) is the reactor coolant system (RCS) pressure high. After assignment of attributes, the Level 1 core damage sequences are binned into one of five plant damage state (PDS) bins defined by the PVNGS-specific combination of attributes and boundary conditions, which provide the interface between the Level 1 and Level 2 analysis. APS noted that a total of seven PDS bins were defined, however, no Level 1 core damage sequences were identified for two of the PDS bins. The PDS bins, boundary conditions, and CETs are described in the response to an NRC staff RAI (APS 2009b).

Each PDS is analyzed through the Level 2 CETs to evaluate the phenomenological progression of the sequence. The process of assigning Level 2 CET sequences to release categories is described in the ER and in response to NRC staff RAIs (APS 2009b). The CET end states are assigned to one of 12 release categories based on characteristics that determine the timing and magnitude of the release, whether or not the containment remains intact, and isotopic composition of the release material. The frequency of each release category was obtained by summing the frequency of the individual accident progression CET endpoints binned into the release category.

Source term release fractions were developed for each of the 12 release categories based on the results of plant-specific calculations using the Modular Accident Analysis Program (MAAP) Version 4.0.5 (APS 2009b). A single MAAP calculation was performed for each of the 12 release categories (APS 2009b). The release categories and their frequencies and release characteristics are presented in Tables D.2-2 and D.3-2 of Appendix D to the ER (APS 2008a) and in Tables 2.E.ii-1 and 2.E.iii-1 of the RAI responses (APS 2009b).

The revisions to the Level 2 model since the IPE to update the methodology and to address peer review recommendations are described in Section D.2 of the ER and in response to NRC staff RAIs (APS 2009b). While the revised Level 2 PRA model was not included in the 1999 CEOG peer review, it was included in the September 2008 self-assessment mentioned previously. As discussed previously, only one deficiency identified in the self-assessment specifically involves the Level 2 analysis and APS determined that the Level 2 PRA model used in the SAMA evaluation relative to this deficiency was conservative (APS 2009b). The NRC staff considers APS's explanation for this deficiency reasonable and concludes that final resolution of the deficiency is not likely to impact the results of the SAMA analysis. Based on the NRC staff's review of the Level 2 methodology, that APS has adequately addressed NRC staff RAIs, that the Level 2 PRA model was reviewed in more detail as part of the September 2008 self-assessment, and that the deficiencies from the self-assessment have been adequately addressed, the NRC staff concludes that the Level 2 PRA provides an acceptable basis for evaluating the benefits associated with various SAMAs.

As indicated in the ER, the reactor core radionuclide inventory used in the consequence analysis was based on the licensed thermal power of 3990 MWt. In response to an NRC staff RAI, APS stated that there are currently no plans to request a power uprate in any of the three PVNGS units (APS 2009b).

The NRC staff reviewed the process used by APS to extend the containment performance (Level 2) portion of the PRA to an assessment of offsite consequences (essentially a Level 3 PRA). In response to an NRC staff RAI, APS clarified that although a Level 3 model was developed for the IPE, a new Level 3 model was developed for the SAMA analysis (APS 2009b). The staff review included consideration of the source terms used to characterize fission product releases for the applicable containment release categories and the major input assumptions used in the offsite consequence analyses. The MACCS2 code was utilized to estimate offsite consequences. Plant-specific input to the code includes the source terms for each release category and the reactor core radionuclide inventory (both discussed above), site-specific meteorological data, projected population distribution within an 80 kilometer (50-mile) radius for the year 2040, emergency evacuation modeling, and economic data. This information is provided in Section D.3 of Attachment D to the ER (APS 2008a) and in response to NRC staff RAIs (APS 2009b).

All releases were modeled as occurring at ground level. The thermal content of each of the releases is assumed to be at ambient (buoyant plume rise was not modeled). Wake affects for the 64-meter (210-foot) high and 47-meter (154-foot) diameter containment building were included in the model. Sensitivity analyses were performed for the elevation, wake effects and thermal content of the releases. Increasing the release height from ground level to the top of containment increased the population dose risk by 7 percent and the offsite economic cost risk by 8 percent. Increasing the release heat to 1 MW in up to 4 segments increased the population dose risk by 2 percent and the offsite economic cost risk by 1 percent. Decreasing the building proximity wake effects by 50 percent decreased the population dose risk and offsite economic cost risk by 3 percent and 4 percent, respectively, while increasing the building wake effects to 200 percent of the baseline assumption increased the population dose risk and offsite economic cost risk by 4 percent and 6 percent, respectively. During the internal review of the SAMA analysis, APS discovered that the Level 3 analysis used a wake height based on the total height of the containment building (210 feet) rather than the height above grade (190 feet). A corrected wake height results in a decrease of less than 1 percent in both population dose risk and offsite economic cost risk. Use of a lower surface roughness, simulating a desert instead of a suburban area, decreased the population dose risk by 7 percent and the offsite economic cost risk by 10 percent. Based on the information provided, the NRC staff concludes that the release parameters utilized are acceptable for the purposes of the SAMA evaluation.

APS used site-specific meteorological data for the 2003 calendar year as input to the MACCS2 code. The development of the meteorological data is discussed in Section D.3.5 of

Attachment D to the ER. The data were collected from the onsite meteorological tower located west-northwest of the reactor buildings. Data from 2004 and 2005 were also considered, but the 2003 data were chosen because they were found to result in the maximum economic cost and dose risks (APS 2008a). Specifically, using the year 2004 and 2005 meteorological data decreased the population dose risk and offsite economic cost risk by 14 to 16 percent and 16 to 17 percent, respectively. Missing data were filled in by (in order of preference): using corresponding data from another level (taking the relationship between the levels as determined from immediately preceding hours), interpolation (if the data gap was less than 4 hours), or using data from the same hour and a nearby day of a previous year. The base case analysis assumed perpetual rainfall in the last spatial segment of the model (40-50 miles) to assure conservatively high wet deposition of radionuclides within the model domain. A sensitivity analysis showed that removing the assumption of perpetual rainfall in the last segment surrounding the site would result in a 40 percent reduction in population dose risk and a

49 percent reduction in offsite economic cost risk. The NRC staff notes that previous SAMA analyses results have shown little sensitivity to year-to-year differences in meteorological data and concludes that the approach taken for collecting and applying the meteorological data in the SAMA analysis is reasonable.

The population distribution the licensee used as input to the MACCS2 analysis was estimated for the year 2040 using year 2000 U.S. Census Bureau Data, as accessed by the SECPOP2000 program (NRC 2003), and the expected annual population growth rate. The population distribution was determined for each of 16 directions and each of 10 concentric rings. In cases where a sector consisted of more than one county, an area-fraction weighting factor was applied to the projected county contributions. The population estimate for the year 2040 was projected using an exponential growth rate calculated based on state county population projections (Arizona Department of Economic Security 2006) and the 2000 U.S Census Bureau Data (USCB 2000). In response to an NRC staff RAI, APS identified that standard exponential population growth equations were used for population growth (APS 2009b). Although population growth is sometimes represented by a linear equation, the use of the exponential equation conservatively projects a larger population. According to the 2005 Palo Verde Evacuation Time Analysis (Maricopa 2005), other than the plant staff, there is no significant transient population within the 10-mile radius. Therefore, only resident population was used in the analysis. In response to an NRC staff RAI, APS provided the year 2040 population distribution for the 50-mile radius at 10-mile intervals (APS 2009b). The NRC staff considers the methods and assumptions for estimating population reasonable and acceptable for purposes of the SAMA evaluation.

The emergency evacuation model was modeled as a single evacuation zone extending out 16 kilometers (10 miles) from the plant. APS assumed that 95 percent of the population would evacuate. This assumption is conservative relative to the NUREG-1150 study (NRC 1990), which assumed evacuation of 99.5 percent of the population within the emergency planning zone (EPZ). The evacuated population was assumed to move at an average speed of approximately 2.9 meters per second (6.6 miles per hour) with a delayed start time of 75 minutes after declaration of a general emergency. The evacuation speed was estimated by multiplying the year 2005 evacuation speed of 3.4 m/sec (Maricopa 2005) by the ratio of the year 2005 and year 2040 EPZ populations. In response to an NRC staff RAI, APS provided the year 2005 EPZ population distribution for the 10-mile radius at 1-mile intervals (APS 2009b). A sensitivity analysis was performed in which the evacuation speed was increased to the year 2005 evacuation speed of 3.4 m/sec (7.6 mph). The results were less than a one percent decrease in the total population dose. The NRC staff noted that the evaluation speed for the year 2040 is about 13 percent lower than the baseline evacuation speed while the population growth is approximately double from 2006 to 2040 and requested APS clarify this discrepancy (NRC 2009). In response to the RAI, APS clarified that the population growth in the EPZ is about 16 percent, which compares well with the assumed reduction in evacuation speed (APS 2009b). The NRC staff concludes that the evacuation assumptions and analysis are reasonable and acceptable for the purposes of the SAMA evaluation.

Much of the site-specific economic data was provided from the 2002 Census of Agriculture (USDA 2004) for each of the five counties surrounding the plant to a distance of 50 miles. These included the fraction of land devoted to farming, annual farm sales, the fraction of farm sales resulting from dairy production, and information on regional crops. The value of farm and non-farm land were taken from state and local analyses (Arizona 2003, GPEC 2005). In addition, generic economic data that applies to the region as a whole was taken from the MACCS2 sample problem input. This included parameters describing the cost of evacuating and relocating people, land decontamination, and property condemnation. An escalation factor of 1.86 (USDL 2007) was applied to these parameters to account for cost escalation from 1986 (the year the input was first specified) to 2007. No economic parameters were derived using the SECPOP2000 code and, therefore, the problems recently identified with that portion of the code have no impact on the SAMA analysis.

The NRC staff concludes that the methodology used by APS to estimate the offsite consequences for PVNGS provides an acceptable basis from which to proceed with an assessment of risk reduction potential for candidate SAMAs. Accordingly, the NRC staff based its assessment of offsite risk on the CDF and offsite doses reported by APS.

F.3 POTENTIAL PLANT IMPROVEMENTS

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by APS are discussed in this section.

F.3.1 Process for Identifying Potential Plant Improvements

APS's process for identifying potential plant improvements (SAMAs) consisted of the following elements:

- Review of the most significant basic events from the current, plant-specific PRA,
- Review of potential plant improvements identified in the PVNGS IPE and IPEEE,
- Review of SAMA candidates identified for license renewal applications for six other U.S. Combustion Engineering and Westinghouse PWR plants, and
- Review of other industry documentation discussing potential plant improvements.

Based on this process, an initial set of 23 candidate SAMAs, referred to as Phase I SAMAs, was identified. In Phase I of the evaluation, APS performed a screening of the initial list of SAMAs and eliminated SAMAs from further consideration using the following criteria:

- The SAMA is not applicable to APS due to design differences or has already been implemented at APS or
- The SAMA has estimated implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at PVNGS.

Based on this screening, 10 SAMAs were eliminated leaving 13 for further evaluation. The remaining SAMAs, referred to as Phase II SAMAs, are listed in Table D.5-4 of Attachment D to the ER (APS 2008a). In Phase II, a detailed evaluation was performed for each of the 13 remaining SAMA candidates, as discussed in Sections F.4 and F.6 below.

As previously discussed, APS accounted for the potential risk reduction benefits associated with each SAMA by separately quantifying the benefits using the internal event and fire event models. For internal event-related SAMAs, APS accounted for the potential additional risk reduction benefits associated with non-fire external events (e.g., seismic, high wind, and other events) by multiplying the estimated benefits for internal events by a factor of 0.464. For fire-related SAMAs, APS separately estimated the risk reduction benefits using the PVNGS Fire PRA model. The estimated SAMA benefits for internal events, fire events, and non-fire external events were then summed to provide an overall benefit.

F.3.2 Review of APS's Process

APS's efforts to identify potential SAMAs focused primarily on areas associated with internal initiating events, but also included explicit consideration of potential SAMAs for fire events. The initial list of SAMAs generally addressed the accident sequences considered to be important to CDF from functional, initiating event, and risk reduction worth (RRW) perspectives at PVNGS, and included selected SAMAs from prior SAMA analyses for other plants.

APS provided a tabular listing of the Level 1 PRA basic events sorted according to its RRW (APS 2008a). SAMAs impacting these basic events would have the greatest potential for reducing risk. APS used a RRW cutoff of 1.01, which corresponds to about a one percent change in CDF given 100-percent reliability of the SAMA. This equates to a benefit of approximately $58,000, after the benefits have been multiplied by a factor of 2.5 to account for external events (APS 2009b) and implementation at the three units at PVNGS. All basic events in the Level 1 listing were reviewed to identify potential SAMAs. All but one of the basic events was addressed by one or more SAMAs (APS 2008a). APS explained that no actions have been identified to improve the reliability of the one basic event not addressed, 1HLI-3HR-OP-2HR, which is an operator action that is proceduralized, is performed by operators in the plant simulator, and, as a result, is already assumed to have a reasonable reliability (2.0E-03). Based on the use of a relatively low probability of failure for an operator action and the low RRW (1.013) for this basic event, the NRC staff agrees that a SAMA to address this event is not likely to be cost beneficial.

APS also provided and reviewed the Level 2 PRA basic events, down to a RRW of 1.01, for the release categories contributing over 97 percent of the population dose-risk. The Level 2 basic events for the remainder of the release categories were not included in the review so as to prevent high frequency-low consequence events from biasing the importance listing. All but two of the basic events were addressed by one or more of the SAMAs (APS 2008a). The two basic events not addressed either had no physical meaning (flag event) or provided no risk insights (split fraction having a probability of 1.0). As a result of the review of the Level 1 and Level 2 basic events, 17 SAMAs were identified.

APS reviewed the Phase II SAMAs from prior SAMA analyses for one Westinghouse PWR and five Combustion Engineering PWR sites. APS's review determined that the majority of these Phase II SAMAs were already represented by a SAMA identified from the Level 1 and 2 importance list reviews, have low potential for risk reduction at PVNGS (i.e., address basic events having an RRW less than 1.01), were already implemented at PVNGS, or were not applicable to PVNGS. This review resulted in one additional SAMA being identified.

APS considered the potential plant improvements described in the IPE in the identification of plant-specific candidate SAMAs for internal events. The PVNGS IPE identified four improvements associated with core damage as follows: (1) change the source of power for the main steam and feedwater isolation valve logic cabinets, (2) change the loss of power failure mode of the Train A steam generator downcomer containment isolation valves to fail open, (3) provide a backup source of control power for the Train N auxiliary feedwater pump circuit breaker, and (4) install temperature detectors in the DC equipment rooms, with an alarm in the main control room. The four improvements have been implemented at PVNGS (APS 2008a).

As discussed in Section F.2.2, the PVNGS PRA model does not include internal flooding events. Accordingly, APS reviewed the IPE internal flooding analysis for PVNGS for the purpose of identifying potential SAMAs. Using the assumed internal flooding CDF of 1.0×10^{-7} per year for PVNGS, and assuming that this risk was distributed among the Level 2 release categories in the same proportion as for the internal events CDF, APS determined that even a low-cost procedure SAMA that eliminated all internal flooding risk would not be cost effective. The NRC staff concludes that the opportunity for internal flooding-related SAMAs has been adequately explored and that it is unlikely that there are any cost-beneficial, internal flooding-related SAMA candidates.

As discussed in Section F.2.2, automatic static transfer switches for the Vital AC have been installed in Units 2 and 3 but not in Unit 1 (APS 2008a). In response to an NRC staff RAI asking APS to provide an assessment of a SAMA to install an automatic static transfer switch in Unit 1, APS explained that the transfer switches have a low risk significance in the PRA model and that the PVNGS corrective action program already includes an action to install the automatic transfer switches in Unit 1 (APS 2009b). Since the basic event for failure of the automatic transfer switches is not on the Level 1 or Level 2 importance lists, confirming the APS statement that the static transfer switches have a low risk significance, the NRC staff agrees that a SAMA to install automatic static transfer switches in Unit 1 is not likely to be cost beneficial.

Based on this information, the NRC staff concludes that the set of SAMAs evaluated in the ER, together with those identified in response to NRC staff RAIs, addresses the major contributors to internal event CDF.

Although the IPEEE did not identify any fundamental vulnerabilities or weaknesses related to external events, three improvements related to internal fire events and one improvement related to seismic events were identified. The four improvements have been implemented at PVNGS (APS 2008a).

In a further effort to identify external event SAMAs, APS reviewed the top 10 fire compartments contributing to fire CDF based on the results of the PVNGS Fire model. These compartments contribute over 92 percent (2.51×10^{-6} per year) of the total fire CDF (2.72×10^{-6} per year). The eleventh largest fire compartment contributes less than one percent of the total fire CDF. As a result of this review, APS identified five Phase I SAMAs to reduce fire risk (APS 2008a). The NRC staff concludes that the opportunity for fire-related SAMAs has been adequately explored and that it is unlikely that there are additional potentially cost-beneficial, fire-related SAMA candidates.

For seismic events, APS reviewed the PVNGS IPEEE seismic results to determine if: (1) there were any unfinished plant enhancements required to ensure that the equipment on the safe shutdown list would be capable of withstanding the review level earthquake (RLE), (2) there were any additional plant enhancements that were identified to reduce seismic risk but were not implemented at PVNGS, and (3) there were any outlier issues that were screened in the IPEEE that could impact seismic risk. APS did not identify any additional SAMAs as a result of this review (APS 2008a). The NRC staff concludes that the opportunity for seismic-related SAMAs has been adequately explored and that it is unlikely that there are any cost-beneficial, seismic-related SAMA candidates.

As stated earlier, the APS IPEEE analysis of other external hazards (high winds, tornadoes, external floods, and other external events) did not identify opportunities for improvements for these events. However, APS's review of the IPEEE analysis of tornado events revealed that the PVNGS design basis tornado was assumed to have a maximum wind speed of 360 miles per hour (mph) when the APS Updated Final Safety Analysis Report (UFSAR) describes the design basis tornado to have a maximum wind speed of 300 mph. APS developed a beyond design basis tornado CDF of 5.75×10^{-9} per year, estimated a cost-risk associated with this tornado frequency, and concluded that there were no plant improvements, including low-cost procedure changes, that would be cost effective even if the entire tornado risk were eliminated. Based on this result and the results of the IPEEE, the licensee concluded that the other external hazards would be negligible contributors to overall core damage and did not consider any plant specific SAMAs for these events.

The NRC staff questioned APS about lower cost alternatives to some of the SAMAs evaluated (NRC 2009), including:

- Modify procedures to shed component cooling water (CCW) loads on loss of essential raw cooling water to extend component cooling water heat-up time.

- Install backwash filters in place of existing service water pump discharge strainers to reduce probability of common cause failures.

In response to the RAIs, APS addressed the suggested lower cost alternatives (APS 2009b). This is discussed further in Section F.6.2.

The NRC staff notes that the set of SAMAs submitted is not all-inclusive, since additional, possibly even less expensive, design alternatives can always be postulated. However, the NRC staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered.

The NRC staff concludes that APS used a systematic and comprehensive process for identifying potential plant improvements for PVNGS, and that the set of SAMAs evaluated in the ER, together with those evaluated in response to NRC staff inquiries, is reasonably comprehensive and, therefore, acceptable. This search included reviewing insights from the plant-specific risk studies, and reviewing plant improvements considered in previous SAMA analyses. While explicit treatment of external events in the SAMA identification process was limited, it is recognized that the prior implementation of plant modifications for fire risks and the absence of external event vulnerabilities reasonably justifies examining primarily the internal events risk results for this purpose.

F.4 RISK REDUCTION POTENTIAL OF PLANT IMPROVEMENTS

APS evaluated the risk-reduction potential of the 13 remaining SAMAs that were applicable to PVNGS. The SAMA evaluations were performed using realistic assumptions with some conservatism. On balance, such calculations overestimate the benefit and are conservative.

APS used model re-quantification to determine the potential benefits. The CDF and population dose reductions for internal events were estimated using the PVNGS PRA model, Rev. 15. The fire CDF reduction for fire events was estimated using the PVNGS Fire PRA model. The population dose reduction for fire events was not directly calculated since the fire PRA model does not include a Level 2 model. Rather, it was assumed that the reduction in total fire risk for each SAMA was directly proportional to the calculated reduction in fire CDF for each SAMA.

The changes made to the model to quantify the impact of SAMAs are detailed in Section D.6 of Attachment D to the ER (APS 2008a). Table F-5 lists the assumptions considered to estimate the risk reduction for each of the evaluated SAMAs, the estimated risk reduction in terms of percent reduction in CDF and population dose, and the estimated total benefit (present value) of the averted risk. The estimated benefits reported in Table F-5 reflect the combined benefit in both internal and external events. The determination of the benefits for the various SAMAs is further discussed in Section F.6.

The NRC staff questioned the assumptions used in evaluating the benefits or risk reduction estimates of certain SAMAs provided in the ER (NRC 2009). For example, SAMA 6, “develop procedures to guide recovery actions for spurious electrical protection faults,” SAMA 11, “alternate cooling flow to SDC heat exchangers,” and SAMA 13, “mitigate loss of Turbine Building Cooling Water (TCW) events: provide permanent, hard-piped connections between the fire protection system and critical loads,” were each reported in the ER to result in no reduction in fire CDF. In response to an RAI, APS explained that the basic events addressed by SAMAs 6 and 13 do contribute to the PVNGS fire CDF but that their contribution is very low (APS 2009b). Relative to SAMA 11, APS explained that since the enhancement is to use fire water to provide an alternate means of cooling the shutdown cooling system (SDC) heat exchangers, this enhancement cannot be credited to mitigate fire events because the availability of fire water is already credited in the fire PRA to provide fire suppression. SAMA 11 therefore provides no reduction in fire CDF. The NRC staff considers the assumptions, as clarified, to be reasonable and acceptable for purposes of the SAMA evaluation.

In another RAI, the NRC staff noted that the approach used by APS to calculate the reduction in fire risk (based on the percent fire CDF reduction) is not conservative for SAMAs in which the benefit is dominated by the reduction in population dose risk or offsite economic cost risk, and requested that APS provide an assessment of the impact of this non-conservative approach on the SAMA analysis (NRC 2009). In response to the RAI, APS agreed that the reduction in population dose risk and offsite economic cost risk results for SAMA 4, “SBO mitigation (gas turbine generator system (GTGS) not available),” SAMA 8, “add auto start/load capability to the GTGS,” and SAMA 15, “100 percent capacity battery chargers,” would be greater than the reduction in internal event CDF because a disproportionate portion of the CDF for these SAMAs is allocated to release categories that contribute a large portion of the population dose risk and/or offsite economic cost risk for PVNGS (APS 2009b). APS further provided a revised evaluation of SAMA 4, SAMA 8, and SAMA 15, assuming the reduction in fire risk was proportional to the smaller of: (1) the ratio of the internal events population dose calculated for the SAMA to the baseline population dose or (2) the ratio of the internal events offsite economic risk for the SAMA to the baseline offsite economic risk (APS 2009b). The NRC staff considers the revised approach for SAMAs 4, 8, and 15 to be reasonable and conservative for purposes of the SAMA evaluation. The results of the revised evaluations of these SAMAs are described in Section F.6.2.

For SAMA 17, “modify the procedures to preclude reactor coolant pump (RCP) operations that would clear the water seals in the cold leg after core damage,” which was identified to mitigate temperature-induced SGTR events, there was no reduction in internal or fire CDF since changes were only made to the Level 2 model. However, temperature-induced STGR scenarios can also occur in fire scenarios. To account for the reduction in fire risk from this SAMA, the reduction in total fire risk was assumed to be directly proportional to the reduction in the steam generator tube rupture (SGTR) release category frequency in internal events.

For the SAMAs that specifically address fire events (i.e., SAMAs 19, 20, 21, and 22), a bounding estimate of the SAMA benefits was made. The steps used to perform this calculation involved estimating: the approximate contribution to total cost-risk (MACR) from external events; the fraction of the external event cost-risk attributable to fire events; and the portion of the fire-related cost-risk attributable to fire compartments affected by the candidate SAMA. APS conservatively assumed that all of the risk associated with all fire compartments affected by the SAMA is eliminated. (Because population dose was not directly calculated, this is noted as "Not Estimated" in Table G-5). These SAMAs were assumed to have no additional benefits in internal events.

The NRC staff has reviewed APS's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the NRC staff based its estimates of averted risk for the various SAMAs on APS's risk reduction estimates.

1 **Table F-5. SAMA Cost/Benefit Screening Analysis for PVNGS[a]**

SAMA	Assumptions	% Risk Reduction		Total Benefit ($)[b]		Cost ($)
		CDF[d]	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
4 – SBO Mitigation (gas turbine generators (GTGs) not available)	Modify fault tree to include a new basic event, having a failure probability of 5.0E-02, representing the unavailability of the new 480V AC generator.	IE: 20 Fire: 2	34	1.8M[c]	4.8M[c]	5.5M
5 – Install an Automatic Transfer Switch for the Non-Safety Auxiliary Feedwater (AFW) Pump (AFN-P01) Power Supply	Modify fault tree to include connection of the existing AFN-P01 logic to the existing alternate power supply logic for AFW Train B.	IE: 19 Fire: 62	16	1.6M	4.4M	6.8M
6 – Develop Procedures to Guide Recovery Actions for Spurious Electrical Protection Faults	**Reduce the probability that spurious electrical protection on Train A and B engineered safety feature (ESF) buses locks out all power sources from 6.50E-06 to 0.**	**IE: 10** **Fire: 0**	**9**	**490K**	**1.3M**	**360K**
8 – Add Auto Start/Load Capability to the GTGs	**Reduce the probability of failure to operate the GTGs from 1.6E-01 to 5.0E-04 in the internal events model and from 4.8E-01 to 5.0E-04 in the fire model.**	**IE: 8** **Fire: 7**	**22**	**1.4M[c]**	**3.8M[c]**	**3.1M**
10 – Provide a Backup AFW Start Signal on a Lower Steam Generator (SG) Level and Use it for all Three AFW Pumps	Reduce the probability of failure to operate the non-safety AFW (AFN) pump to 5.0E-04 and modify the fault tree to "AND" auto-start of the non-safety AFW pump to auto-start of the safety-related AFW pumps.	IE: 9 Fire: 5	5	370K	1.0M	3.0M
11 – Alternate Cooling Flow to Shutdown Cooling (SDC) Heat Exchangers	Modify fault tree to include connection of the fire protection system to the SDC heat exchangers and a new basic event, having a failure probability of 5.0E-02, representing both hardware and operator alignment failure.	IE: 2 Fire: 0	4	170K	450K	3.0M
12 – Install an Automatic Transfer Switch for the AFW Pump AFB-P01 Power Supply	Modify fault tree to include connection of the existing AFB-P01 logic to the existing alternate power supply logic for AFW Train A.	IE: 15 Fire: 23	11	890K	2.4M	6.8M
13 – Mitigate Loss of Turbine Building Cooling Water (TCW) Events: Provide Permanent, Hard-piped Connections Between the Fire Protection System and Critical Loads	Reduce the probability of loss of TCW initiating event from 8.92E-03 to 8.92E-04. Modify fault tree to include connection of the fire protection system to the critical loads and a new basic event, having a probability of failure of 1.0E-02, representing both hardware and operator alignment failure.	IE: 2 Fire: 0	1	63K	170K	3.0M

SAMA	Assumptions	% Risk Reduction		Total Benefit ($)[b]		Cost ($)
		CDF[d]	Population Dose	Baseline (Internal + External)	Baseline With Uncertainty	
14 – Provide a Permanent, Hard-piped Suction Line from the Reactor Makeup Water Tank (RMWT) to AFN-P01	Modify fault tree to include connection of the RMWT to AFW and a new HEP event, having a failure probability of 2.3E-03, representing failure of the operator to align AFW to RMWT.	IE: 3 Fire: 2	2	140K	380K	6.6M
15 – 100 Percent Battery Chargers	Modify fault tree to include the DC battery chargers as a viable power source for most loads.	IE: 4 Fire: 3	9	580K[c]	1.56M[c]	1.64M
17 – Modify the Procedures to Preclude RCP Operations that would Clear the Water Seals in the Cold Leg after Core Damage	**Reduce the probability that the RCP loop seal will be cleared after core damage from 1.4E-01 to 1.4E-02.**	**IE: 0 Fire: 0**	**2**	**240K**	**650K**	**410K**
19 – Install Heat Sensors at Likely Ignition Sources to Allow Early Automatic Suppression Initiation	Eliminate all fire risk for fire compartments FZ 5A and FZ 5B.	IE: 0 Fire: 14	Not Estimated	180K	480K	4.7M
20 – Install Fire Barriers Between Fire Zone TB1 and TB5	Eliminate all fire risk for fire compartment FZ TB5.	IE: 0 Fire: 7	Not Estimated	83K	220K	3.6M
21 – Install Fire Resistant Cable Wrap on Selected Cables in Fire Compartment TB4B	Eliminate all fire risk for fire compartment FZ TB4B.	IE: 0 Fire: 1	Not Estimated	15K	41K	3.4M
22 – Enhance the MCC M71 Fire Barriers	Eliminate all fire risk for fire compartment FZ 42A.	IE: 0 Fire: 1	Not Estimated	14K	37K	3.3M
23 – Enhance Procedures to Direct Steam Generator Flooding for Release Scrubbing	**Eliminate all releases for sequences in which makeup to the steam generators is available.**	**IE: 0 Fire: 0**	**3**	**160K**	**440K**	**420K**

[a] SAMAs in bold are potentially cost-beneficial.
[b] Estimated benefits reflect revised values provided in response to NRC staff RAI 3.c (APS 2009b).
[c] Estimated benefits reflect revised values provided in response to NRC staff RAI 5.a.ii (APS 2009b).
[d] IE: internal events; Fire: internal fire events.

F.5 COST IMPACTS OF CANDIDATE PLANT IMPROVEMENTS

APS estimated the costs of implementing the 13 candidate SAMAs through the development of site-specific cost estimates and use of other licensees' estimates for similar improvements. The cost estimates conservatively did not include the cost of replacement power during extended outages required to implement the modifications (APS 2008a). The cost estimates provided in the ER did not account for inflation, which is considered another conservatism.

The NRC staff reviewed the bases for the applicant's cost estimates (presented in Table D.5-3 of Attachment D to the ER and in APS 2008c). For certain improvements, the NRC staff also compared the cost estimates to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors. The NRC staff noted that the estimated cost of $1.8M for SAMA 4, "SBO Mitigation (GTGs not available)," is significantly higher than the estimated cost of $230K to $494K for similar improvements evaluated as SAMAs at three other plants that have applied to the NRC for license renewal, i.e., Susquehanna, Brunswick, and Indian Point nuclear power plants (NRC 2009). In response to the RAI, APS clarified that the APS portable 480V AC generator must be capable of supporting a battery charger for long-term auxiliary feedwater operation and at least two charging pumps for reactor coolant system makeup (APS 2009b). APS further noted that the size of this portable generator is larger than the portable generators evaluated for the other plants because those portable generators were only needed to maintain control power and level instrumentation. APS estimated the cost to just procure each portable generator to be $640K. The NRC staff considers the estimated cost for PVNGS to be reasonable and acceptable for purposes of the SAMA evaluation.

APS stated in the ER that the estimated cost of $360K, $410K, and $420K for SAMA 6, "develop procedures to guide recovery actions for spurious electrical protection faults," SAMA 17, "modify the procedures to preclude RCP operations that would clear the water seals in the cold leg after core damage," and SAMA 23, "enhance procedures to direct steam generator flooding for release scrubbing," respectively, are significantly higher than the $50K to $100K generally assumed in other SAMA analyses for new or modified procedures because the scope of the PVNGS procedures is greater than the scope of the industry procedure SAMAs, which involve only minor procedure modifications (APS 2008a). In response to an NRC staff RAI requesting further clarification and justification for the cost of these procedure SAMAs, APS stated that it has decided to implement these SAMAs at PVNGS and that further evaluation of these SAMAs is therefore not necessary (APS 2009b). Although the NRC staff believes that the cost estimates for these procedure-related SAMAs appear high, given that these SAMAs were determined to be potentially cost beneficial even with a high implementation cost, and that APS has committed to implement these SAMAs, the NRC staff finds this response acceptable.

The NRC staff requested additional clarification on why the estimated cost of $2.3M is the same for both SAMA 5, "install an automatic transfer switch for the non-safety AFW pump (AFN-P01) power supply," and SAMA 12, "install an automatic transfer switch for the AFW Pump AFB-P01 power supply," when SAMA 5 involves installation of a non-safety automatic transfer switch while SAMA 12 involves installation of a safety-related transfer switch (NRC 2009). In response to the RAI, APS clarified that the these estimates were "order of magnitude" estimates not developed at a sufficient level of detail to distinguish between the design differences for the two SAMAs (APS 2009b). APS further noted that since the cost estimate for SAMA 5 is substantially higher than the estimated benefit (even after accounting for both external events and uncertainty), a more in-depth cost analysis would not likely reduce the cost estimate sufficiently to result in the SAMA becoming cost beneficial. The NRC staff further questioned why the cost of installing the automatic transfer switches for the AFW pumps was $2.3M when the estimated implementation cost for installing automatic transfer switches for the vital AC on Unit 1 was $180K. APS responded that the cost difference was due to significant differences in the scope of the modifications, including: (1) the engineering work for the vital AC switches has already been completed since the transfer switches have already been installed in Units 2 and 3; (2) larger voltage breakers are required for the AFW pumps due to significantly higher electrical load and voltage that the AFW pump switches would have to transfer; (3) the 4.16 kV switchgear may need to be expanded to provide capacity for the AFW pump breakers; (4) an Appendix R electrical panel for the emergency diesel generator B may need to be relocated to provide room for the AFW pump transfer switch modification; (5) installation of the AFW pump transfer switches will require numerous changes to electrical calculations and procedures, new medium voltage cabling, and power supply interlocks not required for the vital AC transfer switches; and (6) new wiring may need to be run into the main control room for the AFW pump transfer switch modification (APS 2010). Based on this additional information, the NRC staff considers these estimated costs to be reasonable and acceptable for purposes of the SAMA evaluation.

The NRC staff concludes that the cost estimates provided by APS are sufficient and appropriate for use in the SAMA evaluation.

F.6 COST-BENEFIT COMPARISON

PVNGS cost-benefit analysis and the NRC staff's review are described in the following sections.

F.6.1 APS's Evaluation

The methodology used by APS was based primarily on NRC's guidance for performing cost-benefit analysis, i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997a). The guidance involves determining the net value for each SAMA according to the following formula:

Net Value = (APE + AOC + AOE + AOSC) - COE where,
APE = present value of averted public exposure ($)
AOC = present value of averted offsite property damage costs ($)
AOE = present value of averted occupational exposure costs ($)
AOSC = present value of averted onsite costs ($)
COE = cost of enhancement ($).

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA and it is not considered cost beneficial. APS's derivation of each of the associated costs is summarized below.

NUREG/BR-0058 has recently been revised to reflect the agency's policy on discount rates. Revision 4 of NUREG/BR-0058 states that two sets of estimates should be developed, one at 3 percent and one at 7 percent (NRC 2004a). APS provided a base set of results using the 3 percent discount rate and a sensitivity study using the 7 percent discount rate (APS 2008a).

Averted Public Exposure (APE) Costs

The APE costs were calculated using the following formula:

APE = Annual reduction in public exposure (Δ person-rem per year)
x monetary equivalent of unit dose ($2000 per person-rem)
x present value conversion factor (15.04 based on a 20-year period with a 3-percent discount rate).

As stated in NUREG/BR-0184 (NRC 1997a), it is important to note that the monetary value of the public health risk after discounting does not represent the expected reduction in public health risk due to a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected annual loss due to a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these potential future losses to present value. For the purposes of initial screening, which assumes elimination of all severe accidents due to internal events, APS calculated an APE of approximately $410,000 for the 20-year license renewal period (APS 2008a).

Averted Offsite Property Damage Costs (AOC)

The AOCs were calculated using the following formula:

AOC = Annual CDF reduction
x offsite economic costs associated with a severe accident (on a per-event basis)
x present value conversion factor.

For the purposes of initial screening, which assumes all severe accidents due to internal events are eliminated, APS calculated an annual offsite economic risk of about $14,900 based on the Level 3 risk analysis. This results in a discounted value of approximately $225,000 for the 20-year license renewal period (APS 2008a).

Averted Occupational Exposure (AOE) Costs

The AOE costs were calculated using the following formula:

AOE = Annual CDF reduction
x occupational exposure per core damage event
x monetary equivalent of unit dose
x present value conversion factor.

APS derived the values for averted occupational exposure from information provided in Section 5.7.3 of the regulatory analysis handbook (NRC 1997a). Best estimate values provided for immediate occupational dose (3300 person-rem) and long-term occupational dose (20,000 person-rem over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in the handbook in conjunction with a monetary equivalent of unit dose of $2000 per person-rem, a real discount rate of 3 percent, and a time period of 20 years to represent the license renewal period. For the purposes of initial screening, which assumes all severe accidents due to internal events are eliminated, APS calculated an AOE of approximately $3,100 for the 20-year license renewal period (APS 2008a).

Averted Onsite Costs

Averted onsite costs (AOSC) include averted cleanup and decontamination costs and averted power replacement costs. Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. APS derived the values for AOSC based on information provided in Section 5.7.6 of NUREG/BR-0184, the regulatory analysis handbook (NRC 1997a).

APS divided this cost element into two parts–the onsite cleanup and decontamination cost, also commonly referred to as averted cleanup and decontamination costs, and the replacement power cost.

Averted cleanup and decontamination costs (ACC) were calculated using the following formula:

ACC = Annual CDF reduction
x present value of cleanup costs per core damage event
x present value conversion factor.

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in the regulatory analysis handbook to be $\$1.5 \times 10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension. For the purposes of initial screening, which assumes all severe accidents due to internal events are eliminated, APS calculated an ACC of approximately $99,000 for the 20-year license renewal period.

Long-term replacement power costs (RPC) were calculated using the following formula:

RPC = Annual CDF reduction
x present value of replacement power for a single event
x factor to account for remaining service years for which replacement power is required
x reactor power scaling factor

APS based its calculations on the rated PVNGS net electric output of 1338 megawatt-electric (MWe) per unit and scaled up from the 910 MWe reference plant in NUREG/BR-0184 (NRC 1997). Therefore APS applied a power scaling factor of 1338/910 to determine the replacement power costs. For the purposes of initial screening, which assumes all severe accidents due to internal events are eliminated, APS calculated an RPC of approximately $41,000 and an AOSC of approximately $140,000 for the 20-year license renewal period (APS 2008a).

Using the above equations, APS estimated the total present dollar value equivalent associated with completely eliminating severe accidents from internal events at PVNGS to be about $778,000 for a single unit. Use of a multiplier of 2.0 to account for external events increases the value to $1,556,000. Because all SAMA costs and benefits were provided on a site basis, APS tripled this value to obtain the three-unit site value of $4,668,000. This represents the dollar value associated with completely eliminating all internal and external event severe accident risk at all three PVNGS units, and is also referred to as the Modified Maximum Averted Cost Risk (MMACR).

APS's Results

If the implementation costs for a candidate SAMA exceeded the calculated benefit, the SAMA was considered not to be cost beneficial. In the baseline analysis contained in the ER (using a 3 percent discount rate), APS identified no potentially cost-beneficial SAMAs. Based on the consideration of analysis uncertainties, APS identified two potentially cost-beneficial SAMAs (SAMAs 6 and 17). In response to NRC staff RAIs, APS provided the results of revised baseline and uncertainty analyses in which the multipliers used to account for additional SAMA benefits in external events were increased to account for a potentially larger seismic CDF. Use of the revised multipliers resulted in identification of one potentially cost-beneficial SAMA in the baseline analysis (SAMA 6), and two potentially cost-beneficial SAMAs when uncertainties are considered (SAMAs 17 and 23).

In response to another NRC staff RAI, APS provided the results of a revised baseline and uncertainty analyses for three SAMAs assuming the reduction in fire risk was proportional to the smaller of: (1) the ratio of the internal events population dose calculated for the SAMA to the baseline population dose or (2) the ratio of the internal events offsite economic risk for the SAMA to the baseline offsite economic risk. The revised uncertainty analysis resulted in the identification of one additional potentially cost-beneficial SAMA (SAMA 8).

The potentially cost-beneficial SAMAs are:

- SAMA 6 – Develop procedures to guide recovery actions for spurious electrical protection faults.

- SAMA 8 – Add auto start/load capability to the GTGS.

- SAMA 17 – Modify the procedures to preclude RCP operations that would clear the water seals in the cold leg after core damage.

- SAMA 23 – Enhance procedures to direct steam generator flooding for release scrubbing.

The potentially cost-beneficial SAMAs, and APS's plans for further evaluation of these SAMAs are discussed in more detail in Section F.6.2.

F.6.2 Review of APS's Cost-Benefit Evaluation

The cost-benefit analysis performed by APS was based primarily on NUREG/BR-0184 (NRC 1997a) and discount rate guidelines in NUREG/BR-0058 (NRC 2004), and was executed consistent with this guidance.

SAMAs identified primarily on the basis of the internal events analysis could provide benefits in certain external events, in addition to their benefits in internal events. APS accounted for the potential risk reduction benefits associated with external events by applying a multiplier to the estimated benefits for internal events. As previously discussed, in the Phase I analysis reported in the ER, APS multiplied the estimated benefits for internal events by a factor of 2.0 to account for external events, and in the Phase II analysis separately quantified the internal event and fire event benefits and estimated the benefits in non-fire external events by applying a multiplier of 0.464 to the internal events benefits. For fire-related SAMAs (SAMAs 19 through 22), APS separately estimated the risk reduction benefits using the PVNGS Fire PRA model. The estimated SAMA benefits for internal events, fire events, and non-fire external events were then summed to provide an overall benefit. In response to NRC staff RAIs, APS revised the Phases I and II analyses to reflect a higher seismic CDF as discussed in Section F.2.2 (APS 2009b). For the Phase I analysis, APS multiplied the estimated benefits for internal events by a factor of 2.5 to account for external events (based on a seismic CDF of 4.75×10^{-6} per year, a fire CDF of 2.72×10^{-6} per year, a negligible contribution from other external events, and an internal events CDF of 5.07×10^{-6} per year). Similarly, for the Phase II analysis, APS multiplied the estimated benefits for internal events by a factor of 0.955 to account for non-fire external events (based on a seismic CDF of 4.75×10^{-6} per year, a negligible contribution from other external events, and an internal events CDF of 5.07×10^{-6} per year). As a result of the revised baseline analysis of the Phase I and II SAMAs (using a 3 percent real discount rate), APS found one SAMA (SAMA 6, as described above) to be potentially cost beneficial. In response to NRC staff RAI 5.c, APS committed to implement this SAMA at PVNGS (APS 2009b).

APS considered the impact that possible increases in benefits from analysis uncertainties would have on the results of the SAMA assessment. In the ER and in response to NRC staff RAIs, APS presents the results of an uncertainty analysis of the internal events CDF which indicates that the 95th percentile value is a factor of 2.7 times the point estimate CDF for PVNGS. APS considered whether any additional Phase I SAMAs might be retained for further analysis if the benefits from internal events, fire events, and non-fire external events were increased by a factor of 2.7. Seven such SAMAs were identified:

- SAMA 2 – Replace one low pressure condensate pump with a high pressure motor driven pump (or add a booster pump) and add hotwell makeup controls to the main control room (MCR) from a non-condensate storage tank (CST) source.

- SAMA 3 – Install an independent AFW system with a dedicated power supply.

- SAMA 5 – Install an automatic transfer switch for the non-safety AFW pump (AFN-P01) power supply.

- SAMA 7 – Add auto start capability to AFN-P01 on low steam generator level and an automatic power transfer switch to address loss of main feedwater (MFW) cases with Division 1 power failures and operator start errors.

- SAMA 9 – Install a backup control element assembly drive mechanism.

- SAMA 12 – Install an automatic transfer switch for the AFW pump AFB-P01 power supply.

- SAMA 14 – Provide a permanent, hard-piped suction line from the RMWT to AFN-P01.

However, based on further consideration of the limited benefit of eliminating the events addressed by SAMAs 2, 3, 7, and 9, APS concluded that these four SAMAs would not be cost beneficial even if they were completely reliable. The specific rationale is provided in the response to NRC staff RAI 3.c (APS 2009b). The NRC staff considers the applicant's rationale for eliminating SAMAs 2, 3, 7, and 9 from further consideration in the Phase II evaluation to be reasonable.

APS also considered the impact on the Phase II screening if the estimated benefits from internal events, fire events, and non-fire external events were increased by a factor of 2.7. The additional Phase I SAMAs, SAMA 5, 12 and 14 as described above, were included in this sensitivity analysis. Two SAMAs became cost beneficial in APS's analysis (SAMAs 17 and 23, as described above). Although not cost-beneficial in the baseline analysis, APS has committed to implement these two SAMAs at PVNGS (APS 2009b).

APS provided the results of additional sensitivity analyses in the ER, including use of a 7 percent discount rate and variations in MACCS2 input parameters. These analyses did not identify any additional potentially cost-beneficial SAMAs (APS 2008a).

As discussed in Section F.4, in response to an NRC staff RAI, APS provided a revised evaluation of SAMA 4, "SBO mitigation (gas turbine generator system (GTGS) not available)," SAMA 8, "add auto start/load capability to the GTGS," and SAMA 15, "100 Percent battery chargers," assuming the reduction in fire risk was proportional to the smaller of (1) the ratio of the internal events population dose calculated for the SAMA to the baseline population dose or (2) the ratio of the internal events offsite economic risk for the SAMA to the baseline offsite economic risk (APS 2009b). As a result of the revised baseline and uncertainty analysis for these Phase II SAMAs (using a 3 percent real discount rate), SAMA 8 became potentially cost beneficial. In response to a follow-up NRC staff RAI, APS stated that SAMA 8 would be considered for further implementation at PVNGS (APS 2010).

As indicated in Section F.3.2, for certain SAMAs considered in the ER, there may be alternatives that could achieve much of the risk reduction at a lower cost (NRC 2009). The NRC staff asked the applicant to evaluate additional lower cost alternatives to the SAMAs considered in the ER, as summarized below:

- Modify procedures to shed CCW loads on loss of essential raw cooling water to extend component cooling water heat-up time. In response to the NRC staff RAI, APS noted that for many nuclear plants, loss of the essential raw water cooling system results in failure of: (1) RCP seal cooling, which requires essential raw water for heat removal, and (2) RCP seal injection, which is provided by the charging pumps and which, in turn, requires essential raw water to provide pump or lube oil cooling (APS 2009b). APS clarified that for PVNGS, the essential cooling water system provides backup cooling to the nuclear cooling water system, which provides RCP seal cooling. APS reviewed the basic events importance lists and determined that the loss of nuclear cooling water initiating event has a Level 1 RRW of 1.002 and a Level 2 RRW of 1.001, both of which are well below the RRW cutoff threshold of 1.01 used by APS to identify basic events for which SAMAs would have the greatest potential for reducing risk. APS further clarified that the PVNGS charging pumps do not require a separate system to provide cooling and therefore loss of essential cooling water does not result in a loss of seal injection. Based on this logic, APS concluded that no further evaluation of this alternative is warranted. The NRC staff agrees with this conclusion.

- Install backwash filters in place of existing service water pump discharge strainers to reduce probability of common cause failures. In response to the NRC staff RAI, APS clarified that the functions provided by the service water system at other plants appears to be provided by the essential spray pond at PVNGS (APS 2009b). APS further indicated that common cause plugging or blocking of the discharge path in the PVNGS essential spray pond system has not been identified as a contributor to severe accident risk at PVNGS. As a result, APS did not identify a SAMA to address essential spray pond discharge path plugging. The NRC staff concludes that this alternative has been adequately addressed.

The NRC staff notes that all of the potentially cost-beneficial SAMAs (SAMAs 6, 8, 17, and 23) identified in APS's original or revised baseline or uncertainty analyses are included within the set of SAMAs that APS plans to further evaluate for implementation. The NRC staff concludes that, with the exception of the potentially cost-beneficial SAMAs discussed above, the costs of the other SAMAs evaluated would be higher than the associated benefits.

F.7 CONCLUSIONS

APS compiled a list of 23 SAMAs based on a review of the most significant basic events from the plant-specific PRA, insights from the plant-specific IPE and IPEEE, Phase II SAMAs from license renewal applications for other plants, and review of other industry documentation. An initial screening removed SAMA candidates that (1) are not applicable to APS due to design differences or have already been implemented at PVNGS, or (2) have estimated implementation costs that would exceed the dollar value associated with completely eliminating all severe accident risk at PVNGS. Based on this screening, 10 SAMAs were eliminated leaving 13 candidate SAMAs for evaluation.

For the remaining SAMA candidates, a more detailed design and cost estimate were developed as shown in Table F-5. The cost-benefit analyses, as revised in response to NRC staff RAIs, showed that one of the SAMA candidates was potentially cost beneficial in the baseline analysis (i.e., SAMA 6). APS performed additional analyses to evaluate the impact of parameter choices and uncertainties on the results of the SAMA assessment. As a result, two additional SAMAs were identified as potentially cost beneficial (SAMAs 17 and 23). In response to another NRC staff RAI regarding the method used to assess the fire-related population dose and offsite economic cost reduction for certain SAMAs, APS identified one additional potentially cost-beneficial SAMA (SAMA 8). APS has committed to implement the first three SAMAs (SAMA 6, 17, and 23) and also indicated that it will further consider the last SAMA (SAMA 8) for potential implementation.

The NRC staff reviewed the APS analysis and concludes that the methods used and the implementation of those methods was sound. The treatment of SAMA benefits and costs support the general conclusion that the SAMA evaluations performed by APS are reasonable and sufficient for the license renewal submittal. Although the treatment of SAMAs for external events was somewhat limited, the likelihood of there being cost-beneficial enhancements in this area was minimized by improvements that have been realized as a result of the IPEEE process, separate analysis of fire events and fire-related SAMAs, and inclusion of a multiplier to account for non-fire external events.

The NRC staff concurs with APS's identification of areas in which risk can be further reduced in a cost-beneficial manner through the implementation of the identified, potentially cost-beneficial SAMAs. Given the potential for cost-beneficial risk reduction, the NRC staff agrees that further evaluation of these SAMAs by APS is warranted. However, these SAMAs do not relate to adequately managing the effects of aging during the period of extended operation. Therefore, they need not be implemented as part of license renewal pursuant to Title 10 of the *Code of Federal Regulations*, Part 54.

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11. ABSTRACT *(200 words or less)*

This draft supplemental environmental impact statement (DSEIS) has been prepared in response to an application submitted by Arizona Public Service Company (APS) to renew the operating license for the Palo Verde Nuclear Generating Station for an additional 20 years.

This DSEIS includes the analysis that evaluates the environmental impacts of the proposed action and alternatives to the proposed action. Alternatives considered include replacement power from new supercritical coal-fired generation; natural gas combined-cycle generation; new nuclear generation; a combination of alternatives that includes natural gas combined-cycle generation, energy conservation, and solar; and not renewing the license (the no-action alternative).

The NRC's preliminary recommendation is the adverse environmental impacts of license renewal for PVNGS are not great enough to deny the option of license renewal for energy-planning decisionmakers. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by APS; (3) consultation with Federal, State, and local agencies; (4) the NRC staff's own independent review; and (5) the NRC staff's consideration of public comments received during the scoping process.

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