March 4, 1982

Robert M. Lazo, Esq., Chairman
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Richard F. Cole
Administrative Judge
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. Dixon Callahan
Administrative Judge
Union Carbide Corporation
P.O. Box Y
Oak Ridge, Tennessee 37830

DISTRIBUTION
XXXXXX
Dewey
Gutierrez
Reis
Lessy
Cunningham/Murray
Christenbury/Olmstead/Scinto
FF (2)
NRC Docket File:
PDR/LPDR
F. Miraglia 110
M.Licitra P433

In the Matter of
Arizona Public Service Company, *et al.*
(Palo Verde Nuclear Generating Station, Units 1, 2 and 3)
Docket Nos. STN 50-528, STN 50-529, STN 50-530

Dear Administrative Judges:

Enclosed is an advance copy of the Final Environmental Statement for the Palo Verde nuclear units which I am sending to you and the parties to this proceeding. This is a complete and final copy of this report. For your convenience, I shall send you and the other parties a copy of this report in booklet form after it becomes available from the printers.

Sincerely,

Lee Scott Dewey
Counsel for NRC Staff

Enclosure: As Stated

cc: (w/enclosure)
Arthur C. Gehr, Esq.
Charles Bischoff, Esq.
Rand L. Greenfield
Ms. Lee Hourihan
Docketing and Service Section

DS07

OFFICE	OELD					
SURNAME	LDewey/dkw EJReis	LD 3/2/81				
DATE	03/ /82					

NUREG-0841

Final Environmental Statement

related to the operation of Palo Verde Nuclear Generating Station, Units 1, 2, and 3

Docket Nos. STN 50-528, STN 50-529, and STN 50-530

Arizona Public Service Company, et al.

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

February 1982

NUREG-0841 FES RELATED TO THE OPERATION OF PALO VERDE NUCLEAR GENERATING STATION UNITS 1, 2, AND 3 FEBRUARY 1982

SUMMARY AND CONCLUSIONS

This Final Environmental Statement (FES) related to operation of the Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3, was prepared by the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation (the staff).

1. This action is administrative.

2. The proposed action is the issuance of operating licenses to the Arizona Public Service Company (APS, applicant) for the startup and operation of PVNGS, Units 1, 2, and 3, located in Maricopa County, about 24 km (15 mi)* west of Buckeye, Arizona. (PVNGS is owned jointly by five utilities, referred to as participants.)

   The facility will employ three pressurized-water reactors (PWRs) producing 3817 megawatts thermal (MWt) each. Steam turbine-generators will use this heat to provide a nominal net electrical output of 1270 megawatts (MWe) per unit. The maximum design thermal output of each unit is 4100 MWt. The exhaust steam will be condensed by cooled water from three circular mechanical-draft cooling towers per unit. Secondarily treated sewage effluent from a pipeline in the vicinity of the City of Phoenix, Arizona, 91st Avenue sewage treatment plant will be the sole source of cooling water.

3. The information in this statement represents the second assessment of the environmental impact associated with PVNGS Units 1, 2, and 3 pursuant to the guidelines of the National Environmental Policy Act of 1969 (NEPA) and Title 10 of the Code of Federal Regulations (10 CFR) Part 51 of the Commission's Regulations. After receiving an application in July 1974 to construct this station, the staff carried out a review of impacts that would occur during its construction and operation. That evaluation was issued as a Final Environmental Statement--Construction Phase (FES-CP) in September 1975. After this environmental review, a safety review, an evaluation by the Advisory Committee on Reactor Safeguards, and public hearings in Phoenix, Arizona, on February 23-27, 1976, the U.S. Nuclear Regulatory Commission issued Construction Permits Nos. CPPR-141, CPPR-142, and CPPR-143 in May 1976 for the construction of PVNGS Units 1, 2, and 3. As of September 1981, the construction of Unit 1 was about 92 percent complete, Unit 2 was 68 percent complete, and Unit 3 was 26 percent

*Throughout the text of this document values are presented in both metric and English units. For the most part, measurements and calculations were originally made in English units and subsequently converted to metric. The number of significant figures given in a metric conversion is not meant to imply greater or lesser accuracy than that implied in the original English value.

complete. The applicant estimates fuel-loading dates of November 1982, November 1983, and November 1985 for Units 1, 2, and 3, respectively. In October and December 1979, respectively, the applicant applied for operating licenses for the units and submitted the required safety and environmental reports in support of the application.

4. The staff has reviewed the activities associated with the proposed operation of the station and the potential impacts, both beneficial and adverse, which are summarized as follows:

   a. The generating capacity provided by operation of PVNGS Units 1, 2, and 3 will help support the increasing load demand of the southwestern United States and will result in increased system and regional reliability of the Western Systems Coordinating Council. Electric energy production from PVNGS will be less expensive than any other generation alternative and will reduce the dependence of the participants on scarce oil and gas fuels (Section 2).

   b. Alteration of approximately 1640 ha (4050 acres) of land for the station has been necessary. Of this, about 1250 ha (3100 acres) will be used for the station structures (Section 4.2.2).

   c. There are no activities or facilities related to operation of the PVNGS which will affect any floodplains (Section 5.3.3).

   d. The potential for adverse impacts on groundwater quality has been reduced by changes in the design of the evaporation pond and water storage reservoir liners. There are no station discharges to surface water bodies (Section 5.3).

   e. Based on sewage effluent projections and records of past sewage effluent use by others, it is expected that there will be a sufficient amount of sewage effluent to permit operation of all three nuclear units during the critical year 1986 and throughout the life of the station (Section 5.3.1.1).

   f. Station cooling towers will produce no appreciable impacts from fogging and drift deposition; the impacts that do occur will be less than predicted in the FES-CP (Sections 5.4 and 5.5).

   g. Reduction in wastewater flows in the Salt-Gila River system will result in a short-term reduction of riparian habitat (Section 5.5).

   h. Station operation is not expected to result in any appreciable impact on endangered species or their critical habitat in the region (Section 5.6).

   i. The operation of PVNGS will not adversely impact existing archeological resources or historic sites (Section 5.7).

   j. No significant social or economic impacts on nearby communities are expected as a result of station operation (Section 5.8).

   k. The combined actions of diversion of 91st Avenue sewage effluent and treatment at PVNGS will reduce the amounts of pathogens and chemical toxins discharged into the Gila River and emitted as cooling tower drift. As a result, public health risks associated with these agents are expected to be minimal (Section 5.8).

l. Operational noise levels are not expected to be objectionable to nearby residents (Section 5.8).

m. No significant environmental impacts are anticipated from normal releases of radioactive materials (Section 5.9.1).

5. The Draft Environmental Statement (DES) was made available to the public, to the Environmental Protection Agency, and to other specified agencies in October 1981, as listed in Section 8. THe comments received from Federal, state, and local agencies, groups, and individuals on the Draft Environmental Statement are appended this statement Appendix I. The staff has considered these comments. The staff responses are in Section 9.

6. The accident analysis section has been revised to include severe accidents and the lessons learned from the accident at Three Mile Island Unit 2 (Section 5.9.2).

7. The analysis of the health effects of the uranium fuel cycle has been revised to include the latest available information (Section 5.10).

8. On the basis of the analyses and evaluations set forth in this statement, and after weighing the environmental, economic, technical, and other benefits against environmental and economic costs and after considering available alternatives at the operating-license stage, the staff concludes that the action called for under NEPA and 10 CFR Part 51 is the issuance of operating licenses for PVNGS Units 1, 2, and 3, subject to the following conditions for the protection of the environment:

   a. Before engaging in additional construction or operational activities that may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant shall provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and shall receive written approval from that office before proceeding with such activities.

   b. The applicant shall carry out the environmental monitoring programs outlined in Section 5 of this statement, as modified and approved by the staff, and implemented in the environmental protection plan and the technical specifications that will be incorporated in the operating licenses for PVNGS Units 1, 2, and 3.

   c. If evidence of irreversible environmental damage or harmful environmental effects are detected during the operating life of the station, the applicant shall prov the staff with an analysis of the problem and a proposed course of action to alleviate it.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

FOREWORD

This environmental statement was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (the staff), in accordance with the Commission's regulations in 10 CFR Part 51, which implement the requirements of the National Environmental Policy Act of 1969 (NEPA).

NEPA states, among other things, that it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the nation may:

- Fulfill the responsibilities of each generation as trustee of the environment for succeeding generations.
- Assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings.
- Attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences.
- Preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment that supports diversity and variety of individual choice.
- Achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities.
- Enhance the quality of renewable resources and approach the maximum-attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, Section 102(2)(C) of NEPA calls for preparation of a detailed statement on:

(i) the environmental impact of the proposed action

(ii) any adverse environmental effects that cannot be avoided should the proposal be implemented

(iii) alternatives to the proposed action

(iv) the relationship between local short-term uses of the human environment and the maintenance and enhancement of long-term productivity

(v) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented

An Environmental Report accompanies each application for a construction permit or a full-power operating license. A notice of availability of the report is issued. Any comments by interested persons on the report are considered by the staff. In conducting the required NEPA review, the staff meets with the applicant to discuss items of information in the Environmental Report, to seek new information from the applicant that might be needed for an adequate assessment and to ensure that the staff has a thorough understanding of the proposed project. In addition, the staff seeks information from other sources that will assist in the evaluation and visits and inspects the project site and surrounding vicinity. Members of the staff may meet with state and local officials who are charged with protecting state and local interests. On the basis of all the foregoing and other such activities or inquiries as are deemed useful and appropriate, the staff makes an independent assessment of the considerations specified in Sect. 102(2)(C) of the NEPA and 10 CFR Part 51.

This evaluation leads to the publication of a Draft Environmental Statement, prepared by the Office of Nuclear Reactor Regulation, which is then circulated to Federal, state, and local government agencies for comment. A summary notice is published in the Federal Register of the availability of the applicant's Environmental Report and the Draft Environmental Statement (DES). Interested persons were also invited to comment on the proposed action and the draft statement. Comments received on the DES are reproduced in Appendix I. The staff's responses to these comments are in Section 9.

After receipt and consideration of comments on the draft statement, the staff prepares a Final Environmental Statement, which includes a discussion of questions and objections raised by the comments and the disposition thereof; a final cost-benefit analysis, which considers and balances the environmental effects of the facility and the alternatives available for reducing or avoiding adverse environmental effects with the environmental, economic, technical, and other benefits of the facility; and a conclusion as to whether--after the environmental, economic, technical, and other benefits are weighed against environmental costs and after available alternatives have been considered--the action called for, with respect to environmental issues, is the issuance or denial of the proposed permit or license or its appropriate conditioning to protect environmental values. This Final Environmental Statement and the Safety Evaluation Report prepared by the staff are submitted to the Atomic Safety and Licensing Board (ASLB) for its consideration at public hearings held in connection with all construction permit applications and with operating license applications as ordered.

This environmental review deals with the impacts of operation of the Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3. Assessments relating to operation that are presented in this statement augment and update those described in the Final Environmental Statement-Construction Phase (FES-CP) that was issued in September 1975 in support of issuance of construction permits for PVNGS Units 1, 2, and 3.

The information to be found in the various sections of this statement updates the FES-CP in four ways: (1) by evaluating changes to facilitate design and operation that will result in different environmental effects of operation (including those which would enhance as well as degrade the environment) from those projected during the preconstruction review; (2) by reporting the results of relevant new information that has become available since the issuance of the FES-CP; (3) by factoring into the statement new environmental policies and statutes that have a bearing on the licensing action; and (4) by identifying unresolved environmental issues or surveillance needs which are to be resolved by means of license conditions. (No unresolved environmental issues or surveillance needs have been identified in this statement for PVNGS Units 1, 2, and 3.)

The staff recognizes the difficulty a reader would encounter in trying to establish the conformance of this review with the requirements of NEPA with only updating informati-- Consequently, the FES-CP was reproduced as Appendix A of the Dra ıvironmental Statement; a copy may be obtained by writing to the Direct.., Division of Licensing, at the address below. Introductory resumés in appropriate sections of this statement summarize both the extent of updating and the degree to which the staff considers the subject to be adequately reviewed.

Copies of this statement are available for inspection at the Commission's Public Document Room, 1717 H Street NW, Washington, DC, and at the Phoenix Public Library, Science and Industry Section, 12 East McDowell Road, Phoenix, Arizona, 85004. Single copies may be obtained by writing to

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Mr. E. A. Licitra is the NRC Licensing Project Manager for this project. He may be contacted at the above address or at 301/492-7200.

1 INTRODUCTION

The proposed action is the issuance of operating licenses to the Arizona Public Service Company (APS), hereinafter referred to as the applicant, for startup and operation of the Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3 in Maricopa County near Buckeye, Arizona. PVNGS is jointly owned by five utilities, hereinafter referred to as the participants. The participants and their percentages of ownership to be effective when Unit 1 begins operation are: Arizona Public Service, 29.1; Salt River Project Agricultural Improvement and Power District, 29.1; El Paso Electric, 15.8; Southern California Edison, 15.8; and Public Service of New Mexico, 10.2. On July 31, 1981 and November 6, 1981, the applicant filed applications for amendments to the PVNGS construction permits (CP). The purpose of the first application was to reflect in the CP the transfer by Salt River Project Agricultural Improvement and Power District to the Southern California Public Power Authority and Los Angeles Department of Water and Power of an undivided ownership interest of 5.91 percent and 5.7 percent, respectively, as tenants in common with the other participants in PVNGS. The purpose of the second application was to reflect in the CP the transfer by El Paso Electric to the M-S-R Public Power Agency of a 3.95 percent undivided ownership interest as a tenant in common with the other participants in PVNGS.

The generating system of each of the three units consists of a pressurized-water reactor (PWR) system, steam turbine generator, a heat-dissipation system, and associated auxiliary facilities and engineered safeguards. Waste heat will be dissipated to the atmosphere from nine circular mechanical-draft cooling towers (three per unit). The cooling water source will be secondarily treated sewage effluent from a pipeline in the vicinity of the City of Phoenix, Arizona, 91st Avenue sewage treatment plant.

The design power levels for each reactor are 3817 megawatts thermal (MWt) and 1304 megawatts (MWe); inplant consumption of electric power per unit will be about 34 MWe, yielding a nominal electrical output of 1270 MWe per unit. The stretch (maximum-design) power level is 4100 MWt per unit (ER-OL, Sec. 3.2).*

1.1 Administrative History

On July 11, 1974, the applicant filed an application with the Atomic Energy Commission (AEC, now Nuclear Regulatory Commission (NRC)), for a permit to

* "Palo Verde Nuclear Generating Station Units 1, 2, and 3 Environmental Report, Operating License Stage," issued by Arizona Public Service Company in December 1979. This document is cited as ER-OL. "Palo Verde Nuclear Generating Station Units 1, 2, and 3, Final Safety Analysis Report," issued by the applicant in October 1979, is referred to as the FSAR. The Final Environmental Statement - Construction Phase (NUREG-75/078), published in September 1975, is referred to as the FES-CP. Other reference material used in the preparation of this report is identified by a notation in parentheses after its citation and listed at the end of the chapter in which it is cited.

construct PVNGS Units 1, 2, and 3. The conclusions resulting from the staff's environmental review were issued as the Final Environmental Statement - Construction Phase (FES-CP) in September 1975. Following reviews by the NRC regulatory staff and its Advisory Committee on Reactor Safeguards, public hearings were held before an Atomic Safety and Licensing Board in Phoenix, Arizona, on February 23, 1976. Construction Permits Nos. CPPR-141, CPPR-142, and CPPR-143 were issued in May 1976 for Units 1, 2, and 3, respectively.

On October 1, 1979, the applicant submitted an application, including a Final Safety Analysis Report (FSAR) and Environmental Report (ER-OL), requesting issuance of operating licenses for PVNGS Units 1, 2, and 3. The FSAR and ER-OL were docketed on June 20, 1980. Operational safety and environmental reviews were then initiated.

As of September 1981, construction of PVNGS Units 1, 2, and 3 was about 92 percent, 68 percent, and 26 percent complete, respectively. The applicant estimates that Units 1, 2, and 3 will be ready for fuel loading in November 1982, November 1983, and November 1985, respectively.

1.? Permits and Licenses

In Section 12 of the ER-OL the applicant provided a listing (as of October 1979) of environmentally related permits, approvals, and licenses required from Federal and state agencies in connection with the proposed project. The staff has reviewed the listing and is not aware of any present non-NRC licensing difficulties that would significantly delay or preclude the proposed operation of the station.

2 PURPOSE AND NEED FOR ACTION

2.1 Résumé

When the FES-CP was issued in September 1975, the staff concluded that PVNGS Units 1, 2, and 3, nominally rated at 1270 MWe each, should be allowed to operate to supply the power needs in the participants' service area. At that time, APS, the lead applicant for the project, had scheduled Units 1, 2, and 3 to begin commercial operation in 1982, 1984, and 1986, respectively. These dates were predicated on 7.9 percent annual growth rate in electrical-energy usage between the years 1964 and 1974 (FES-CP, Table 8.3). The applicant had predicted that the average annual rate of growth of electrical-energy usage would be 8.8 percent between 1974 and 1984 (FES-CP, Table 8.8). However, the actual growth rate from 1974 to 1978 was 3.4 percent per year (ER-OL, Table 1.1-5).

The current projection of the average annual rate of growth (AARG) of electrical energy usage for the years 1981 to 1990 is 3.5 percent (ER-OL, Supplement 2, March 1981). This decline in the expected growth rate of electrical-energy usage is not unique to the participants' service area; rather, it is representative of a national trend, attributable, in part, to conservation, to higher prices for electricity, and to an overall slowdown in economic growth ("Energy Review," Spring 1980). For the United States as a whole, the AARG in sales of electricity has steadily declined from 6.1 percent in 1976 to 1.1 percent in 1980.

One response by utilities to this decline in expected growth rate has been to adjust the projected expansion of capacity by delaying planned additions to their systems. It is in this context that the applicant has delayed the commercial availability of PVNGS Units 1, 2, and 3. The applicant's current schedule is for Units 1, 2, and 3 to begin commercial operation in 1983, 1984, and 1986, respectively.

In this statement, the staff evaluates the purpose and need for operation of PVNGS Units 1, 2, and 3 within the context of (1) overall system production costs for generating electricity, (2) availability of alternative fuels, and (3) reliability of the power supply for the service area. The conclusions drawn from this review will be factored into the staff's decision regarding the issuance of operating licenses for PVNGS Units 1, 2, and 3.

2.2 Production Costs

The Palo Verde units were constructed to provide an economical source of base-load energy. Because substantial capital costs, as well as the environmental costs, associated with construction have already been incurred, the only economic factors that are relevant for consideration now are production costs (fuel costs and operating and maintenance costs (O&M)). Capital costs are discussed in Section 3.

In the applicant's analyses of projected production costs with and without the PVNGS units available to the participants' systems, the assumption was made that generating units would be placed on line as demand required and in increasing order of their production costs. For those parts of the participants' systems that have demands exceeding their maximum capabilities, purchase of the unsupplied energy was assumed. Production-cost analyses were performed by the applicant for the years 1981 through 1990, with and without operation of the PVNGS units as scheduled. The results (expressed as cost savings) of these production-cost analyses are shown in Table 2.1. The values given there represent the applicant's estimate of annual production-cost savings if the units are allowed to operate as scheduled. The analyses are based on the PVNGS units operating at an average capacity factor of about 75 percent during these initial years of operation. Based on the experience of nuclear units in general, this capacity factor is probably on the high side. However, even with the units operating at a 60-percent capacity factor, the savings in production costs will still be substantial (see staff calculation for the year 1987 in Table 2.2).

Table 2.1 Applicant's estimate of annual savings in production cost for participants' combined systems as a result of operation of PVNGS units as scheduled ($ millions)*

Year	Annual Savings	Year	Annual Savings
1983	200	1987	1900**
1984	661	1988	2243
1985	894	1989	2484
1986	1488	1990	2759

*From ER-OL, Response to NRC Question 320.1, Tables 1.3-3 to 1.3-8, Supplement 2, March 1981. As estimated by the applicant based on the assumption that needed power would be purchased if PVNGS does not operate.

**See Table 2.2 for calculation of staff estimate of savings in the year 1987 ($1500 million fuel savings and $30 million in O&M).

Estimates of the participants' fuel-cost savings in 1987 resulting from operation of the PVNGS units have also been made by the staff, based on the applicant's estimate of replacement fuel consumption (with the same fuel mix) if the PVNGS units are not operated as scheduled and based on a 60-percent capacity factor. Results are shown in Table 2.2. The staff concludes that the production costs estimated by the applicant are reasonable (compare data in Table 2.2

Table 2.2 Staff estimate of fuel-cost and production-cost savings in 1987 resulting from commercial operation of PVNGS Units 1, 2, and 3

Element	Participant[1]					
	APS	LADWP	EPE	PNM	SRP	SCE
Fuel price[2] ($/MWh)						
Oil	126	131	111	138	126	131
Gas	82	99	68	81	82	99
Coal	25	27	29	19	25	27
Uranium	10.5	10.5	10.5	10.5	10.5	10.5
Replacement fuel[3] (%)						
Oil	70	0	58	12	32	100
Gas	0	0	34	51	3	0
Coal	30	100	8	37	65	0
Replacement fuel cost ($/MWh)	96	27	90	65	59	131
Fuel cost differential ($/MWh)	85.5	16.5	79.5	54.5	48.5	120.5
PVNGS ownership (%)	29.1	5.7	15.8	10.2	23.4	15.8
Energy from PVNGS[4] (10^6 MWh)	5.83	1.14	3.16	2.04	4.69	3.16
Fuel cost savings[5] (10^6 $)	498	19	251	111	227	381

[1] Participants: APS = Arizona Public Service; LADWP = Los Angeles Department of Water and Power; EPE = El Paso Electric; PNM = Public Service of New Mexico; SRP = Salt River Project; SCE = Southern California Edison.

[2] From "Energy Review," Vol. 4, No. 2, Data Resources, Inc., Spring 1980. [Heat rates (Btu/kWh) assumed: oil, 9500; gas, 10,000; coal, 10,000; nuclear, 10,700.]

[3] From ER-OL, Response to NRC Question 320.2, Tables 1.3-4 to 1.3-7, Supplement No. 2, March 1981.

[4] An average capacity factor of 60 percent is assumed.

[5] O&M savings are $30 million for the system; fuel savings add up to $1500 million.

with those for the year 1987 in Table 2.1). The differential in O&M costs between the nuclear units and the units which would provide the replacement energy is usually quite small compared to fuel-cost differential (about 2 percent in this case for the year 1987).

In Table 2.1, savings are shown only through 1990; actually, production-cost savings would continue as long as PVNGS is capable of operating--a period of about 30 years for each unit. The staff concludes that these potential economic savings would constitute a significant benefit to the participants' systems and their customers.

2.3 Diversity of Supply

In addition to the relative economic advantages of nuclear energy over energy from other sources, operation of the PVNGS units will improve the diversity of fuel supply for the area served by the participants. It is important for a public utility to have diverse sources of power available because too much reliance on one or two fuels--especially for baseload operation--could seriously limit the utility's ability to provide power as needed if availability of those fuels declined. Currently, more than 60 percent of PVNGS participants' generating capacity comes from oil or gas. With all three PVNGS units in operation by 1987, the participants' dependence on oil- or gas-fueled capacity in that year would decrease from 74 percent without PVNGS Units 1, 2, and 3, to 64 percent with the PVNGS units. The participating utilities would therefore be better prepared to meet unexpected changes in the supply of scarce fuels, such as interruption of imported oil supply or further limitation on the use of natural gas as a boiler fuel.

Operation of PVNGS units will result in substantial savings of oil and gas. For example, the applicant has estimated (and the staff agrees) that about 22 million barrels of oil and 19 billion ft^3 of natural gas can be saved in 1987 alone if the PVNGS units are operated as scheduled (ER-OL, Supplement 2, Tables 1.3-4 and 1.3-5). This would increase the availability of these more versatile fuel resources for other uses for which there is no available substitute.

Both the improvement in the diversity of fuel supply for the PVNGS service area and the savings in scarce fuels are important factors in support of issuing operating licenses in a timely manner.

2.4 Reliability Analysis

All participants in the PVNGS project are members of the Western Systems Coordinating Council (WSCC), the reliability council generally encompassing the 14 western states and the Province of British Columbia. Within WSCC there are large variations in population and electrical load densities and extremes in distances between resources and load centers. There is a high degree of voluntary coordination affecting the adequacy and reliability of bulk power supply among systems and subregions. As a result of the expansion of interconnections within WSCC over the last decade, there now exists complete interconnection capability between electrical generating systems in the western

Table 2.3 Projected peak demand, generating capability, and reserve margin of participants' combined systems with and without PVNGS Units 1, 2, and 3

Factor	Year							
	1983	1984	1985	1986	1987	1988	1989	1990
Adjusted annual peak demand*(MWe)	25,437	26,226	27,081	27,972	28,877	29,923	30,907	31,932
Generating capability*(MWe)								
With PVNGS	33,003	34,171	34,019	35,047	36,231	37,260	38,342	39,750
Without PVNGS	31,733	31,631	31,479	31,237	32,421	33,450	34,532	35,940
Reserve margin(%)								
With PVNGS	29.7	30.3	25.6	25.3	25.5	24.5	24.1	24.5
Without PVNGS	24.8	20.6	16.2	11.7	12.3	11.8	11.7	12.6
National reserve margin**(%)	34	33	33	32	33	32	28	25

*Capability includes nonfirm purchases and sales; peak demand includes firm purchases and sales. (From ER-OL, Supplement 2, March 1981.)

**From "Energy Review," Vol. 4, No. 4, Data Resources, Inc., Winter 1980-1981.

states. This includes those systems owned by the participants in the PVNGS Units 1, 2, and 3. Although WSCC has no reserve margin requirements for its members, a reserve margin of 15 percent of peak demand is used as a minimum acceptable planning objective by the participants. This figure is the minimum recommended by the Federal Energy Regulatory Commission (FERC). Failure to meet this objective can affect rights to and costs of emergency service.

The participants' reserve margins (which are an accepted measure of system reliability) with and without the PVNGS units in operation are shown for 1983 through 1990 in Table 2.3. Because current forecasts of annual growth rates in both peak demand and energy requirement are lower than were forecasts before 1980, it appears that operation of the PVNGS units can be delayed up to 3 years and still meet the reliability criterion. However, it is possible that one or more of the participants will be unable to meet its load requirement during this period and will have to purchase the unserved energy from other sources. As reported in the Winter 1980-81 issue of "Energy Review," Data Resources, Inc., recently studied the effect of reserve margins on future electricity prices. The conclusion of the study is that in the year 2000 electricity prices will decline when reserve margins increase from 15 percent to 30 percent in five regions of the country where dependence on crude oil or natural gas to generate electricity is greatest. Most of the participants' service areas are in these regions.

The staff concludes that there may be a reliability problem in some of the participants' systems by 1986 if the PVNGS units are not in operation by that time. However, future demand uncertainties could change this either positively or negatively. Although there might be justification for the choice of higher reserve margins, reliability as measured by these reserve margins is not found to be a primary consideration in the timing of the initial operation of the PVNGS units.

2.5 Conclusions

The results of the staff's assessment of purpose and need support a decision to issue the operating licenses for PVNGS Units 1, 2, and 3 in the time frame proposed by the applicant. The fact of overriding importance is that the timely addition of these units to the participants' systems is expected to result in significant savings in both system production costs and scarce fuels. Furthermore, the operation of these units will decrease participants' dependence on fuel supplies of uncertain availability and will increase system reliability.

The operation of these units will result in increased environmental costs and risks. However, these issues have been addressed in various sections of this statement and are summarized in Section 6. Moreover, if the PVNGS units are not allowed to operate, replacement energy will have to be generated. This increased use of other power generation facilities will have its associated environmental costs and risks. Finally, although decommissioning is identified as an incremental cost of operating the PVNGS units, this cost represents only about 15 percent of the projected production-cost savings resulting from PVNGS operation for the year 1987 (Section 5.11).

2.6 References

Data Resources, Inc., "Energy Review," Vol. 4, No. 2, Lexington, MA, Spring 1980.

Data Resources, Inc., "Energy Review," Vol. 4, No. 4, Winter 1980-1981.

3 ALTERNATIVES TO THE PROPOSED ACTION

3.1 Résumé

During the construction-permit stage of the licensing process, the staff analyzed a wide range of alternatives, including the alternative of not adding new production capacity. The staff concluded--based on its analysis of these alternatives, as well as on a cost-benefit analysis--that additional capacity was needed, that nuclear power would be an environmentally acceptable means of providing the capacity, and that PVNGS Units 1, 2, and 3, at a specified site and of a specified design, were acceptable from an environmental perspective. Since that time, the station has been essentially constructed. The economic and environmental costs associated with the construction of the station that have been incurred must be viewed as "sunk costs" in any prospective assessment.

3.2 Alternatives

At the operating-license stage consideration of dramatic plant modifications or the construction of new and different energy sources as alternatives to the existing nuclear facility is not warranted, unless a compelling safety or environmental concern is discovered that was not evident during the construction-permit review. No such compelling consideration has emerged.

The environmental costs associated with any of the alternatives that were considered and foreclosed at the construction-permit review stage would now be prohibitive when compared to the incremental costs of operating the completed station. These alternatives would require significant environmental and capital commitments, in addition to the costs of operation. Further, the delays caused by any proposed change in plans would necessitate an assessment of the cost of providing the energy that could have been produced by the station versus the cost of energy from replacement energy sources during the delay period.

Therefore, it is the staff's view that, at this time, the only alternative to operation of the station is denial of its operation. With no significant environmental or safety objection, the decision is economic. If operation is denied, the most conservative assumption (that is, least costly) is that existing capacity on the applicant's system is available to replace the energy that could have been provided by the station. If, under this scenario, it can be demonstrated that significant production cost savings are available from operation of the station vis-a-vis nonoperation, then the operating alternative is preferable. The NRC staff has evaluated this cost differential (see Section 2.2 of this statement) and finds that savings on the order of $500 million per year per unit would be realized during the proposed initial years of operation of PVNGS Units 1, 2, and 3. Comparable savings would be expected for subsequent years.

After weighing the above-described options, the staff concludes that the preferable choice is operation of PVNGS Units 1, 2, and 3.

4 PROJECT DESCRIPTION AND AFFECTED ENVIRONMENT

4.1 Résumé

This section contains a summary of changes made in plant design since the FES-CP was issued. These changes include the station's external appearance and layout (Section 4.2.1); site land use (Section 4.2.2); plant water use (Section 4.2.3); cooling tower design (Section 4.2.4); the radioactive-waste-management system (Section 4.2.5); nonradioactive-waste-management system (Section 4.2.6); routing of portions of the power transmission system (Section 4.2.7); and the water conveyance pipeline (Section 4.2.8).

New information on the local environment affecting the staff's evaluation of impacts of station operation is also provided. The hydrology and water-quality discussions have been updated (Sections 4.3.1 and 4.3.2). The metecrology and air-quality discussions have been updated to include new information for the region and the site (Section 4.3.3). Changes in terrestrial and aquatic ecology have occurred as a result of implementation of flood control projects since the preconstruction review (Section 4.3.4), and the U.S. Fish and Wildlife Service has identified endangered and threatened species that exist in the PVNGS region (Section 4.3.5). New information on the historic and archeological resources of the site and nearby areas has been provided (Section 4.3.6). Finally, discussions of the local economy, land use, demography, and noise in the station vicinity have been updated or added (Section 4.3.7).

4.2 Project Description

4.2.1 External Appearance and Station Layout

The external appearance and layout of the station have changed relative to the descriptions given in Sections 2 and 3 of the FES-CP. The design of the cooling towers has been changed from rectangular mechanical draft to circular mechanical draft; the cooling towers have been relocated closer to the reactor power blocks and farther from the property line; the location of the evaporation ponds has been moved slightly south and closer to the property line; and the location and shape of the onsite water storage reservoir have been changed. There is now a railroad spur into the site from the Southern Pacific Railroad track about 5 km (3 mi) south of the site, and the portion of Wintersburg Road that formerly traversed the site north-south has been relocated to just outside the western boundary of the site. The channel of the East Wash has been rerouted from the east boundary of the site to the east-side embankment. The general site arrangement as it will exist upon completion of construction is shown in Figure 4.1.

4.2.2 Site Land Use

The site land-use descriptions presented in the FES-CP (Sections 4.1 and 5.1) remain essentially valid, except that the total area of the site has been

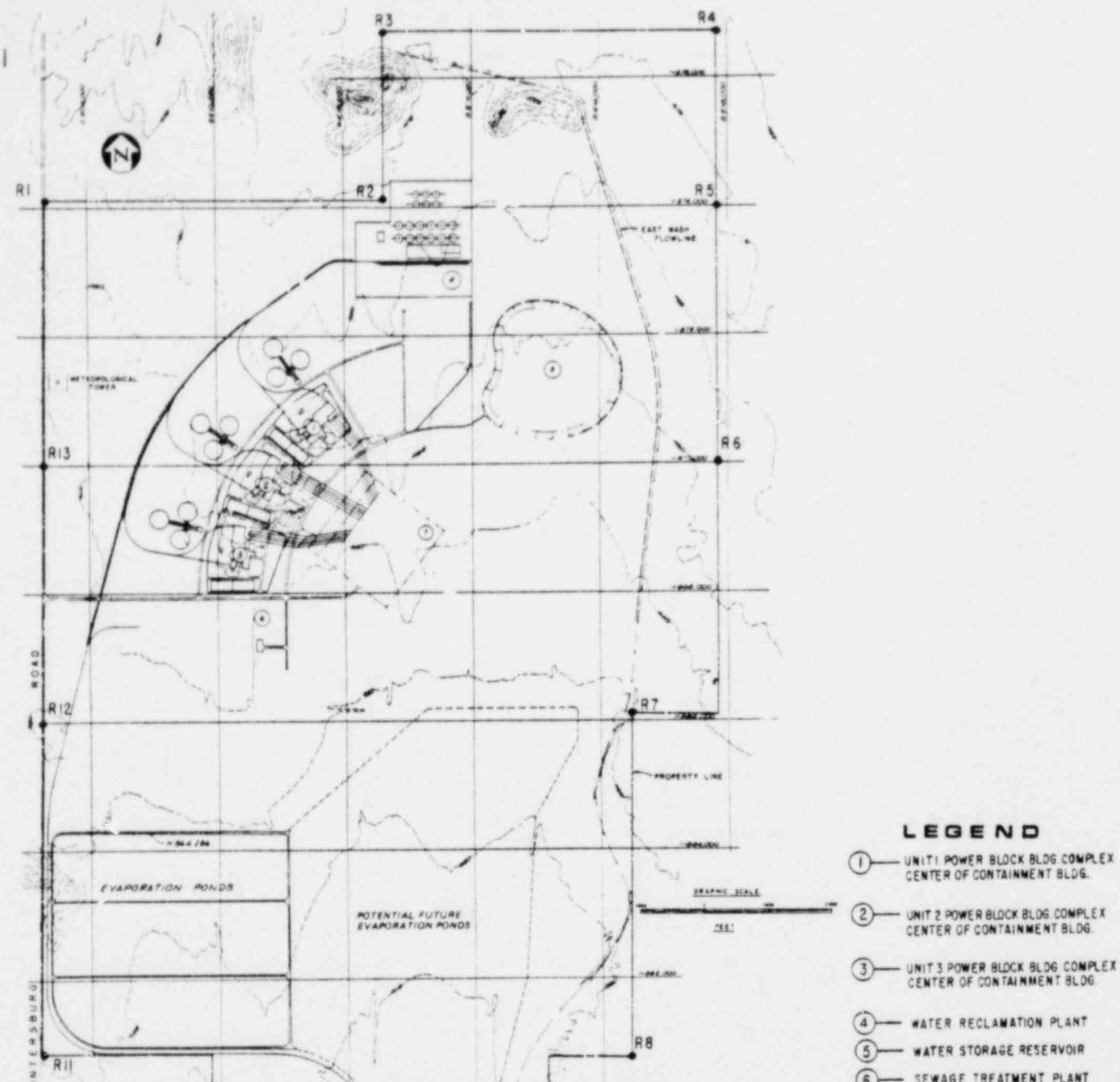

Figure 4.1 Plot plan of the PVNGS site showing locations of principal facilities (modified from ER-OL Figure 3.1-4).

increased from 1500 ha (3700 acres) to 1640 ha (4050 acres). Of this, 1250 ha (3100 acres) will be occupied by station facilities.

4.2.3 Water Use

Many of the design water-system flow and use rates for the station have been changed from those given in the FES-CP (Section 3.3) because of the redesign of the cooling towers (ER-OL, p. 3A-3, response to Question 3A.5). The total design annual makeup water requirement per unit is now estimated by the applicant to be 2.6 x 10^7 m^3/year (21,350 acre-ft/year) per unit (ER-OL, p. 3.3-1), about 16 percent less than stated in the FES-CP. The staff has reviewed the applicant's estimate and finds it reasonable.

Primary changes in plant water use (per unit) are reductions of (1) circulating water system flow from 39 m^3/s (620,000 gpm) to 37 m^3/s (587,000 gpm); (2) circulating water system cooling tower drift from 3.9 x 10^{-3} m^3/s (62 gpm) to 1.6 x 10^{-3} m^3/s (26 gpm); and (3) reservoir evaporation and seepage from 1.5 x 10^{-1} m^3/s (2450 gpm) to 1.8 x 10^{-2} m^3/s (280 gpm). A detailed description of plant water use is given in the ER-OL, Section 3.3.

4.2.4 Cooling System

The general description of the station water source and cooling system presented in the FES-CP (Section 3.3) remains valid, except for the changes described below.

4.2.4.1 Reservoir and Evaporation Pond

Soil-cement bottom liners originally were planned for the water storage reservoir and evaporation pond (FES-CP, Section 3.3); however, this has been changed. The bottom liners will now consist of spray-lined rubberized asphalt at least 200 mils thick, and the sides of the reservoir and pond will be lined with 45-mil-thick reinforced Hypalon (ER-OL, Sections 3.6 and 3.7). The permeability of the liners is estimated to be about 10^{-10} cm/sec.

4.2.4.2 Cooling Towers

The design of the cooling towers has been changed to three circular mechanical-draft cooling towers per unit, with 16 fans per tower (ER-OL, Sec. 3.4), instead of three rectangular mechanical-draft towers with 14 cells with one fan each per tower. Each of the round towers will be 92 m (300 ft) in diameter at the base and 20 m (64 ft) high, with 16 fans. Design characteristics of the new cooling tower system are given in the ER-OL, Table 3.4-1. As a result of the design change, drift loss of circulating water from the towers will be reduced from the value of 0.01 percent given in Table 3.2 of the FES-CP to 0.0044 percent. The latter value is a manufacturer's guarantee and is typical of drift losses from circular mechanical-draft cooling towers. The towers have been relocated closer to the power blocks and farther from the station boundary (Figure 4.1).

4.2.5 Radioactive-Waste-Management Systems

Under requirements set by Title 10 of the Code of Federal Regulations Section 50.34a (10 CFR 50.34a), an application for a permit to construct a nuclear power reactor must include a preliminary design for equipment to keep levels of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable (ALARA). The term ALARA takes into account the state of technology and the economics of improvements (1) in relation to benefits to the public health and safety and other societal and socioeconomic considerations and (2) in relation to the utilization of atomic energy in the public interest. Appendix I to 10 CFR Part 50 provides numerical guidance on radiation dose design objectives for light-water-cooled nuclear power reactors (LWRs) to meet the requirement that radioactive materials in effluents released to unrestricted areas be kept ALARA.

To comply with the requirements of 10 CFR 50.34a, the applicant provided final designs of radwaste systems and effluent control measures for keeping levels of radioactive materials in effluents ALARA within the requirements of Appendix I to 10 CFR Part 50. Because there are no liquid effluents, the applicant provided an estimate of the quantity of each principal radionuclide expected to be released annually to unrestricted areas in only the gaseous effluents produced during normal reactor operations, including anticipated operational occurrences.

The staff's detailed evaluation of the radwaste systems and the capability of these systems to meet the requirements of Appendix I is presented in Chapter 11 of the staff's Safety Evaluation Report (SER), which was issued in November 1981. The quantities of radioactive material that the staff now calculates will be released from the plant during normal operations, including anticipated operational occurrences, are presented in Appendix C of this statement, along with examples of the calculated doses to individual members of the public and to the general population resulting from these effluent quantities.

As part of the operating license for this station, the NRC will require Technical Specifications limiting release rates for radioactive material in the effluents and requiring routine monitoring and measurement of all principal release points to ensure that the station operates in conformance with the radiation-dose design objectives of Appendix I.

The staff's detailed evaluation of the solid radwaste system and its capability to accommodate the solid wastes expected during normal operations, including anticipated operational occurrences, is presented in Chapter 11 of the SER. On the basis of its evaluation and on recent data from operating PWRs, the staff estimates that approximately 510 mα (18,000 ft^3) of "wet" solid wastes containing approximately 1600 Ci of radioactivity (mainly the long-lived fission and corrosion products (Cs-134, Cs-137, Co-58, Co-60, and Fe-55) and approximately 340 m^3 (12,000 ft^3) of "dry" solid wastes containing less than 5 Ci of radioactivity will be shipped offsite annually from each unit of Palo Verde to a licensed burial site. The packaging and shipping of all these wastes will be in conformance with the applicable requirements of 10 CFR Parts 20 and 71 and 49 CFR Parts 170-178.

4.2.6 Nonradioactive-Waste-Management Systems

Modifications in station design and operation procedure will change the amounts and types of nonradioactive wastes as compared to predictions given in the FES-CP, Sections 3.6 and 3.7. The major changes consist of (1) a substantial increase in the estimated amount of solid wastes to be generated in the water reclamation plant and (2) moderate increases in the amount of chlorine added to the makeup water and in the period of application for biofouling control. However, none of the wastes will be discharged to any natural surface water body. Solids will be disposed of in an onsite solid-waste landfill or in a commercial sanitary landfill off the site; liquids will be discharged into an onsite evaporation pond. Most of the nonradioactive wastes disposed of will be cooling tower blowdown and water treatment wastes. A detailed description of chemicals used in plant water treatment is given in the ER-OL, Sections 3.6 and 3.7.

4.2.6.1 Solid and Liquid Wastes

The 80-ha (200-acre) onsite solid-waste-disposal area will be used for disposal of about 4.2×10^7 kg/yr (4.6×10^4 tons/yr) of spent lime sludge from the water-reclamation plant, as well as about 1.4×10^5 kg/yr (154 tons/yr) of materials from the service building (such as paper, rags, and grit). The solid-waste-disposal area will not be lined.

The nonradioactive liquid wastes discharged to the evaporation pond will consist primarily of cooling-tower blowdown, with lesser amounts of spent demineralizer regenerant, service-water-treatment wastes, and power-plant washdown. Liquid wastes will contain a maximum of about 1.1×10^5 kg/day (120 tons/day) of dissolved salts, as well as minor amounts of suspended solids, heavy metals, and organic chemicals. The evaporation pond liner system is described in Section 4.2.4.1 above. The pond will initially occupy 100 ha (250 acres) and will eventually be expanded to 270 ha (670 acres). The natural evaporation rate in the area, 3 m/yr (120 in./yr) (Chow), greatly exceeds the rate at which wastewater will be added, 1.6×10^{-3} m^3/s (26 gpm); thus, the staff concludes that, during much of the year, the liquid surface will only cover a small area near the discharge orifice.

4.2.6.2 Cooling Tower Drift

Each cooling tower will discharge about 1.6×10^{-3} m^3/s (26 gpm) of circulating water to the atmosphere as drift. The drift will be produced at a rate of 0.8 kg/s (1×10^2 lb/min) (total for all three units) of dissolved salts, plus minor amounts of suspended solids, heavy metals, and organic chemicals. The applicant's prediction of concentrations of constituents in blowdown and drift are given in Table 3.6-1 of the ER-OL. The staff considers those estimates to be reasonable.

4.2.6.3 Other Wastes

Sanitary Wastes

The sanitary waste system is now designed to handle 130 m^3 (35,000 gal) of waste per day, 30 percent less than the design evaluated in the FES-CP (Section 3.7.1). The peak-operation work force is expected to be 844 persons per day (ER-OL, Table 8.1-3A). Assuming a water usage of 1.5×10^{-6} m^3/s (35 gpd) per person (Metcalf and Eddy), the staff has determined that the design capacity of the sanitary system is sufficient. The sanitary waste treatment scheme described in the FES-CP remains valid.

About 7.3 x 10^3 kg/yr (8 tons/yr) of dry sanitary sludge will be produced during normal operations. The sludge will be transported offsite to an existing licensed sanitary landfill area. The treated wastewater effluent will be routed to the water reclamation plant (ER-OL, Section 3.7.1).

Gaseous Effluents

As described in Section 3.7.2 of the FES-CP, the stationary sources of combustion-product gaseous effluents during PVNGS operation will be six standby diesel generator units, two plant auxiliary boilers, and the water reclamation plant recalcining furnace. The applicant's updated estimates of the amounts of gaseous effluents expected from these sources (ER-OL, Section 3.7.3) are from 20 to 85 percent less than the amounts listed in the FES-CP. The applicant's estimates are within the normal range expected for each of the source units.

The design of the recalcining furnace at the water reclamation plant was completed after the FES-CP was issued. The applicant's estimates of gaseous heavy metals discharged during lime recalcination (Table 4.1) are based on a maximum furnace temperature of 980°C (1800°F), 75 percent solids recovered in the classifying centrifuge, 65 percent recalcining reduction efficiency, and 99.5 percent furnace wet scrubber efficiency (ER-OL, Section 3.7.3).

Table 4.1 Heavy metal gaseous emissions from lime recalcination furnace[1]

Substance	Emission (kg/yr)	Substance	Emission (kg/yr)
Arsenic	0.01	Iron	9.3
Barium	0.01	Lead	0.9
Beryllium	0.3[2,3]	Mercury	0.07[2,3]
Cadmium	0.1	Selenium	0.001
Chromium	0.9	Silver	0.4
Copper	0.3	Zinc	1.1

[1] Except as noted, applicant's estimates from ER-OL, Table 3.7-1

[2] Assumed maximum wastewater flow from which all heavy metals were removed with 75% solids removed in classifying centrifuge and 99.5% scrubber efficiency.

[3] Staff estimate based on beryllium concentration of 0.02 mg/L in wastewater

[4] Staff estimate based on mercury concentration of 0.0005 mg/L in wastewater

4.2.7 Power Transmission System

Since publication of the FES-CP, the applicant has modified routes for portions of the transmission system; the configuration and design of the conductors and towers for the transmission system have not been altered. When completed, the system will consist of three parts: "Project 1," "Project 3," and the "PVNGS-to-Devers" project. Project 1 has been modified from the descriptions given in the FES-CP (Section 3.8.1); Project 3 is the same as was described in the FES-CP (Section 3.8.3); and Projects 2 and 4 described in the FES-CP (Section 3.8.2 and Final Supplement) are no longer part of the transmission system. As a result of the changes, the transmission system rights-of-way will extend a total of 1007 km (626 mi) and occupy 6700 ha (16,600 acres) instead of the 871 km (541 mi) and 5900 ha (14,500 acres) indicated in the FES-CP; the area actually occupied by the tower bases will be much smaller.

4.2.7.1 Project 1

Project 1 will consist of three 525-kV lines originating at the PVNGS and terminating at three existing substations: Westwing, Kyrene, and Saguaro. The routes of Project 1 are shown in Figure 4.2.

The description of the PVNGS-to-Westwing route given in the FES-CP (Section 3.8.1) remains valid. The Westwing route originally was planned as a two-line corridor; however, the applicant has determined that only one line is now required. Construction of that line (PVNGS to Westwing substation transmission line No. 1) was completed in November 1979. A second line may be added at a later date (ER-OL, Section 3.9.1.1).

The PVNGS-to-Kyrene route leaves PVNGS in a common corridor with the Saguaro route. From Mile 7 to Mile 24.6, the Kyrene/Saguaro corridor parallels an El Paso Natural Gas Co. (EPNG) pipeline route in an easterly direction. From Mile 24.6 the Kyrene route runs northeasterly for 16 km (10 mi), passing through Rainbow Valley, to an EPNG pipeline route that it parallels from Mile 34.6 to Mile 36.7. The Kyrene route then parallels a Tucson Electric Power Co. 345-kV line to Mile 40.2. The route then turns east, paralleling a U.S. Bureau of Reclamation 230-kV line to Mile 44.9. The route proceeds 15 km (9.5 mi) southeast to the boundary of the Gila River Indian Reservation. At Mile 54.4, the route proceeds east for about 24 km (15 mi) and crosses Interstate 10 at Mile 69. The route then turns northeast at Mile 69.5 and reaches the Kyrene substation at Mile 74. Construction of the PVNGS-to-Kyrene line began in April 1981 and is expected to be completed in August 1982.

The description of the PVNGS-to-Saguaro route given in Section 3.8.1 of the FES-CP remains valid. Construction is expected to begin in June 1984 and to be completed in April 1986.

4.2.7.2 Project 3

The description of Project 3 (Greenlee substation to the Rio Grande power station terminal) given in Section 3.8.3 of the FES-CP remains valid. Construction is expected to begin in January 1983 and to be completed in May 1984.

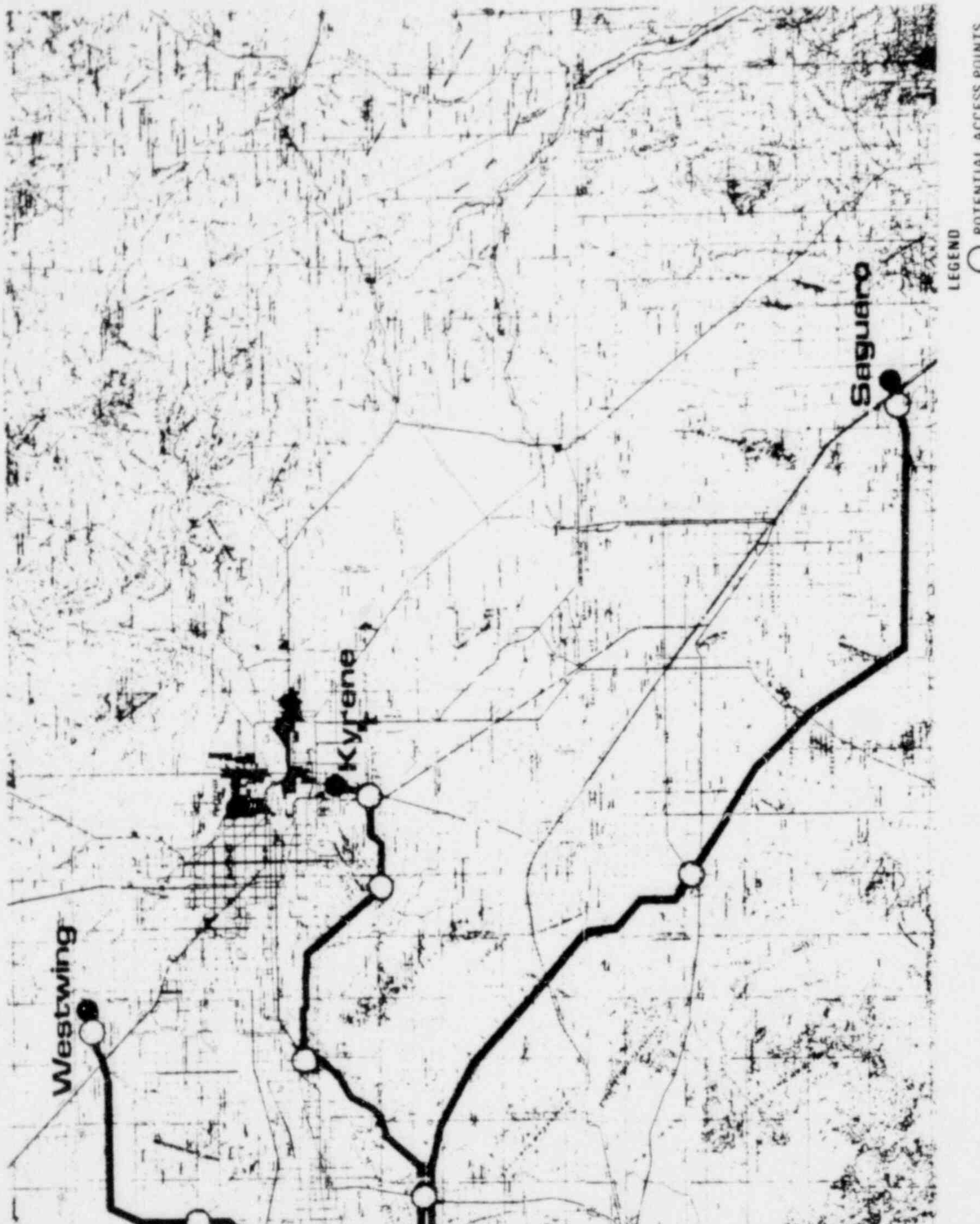

Figure 4.2 PVNGS transmission line routes, Project 1 (from ER-OL Supplement 2, Figure 3.9-1).

4.2.7.3 PVNGS to Devers

The PVNGS-to-Devers transmission system is evaluated in the U.S. Department of the Interior (Bureau of Land Management) and U.S. Nuclear Regulatory Commission document entitled "Final Environmental Statement, Palo Verde-Devers 500-kV Transmission Line," which was issued in February 1979; it will not be further considered in this document.

4.2.8 Water Conveyance System

The wastewater conveyance pipeline route from the Phoenix 91st Avenue sewage treatment plant to the PVNGS site was selected, and construction of the pipeline has been completed since issuance of the FES-CP. The original design was for a route 57.1 km (35.5 mi) long (FES-CP, Section 3.9). The current route (shown in Figure 4.3) is 58.7 km (36.5 mi) long. A 290-cm (114-in.) pipeline leaves the 91st Avenue sewage treatment plant conveying wastewater by means of gravity flow for about 10 km (6 mi) before the pipeline is reduced to a 240-cm (96-in.) diameter. At 15 km (9.3 mi), the pipeline reaches a turnout for delivery of portions of the effluent to the Buckeye Irrigation Co. canal. The effluent proceeds by gravity flow for 30.9 km (19.2 mi) to the Hassayampa pumping station. The effluent is then pumped the remaining 13 km (8 mi) to the PVNGS site via a 170-cm (66-in.) pipeline (ER-OL, Section 3.9.2).

The entire length of pipeline is underground; the manholes and vents project 0.3 to 0.6 m (1 to 2 ft) above grade at 0.8-km (0.5-mi) intervals. A 15-m (50-ft) wide permanent access right-of-way extends the entire length of the pipeline. More than half of the pipeline route is through agricultural land. The right-of-way sections passing through such land are now being renovated for future cultivation. About one-third of the route is through open desert.

4.3 Project-Related Environmental Descriptions

4.3.1 Hydrology

4.3.1.1 Surface Water

The surface water descriptions in Sections 2.2.3 and 2.5.1 of the FES-CP are still valid with some minor updating. In addition, Section 5.3.3 of this report contains a discussion of the hydrologic effects of alterations in the floodplain as required by Executive Order 11988, Floodplain Management.

In the FES-CP, it was stated that the maximum recorded flow in the Gila River below Gillespie Dam, which is about 15 mi south of the station, was 2407 m^3/s (85,000 cfs) and had occurred on December 28, 1923. This flood has been exceeded twice since September 1975 when the FES-CP was published. On March 3, 1978 a flow of 2630 m^3/s (92,900 cfs) occurred. Less than a year later, on December 20, 1978, a flood measuring 3540 m^3/s (125,000 cfs) occurred on the Gila River at the same location.

Streams in the area are usually dry and do not provide a steady surface water supply. However, flow in the Salt and Gila Rivers immediately downstream from the 91st Avenue and 23rd Avenue sewage treatment plants in Phoenix is perennial,

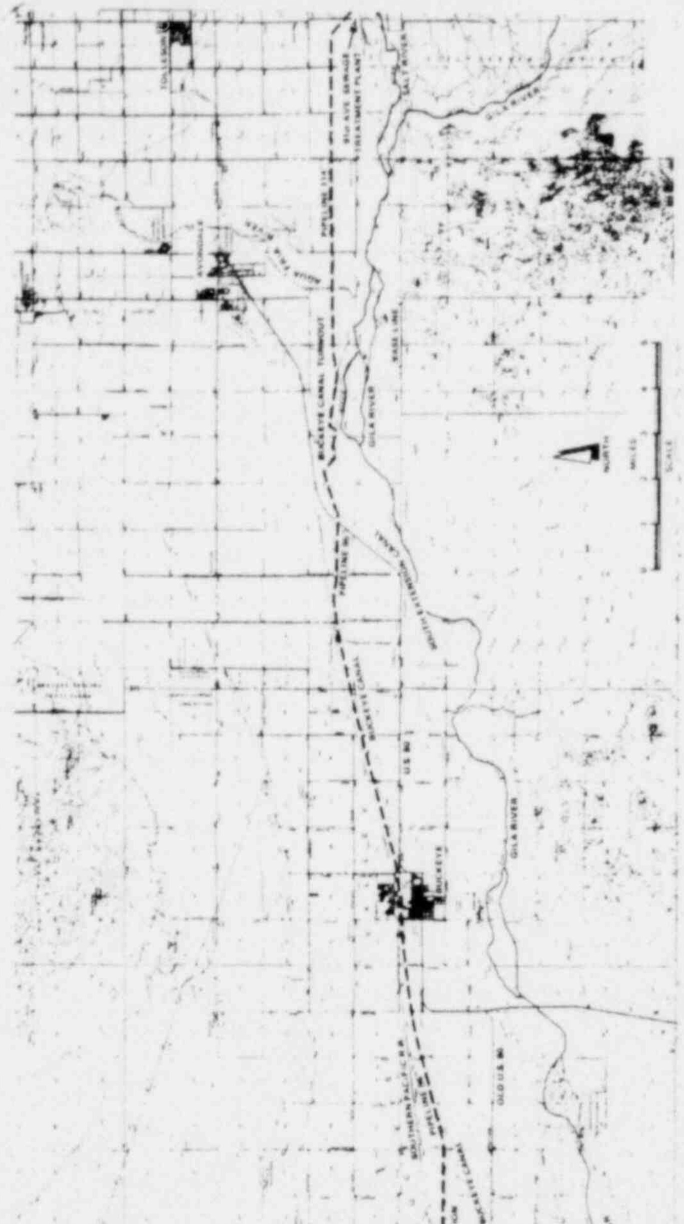

Figure 4.3 PVNGS wastewater conveyance pipeline route (from ER-OL, Supplement 2, Figure 3.9-5)

consisting mostly of effluent from the plants. The PVNGS will use some of the sewage effluent from the 91st Avenue plant for cooling water purposes. This effluent will be transported to the PVNGS by an underground pipeline as described in Section 4.2.8.

4.3.1.2 Groundwater

The groundwater descriptions in Sections 2.2.3 and 2.5.2 of the FES-CP are still valid with some updating of the data base. Since the FES-CP, additional exploratory borings have been made and groundwater observation wells have been constructed onsite. These borings and wells permit a better characterization of subsurface stratigraphy and groundwater conditions.

The hydrogeologic profile beneath the station is defined by three major sedimentary units. These are defined as the Upper Alluvial Unit, the Middle Fine-Grained Unit, and the Low Coarse-Grained Unit.

The Upper Alluvial Unit consists primarily of fluvial silty and gravelly sands with discontinuous clay and silty clay lenses. This unit extends to a depth of about 9 to 18 m (30 to 60 ft) beneath the station.

The Middle Fine Grained Unit consists of massive, continuous layers of clay and silty clay, with discontinuous lenses of clayey silt, clayey sand, and silty sand. This unit is about 76 m (250 ft) thick beneath the station.

The Lower Coarse Grained Unit consists of variably cemented conglomerate of volcanic flow, tuff, and sandstone. This unit has ground water under artesian conditions and is the regional aquifer. The Middle Fine-Grained Unit serves as an effective aquiclude, isolating the Upper Alluvial Unit from the regional aquifer. Groundwater exists under water table conditions in the Upper Alluvial Unit.

The PVNGS is located in an area that was under cultivation from about 1950 to 1975. Water for crop irrigation was pumped from the regional aquifer. Most of this water was consumed by crops but some infiltrated the soil and formed a perched groundwater mound on top of the Middle Fine Grained Unit. Since 1975, when agricultural activity stopped at the site, the groundwater mound has declined slowly by flowing radially outward from the center of the mound and to a much lesser degree, by downward movement through the middle unit. During the period 1975 to 1981, the perched groundwater mound declined at an average rate of about 0.6 m/yr (2 ft/yr). The opposite effect has occurred in the regional aquifer where water levels have risen since irrigation at the site was stopped in late 1975.

During the period 1962 through 1972, four irrigation wells within the PVNGS boundary yielded an average of about 7.40×10^6 m^3/yr (6000 acre-ft/yr) of water. This heavy pumpage resulted in a localized depression in regional groundwater levels beneath the site. When construction of the PVNGS was started in 1976, only two of the four onsite wells were retained for use during construction. During the period 1976 through 1978, the combined pumpage rate from these two onsite wells averaged about 4.32×10^5 m^3/yr (350 acre-ft/yr). This quantity is about 6 percent of the annual withdrawal during the last few years of irrigation. This reduction in groundwater withdrawal (7.40×10^6 m^3/yr to 4.32×10^5 m^3/yr (6,000 to 350 acre-ft/yr)) has resulted in a water level rise in the regional aquifer of about 6.1 m (20 ft).

4.3.2 Water Quality

4.3.2.1 Surface Water

The applicant has provided updated information on surface water quality. Periodic water-quality data obtained by the U.S. Geological Survey below Gillespie Dam show a maximum dissolved solids concentration of 4470 mg/L, an average of 3312 mg/L, and a minimum of 195 mg/L (ER-OL, Section 2.4.1).

4.3.2.2 91st Avenue Sewage Effluent

The 91st Avenue sewage treatment facility (from which PVNGS cooling water will be obtained) treats the wastewater from much of the Phoenix metropolitan area. Treatment includes screening of coarse solids, grit removal, primary sedimentation, secondary treatment by the activated sludge process, final clarification, and chlorination. The facility consists of three 1.3-m^3/s (30-million gpd) operating modules, for a total capacity of 3.9 m^3/s (90 million gpd). Another 1.3-m^3/s module is currently being built; construction is expected to be completed in 1983 (City of Phoenix). In January 1981, the 91st Avenue facility was operating about 0.2 m^3/s (5 million gpd) above capacity, resulting in the discharge of lower quality effluent than the plant is designed for.

The 5-day biochemical oxygen demand has been estimated by the 91st Avenue plant personnel to range between 16 and 38 mg/L. The facility has been granted a variance to exceed the 30 mg/L limit (up to a maximum of 60 mg/L) until the fourth operating module is completed. Based on population projections, the sewage treatment plant personnel expect the 60 mg/L limit to be reached by the end of 1981.

Although the 91st Avenue facility was designed to treat only domestic wastes, an estimated 10 percent of the sewage coming to the plant comes from commercial and industrial sources, resulting in increased concentrations of heavy metals and other wastes in the influent. The personnel at the treatment plant have observed periods when loads of industrial wastes have proven toxic to the aerobic organisms in the activated sludge, resulting in shutdown of portions of the facility for up to 8 days. However, the applicant expects that these shock loads can be detected before the effluent reaches PVNGS (Engineering News Record). The staff expects poorer water quality in the 91st Avenue effluent during these periods, but this should not affect the biological nitrification system in the PVNGS water reclamation plant, because the small portion of the poor quality effluent that is discharged from the 91st Avenue plant prior to shutdown will be diverted away from PVNGS and discharged into the Gila River.

4.3.2.3 Groundwater

The description of the groundwater quality given in Section 2.5.3 of the FES-CP remains valid.

4.3.3 Meteorology and Air Quality

4.3.3.1 Meteorology

The meteorological conditions described in the CP-FES have not changed and will not be further described here.

4.3.3.2 Air Quality

Information on the air quality in Maricopa County has become available since issuance of the FES-CP (Petrenka and ER-OL, Section 2.3.2.1.7). The Phoenix metropolitan area is not in compliance with National Ambient Air Quality Standards (NAAQS) for three pollutants: carbon monoxide (CO), ozone (O_3), and total suspended particulates (TSP) (Petrenka). Data from Buckeye, Arizona (29 km (18 mi) east of PVNGS) indicate that, with the exception of TSP, the area is in compliance with NAAQS (ER-OL, Table 2.3-24B). Because of natural phenomena such as dust storms and agricultural activities, as well as vehicle traffic on unpaved roads, the applicant stated that the general area in which the PVNGS site is located probably is not in compliance with standards for TSP (ER-OL, Table 2.3.24B).

4.3.4 Ecology

The ecology in the vicinity of the PVNGS is generally the same as was described in the FES-CP (Section 2.7),* with the exception of the aquatic systems of the nearby Salt and Gila Rivers, which have continued to be disrupted by Maricopa County Flood Control District management of river flows. Riparian vegetation occurs in varying densities along the Salt-Gila system; some of this vegetation is dependent on wastewater effluent from the 23rd Avenue and 91st Avenue sewage plants (Hasse, Blair, and NUREG-0522). Of the four river segments shown in Figure 4.4, portions of the riparian habitat in Segments B and D have been altered since issuance of the FES-CP.

In River Segment B, the Maricopa County Flood Control District completed clearing a 300-m (100-ft) strip from 91st Avenue to 123rd Avenue in January 1981 (Blair). Most of the salt cedars in the strip were cleared, but the cottonwoods and willows were preserved.

In River Segment D, the Maricopa County Flood Control District cleared about 10 km (6 mi) of salt cedars upstream from Gillespie Dam in a strip 90 m (300 ft) wide during 1980. In December of 1980, an additional 12 ha (30 acres) of salt cedars were cleared from immediately above Gillespie Dam (Blair). An additional strip about 14 to 23 km (8.6 to 14 mi) long and 0.3 to 0.6 km (0.2 to 0.4 mi)

*Detailed descriptions can also be found in Haase, Blair, Halpenny 1975 and 1977, NUREG-0522, and Wigal.

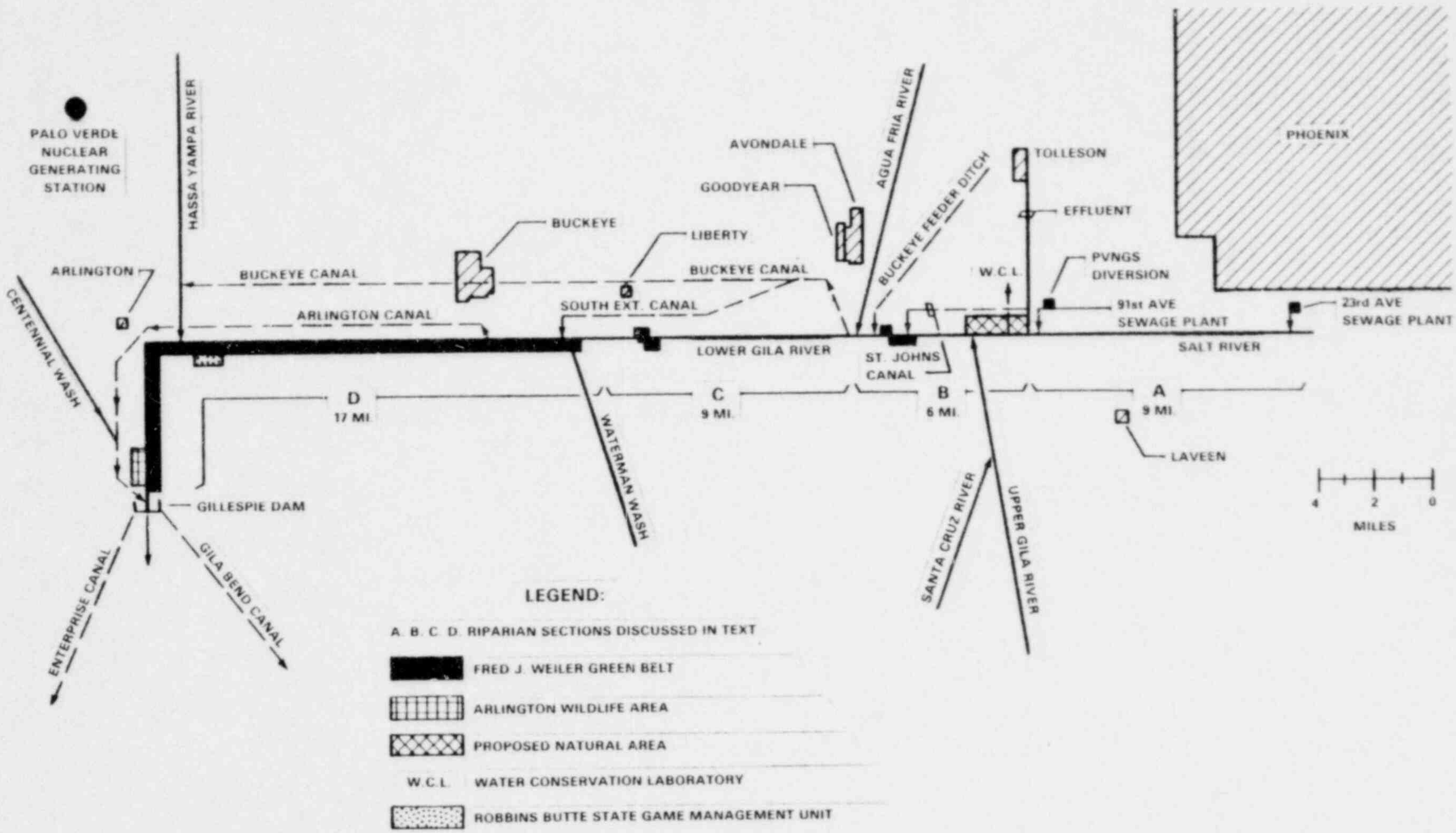

Figure 4.4 Diagram of the major water sources and diversions, Phoenix 23rd Avenue Sewage Plant to Gillespie Dam (NUREG-0522).

wide between 123rd Avenue and the Gillespie Dam may also be cleared. This portion of the Gila River, which is within the jurisdiction of the U.S. Bureau of Land Management and U.S. Fish and Wildlife Service, underwent an environmental assessment by Federal and state wildlife agencies (Blair). The U.S. Fish and Wildlife Service filed a final environmental impact statement on clearing of vegetation along the Salt and Gila Rivers from the 91st Avenue plant to Gillespie Dam on November 1981 (Blair).

4.3.5 Threatened and Endangered Species

Since issuance of the FES-CP, the U.S. Fish and Wildlife Service has determined that only three species Federally listed or proposed as threatened or endangered are in the vicinity of PVNGS (Appendix B). These species are the peregrine falcon, southern bald eagle, and Yuma clapper rail. None have been observed on the PVNGS site. The Yuma clapper rail is known to nest in marshes north of the proposed crossing of the PVNGS-Devers transmission line on the Colorado River (Bureau of Land Management). The bald eagle also forages along the Colorado River. The peregrine falcon may hunt in the vicinity of PVNGS.

In addition to the federally listed species, several species listed by the state as endangered or unique (Arizona Game and Fish Commission) are known to occur in areas affected by PVNGS. These species are discussed in the FES-CP (Section 2.7) and in Chow and Halpenny 1977 and 1978.

4.3.6 Historic and Archeological Sites

There are no registered historic properties, natural areas, or scenic features on or near the PVNGS site (ER-OL, pp. 2.6-1 and 2). Thirteen archeological sites were found on the site; the archeological evidence at these sites has been preserved and analyzed to the satisfaction of the State Historic Preservation Officer (SHPO) (ER-OL, p. 2.6-1).

Thirteen archeological sites were found during a survey of the wastewater conveyance right of way. The SHPO has approved the plan for protecting these sites and indicated that five of the sites were eligible for the National Register (Hall 1977). There are no registered historic properties currently located in or near the right-of-way (ER-OL, p. 2.6-4). The five elements of the PVNGS transmission system have been described in Section 4.2.7. The archeological mitigation plan for the Westwing transmission corridor had been approved by the SHPO (Hall 1978). Two sites were excavated and their contents analyzed (Yablon). The Bureau of Land Management and the SHPO determined that five sites found in the Kyrene corridor would not be adversely affected by the transmission line (Hall 1979). This determination was concurred in by the Advisory Council on Historic Preservation (Wall). There are no historic properties located on or near these proposed transmission routes (ER-OL, p. 2.6-3). Archeological surveys of the Project 3 corridor indicate minimal impact on noneligible archeological sites (New Mexico Environmental Institute). No historic properties or natural features are located on or near this proposed route (ER-OL, p. 2.6-3). No archeological surveys have been undertaken in the PVNGS-to-Saguaro corridor because the construction of this line is not scheduled until 1984-1986. When a final alignment for the Saguaro transmission line is selected, appropriate archeological surveys will be undertaken and submitted for staff review and evaluation pursuant to condition 7.f. of the construction permit (FES-CP, p. iii).

4.3.7 Socioeconomic Characteristics

The general socioeconomic characteristics of the PVNGS region are described in Section 2.2 of the FES-CP. However, since issuance of that document there have been major demographic changes in the immediate vicinity of the PVNGS site and in the surrounding region. Changes in the site vicinity have, for the most part, been related to station construction; changes in the region have been related chiefly to the continuing growth and development of the Phoenix metropolitan area.

4.3.7.1 Demography

The 1980 U.S. Census data indicate that considerable population growth was experienced in the PVNGS region over the past decade (Bureau of Census, Arizona Department of Economic Security). Overall, within 80 km (50 mi) of the site the population of communities with 500 or more people increased 44.5 percent; however, there was considerable variation among communities. The greatest rates of growth occurred in suburbs northwest of Phoenix.

Between 1970 and 1978 the population within an 8-km (5-mi) radius of PVNGS increased 437 percent (from 211 to 1134 persons) (Figure 2.5, FES-CP; Figure 2.1-3, ER-OL). Approximately 95 percent of this growth occurred in the northeastern portion of the 8-km (5-mi) radius. Most of this growth can be attributed to the expansion of trailer parks on Salome Highway at Wintersburg Road and at 371st Avenue (ER-OL, Section 2.1.3.1.1). Similar growth (from 0 to 174 persons) occurred about 13 km (8 mi) northwest of PVNGS, mainly as a result of a new housing development just south of the Interstate 10-Tonapah Interchange (411th Avenue). The expansion of the two trailer parks and the construction of new housing were principally because of the influx of workers for the PVNGS construction.

4.3.7.2 Offsite Land Use

Since issuance of the FES-CP, land-use changes have occurred within the PVNGS region as a result of construction of the station and as a result of general growth in the Phoenix metropolitan area.

There is now an interchange at the intersection of Interstate 10 and Wintersburg Road, the main public access route to the station. This interchange, not planned at the time the FES-CP was issued, improves access to the station for commuters from the Phoenix area by by-passing the City of Buckeye. Interstate 10 is now completed to Dysart Road (131st Avenue), about 10 km (6 mi) west of the Phoenix city limits.

Expansion of the Phoenix metropolitan area has resulted in other land-use changes in the PVNGS region. A 4422-unit housing complex is being constructed about 8 km (5 mi) north-northeast of Buckeye and 32 km (20 mi) from PVNGS, and a 60-unit apartment complex is being constructed in east Buckeye.

4.3.7.3 Economics

Arizona is a "Sun Belt" state that has been experiencing rapid economic growth. Between 1970 and 1980, while the state's population increased 53.1 percent, personal income, per capita income, and employment increased 261.1 percent, 137.1 percent, and 72.5 percent, respectively, much greater than the national average. Maricopa County, where PVNGS is located, experienced similar levels of growth over this period and is expected to continue such growth during the 1980s (Western Savings and Loan, pp. 12, 14, and 15).

4.3.7.4 Ambient Noise

Before construction, the applicant measured ambient sound pressure levels at 10 sampling points on and around the site (see ER-OL, Figures 2.7-1 through 2.7-3). The quantity measured was L_{50}, which is defined as the A-weighted sound level equaled or exceeded 50 percent of the time. Levels at the sampling points varied from 17 to 60 dBA, with an overall measured average of 34 dBA (ER-OL p. 2.7-1). The dominant ambient source is traffic on the Buckeye-Salome Road.

4.4 References

Arizona Department of Economic Security, "Preliminary 1980 Census Estimates," 1981.

Arizona Game and Fish Commission, "Threatened and Unique Wildlife of Arizona," October 1978.

Blair, Benham, and Affiliates, Inc., preparers, "Draft Environmental Impact Statement, Cleaning of Phreatophytic Vegetation from the Salt and Gila Rivers, Ninety-first Avenue to Gillespie Dam, Maricopa County, Arizona," for Flood Control District of Maricopa County, Phoenix, June 1981; "Final Statement," November 1981.

Bureau of the Census, "Advance Report, 1980 Census of Population and Housing, Arizona," U.S. Dept. of Commerce, PCH-80-V-4, 1981.

Bureau of Land Management, Phoenix, and Nuclear Regulatory Commission, "Final Environmental Statement, Palo-Verde-Devers 500 kV Transmission Line," February 1979.

Chow, V.T, "Handbook of Applied Hydrology," p. 11-8, McGraw-Hill, 1964.

City of Phoenix, "91st Avenue Sewage Treatment Plant," Division of Sewers, Water and Sewers Department, August 1978.

Engineering News Record, "A-Plants Rely on Jinx-Free AWT," April 17, 1980.

Haase, E.F., "Draft Environmental Study: Gila River from the Confluence of the Salt River Downstream to Gillespie Dam," prepared for the U.S. Army Engineering District, Los Angeles, January 1973.

Hall, Dorothy, Arizona SHPO, letter dated August 9, 1977, to Dr. Robert Gilbert, NRC.

Hall, Dorothy, Arizona SHPO, letter dated September 9, 1978, to Bob Buffington, Arizona State Director of Bureau of Land Management.

Hall, Dorothy, Arizona SHPO, letter dated February 27, 1979, to Bob Buffington, Arizona State Director of Bureau of Land Management.

Halpenny, L.C. and D.K. Greene, "Water Balance Investigations of River Bed, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Arizona," Water Development Corp., Tucson, 1975.

Halpenny, L.C., and S.D. Clark, "1977 Supplement to Water Balance Investigations of River Bed, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Arizona," Water Development Corp., Tucson, 1977.

Metcalf and Eddy, "Wastewater Engineering: Collection, Treatment, Disposal," p. 31, McGraw-Hill, 1972.

New Mexico Environmental Institute, "Environmental Impact Study of Proposed 345-kV Power Transmission Line Corridors from Dona Ana County, New Mexico to Greenlee County, Arizona," prepared for the EL Paso Electric Company, January 1974.

Petrenka, R., "1979 Maricopa County Non-attainment Area Report on Reasonable Further Progress Toward Attainment of Federal Air Quality Standards for Carbon Monoxide, Ozone and Total Suspended Particulates," Maricopa County Department of Health Services, Bureau of Air Pollution Control, October 1980.

U.S. Nuclear Regulatory Commission, "Draft Environmental Statement Related to Construction of Palo Verde Nuclear Generating Station Units 4 & 5," Docket Nos. STN 50-592, STN 50-593, NUREG-0522, April 1979.

Wall, Louis S., Western Office of Review and Compliance, letter dated April 6, 1979 to Acting State Director, Bureau of Land Management.

Western Savings and Loan Association Marketing Research Department, "Forecast 1981," 1981.

Wigal, D.D., "A Survey of the Nesting Habitats of the White-winged Dove in Arizona," Arizona Game and Fish. Dept., Research Div., Special Report No. 2, 1973.

Yablon, Ronald, preparer, "Final Report No. 4: Palo Verde to Westwing Transmission System: Intensive Survey of Tower Pulling Locations and Selected Small Parcels," submitted by Donald E. Weaver, Jr. of the Museum of Northern Arizona, November 16, 1978.

5 ENVIRONMENTAL CONSEQUENCES AND MITIGATING ACTIONS

5.1 Résumé

Environmental consequences of operation of PVNGS Units 1, 2, and 3 related to new information or design changes that have occurred since the FES-CP review are evaluated in the following sections. Where relevant, discussions of monitoring and mitigative actions have been included as part of the appropriate subsections. Water use and water quality impacts have changed because of changes in station design and operation (Section 5.3). The magnitude of impacts on air quality from fogging and drift during station operation is expected to be less than was projected in the FES-CP because of design changes and new information (Section 5.4). Anticipated impacts on terrestrial ecology and riparian habitats have changed since the preconstruction review as a result of changes in station design and operation procedures (Section 5.5). Potential impacts on endangered and threatened species in the PVNGS region are evaluated in Section 5.6. Impacts expected on the historic and archeological sites are reevaluated on the basis of new information (Section 5.7). There have been changes in the estimates of the operating work force, resulting in changes in impacts expected on the local economy, tax revenues generated, and community services and institutions; potential impacts on public health from station operation are also evaluated on the basis of new information (Section 5.8). New information on radiological impacts, the uranium fuel cycle impacts, decommissioning, and emergency planning impacts is provided (Sections 5.9 through 5.12).

5.2 Site Land Use

The station site is approximately 140 ha (350 acres) larger than stated in the FES-CP. There have been no other land-use changes, and the staff's evaluation of land-use impacts given in Section 5.1 in the FES-CP remains valid. More than 50 percent of the PVNGS construction has been completed.

5.3 Water

5.3.1 Use

5.3.1.1 Surface Water

Sections 4.2.1 and 5.5.1.1 of the FES-CP provided a description of surface water use. The following material supplements that description.

The primary source of cooling water for the PVNGS will be sewage effluent from the Phoenix 91st Avenue sewage treatment plant and from the City of Tolleson sewage treatment plant (see Figure 4.3).

In the FES-CP, availability of sewage effluent was estimated by assuming a linear increase in sewage effluent based on projected population growth. Since issuance of the FES-CP, projections of sewage effluent production were made independently by the U.S. Army Corps of Engineers (COE) in 1979 and the U.S.

Environmental Protection Agency (EPA) for the Maricopa Association of Governments (EPA 1979), and by the City of Phoenix Water and Sewer Department. These projections are shown in Table 5.1.

Table 5.1 1979 projected flows from the 91st Avenue plant, m^3 (acre-ft), 1980-2000

Estimate	1980	1983	1986	1990	1995	2000
COE-EPA	1.17×10^8 (94,600)	1.35×10^8 (109,800)	1.46×10^8 (118,000)	1.57×10^8 (127,300)	1.72×10^8 (139,200)	1.89×10^8 (153,400)
City of Phoenix	1.24×10^8 (100,200)	1.43×10^8 (116,000)	1.62×10^8 (131,600)	1.89×10^8 (153,100)	2.21×10^8 (179,500)	2.45×10^8 (205,900)

The COE-EPA projections were prepared on the basis of the Arizona Department of Economic Security (ADES) population projections made in 1977, population allocations made by the Maricopa Association of Governments (MAG), wastewater unit flows developed in the MAG 208 Water Quality Management Program (MAG 208 Program), and waste flow reduction projections also developed in the MAG 208 program. More recent population projections (July 1978) made by the ADES show a slightly larger population for the year 2000 and an earlier staging of population growth (EPA 1979). Because these 1978 projections indicate a higher population than that expected when the COE-EPA sewage effluent projections were made, the staff concludes that there will probably also be a correspondingly higher amount of sewage effluent available than the COE-EPA values shown in Table 5.1. This possibility is supported by the fact that, in 1980, the actual flow from the 91st Avenue plant was larger than the flow projected by COE-EPA. This flow was 1.22×10^8 m^3 (99,100 acre-ft). The COE-EPA projected flow for 1980 is 1.17×10^8 m^3 (94,600 acre-ft).

More recently, in August 1981, the City of Phoenix revised its 1979 sewage effluent projections (Steyler 1981). In September 1981, MAG also revised the projections that the COE-EPA had made in 1979 (MAG 1981). As shown in Table 5.2, both of these more current projections indicate that more sewage effluent will be available than had been projected in 1979.

Table 5.2 1981 projected flows from the 91st Avenue plant, m^3 (acre-ft), 1985-2000

Estimate	1985	1986	1990	1995	2000
COE-EPA	1.43×10^8 (116,030)	1.47×10^8 (119,500)	1.64×10^8 (133,280)	1.84×10^8 (149,410)	2.09×10^8 (169,680)
City of Phoenix	1.77×10^8 (143,470)	1.85×10^8 (150,300)	2.19×10^8 (177,810)	2.61×10^8 (211,800)	3.06×10^8 (247,740)

In Section 5.5.1.1 of the FES-CP, it was determined that the least amount of sewage effluent available in the Salt and Gila Rivers downstream of the PVNGS diversion would occur when all three Palo Verde units were to be operational. This conclusion is still valid. The amount of sewage effluent projected to be available in 1986, the earliest that all three units would be operational (Table 5.2), varies from a high of 1.85×10^8 m^3 (150,300 acre-ft) to a low of 1.47×10^8 m^3 (119,500 acre-ft). However, not all of this sewage effluent will be available for use by the PVNGS. There are other contracted users of sewage effluent who have prior commitments. These are shown in Table 5.3.

Table 5.3 Committed sewage effluent, m^3/yr (acre-ft/yr)

User	Effluent volume
Buckeye Irrigation District (BID)	3.70×10^7(30,000)
Arizona Game and Fish Department (AGFD)	9.00×10^6 (7,300)
Total	4.60×10^7 (37,300)

In addition, the U.S. Water Conservation Laboratory (WCL) has a prior commitment of 1.48×10^6 m^3/yr (1200 acre-ft/yr). However, this commitment has not been used since 1978 when the WCL research facilities were washed out by flood waters.

The BID and the AGFD, by having prior commitments, are entitled to divert an amount equal to their respective commitments before PVNGS diverts effluent for station use. The BID, under an agreement with the City of Phoenix, has a right to divert 2500 acre-ft/month to satisfy its commitment of 3.7×10^7 m^3/yr (30,000 acre-ft/yr). The AGFD's agreement is for delivery of 6.52 million gpd of effluent to the Salt River channel for an annual equivalent of 9.00×10^6 m^3 (7300 acre-ft).

The applicant has informed the staff that AGFD had abandoned its attempt to perfect its right under Arizona state law as an instream use for fish and wildlife enhancement. However, in responding to the Palo Verde DES, the AGFD advised the staff that it is utilizing its commitment of 9.00×10^6 m^3 (7,300 acre-ft/yr) and intends to continue to do so.

In addition to the contract that BID has with the City of Phoenix, it also has water rights in the Salt-Gila River system, which were granted under a court decree known as the Benson-Allison Decree. During a 5-year period from 1972 to 1977, the BID diverted an average of about 1.01×10^8 m^3(82,000 acre-ft/yr) at the Buckeye Heading. This figure reflects water in the Gila River from all sources upstream and BID's contractual commitment from the City of Phoenix, which was delivered to the river channel. Of the 1.01×10^8 m^3 (82,000 acre-ft), about 1.79×10^7 m^3 (14,500 acre-ft) came from the Salt River Project feeder ditch. The balance or about 8.33×10^7 m^3 (67,500 acre-ft) is assumed to be effluent from Phoenix 91st Avenue and 23rd Avenue sewage treatment plants (EPA 1979). Thus, during the past few years the BID has diverted more than twice its commitment of 3.7×10^7 m^3/yr (30,000 acre-ft/yr).

The amount of sewage effluent that will be available for use by the BID in 1986, when all three PVNGS units become operational, will depend on whether or not the AGFD utilizes its commitment. Because the AGFD has stated that it intends to do so in the future, the staff in its analysis assumed that 9.00×10^6 m^3 (7300 acre-ft) of the effluent discharged from the 91st Avenue plant in 1986 will be available only for AGFD use. Table 5.4 shows the amount of effluent that will be available in 1986 for use by the BID.

Table 5.4 Sewage effluent available for use by the Buckeye Irrigation District in 1986

Source	COE-EPA 1981 projections, m^3 (acre-ft)	Phoenix 1981 projections, m^3 (acre-ft)
Projected flows from the 91st Avenue Plant	1.47×10^8 (119,500)	1.85×10^8 (150,300)
PVNGS	7.91×10^7 (64,100)	7.90×10^7 (64,100)
AGFD	9.00×10^6 (7,300)	9.00×10^6 (7,300)
Sewage effluent available for BID use	5.93×10^7 (48,100)	9.73×10^7 (78,900)

Assuming that the Phoenix projections are accurate, there will be sufficient effluent available to meet BID's 1972-1977 average use of 8.33×10^7 m^3/yr (67,500 acre-ft/yr) of effluent during the critical period of 1986. If, instead, the COE-EPA projections prove to be accurate, there will be a shortage of effluent from the 91st Avenue plant of about 2.40×10^7 m^3 (19,400 acre-ft).

The BID may continue to divert waters flowing in the river at its headgate in accordance with the Benson-Allison Decree. The staff believes that all or at least a major portion of this storage may be made up from the effluent being discharged into the river by Phoenix's 23rd Avenue sewage treatment plant. It is estimated (EPA 1979) that in 1986, the 23rd Avenue plant will discharge about 5.06×10^7 m^3 (41,000 acre-ft). Although the Roosevelt Irrigation District has a prior right to purchase up to 2.47×10^7 m^3 (20,000 acre-ft/yr) of this effluent, it has not yet exercised this right. In addition, McDonald Farms presently withdraws an unmeasured amount of effluent from the 23rd Avenue plant discharge canal (EPA 1979).

Another source of effluent is the City of Tolleson sewage treatment plant, which is located about 0.4 km (1/4-mile) west of the 91st Avenue plant. This facility is being expanded from 4.0 million gpd (mgd) to 8 mgd (5.53×10^6 m^3/yr to 1.11×10^7 m^3/yr or 4480 acre-ft/yr to 8960 acre-ft/yr) and is scheduled to be completed in 1982. On June 12, 1981, the applicant, the Salt River Project Agricultural Improvement and Power District, and the City of Tolleson entered into an agreement for the purchase and delivery of a maximum of 8.3 mgd (1.15×10^7 m^3 or 9292 acre-ft/yr) of effluent for use at the PVNGS. The contract recognizes Tolleson's prior commitment of up to 2.0 mgd (2.76×10^6 m^3/day or 2240 acre-ft/yr) to a local turf-grass farmer, plus an amount equal to 10 percent of the effluent available in excess of 2 mgd that Tolleson is reserving for its own use. The applicant has stated that the Tolleson effluent will be used by the PVNGS before it uses effluent from the 91st Avenue plant, thus potentially increasing the flow to the Salt River from the 91st Avenue plant and the amount of effluent available for BID use.

The above discussion assumes that BID will continue to use more than twice its commitment. Should BID use only the amount of its commitment, both the COE-EPA and the Phoenix sewage effluent projections indicate that in 1986 there will be more than enough sewage effluent available to satisfy all prior commitments plus the PVNGS needs.

The staff concludes that there will be a sufficient amount of sewage effluent available for use by the PVNGS during the critical year 1986 and throughout the life of the station.

In the FES-CP (Section 5.5.1.1) it was determined that usage of sewage effluent by the PVNGS would result in a reduction of water in the Salt and Gila Rivers downstream of the 91st Avenue Plant. The magnitude of this reduced flow was determined from the projected sewage effluent availability. Both the 1981 COE-EPA and the Phoenix projections of sewage effluent in Table 5.2 are lower than the FES-CP projections. However, as described in Section 4.2.3, the amount of effluent to be used by the PVNGS is also less than what was assumed in the FES-CP. The magnitude of flow in the Salt and Gila Rivers downstream of the 91st Avenue Plant, as determined in the FES-CP, is compared to current estimates, based on the two projections of 1986 sewage effluent in Table 5.5.
If the Phoenix projections prove to be accurate, the reduction of water in the Salt and Gila Rivers will be less than what was determined in the FES-CP. If the COE-EPA projections are accurate, the amount of water available in the Salt and Gila Rivers will be slightly less (about 1½ percent) than predicted in the FES-CP. This slight reduction, however, will not change the impact on riparian vegetation that was determined in the FES-CP review, except as described in Section 5.5.1.2

The staff concludes that the availability of water in the Salt and Gila Rivers downstream of the 91st Avenue plant will be similar to that predicted in the FES-CP.

Table 5.5 Projections of flow in the Salt and Gila Rivers compared to FES-CP values, m^3 (acre-ft)

	FES-CP values	COE-EPA projections	Phoenix projections
Total sewage effluent available when all three PVNGS units become operational	1.62×10^8 (132,000)	1.47×10^8 (119,500)	1.85×10^8 (150,300)
PVNGS usage for 3 units	9.35×10^7 (75,800)	7.9×10^7 (64,100)	7.9×10^7 (64,100)
Sewage effluent in excess of PVNGS usage	6.93×10^7 (56,200)	6.83×10^7 (55,400)	1.06×10^8 (86,200)

5.3.1.2 Groundwater

Groundwater will be pumped from the regional aquifer for domestic purposes. It is estimated that the station will require about $1.97 \times 10^6 m^3/yr$ (1600 acre-ft/yr). This rate of groundwater withdrawal is less than one-third of the withdrawal rate during the last few years of irrigation. Thus, the staff concludes that as a result of this decreased pumping rate, groundwater declines in the regional aquifer beneath the site will occur at a slower rate than that observed during the period of agricultural activity at the site.

5.3.2 Quality

5.3.2.1 Groundwater

The new liner systems for the water-storage reservoir and evaporation pond (Section 4.2.4) have a lower permeability (about 4 orders of magnitude) than the original design, thus reducing the amount of seepage expected to groundwater and reducing the potential for adverse impacts on groundwater quality.

The staff estimates that about 210 m^3 (0.2 acre-ft) of water per year will seep from the storage reservoir down into the perched-water table. The reservoir water is projected to contain 1000 mg/l of total dissolved solids (TDS), and because the TDS concentrations in the perched zone already are in the range of 1000 to 5000 mg/l, the seepage would have a small, but immeasurable, beneficial effect on the water quality of the perched zone.

The conclusion given in Section 5.2.3 of the FES-CP that very little water will seep through the evaporation pond liner remains valid. The applicant has determined that waste solutions discharged to the pond would be nonhazardous according to the EPA Resource Conservation and Recovery Act (RCRA) and Arizona Department of Health Services criteria. Final determination by EPA of RCRA compliance will not be made until the exact chemical composition is determined; the solution has already been determined nonhazardous according to the current criteria established by Arizona Hazardous Waste Regulations (ER-OL, Section 3A, Supplement 3). However, the evaporation pond will require approval/permits from the Arizona Department of Health Services, Bureau of Waste Control.

The applicant does not expect the nonradioactive solid wastes that will be disposed of onsite to be hazardous, and does not plan to line the solid-waste-disposal area (ER-OL, Section 3.7, and Appendix 3A). Although the solid wastes will contain contaminants that could be considered hazardous if 100 percent leaching occurred, the leach rates associated with the types of solid wastes to be disposed of onsite are generally low (Gray and Parker). Thus, the staff finds the decision not to line the disposal area acceptable. However, the solid-waste disposal area will require final approval by the Arizona Department of Health Services, Bureau of Waste Control.

5.3.2.2 Surface Water

Because there will be no station effluents discharged to natural surface water bodies, station operation will have no direct adverse impacts on the quality of surface water.

5.3.2.3 Monitoring and Mitigation

The integrity of the evaporation pond liner will be confirmed by periodic monitoring of leak-detection system collection points and of groundwater monitoring wells. If a leak is detected, the applicant intends to isolate the affected area and locally repair or replace the defective lining (ER-OL, Section 3.6.3.1).

During startup of the water reclamation plant, leach-rate tests, using the standard EP (Extraction Procedure) toxicity method, will be performed on the nonradioactive solid wastes to be disposed of onsite. If the leach rate exceeds the allowable limit (currently 100 percent), the applicant is committed to handling the solid wastes in accordance with the RCRA (ER-OL, Appendix 3A, Supplement 3).

5.3.3 Floodplain Aspects

The objective of the Executive Order 11988, "Floodplain Management," is "...to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative...."

There are five streams in the vicinity of the PVNGS. These are the Gila River, Hassayampa River, Centennial Wash, Winters Wash, and East Wash. With the exception of East Wash, the floodplains of these streams have not been affected by construction of the PVNGS, nor will they be affected by its operation. The East Wash channel which originally traversed the site from north to south had to be relocated during construction of the PVNGS. The new channel runs along the east site boundary and is designed to convey flows up to the magnitude of the Probable Maximum Flood (PMF), a much more severe event than the 100-yr flood. Because the new channel is now complete, the staff concludes that there are no activities or facilities related to the operation of the PVNGS which will affect any floodplains.

5.4 Air Quality

5.4.1 Fog and Drift

Although the effluents from the station's cooling towers will have atmospheric impacts (such as fogging due to the visible plume, wetting and salt deposition due to drift, visible plumes aloft), the staff believes that operation of these towers will produce no appreciable offsite impacts, and the impacts that may occur will be less than those predicted in the FES-CP (Section 5.3.2). This conclusion is based primarily on more recent observations of atmospheric impacts at power plants with mechanical-draft cooling towers (MDCTs) and on the changes in the location and design of the PVNGS towers (from rectangular to circular MDCTs).

The relocation of the cooling towers to positions much closer to the power blocks than originally proposed will help reduce offsite impacts of cooling tower plumes, fogging, and drift deposition. (The shortest distance between one of the cooling towers and the station boundary (along Wintersburg Road) for the rectangular MDCTs original proposed was about 120 m (400 ft) (FES-CP, Figure 2.3, Appendix A); for the new design, the shortest distance is 500 m (1600 ft) (Figure 4.1). Observations of impacts at operating power plants indicate that fogging and drift effects are limited to areas less than 1 km (0.6 mi) from the towers (Hanna 1975 and 1978, Champion, Carson, and Englesson). The primary offsite effect will be the esthetic impact of visible plumes in the air.

Part of the moisture in the cooling tower effluents will recondense to form a visible plume except during extremely hot and dry summer days. Under most meteorological conditions, this visible plume will rise above the cooling tower and either evaporate or level off some distance above the ground. The median visible plume lengths from nuclear power plants (with two units the size of the PVNGS reactors) in the humid, cool East are less than 0.5 km (0.3 mi) in summer and 1 km (0.6 mi) in winter (Hanna 1978). Under very cold, humid winter conditions, plumes more than 50 km (31 mi) long have been observed (Hanna 1978). The staff expects visible plumes from PVNGS to be much shorter because of the milder, less humid winter conditions expected in the vicinity of PVNGS.

During periods of strong winds, aerodynamic downwash will bring the plumes to the ground quite close to the towers; because of their buoyancy, the plumes will then rise above the ground within a short distance (100 to 300 m, or 330 to 1000 ft) of the towers (Hanna 1975 and 1978, Champion, Carson, and Englesson). The critical wind speed for the onset of aerodynamic downwash at rectangular MDCTs is about 3 to 5 m/s measured perpendicular to the long axis of the tower (Hanna 1975 and 1978). Limited field data from one operational circular mechanical-draft cooling tower (Dickey) and from water-tunnel model studies (Dickey, Kennedy, and Jain) show that the critical wind speed for circular MDCTs is much higher (the exact value has not been determined) than that for rectangular MDCTs. Model studies further indicate that the plume rise from a cluster of towers is greater than that from a single tower (Policastro).

Hence, the staff believes that the change in cooling tower design from rectangular to circular will result in significantly less fogging near the towers, greater plume rise, and longer visible plumes aloft.

Drift studies at operating MDCTs show that almost all drift droplets that reach the ground do so within a few hundred meters of the towers (Hanna 1975 and 1978, Champion, Carson, Englesson). With the change in design of cooling towers, the drift rate is expected to be only 0.0044 percent of the circulating water flow (ER-OL, Table 3.4-1) rather than the 0.01 percent calculated for the FES-CP. The staff's analysis of predicted drift deposition impacts is discussed in Section 5.5.1.1 of this statement.

Based on the above evaluations, the staff concludes that the change in design and in the location of the station's cooling towers will result in no appreciable offsite impacts due to fogging and will result in drift deposition rates that will be less than those predicted in the FES-CP.

5.4.2 Emissions and Dust

The maximum amount of particulates emitted from the cooling towers with the tower drift will be 2060 kg (4550 lb) per day; this calculation is based on a total solids level of 14,710 ppm in the circulating water system (ER-OL, Table 3.6-1), the drift emissions given in Table 3.4-1 of the ER-OL, full operation of all three reactors, and complete evaporation of the drift droplets before they fall to the ground. The particulate concentrations in the air leaving the towers under these conditions would be about 260 $\mu g/m^3$ (equal to the 24-hr National Ambient Air Quality Standards (NAAQS) for total suspended particulates at ground level). Because plume dilution and meander will rapidly reduce this peak concentration aloft, the staff expects no violations of NAAQS either off or on the site due solely to operation of PVNGS cooling towers.

There will be three principal stationary sources of combustion-product air pollutants during operation of the PVNGS: the standby diesel generators, auxiliary boilers, and recalciners (at the water reclamation plant). These emission sources and modes of their operation are discussed in Section 4.2.6 of this document and in Sections 3.7 and 5.4.2 of the ER-OL.

Using three EPA-developed dispersion models (ISC, RAM, and CRSTER) and conservative assumptions as to the duration of use of the diesel generators and auxiliary boilers, the applicant has calculated that the maximum offsite concentrations of sulfur oxides, particulates, nitrogen oxides, and carbon monoxide resulting from operation of these three stationary sources will not violate applicable state and Federal air-quality standards (ER-OL, Tables 5.4-1 and 5.4-2). A review of these model calculations leads the staff to agree with the applicant's conclusions.

Trace metal release rates to the atmosphere from the recalciners are given in Table 4.1. Trace metal emissions from this small source will be comparable to those from other oil-fired boilers of a similar heat rate. Of the several elements listed, NAAQS exist for only lead (quarterly average 1.5 $\mu g/m^3$ or less). Based on Table 5.4-2 of the ER-OL, the staff has calculated that because the lead emissions are less than 0.1 percent of the total particulates emitted by the recalciner (about 39 kg (84 lbs) per day (ER-OL, Table 5.4-1)), the maximum offsite, long-term lead concentration will be of the order of 0.0002 μg/m^3, far below the NAAQS. The U.S. Environmental Protection Agency (EPA) and State of Arizona emission standard for beryllium is 10 gm per 24 hr (40 CFR Part 61.32); the limit for mercury is 2300 gm per 24 hr (40 CFR Part 61.52). The staff expects that actual emissions of these two elements will be less than the EPA standards. The staff is not aware of any other effluent limitations on the other trace metals listed in Table 4.1. The staff expects no adverse impacts from the emissions from the recalciner at the PVNGS.

Other nonradioactive air pollutants will include (1) fugitive dust due to strong winds and operation of vehicles off paved roads and (2) exhaust emissions from vehicles (ER-OL, Sections 3.4.1 and 3.7.3).

The magnitude of the air-quality impacts from dust raised by vehicles will depend on the onsite traffic levels and patterns and on the success of any mitigative actions undertaken by the applicant (for example, sprinkling of unpaved roads). The conversion of 50 percent of the PVNGS site from agricultural use to uncultivated fields will eliminate fugitive dust caused by agricultural activities such as plowing and cultivating and will reduce the potential for dust storms.
Thus, the staff concludes that operation of PVNGS should not adversely impact the air quality in the region.

The applicant has evaluated the impact on air quality of vehicles entering and leaving the site using a conservative dispersion evaluation (ER-OL Section 5.4.2). The applicant concludes that the only significant concentrations are carbon monoxide, which are a factor of 100 below the NAAQS. The staff agrees with this evaluation and concludes that the air quality will not be severely impacted by vehicular emissions.

5.5 Ecology

5.5.1 Terrestrial

5.5.1.1 Station

Drift Deposition

As described in Sections 4.2.6.2 and 5.4.1 of this statement, drift deposition is predicted to be less than that estimated in the FES-CP (Sections 5.3.3 and 5.5.2). The maximum offsite deposition rate is now estimated to be 13.4 kg/ha (12 lb/acre) of solids per year, primarily concentrated salts. The staff has calculated that the soils in the PVNGS region contain about 2500 to 4800 kg/ha (2250 to 4300 lb/acre) of salt in the top 15 cm (6 in.). Even if all solids from offsite drift deposition accumulated in desert soils over the lifetime of PVNGS, soil salinity would not be altered sufficiently to impact biota (NUREG-0522). Thus, the staff does not expect impacts from salt-drift deposition.

Onsite Water Storage Reservoir

As described in the FES-CP (Section 5.5.1.2), migratory waterfowl are likely to be attracted to the water storage reservoir as a source of water and food. The design of the water storage reservoir liner has been changed since the FES-CP;

rubberized asphalt will now be used instead of soil-cement. Because the synthetic rubber layer of the new liner may be more inhibitory toward emergent vegetation than soil-cement (Keys), there may be a smaller potential for development of nesting habitat and cover than was assessed in the FES-CP. Other staff evaluations given in the FES-CP relating to the potential for impacts resulting from wildlife use of the reservoir remain valid.

Evaporation Pond

The staff's evaluation (FES-CP Section 5.5.2) of potential wildlife impacts from the discharges to the evaporation pond remains valid because conditions have not altered since that assessment.

Noise

The effects of noise on desert wildlife are not well known (NUREG-0522, Fletcher 1971 and 1978). If wildlife respond to noise in a manner similar to the way humans respond, the effects of station noise on local wildlife should not be noticeable much beyond the site boundaries because sound attenuates rapidly with distance. However, the staff believes that noise may discourage some wildlife from using habitat immediately adjacent to the site.

5.5.1.2 Wastewater Diversion

As indicated in Section 5.3.1, the effect of PVNGS on water availability in the Salt and Gila Rivers will be about the same as was predicted in Section 5.5.1.1 of the FES-CP. Consequently, there will be no appreciable changes in the impacts to riparian vegetation.

Vegetation in Segment B (see Figure 4.4) is primarily dependent upon wastewater effluent as a water source. The water table in this segment is too deep to support the dense vegetation currently present (NUREG-0522, Fletcher 1971, Maricopa, Blair, Halpenny 1975 and 1977). Thus, the staff believes that vegetation could be reduced by amounts proportional to the projected reductions in wastewater flow if the water is diverted for PVNGS and the Buckeye Irrigation District. The exact amount of this reduction will depend upon the degree to which the riparian vegetation is dependent upon water flow and streamflow current patterns.

Diversion will also result in reduction of flows in Segments C and D; however, Segment C should not be greatly impacted by the decreased water availability, primarily because vegetation is currently sparse. Wastewater effluent is less than 16 percent of the input to Segment D; thus, the greenbelt immediately above Gillespie Dam should not be greatly affected by diversion.

The staff concludes, based on the estimates given in Section 5.3.1, that diversion of wastewater for PVNGS and Buckeye Irrigation District could result in a reduction of high-quality wildlife habitat in Segment B in 1986, and anticipates that most of the riparian habitat would recover by the year 2000 when water flow will achieve nearly 100 percent of 1980 levels.

5.5.1.3 Transmission System

Operation

Induced Voltages and Low-Level Electrostatic Fields. The staff has reviewed the environmental impacts which could be associated with the operation of the PVNGS transmission system. The potential sources of impacts are (1) ozone production, (2) induced electrical currents, (3) electric fields, and (4) corridor maintenance.

Except for items (2) and (3), impacts associated with the operation of PVNGS transmission lines are not expected to change significantly from those discussed at the CP stage of review.

Potential biological effects from electrical fields associated with transmission lines have been reviewed by the staff (Department of Energy, EPRI) While experimental work is still underway on the biological effects of electric fields along transmission lines, the staff has found no evidence at this time that the operation of PVNGS transmission lines will have a significant effect on the health of humans or that it will affect plant or animal life.

The applicant has designed its transmission system in accordance with practices approved by the National Electric Safety Code to ensure the safeguard of persons from shock hazards arising from operation of transmission lines.

The staff believes it unlikely that induced shock, described in Section 5.5.2.2 of the FES-CP, will be a problem to biota along the transmission line corridors. Most natural biota are normally grounded and are unlikely to accumulate lethal voltages. Even raptors perched on the towers are unlikely to build up an induced voltage because they are grounded through the tower. The line spacing would be sufficiently great to preclude short circuiting by outspread eagle wings (2.4 m or 8 ft) (NUREG-0522).

Ozone and Noise. The staff's evaluation in Section 5.5.2.2 of the FES-CP that the ozone and audible noise generated by the corona discharge during transmission line operation will not affect biota in the vicinity of the lines remain valid.

Rights-of-Way Maintenance

Maintenance plans for the transmission line rights of way have not changed since the FES-CP was issued. Thus, the staff's evaluation that adverse biotic impacts would be minimal remains valid.

5.5.1.4 Monitoring

Although diversion of wastewater from the Salt-Gila streambed will be a major impact of PVNGS operation on riparian habitat, the staff does not feel an ecological monitoring program should be required. Monitoring of the riparian vegetation will not distinguish the impacts of diversion from the effects of other phenomena, such as flooding. In addition, the effects of water diversion are largely unmitigatable, except by providing an alternative source of water flow.

5.5.2 Aquatic

There are no natural aquatic systems on the PVNGS site. The storage reservoir and the evaporation pond will provide some artificial aquatic habitat for the lifetime of the station. This will not affect the integrity of any populations of aquatic biota in the PVNGS region, because these habitats will not be associated with natural aquatic systems.

Withdrawal of water from the Salt-Gila system will reduce aquatic habitat in the area below 91st Avenue. However, because of PVNGS design changes, less water will be diverted from the Salt-Gila system than was predicted in the FES-CP (Section 5.5.1.1). Thus, the staff concludes 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. Reduction in wastewater flow through the stream bed may enhance development of more naturally structured aquatic communities by improving water quality (NUREG-0522).

5.6 Threatened and Endangered Species

As indicated in Section 4.3.5 and Appendix B, three species listed as threatened or endangered may be impacted by operation of PVNGS. These are the peregrine falcon, the bald eagle, and the Yuma clapper rail.

The staff has concluded that PVNGS operation may influence only a small portion of the foraging areas of the two raptor species, the peregrine falcon and the bald eagle. Electrocution of these species on transmission lines is unlikely because the conductor spacing is too great for raptors to ground themselves while in contact with a conductor.

The Yuma clapper rail has been reported as occasionally breeding (three observations) in the marshes of the Salt-Gila system below 91st Avenue (Blair). Reduction of the marshes in River Segment B (lower Gila River) would also reduce breeding habitat available for this species. However, there have been only infrequent sightings of the clapper rail nesting in this area, and it is unlikely that the clearing of these marshes will eliminate critical breeding habitat. Primary breeding areas are located along the Colorado River. The U.S. Bureau of Land Management and U.S. Fish and Wildlife Service have concluded that the PVNGS-to-Devers transmission line would have no adverse impacts on the Yuma clapper rail populations where the transmission line crosses the Colorado River (Bureau of Land Management, U.S. Fish and Wildlife Service).

5.7 Historic and Archeological Sites

Based on the surveys undertaken and the mitigation plans developed, the operation of PVNGS will not adversely impact existing archeological resources or historic sites, (see letter from State Historic Preservation Officer to Director, Division of Licensing, February 3, 1982, in Appendix H that is in agreement with the staff evaluation). The staff is working with the applicant to get a formal determination of eligibility to the Keeper of the National Register for four sites in the wastewater conveyance system and a letter from the New

Mexico SHPO on sites in the Project 3 corridor (Tedesco). The applicant is taking appropriate measures to protect the area during this process. If these sites are determined eligible and any ground disturbance of these areas become necessary in the future, the applicant will notify the NRC and will consult with the SHPO to develop an appropriate mitigation plan. At this time the staff believes the possibility of operational disturbances is remote.

5.8 Socioeconomics

5.8.1 Local Economy

The economic benefits to be generated by the operation of PVNGS are detailed in Section 8.1 of the ER-OL (with supplements). In some cases, the applicant expects these benefits to be different from those originally projected in the FES-CP (Section 5.6). In summary, when the station is fully operating, the staff and applicant now expect it annually to produce (in 1986 dollars) about $1.58 billion worth of electricity, pay 844 operating personnel about $27.7 million in salaries, make local purchases averaging about $18.9 million, and buy $1.3 to $1.9 million worth of wastewater effluent from Phoenix and five other nearby cities. The staff believes that these economic benefits are large enough to contribute incrementally to local economic growth but are not so large as to distort the local economy. For example, although PVNGS's annual payroll will be fairly large, its effects will be spread out over the county (see Section 5.8.3) and will represent less than 0.2 percent of the county's current total annual personal income of nearly $14 billion (Western Savings and Loan, p. 15).
Fewer workers are expected to live in the site vicinity during operation; thus there will be some reduction in demand for trailer park space and other commercial services (see Section 5.8.3). However, because the transition from the construction to the operation phase will occur over several years, there should be sufficient time for the commercial sector to adjust to the new, lower level of demand.

As noted in Section 4.3.7, both the population and economy of the PVNGS region have grown considerably since 1970. The additional electricity the station is expected to provide in the area could, in turn, contribute to further economic growth.

5.8.2 Tax Benefits

Tax benefits to be generated by the operation of PVNGS are discussed in Section 8.1 of the ER-OL. Based on current tax rates, when the station is operating fully, it is expected that each year the station will pay (in 1986 dollars) at least $126 million in state and local property taxes, and its workers will pay about $0.4 and $5.6 million in state and Federal income taxes, respectively, as well as nearly $1 million in state sales taxes. These payments will represent but a small part of the total tax revenues of the State of Arizona or of Maricopa County; however, the benefits for certain local tax jurisdictions, especially the Ruth Fisher Elementary School District and the Maricopa County Junior College District, will be substantial, amounting to as much as half of their annual revenues from property taxes (FES-CP, p. 10-8). Similar substantial benefits may also eventually accrue to the Arlington Elementary School District and the Buckeye Union High School District (ER-OL, p. 8.1-10).

5.8.3 Offsite Land Use

There have been no changes in proposed PVNGS operation that would appreciably change land-use impacts from those forecast at the CP stage of review. The operation work force of 844 people will be three times larger than projected in the FES-CP (Section 8.1.2.1.2, Supplement 2, ER-OL; Section 5.6.2, FES-CP). However, it will only be about one-seventh the size of the construction work force at its peak level (Tables 8.1-3, 8.1-3A, Supplement 2, ER-OL); thus the staff expects the operation work force to have a much smaller impact on offsite land use.

5.8.4 Community Services and Institutions

Because the PVNGS operating work force will be about one-seventh the size of the peak construction work force, there should be much less demand for housing, fire and police protection, education, water, sewage disposal, and other community services in the PVNGS vicinity during operation than during construction. Furthermore, local tax benefits from station operation (Table 8.1-5, ER-OL) will help make it possible for local officials to respond to such PVNGS-related demands for new community services as may arise.

The operation work force can benefit from housing and public facilities built during station construction, including housing being constructed in and near Buckeye and from expanding residential developments in the Phoenix metropolitan area (Section 8.2.2.1, ER-OL). The applicant plans to run express commuter buses over a recently upgraded highway system from the Phoenix area for the 75 percent of the operation work force expected to live in or near the city (Section 5.6.3, Table 5.6-2, Supplement 2, ER-OL). The staff believes that this service will help reduce traffic congestion near the station during peak commuter periods.

5.8.5 Health Effects

Three types of potential health effects--(1) those resulting from exposure to cooling tower aerosols, (2) those from contracting of the disease coccidioidomycosis as a result of dust being raised during station operation, and (3) those resulting from noise generated during PVNGS operation--are considered.

Cooling Tower Aerosols

The staff has reviewed proposed station operation procedures and recent literature and has found no reasons to change the conclusion in Section 5.6.1.4 of the FES-CP that no public health effects are expected from cooling tower aerosols emitted under the proposed operating conditions. There have been no substantial changes in the quality of the water to be used at PVNGS for cooling purposes or in PVNGS water-treatment operations that would alter (from those levels calculated in the FES-CP) the numbers of pathogens or amount of toxic substances emitted in aerosols from the cooling towers (see Section 4.2.6.1). In addition, a monitoring program (Adams) and several epidemiological studies (Fannin, Carnow, Johnson 1978 and 1979, Shuval, Gartside, Clark, Sekla, Rylander, Dean) published since issuance of the FES-CP have revealed no evidence that aerosols from wastewater-related facilities cause adverse health effects among nearby residents.

Legionnaires' Disease (caused by the bacterium *Legionnella pneumophila*) recently has been associated with aerosols from air conditioning cooling towers (Lester). However, the disease has not been associated with power plant cooling towers like the ones to be used at PVNGS. A study still in progress (Tyndall) found levels of Legionnaires' Disease bacteria in power plant cooling tower waters from less than 1 to 2 orders of magnitude greater than levels in the associated supply waters. The levels found in the towers were consistently below the levels found in towers implicated in some Legionnaires' Disease outbreaks. Therefore, the staff believes that PVNGS cooling towers will not be a significant source of Legionnaires' Disease.

Coccidioidomycosis

Eleven cases of coccidioidomycosis (valley fever) among station construction personnel have been reported to the Arizona Department of Health Services during the construction period (IE, Dominguez). A potential for more cases could result from dust raised during operation from grounds maintenance and transport of materials to and from the site over unpaved roads . The Arizona Department of Health Services recommends that adequate environmental control measures be implemented to reduce this potential (Dominguez). The staff thus recommends continued implementation of dust-control procedures outlined in the FES-CP (Sections 4.5.1 and 4.5.2) during station operation.

Noise

Sound pressure levels expected to result from operation of the units have been calculated at 13 receptor locations on the property line (see Figure 4.1) and at the location of the nearest residence, about 1.9 km (1.2 mi) north of the cooling towers (ER-OL, Table 2.7-1). The calculations were based on the methodology described in the Electric Power Plant Environmental Noise Guide (Edison) and on the assumption that the units are operating at full power continuously. The principal noise sources considered in this analysis are the nine round mechanical-draft cooling towers, the three reactor units and associated equipment, the switchyard, and the reclamation pumps. The locations of each source and the source power levels are listed in the ER-OL, Table 5.6-1.

The resulting calculated sound pressure levels, L, and day-night equivalent sound levels, L_{dn}, at the receptor sites and at the nearest residence are listed in Table 5.6. Also included are the applicant's estimates of L_dn as interpolated by the staff from the sound level contours on ER-OL Figure 5.6-2.

In all cases, the staff's estimates are lower than the applicant's. The staff did not take into account traffic noise on Buckeye-Salome Road.

There are no state or county noise regulations that apply to the operation of PVNGS; however, the U.S. Environmental Protection Agency has set up guidelines which can be compared with the staff's analysis (EPA).

EPA recommends a limit of 70 dBA for the 24-hr equivalent sould level (Leq(24)) for farmland and general unpopulated land. This is primarily for protection from hearing loss. From Table 5.6, it is apparent that this level is already satisfied at the property line (receptor locations R1 through R13), and the sound level continues to decrease inversely with the distance.

For farm residences and residential areas with outside space, the recommendations for the day-night equivalent sound level (L_{dn}) are 55 dBA outdoors and 45 dBA indoors. The calculated sound levels for the PVNGS operational phase at most receptors and at the nearest residence are within 3 dBA of ambient, and the plant contributes a negligible amount.

Table 5.6 Noise levels at receptor locations shown in Figure 4.1 and at the nearest residence

		L_{dn} (dBA)	
Receptor	L(dBA)	Staff	Applicant
R1	45	50	56
R2	48	54	60
R3	43	46	54
R4	42	43	55
R5	43	44	52
R6	43	45	56
R7	43	45	56
R8	42	43	47
R9	42	43	45
R10	42	43	45
R11	42	43	48
R12	45	50	63
R13	52	58	55
Nearest residence	43	45	-

The staff thus concludes that noise produced by operation of the station will be well below the EPA-identified noise levels for protection of the public health and welfare.

5.9 Radiological Impacts

Regulatory Requirements

Nuclear power reactors in the United States must comply with certain regulatory requirements in order to operate. The permissible levels of radiation in unrestricted areas and of radioactivity in effluents to unrestricted areas are recorded in 10 CFR Part 20, Standards for Protection Against Radiation.

These regulations specify limits on levels of radiation and limits on concentrations of radionuclides in the facility's effluent releases to the air and water (above natural background) under which the reactor must operate. These regulations state that no member of the general public in unrestricted areas shall receive a radiation dose, as a result of facility operation, of more than 0.5 rems in 1 calendar year, or if an individual were continuously present in an area, 2 mrems in any 1 hour or 100 mrems in any 7 consecutive days to the total body. These radiation-dose limits are established to be consistent with considerations of the health and safety of the public.

In addition to the Radiation Protection Standards of 10 CFR Part 20, there are in 10 CFR Part 50.36a license requirements that are to be imposed on licensees in the form of Technical Specifications on Effluents from Nuclear Power Reactors to keep releases of radioactive materials to unrestricted areas during normal operations, including expected operational occurrences, as low as is reasonably achievable (ALARA). Appendix I of 10 CFR Part 50 provides numerical guidance on dose-design objectives for LWRs to meet this ALARA requirement. Applicants for permits to construct and for licenses to operate an LWR shall provide reasonable assurance that the following calculated dose-design objectives will be met for all unrestricted areas: 3 mrems/yr to the total body or 10 mrems/yr to any organ from all pathways of exposure from liquid effluents; 10 mrads/yr gamma radiation or 20 mrads/yr beta radiation air dose from gaseous effluents near ground level--and/or 5 mrems/yr to the total body or 15 mrems/yr to the skin from gaseous effluents; and 15 mrems/yr to any organ from all pathways of exposure from airborne effluents that include the radioiodines, carbon-14, tritium, and the particulates.

Experience with the design, construction, and operation of nuclear power reactors indicates that compliance with these design objectives will keep average annual releases of radioactive material in effluents at small percentages of the limits specified in 10 CFR Part 20 and, in fact, will result in doses generally below the dose-design objective values of Appendix I. At the same time, the licensee is permitted the flexibility of operation, compatible with considerations of health and safety, to ensure that the public has a dependable source of power, even under unusual operating conditions which may temporarily result in releases higher than such small percentages but which are still well within the limits specified in 10 CFR Part 20.

In addition to the impact created by facility radioactive effluents as discussed above, within the NRC policy and procedures for environmental protection described in 10 CFR Part 51 there are generic treatments of environmental effects of all aspects of the uranium fuel cycle. These environmental data have been summarized in Table S-3 and are discussed in Section 5.10. The environmental impact of transportation of fuel and waste to and from an LWR have been summarized in Table S-4 and are presented in Section 5.9.1 of this report.

Recently the EPA established (40 CFR Part 190) an additional operational requirement for uranium-fuel-cycle facilities including nuclear power plants. This regulation limits annual doses (excluding radon and daughters) for members of the public to 25 mrems total body, 75 mrems thyroid, and 25 mrems other organs from <u>all</u> fuel-cycle facility contributions that may impact a specific individual in the public.

Because there are no liquid effluents released to the environment as a result of routine operation of PVNGS, the following discussion and analysis is concerned with the potential impacts that could result from exposure to radioactive gaseous effluents.

Operational Overview

During normal operations of Palo Verde Units 1, 2, and 3, small quantities of radioactivity (fission and activation products) will be released to the environment. As required by NEPA, the staff has determined the dose estimated to members of the public outside of the plant boundaries as a result of the radiation from these radioisotope releases and relative to natural background radiation dose levels.

These facility-generated environmental dose levels are estimated to be very small because of both the plant design and the development of a program that will be implemented at the facility to contain and control all radioactive emissions and effluents. As mentioned in Section 4.2.5, highly efficient radioactive-waste management systems are incorporated into the plant design. These systems are designed to remove most of the fission product radioactivity that is assumed to leak, in small amounts, from the fuel, as well as most of the activation product radioactivity produced by neutrons in the reactor core vicinity.

The effectiveness of these systems will be measured by process and effluent radiological monitoring systems that permanently record the amounts of radioactive constituents remaining in the various airborne effluent streams. The amounts of radioactivity released through vents and discharge points to be further dispersed and diluted to points outside the plant boundaries are to be recorded and published semiannually in the Radioactive Effluent Release Reports for the facility.

The small amounts of airborne effluents that are released will diffuse in the atmosphere in a fashion determined by the meteorological conditions existing at the time of release, and they are generally much dispersed and diluted by the time they reach unrestricted areas that are open to the public.

Radioisotopes in the facility's effluents that enter unrestricted areas will produce doses through their radiation to members of the general public in a way similar to the way doses are produced from background radiations (that is, cosmic, terrestrial and internal radiations), which also include radiation from nuclear-weapons fallout. These radiation doses can be calculated for the many potential radiological-exposure pathways specific to the environment around the facility--such as direct-radiation doses from the gaseous plume outside of the plant boundaries, or internal radiation-dose commitments from radioactive contaminants that might have been deposited on vegetation, or in meat products eaten by people, or incorporated into milk from cows at nearby farms.

These doses, calculated for the "maximally exposed" individual (that is, the hypothetical individual potentially subject to maximum exposure), form the basis for the NRC staff evaluation of impacts. Actually, these estimates are for a fictitious person because assumptions are made that tend to overestimate the dose that would accrue to members of the public outside the plant boundaries. For example, if this "maximally exposed" individual were to receive the total body dose calculated at the plant boundary as a result of external exposure to the gaseous plume, he/she is assumed to be physically exposed to gamma radiation at that boundary for 70 percent of the year, an unlikely occurrence. Site-specific values for the various parameters involved in each dose pathway are used in the calculations. These include calculated or observed values for the amounts of radioisotopes released in the gaseous effluents, meteorological information (such as wind speed and direction) specific to the site topography, and effluent release points.

An annual land census will identify changes in the use of unrestricted areas to permit modifications in the programs for evaluating principal pathways of exposure. This census specification will be incorporated into the Radiological Technical Specifications and satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. As use of the land surrounding the site boundary changes, revised calculations will be made to ensure that this dose estimate for gaseous effluents always represents the highest dose that might possibly occur for any individual member of the public for each applicable foodchain pathway. The estimate considers, for example, where people live, where vegetable gardens are located, and where cows are pastured.

An extensive radiological environmental monitoring program, designed specifically for the environs of PVNGS, provides measurements of radiation and radioactive contamination levels that exist outside of the facility boundaries both before and after operations begin. In this program, offsite radiation levels are continuously monitored with thermoluminescent detectors (TLDs). In addition, measurements are made on a number of types of samples from the surrounding area to determine the possible presence of radioactive contaminants that, for example, might be deposited on vegetation, be present in drinking water outside the plant, or be incorporated into cow's milk from nearby farms. The results for all radiological environmental samples measured during a calendar year of operation are recorded and published in the Annual Radiological Environmental Operating Report for the facility. The specifics of the final operational-monitoring program and the requirement for annual publication of the monitoring results will be incorporated into the operating license Radiological Technical Specifications for the PVNGS.

5.9.1 Radiological Impacts from Routine Operations

5.9.1.1 Radiation Exposure Pathways: Dose Commitments

The potential environmental pathways through which persons may be exposed to radiation originating in a nuclear power are shown in Figure 5.1.*

*However, it should be noted that for PVNGS, there will be no liquid effluents.

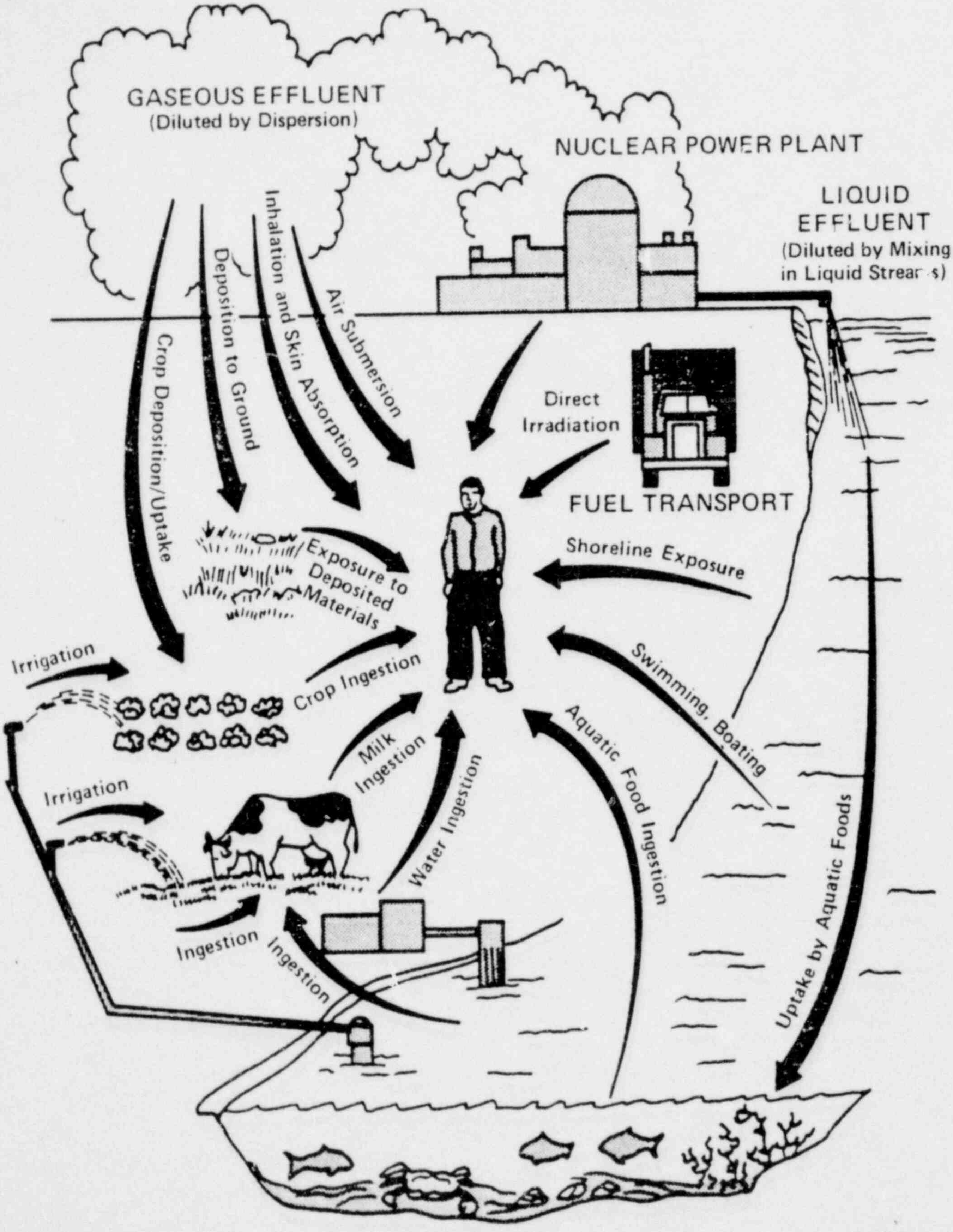

Figure 5.1 Potentially meaningful exposure pathways to individuals

When an individual is exposed through one of these pathways, the dose is determined in part by the amount of time he/she is in the vicinity of the source, or the amount of time the radioactivity is retained in his/her body. The actual effect of the radiation or radioactivity is determined by calculating the dose commitment. The annual dose commitment is calculated to be the total dose that would be received over a 50-yr period, following the intake of radioactivity for 1 yr under the conditions existing 15 yrs after the station begins operation. (Calculation for the 15th year, or mid-point of station operation, represents an average exposure over the life of the plant.) However, with few exceptions, most of the internal dose commitment for each nuclide is given during the first few years after exposure because of the turnover of the nuclide by physiological processes and radioactive decay.

There are a number of possible exposure pathways to man that are appropriate to be studied to determine the impact of routine releases from the PVNGS site on members of the general public living and working outside of the site boundaries, and whether the releases will in fact meet regulatory requirements. A detailed listing of these exposure pathways would include external radiation exposure from the gaseous effluents, inhalation of iodines and particulate contaminants in the air, drinking milk from a cow or eating meat from an animal that feeds on open pasture near the site on which iodines or particulates may have deposited, and eating vegetables from a garden near the site that may be contaminated by similar deposits.

Other less significant pathways include: external irradiation from radionuclides deposited on the ground surface and direct radiation from within the plant itself.

Calculations of the effects for most pathways are limited to a radius of 80 km (50 mi). This limitation is based on several facts. Experience, as demonstrated by calculations, has shown that all individual dose commitments (>0.1 mrems/yr) for radioactive effluents are accounted for within a radius of 80 km from the plant. Beyond 80 km the doses to individuals are smaller than 0.1 mrems/yr, which is far below natural-background doses, and the doses are subject to substantial uncertainty because of limitations of predictive mathematical models.

The NRC staff has made a detailed study of all of the above significant pathways and has evaluated the radiation-dose commitments both to the plant workers and the general public for these pathways resulting from routine operation of the facility. A discussion of these evaluations follows.

5.9.1.1.1 Occupational Radiation Exposure for Pressurized Water Reactors (PWRs)

Most of the dose to nuclear plant workers results from external exposure to radiation from radioactive materials outside of the body rather than from internal exposure from inhaled or ingested radioactive materials. Experience shows that the dose to nuclear plant workers varies from reactor to reactor and from year to year. For environmental-impact purposes, it can be projected by using the experience to date with modern PWRs. Recently licensed 1000-MWe PWRs are operated in accordance with the post-1975 regulatory requirements and guidance that place increased emphasis on maintaining occupational exposure at nuclear power plants ALARA. These requirements and guidance are outlined primarily in 10 CFR Part 20, Standard Review Plan Chapter 12 (NUREG-75/087, now NUREG-0800), and Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable."

The applicant's proposed implementation of these requirements and guidelines is reviewed by the NRC staff during the licensing process, and the results of that review are reported in the staff's Safety Evaluation Reports. The license is granted only after the review indicates that an ALARA program can be implemented. In addition, regular reviews of operating plants are performed to determine whether the ALARA requirements are being met.

Average collective occupational dose information for 239 PWR reactor years of operation is available for those plants operating between 1974 and 1980. (The year 1974 was chosen as a starting date because the dose data for years prior to 1974 are primarily from reactors with average rated capacities below 500 MWe.) These data indicate that the average reactor annual collective dose at PWRs has been about 440 person-rems, with some plants experiencing an average plant lifetime annual dose to date as high as 1300 person-rems (NUREG-0713). These dose averages are based on widely varying yearly doses at PWRs. For example, for the period mentioned above, annual collective doses for PWRs have ranged from 18 to 5262 person-rems per reactor. However, the average annual dose per nuclear plant worker of about 0.8 rem (Ibid) has not varied significantly during this period. The worker dose limit, established by 10 CFR Part 20, is 3 rems/quarter, if the average dose over the worker lifetime is being controlled to 5 rems/yr, or 1.25 rems/quarter if it is not.

The wide range of annual collective doses experienced at PWRs in the United States results from a number of factors, such as the amount of required maintenance and the amount of reactor operations and inplant surveillance. Because these factors can vary widely and unpredictably, it is impossible to determine in advance a specific year-to-year annual occupational radiation dose for a particular plant over its operating lifetime. There may on occasion be a need for relatively high collective occupational doses, even at plants with radiation protection programs designed to ensure that occupational radiation doses will be kept ALARA.

In recognition of the factors mentioned above, staff occupational dose estimates for environmental impact purposes for PVNGS are based on the assumption that the facility will experience the annual average occupational dose for PWRs to date. Thus the staff has projected that the collective occupational doses for each unit at PVNGS will be 440 person-rems, but doses could average as much as 3 times this value over the life of the plant.

In addition to the occupational radiation exposures discussed above, during the period between the initial power operation of Unit 1 and the similar startup of Units 2 and 3, construction personnel working on Units 2 and 3 will potentially be exposed to sources of radiation from the operation of Unit 1. The applicant has estimated that the integrated dose to construction personnel, over a period of 3 years, will be about 31 person-rems. This radiation exposure will result predominantly from Unit 1 radioactive components and gaseous effluents from

Unit 1. Based on experience with other PWRs, the staff finds that the applicant's estimate is reasonable. A detailed breakdown of the integrated dose to the construction workers by the location of their work and its duration is given in Table 12.4-8 of the FSAR.

The average annual dose of about 0.8 rem per nuclear plant worker at operating BWRs and PWRs has been well within the limits of 10 CFR Part 20. However, for impact evaluation, the NRC staff has estimated the risk to nuclear power plant workers and compared it in Table 5.7 below to published risks for other occupations. Based on these comparisons, the staff concludes that the risk to nuclear plant workers from plant operation is comparable to the risks associated with other occupations.

In estimating the health effects resulting from both offsite (see Section 5.9.1.2) and occupational radiation exposures as a result of normal operation of this facility, the NRC staff used somatic (cancer) and genetic risk estimators that are based on widely accepted scientific information. Specifically, the staff's estimates are based on information compiled by the National Academy of Science's Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR I). The estimates of the risks to workers and the general public are based on con-servative assumptions (that is, the estimates are probably higher than the actual number). The following risk estimators were used to estimate health effects: 135 potential deaths from cancer per million person-rems and 258 potential cases of all forms of genetic disorders per million person-rems. The cancer-mortality risk estimates are based on the "absolute risk" model described in BEIR I. Higher estimates can be developed by use of the "relative risk" model along with the assumption that risk prevails for the duration of life. Use of the "relative risk" model would produce risk values up to about four times greater than those used in this report. The staff regards the use of the "relative risk" model values as a reasonable upper limit of the range of uncertainty. The lower limit of the range would be zero because health effects have not been detected at doses in this dose-rate range. The number of potential nonfatal cancers would be approximately 1.5 to 2 times the number of potential fatal cancers, according to the 1980 report of the National Academy of Science's Advisory Committee in the Biological Effects of Ionizing Radiation (BEIR III).

Values for genetic risk estimators range from 60 to 1500 potential cases of all forms of genetic disorders per million person-rems (BEIR I). The value of 258 potential cases of all forms of genetic disorders is equal to the sum of the geometric means of the risk of specific genetic defects and the risk of defects with complex etiology. However, the value of zero cannot be excluded because there is no direct evidence of human effects at doses in this dose-rate range (BEIR III).

The preceding values for risk estimators are consistent with the recommendations of a number of recognized radiation-protection organizations, such as the Inter-national Commission on Radiological Protection (ICRP 1977), the National Council on Radiation Protection and Measurement (NCRP 1975), the National Academy of Sciences (BEIR III), and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 1977).

The risk of potential fatal cancers in the exposed work-force population at the PVNGS and the risk of potential genetic disorders in all future generations of

Table 5.7 Incidence of job-related fatalities

Occupational group	Fatality incidence rates (premature deaths per 10^5 person-years)
Underground metal miners[a]	~1300
Uranium miners[a]	420
Smelter workers[a]	190
Mining[b]	61
Agriculture, forestry, and fisheries[b]	35
Contract construction[b]	33
Transportation and public utilities	24
Nuclear-plant worker[c]	23
Manufacturing[b]	7
Wholesale and retail trade[b]	6
Finance, insurance, and real estate[b]	3
Services[b]	3
Total private sector[b]	10

[a]The President's Report on Occupational Safety and Health, "Report on Occupational Safety and Health by the U.S. Department of Health, Education, and Welfare," E. L. Richardson, Secretary, May 1972.

[b]U.S. Bureau of Labor Statistics, "Occupational Injuries and Illness in the United States by Industry, 1975," Bulletin 1981, 1978.

[c]The nuclear-plant workers' risk is equal to the sum of the radiation-related risk and the nonradiation-related risk. The occupational risk associated with the industry-wide average radiation dose of 0.8 rem is about 11 potential premature deaths per 10^5 person-years due to cancer (using the same risk estimators as used in Appendix G, "Impact of the Uranium Fuel Cycle"). The average nonradiation-related risk for seven U.S. electrical utilities over the period 1970-1979 is about 12 actual premature deaths per 10^5 person-years as shown in Figure 5 of the paper by R. Wilson and E. S. Koehl, "Occupational Risks of Ontario Hydro's Atomic Radiation Workers in Perspective," presented at Nuclear Radiation Risks, A Utility-Medical Dialog, sponsored by the International Institute of Safety and Health in Washington, D.C., September 22-23, 1980. (Note that the estimate of 11 radiation-related premature cancer deaths is potential rather than actual.)

this work-force population is estimated as follows: multiplying the annual plant-worker-population dose (about 1320 person-rems) by the risk estimators, the staff estimates that about 0.18 cancer deaths may occur in the total exposed population and about 0.34 genetic disorders may occur in all future generations of the same exposed population. The value of 0.18 cancer deaths means that the probability of 1 cancer death over the lifetime of the entire work force as a result of 1 year of facility operation is about 18 chances in 100. The value of 0.34 genetic disorders means that the probability of 1 genetic disorder in all future generations of the entire work force as a result of 1 year of facility operation is about 34 chances in 100.

5.9.1.1.2 Public Radiation Exposure

Transportation of Radioactive Materials

The transportation of "cold" (unirradiated) nuclear fuel to the reactor, of spent irradiated fuel from the reactor to a fuel reprocessing plant, and of solid radioactive wastes from the reactor to waste burial grounds is considered in 10 CFR Part 51.20. The contribution of the environmental effects of such transportation to the environmental costs of licensing the nuclear power reactor is set forth in Summary Table S-4 from 10 CFR Part 51.20, reproduced herein as Table 5.8. The cumulative dose to the exposed population as summarized in Table S-4 is very small when compared to the annual dose of about 61,000 person-rems to this same population or 26,000,000 person-rems to the U.S. population from background radiation.

Table 5.8 Environmental impact of transportation of fuel and waste to and from one light-water-cooled nuclear power reactor (Summary Table S-4)[1]

NORMAL CONDITIONS OF TRANSPORT

	Environmental impact
Heat (per irradiated fuel cask in transit)	250,000 Btu/hr
Weight (governed by Federal or State restrictions)	73,000 lbs. per truck; 100 tons per cask per rail car
Traffic density:	
Truck	Less than 1 per day
Rail	Less than 3 per month

Exposed population	Estimated number of persons exposed	Range of doses to exposed individuals[2] (per reactor year)	Cumulative dose to exposed population (per reactor year)[3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem
Along Route	600,000	0.0001 to 0.06 millirem	

ACCIDENTS IN TRANSPORT

	Environmental risk
Radiological effects	Small[4]
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year

[1] Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. I, NUREG-75/038 April 1975. Both documents are available for inspection and copying at the Commission's Public Document Room, 1717 H St. NW., Washington, D.C., and may be obtained from National Technical Information Service, Springfield, Va. 22161. WASH-1238 is available from NTIS at a cost of $5.45 (microfiche, $2.25) and NUREG-75/038 is available at a cost of $3.25 (microfiche, $2.25).

[2] The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

[3] Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case would be 1 man-rem.

[4] Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multireactor site.

Direct Radiation for PWRs

Radiation fields are produced around nuclear plants as a result of radioactivity within the reactor and its associated components, and as a result of radioactive-effluent releases. Because the primary coolant of a PWR is contained in a heavily shielded area, dose rates in the vicinity of PWRs are generally undetectable (less than 5 mrems/yr).

Low-level radioactivity storage containers outside the plant are estimated to make a dose contribution at the site boundary of less than 1 percent of that due to the direct radiation from the plant.

Radioactive Effluent Releases: Air

As pointed out in an earlier section, all effluents from the station will be subject to extensive decontamination, but small controlled quantities of radioactive effluents will be released to the atmosphere. Estimates of site-specific radioisotope-release values have been developed on the basis of the descriptions of operational and radwaste systems in the applicant's ER and FSAR and by using the calculational models and parameters developed by the NRC staff in NUREG-0016 and NUREG-0017. These have been supplemented by extensive use of the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, and should be studied to obtain an understanding of airborne releases from the facility.

These radioactive effluents are then diluted by the air into which they are released before they reach areas accessible to the general public.

Radioactive effluents can be divided into several groups. Among the airborne effluents, the radioisotopes of the noble gases--krypton, xenon, and argon--do not deposit on the ground nor are they absorbed and accumulated within living organisms; therefore, the noble gas effluents act primarily as a source of direct external radiation emanating from the effluent plume. Dose calculations are performed for the site boundary where the highest external-radiation doses to a member of the general public as a result of gaseous effluents have been estimated to occur; these include the total body and skin doses as well as the annual beta and gamma air doses from the plume at that boundary location.

Another group of airborne radioactive effluents--the radioiodines, carbon-14, and tritium--are also gaseous, but these tend to be deposited on the ground and/or absorbed into the body during inhalation. For this class of effluents, estimates of direct external-radiation doses from deposits on the ground, and of internal radiation doses to total body, thyroid, bone, and other organs from inhalation and from vegetable, milk, and meat consumption are made. In analyzing the contributions of various isotopes to specific organs from ground deposition and/or inhalation, the majority of the dose comes from iodine in the thyroid and carbon-14 in the bone.

A third group of airborne effluents, consisting of particulates that remain after filtration of airborne effluents in the plant prior to release, includes fission products such as cesium and barium and corrosion activation products such as cobalt and chromium. The calculational model determines the direct external radiation dose and the internal radiation doses for these contaminants through the same pathways as described above for the radioiodines, carbon-14, and tritium. Doses from the particulates are combined with those of the radioiodines, carbon-14, and tritium for comparison to one of the design objectives of Appendix I to 10 CFR Part 50.

The release values for each group of effluents, along with site-specific meteorological data, serve as input to computerized radiation-dose models that estimate the maximum radiation dose that would be received outside the facility via a number of pathways for individual members of the public, and for the general public as a whole. These models and the radiation dose calculations are discussed in the October 1977 Revision 1 of Regulatory Guide 1.109 and in Appendix D of this statement.

Examples of site-specific dose assessment calculations and discussions of parameters involved are given in Appendix C. Doses from all airborne effluents except the noble gases are calculated for the location (for example, the site boundary, garden, residence, milk cow, meat animal) where the highest radiation dose to a member of the public from all applicable pathways has been established. Only those pathways associated with airborne effluents that are known to exist at a single location are combined to calculate the total maximum exposure to an exposed individual.

5.9.1.2 Radiological Impact on Humans

Although the doses calculated in Appendix C are based on radioactive-waste treatment system capability, the actual radiological impact associated with the operation of the station will depend, in part, on the manner in which the radioactive waste treatment system is operated. Based on its evaluation of the potential performance of the ventilation and radwaste treatment systems, the NRC staff has concluded that the systems as now proposed are capable of controlling effluent releases to meet the dose-design objectives of Appendix I to 10 CFR Part 50.

Operation of the PVNGS will be governed by operating license Technical Specifications that will be based on the dose-design objectives of Appendix I to 10 CFR Part 50. Because these design-objective values were chosen to permit flexibility of operation while still ensuring that plant operations are ALARA, the actual radiological impact of plant operation may result in doses close to the dose-design objectives. Even if this situation exists, the individual doses for the member of the public subject to maximum exposure will still be very small when compared to natural background doses (~100 mrems/yr) or the dose limits specified in 10 CFR Part 20 (500 mrems/yr total body). As a result, the staff concludes that there will be no measurable radiological impact on any member of the public from routine operation of the PVNGS.

Operating standards of 40 CFR Part 190 (the EPA Environmental Radiation Protection Standards for Nuclear Power Plant Operations) specify that the annual dose equivalent must not exceed 25 mrems to the whole body, 75 mrems to the thyroid, and 25 mrems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials (radon and its daughters excepted) to the general environment from all uranium-fuel-cycle operations and radiation from these operations that can be expected to affect a given individual. The NRC staff concludes that under normal operations the PVNGS site is capable of operating within these standards.

The radiological doses and dose commitments resulting from a nuclear power plant are well known and documented. Accurate measurements of radiation and radioactive contaminants can be made with very high sensitivity so that much smaller amounts of radioisotopes can be recorded than can be associated with any possible observable ill effects. Furthermore, the effects of radiation on living systems have, for decades, been subject to intensive investigation and consideration by individual scientists as well as by select committees that have occasionally been constituted to objectively and independently assess radiation dose effects. Although, as in the case of chemical contaminants, there is debate about the exact extent of the effects of very low levels of radiation that result from nuclear power plant effluents, upper bound limits of deleterious effects are well established and amenable to standard methods of risk analysis. Thus the risks to the maximally exposed member of the public outside of the site boundaries can be readily quantified. Further, the impacts on, and risks to, the total population outside of the boundaries can also be readily calculated and recorded. These risk estimates for the PVNGS are presented below.

The risk to the maximally exposed individual is estimated by multiplying the risk estimators presented in Section 5.9.1.1.1 by the annual dose-design objectives for total-body radiation in 10 CFR Part 50, Appendix I. This calculation results in a risk of potential premature death from cancer to that individual from exposure to radioactive effluents (gaseous or liquid) from 1 year of reactor operations of less than one chance in one million.* The risk of potential premature death from cancer to the average individual within 80 km (50 mi) of the reactors from exposure to radioactive effluents from the reactors is much less than the risk to the maximally exposed individual. These risks are very small in comparison to natural cancer incidence from causes unrelated to the operation of the PVNGS facility.

Multiplying the annual U.S. general public population dose from exposure to radioactive effluents and transportation of fuel and waste from the operation

*This risk of potential premature death from cancer to the maximally exposed individual from exposure to radioiodines and particulates would be in the same range as the risk from exposure to other types of effluents.

of this facility (that is, 450 person-rems) by the preceding risk estimators, the staff estimates that about 0.06 cancer deaths may occur in the exposed population and about 0.12 genetic disorders may occur in all future generations of the exposed population. The significance of these risk estimates can be determined by comparing them to the natural incidence of cancer death and genetic abnormalities in the U.S. population. Multiplying the estimated U.S. population for the year 2000 (~260 million persons) by the current incidence of actual cancer fatalities (~20%) and the current incidence of actual genetic diseases (~6%), about 52 million cancer deaths and about 16 million genetic abnormalities are expected (BEIR I; American Cancer Society 1978). The risks to the general public from exposure to radioactive effluents and transportation of fuel and wastes from the annual operation of the PVNGS facility are very small fractions (less than one part in a billion) of the estimated normal incidence of cancer fatalities and genetic abnormalities in the year 2000 population.

On the basis of the preceding comparison (that is, comparing the risk from exposure to radioactive effluents and transportation of fuel and waste from the annual operation of this facility with the risk from the estimated incidence of cancer fatalities and genetic abnormalities in the year-2000 population) the staff concludes that the risk to the public health and safety from exposure to radioactive effluents and the transportation of fuel and wastes from normal operation of the PVNGS facility will be very small.

5.9.1.3 Radiological Impacts on Biota Other Than Humans

Depending on the pathway and radiation source, terrestrial and aquatic biota will receive doses that are approximately the same or somewhat higher than humans receive. Although guidelines have not been established for acceptable limits for radiation exposure to species other than human, it is generally agreed that the limits established for humans are conservative for other species.

Although the existence of extremely radiosensitive biota is possible and increased radiosensitivity in organisms may result from environmental interactions with other stresses (for example, heat or biocides), no biota have yet been discovered that show a sensitivity (in terms of increased morbidity or mortality) to radiation exposures as low as those expected in the area surrounding the facility. Furthermore, at all nuclear plants for which radiation exposure to biota other than humans has been analyzed (Blaylock) there have been no cases of exposure that can be considered significant in terms of harm to the species, or that approach the limits for exposure to members of the public that are permitted by 10 CFR Part 20. The 1972 BEIR Report (BEIR I) concluded that evidence to date indicated that no other living organisms are very much more radiosensitive than humans; thus no measurable radiological impact on populations of biota is expected as a result of the routine operation of this facility.

5.9.1.4 Radiological Monitoring

Radiological environmental monitoring programs are established to provide data where there are measurable levels of radiation and radioactive materials in the site environs, and to show that in many cases no detectable levels exist.

Such monitoring programs are conducted to verify the effectiveness of inplant systems used to control the release of radioactive materials and to ensure that unanticipated buildups of radioactivity will not occur in the environment. Secondarily, the monitoring programs could identify the highly unlikely existence of unmonitored releases of radioactivity from unanticipated release points that are not monitored. An annual surveillance (land census) program will be established to identify changes in the use of unrestricted areas to provide a basis for modifications of the monitoring programs, or of the Technical Specification conditions that relate to the control of doses to individuals.

These programs are discussed in greater detail in NRC Regulatory Guide 4.1, Revision 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," and the Radiological Assessment Branch Technical Position, Revision 1, November 1979, "An Acceptable Radiological Environmental Monitoring Program."*

5.9.1.4.1 Preoperational

The preoperational phase of the monitoring program should provide for the measurement of background levels of radioactivity and radiation and their variations along the anticipated important pathways in the areas surrounding the facility, the training of personnel, and the evaluation of procedures, equipment and techniques. The applicant proposed a radiological environmental-monitoring program to meet these objectives in the ER-CP, and the program was discussed in the FES-CP. This early program has been updated and expanded; it is presented in Section 6.1.5 of the applicant's ER-OL and is summarized here in Table 5.9.

The applicant states that the preoperational program has been implemented (at least 2 years before initial criticality of Unit 1) to document background levels of direct radiation and concentrations of radionuclides that exist in the environment (monitoring of airborne effluents will begin 1 year before initial criticality of Unit 1). The preoperational program will continue up to the initial criticality of Unit 1, at which time the operational radiological monitoring program will commence.

The staff has reviewed the preoperational environmental monitoring plan of the applicant and finds it acceptable as presented.

5.9.1.4.2 Operational

The operational, offsite radiological-monitoring program is conducted to provide data on measurable levels of radiation and radioactive materials in the site environs in accordance with 10 CFR Parts 20 and 50. It assists and provides backup support to the effluent-monitoring program recommended in NRC Regulatory Guide 1.21, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants."

*Available from the Radiological Assessment Branch, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Table 5.9 PVNGS preoperational radiological environmental monitoring program

Exposure pathway and/or sample	Sampling and collection frequency	Type and frequency of analysis	Number and approximate location of samples
Airborne			
Radioiodine and particulates	Continuous sampling collected weekly	Gross beta weekly; I-131 weekly; gamma spectrum monthly; composite of filters	Samples from 12 locations: 6 samples at or near the site boundaries, 3 of which are from offsite locations (in different sectors) of the highest calculated annual average ground level D/Q.*
			5 samples from areas of special interest, 1 of which is from the vicinity of a community having the highest calculated annual average D/Q.
			1 sample from a control location 15-30 km (10-20 mi) distant and in the least prevalent wind direction.
Direct radiation	Quarterly	Gamma dose quarterly	45 stations with two or more dosimeters for measuring dose rate continuously, placed as follows: an inner ring of stations at the site boundary and an outer ring in the 4-to-5 mi range from the site with a station in each sector of each ring, except the NW sector, which is inaccessible (16 sectors x 2 rings minus 1 = 31 stations). 10 additional stations are in local schools and population centers; 4 other stations are used as controls.

*D/Q refers to average annual relative ground deposition rate.

Table 5.9 (continued)

Exposure pathway and/or sample	Sampling and collection frequency	Type and frequency of analysis	Number and approximate location of samples
Waterborne			
Surface	Composite sample over 1-mo period	Gamma spectrum monthly; tritium quarterly	Water storage reservoir evaporation pond
Ground	Quarterly grab sample	Tritium and gamma spectrums quarterly	2 onsite wells
Drinking (well)	Monthly composite of weekly grab sample	Gross beta and gamma spectrums monthly; tritium quarterly	4 wells from surrounding residences
Ingestion			
Milk	Semimonthly for animals on pasture; otherwise, monthly	Gamma spectrum and radioiodine semi-monthly or monthly	Local dairy
Food products	Monthly when available	Gamma spectrum and radioiodine monthly	Local farms

The applicant states that the operational program will in essence be a continuation of the preoperational program described above with some periodic adjustment of sampling frequencies in expected critical exposure pathways--such as increasing milk sampling frequency and deletion of fruit, vegetable, soil, and gamma radiation survey samples. The proposed operational program will be reviewed prior to plant operation. Modification will be based upon anomalies and/or exposure pathway variations observed during the preoperational program.

The final operational-monitoring program proposed by the applicant will be reviewed in detail by the NRC staff, and the specifics of the required monitoring program will be incorporated into the operating license Radiological Technical Specifications.

5.9.2 Postulated Accidents

5.9.2.1 Plant Accidents

The staff has considered the potential PVNGS radiological impacts on the environment of possible accidents in accordance with a Statement of Interim Policy published by the Nuclear Regulatory Commission on June 13, 1980. The following discussion reflects these considerations and conclusions.

Section 5.9.2.2 deals with general characteristics of nuclear power plant accidents, including a brief summary of safety measures to minimize the probability of their occurrence and to mitigate their consequences if they should occur. Also described are the important properties of radioactive materials and the pathways by which they could be transported to become environmental hazards. Potential adverse health effects and impacts on society associated with actions to avoid such health effects are also identified.

Next, actual experience with nuclear power plant accidents and their observed health effects and other societal impacts are described. This is followed by a summary review of safety features of the Palo Verde facility and of the site that act to mitigate the consequences of accidents.

The results of calculations of the potential consequences of accidents that have been postulated in the design basis are then given. Also described are the results of calculations for the Palo Verde site using probabilistic methods to estimate the possible impacts and the risks associated with severe accident sequences of exceedingly low probability of occurrence.

5.9.2.2 General Characteristics of Accidents

The term "accident," as used in this section, refers to any unintentional event not addressed in Section 5.9.1 that results in a release of radioactive materials into the environment. The predominant focus, therefore, is on events that can lead to releases substantially in excess of permissible limits for normal operation. Such limits are specified in the Commission's regulations at 10 CFR Part 20 and 10 CFR Part 50, Appendix I.

There are several features that combine to reduce the risk associated with accidents at nuclear power plants. Safety features in the design, construction, and operation--comprising the first line of defense--are to a very large extent devoted to the prevention of the release of these radioactive materials from their normal places of confinement within the plant. There are also a number of additional lines of defense that are designed to mitigate the consequences of failures in the first line. Descriptions of these features for the Palo Verde plant may be found in the applicant's FSAR and in the staff's SER. The most important mitigative features are described in Section 5.9.2.4(1) below.

These safety features are designed taking into consideration the specific locations of radioactive materials within the plant, their amounts, their nuclear, physical, and chemical properties, and their relative tendency to be transported into and for creating biological hazards in the environment.

(1) Fission Product Characteristics

By far the largest inventory of radioactive material in a nuclear power plant is produced as a byproduct of the fission process and is located in the uranium oxide fuel pellets in the reactor core in the form of fission products. During periodic refueling shutdowns, the assemblies containing these fuel pellets are transferred to a spent-fuel storage pool so that the second largest inventory of radioactive material is located in this storage area. Much smaller inventories of radioactive materials are also normally present in the water that circulates in the reactor coolant system and in the systems used to process gaseous and liquid radioactive wastes in the plant.

These radioactive materials exist in a variety of physical and chemical forms. Their potential for dispersion into the environment depends not only on mechanical forces that might r[illegible]lly transport them, but also upon their inherent properties, part[illegible]y their volatility. The majority of these materials exist as nonvolatile solids over a wide range of temperatures. Some, however, are relatively volatile solids, and a few are gaseous in nature. These characteristics have a significant bearing upon the assessment of the environmental radiological impact of accidents.

The gaseous materials include radioactive forms of the chemically inert noble gases krypton and xenon. These have the highest potential for release into the atmosphere. If a reactor accident were to occur involving degradation of the fuel cladding, the release of substantial quantities of these radioactive gases from the fuel is a virtual certainty. Such accidents are very low frequency but credible events (see Section 5.9.2.3). It is for this reason that the safety analysis of each nuclear power plant incorporates a hypothetical design-basis accident that postulates the release of the entire contained inventory of radioactive noble gases from the fuel into the containment structure. If these noble gases were further released to the environment as a possible result of failure of safety features, the hazard to individuals from these noble gases would arise predominantly through the external gamma radiation from the airborne plume. The reactor containment structure is designed to minimize this type of release.

Radioactive forms of iodine are formed in substantial quantities in the fuel by the fission process and in some chemical forms may be quite volatile. For these reasons, they have traditionally been regarded as having a relatively high potential for release from the fuel. If radioiodines are released to the environment, the principal radiological hazard associated with them is ingestion into the human body and subsequent concentration in the thyroid gland. Because of this, the potential for release to the atmosphere is reduced by the use of special systems designed to retain the iodine.

The chemical forms in which the fission product radioiodines are found are generally solid materials at room temperatures, however, so that they have a strong tendency to condense (or "plate out") upon cooler surfaces. In addition, most of the iodine compounds are quite soluble in, or chemically reactive with, water. Although these properties do not inhibit the release of radioiodines from degraded fuel, they do act to mitigate the release from containment structures that have large internal surface areas and that contain large quantities of water as a result of an accident. The same properties affect the behavior of radioiodines that may "escape" into the atmosphere. Thus, if rainfall occurs during a release, or if there is moisture on exposed surfaces (such as dew), the radioiodines will show a strong tendency to be absorbed by the moisture.

Other radioactive materials formed during the operation of a nuclear power plant have lower volatilities and, therefore, by comparison with the noble gases and iodine, a much smaller tendency to escape from degraded fuel unless the temperature of the fuel becomes very high. By the same token, such materials, if they escape by volatilization from the fuel, tend to condense quite rapidly to solid form again when they are transported to a lower temperature region and/or dissolve in water when it is present. The former mechanism can have the result of producing some solid particles of sufficiently small size to be carried some distance by a moving stream of gas or air. If such particulate materials are dispersed into the atmosphere as a result of failure of the containment barrier, they will tend to be carried downwind and deposit on surface features by gravitational settling or by precipitation (fallout), where they will become "contamination" hazards in the environment.

All of these radioactive materials exhibit the property of radioactive decay with characteristic half-lives ranging from fractions of a second to many days or years (see Table 5.10). Many of them decay through a sequence or chain of decay processes, and all eventually become stable (nonradioactive) materials. The radiation emitted during these decay processes is the reason that they are hazardous materials.

(2) Exposure Pathways

The radiation exposure (hazard) to individuals is determined by their proximity to the radioactive material, the duration of exposure, and factors that act to shield the individual from the radiation. Pathways for the transport of radiation and radioactive materials that lead to radiation exposure hazards to humans are generally the same for accidental as for "normal" releases. These are shown in Figure 5.1. There are two additional possible pathways that could be significant for accident releases that are not shown in Figure. 5.1. One of these is the fallout onto open bodies of water of radioactivity initially carried in the air. The second would be unique to an accident that results in temperatures inside the reactor core sufficiently high to cause melting and subsequent penetration of the basemat underlying the reactor by the molten core debris. This creates the potential for the release of radioactive material into the hydrosphere through contact with ground water. These pathways may lead to external exposure to radiation and to internal exposures if radioactive material is inhaled or ingested from contaminated food or water.

It is characteristic of these pathways that during the transport of radioactive material by wind or by water the material tends to spread and disperse, like a plume of smoke from a smokestack, becoming less concentrated in larger volumes of air or water. The result of these natural processes is to lessen the intensity of exposure to individuals downwind or downstream of the point of release, but

Table 5.10 Activity of radionuclides in a Palo Verde reactor core at 3817 MWt

Group/radionuclide	Radioactive inventory (millions of Curies)	Half-life (days)
A. NOBLE GASES		
Krypton-85	0.67	3,950
Krypton-85m	29	0.183
Krypton-87	56	0.0528
Krypton-88	88	0.117
Xenon-133	203	5.28
Xenon-135	41	0.384
B. IODINES		
Iodine-131	101	8.05
Iodine-132	143	0.0958
Iodine-133	203	0.875
Iodine-134	227	0.0366
Iodine-135	179	0.280
C. ALKALI METALS		
Rubidium-86	0.031	18.7
Cesium-134	8.9	750
Cesium-136	3.6	13.0
Cesium-137	5.6	11,000
D. TELLURIUM-ANTIMONY		
Tellurium-127	7.0	0.391
Tellurium-127m	1.3	109
Tellurium-129	37	0.048
Tellurium-129m	6.3	34.0
Tellurium-131m	15.5	1.25
Tellurium-132	143	3.25
Antimony-127	7.3	3.88
Antimony-129	39.4	0.179
E. AKALINE EARTHS		
Strontium-89	112	52.1
Strontium-90	4.4	11,030
Strontium-91	131	0.403
Barium-140	191	12.8
F. COBALT AND NOBLE METALS		
Cobalt-58	0.93	71.0
Cobalt-60	0.34	1,920
Molybdenum-99	191	2.8
Technetium-99m	167	0.25
Ruthenium-103	131	39.5
Ruthenium-105	86	0.185
Ruthenium-106	30	366
Rhodium-105	59	1.50

Table 5.10 (continued)

Group/radionuclide	Radioactive inventory (millions of Curies)	Half-life (days)
G. RARE EARTHS, REFRACTORY OXIDES AND TRANSURANICS		
Yttrium-90	4.6	2.67
Yttrium-91	143	59.0
Zirconium-95	179	65.2
Zirconium-97	179	0.71
Niobium-95	179	35.0
Lanthanum-140	191	1.67
Cerium-141	179	32.3
Cerium-143	155	1.38
Cerium-144	101	284
Praseodymium-143	155	13.7
Neodymium-147	72	11.1
Neptunium-239	1960	2.35
Plutonium-238	0.068	32,500
Plutonium-239	0.025	8.9×10^6
Plutonium-240	0.025	2.4×10^6
Plutonium-241	4.0	5,350
Americium-241	0.0020	1.5×10^5
Curium-242	0.60	163
Curium-244	0.027	6,630

Note: The above grouping of radionuclides corresponds to that in Table 5.12.

they also tend to increase the number who may be exposed. For a release into the atmosphere, the degree to which dispersion reduces the concentration in the plume at any downwind point is governed by the turbulence characteristics of the atmosphere which vary considerably with time and from place to place. This fact, taken in conjunction with the variability of wind direction and the presence or absence of precipitation, means that accident consequences are very much dependent upon the weather conditions existing at the time.

(3) Health Effects

The cause-and-effect relationships between radiation exposure and adverse health effects are quite complex (CONAES, Land), but they have been more exhaustively studied than any other environmental contaminant.

Whole-body radiation exposure resulting in a dose greater than about 10 rems for a few persons and about 25 rems for nearly all people over a short period of time (hours) is necessary before any physiological effects to an individual are clinically detectable. Doses about 10 to 20 times larger than the latter dose, also received over a relatively short period of time (hours to a few days), can be expected to cause some fatal injuries. At the severe but extremely low probability end of the accident spectrum, exposures of these magnitudes are theoretically possible for persons in the close proximity of such accidents if measures are not or cannot be taken to provide protection, such as by sheltering or evacuation.

Lower levels of exposures may also constitute a health risk but the ability to define a direct cause-and-effect relationship between any given health effect, and a known exposure to radiation is difficult given the backdrop of the many other possible reasons why a particular effect is observed in a specific individual. For this reason, it is necessary to assess such effects on a statistical basis. Such effects include randomly occurring cancer in the exposed population and genetic changes in future generations after exposure of a prospective parent. Cancer in the exposed population may begin to develop only after a lapse of 2 to 15 years (latent period) from the time of exposure and then continue over a period of about 30 years (plateau period). However, in the case of exposure of fetuses (in utero), cancer may begin to develop at birth (no latent period) and end at age 10 (that is, the plateau period is 10 years). The health conse-quences model currently being used is based on the 1972 BEIR Report of the National Academy of Sciences.

Most authorities agree that a reasonable--and probably conservative--estimate of the randomly occurring number of health effects of low levels of radiation exposure to a large number of people is within the range of about 10 to 500 potential cancer deaths (although zero is not excluded by the data) per million person-rems. The range comes from the latest Advisory Committee on the Biological Effects of Ionizing Radiation Report (BEIR III, 1980) which also indicates a probable value of about 150. This value is virtually identical to the value of about 140 used in the current NRC health-effects models. In addition, approximately 220 genetic changes per million person-rems would be projected by BEIR III over succeeding generations. That also compares well with the value of about 260 per million person-rems currently used by the NRC staff.

(4) Health-Effects Avoidance

Radiation hazards in the environment tend to disappear by the natural process of radioactive decay. Where the decay process is slow, however, and where the material becomes relatively fixed in its location as an environmental contaminant (for example, in soil), the hazard can continue to exist for a relatively long period of time--months, years, or even decades. Thus, a possible consequential environmental societal impact of severe accidents is the avoidance of the health hazard--rather than the health hazard itself--by restrictions on the use of the contaminated property or contaminated foodstuffs, milk, and drinking water. The potential economic impacts that this can cause are discussed below.

5.9.2.3 Accident Experience and Observed Impacts

The evidence of accident frequency and impacts in the past is a useful indicator of future probabilities and impacts. As of mid-1981, there were 71 commercial nuclear power reactor units licensed for operation in the United States at 50 sites with power-generating capacities ranging from 50 to 1130 MWe. (Each Palo Verde unit is designed for 1270 MWe.) The combined experience with these units represents approximately 500 reactor years of operation over an elapsed time of about 20 years. Accidents have occurred at several of these facilities (Bertini, Marsh). Some of these have resulted in releases of radioactive material to the environment, ranging from very small fractions of a curie to a few million curies. None is known to have caused any radiation injury or fatality to any member of the public, nor any significant individual or collective public radiation exposure, nor any significant contamination of the environment. This experience base is not large enough to permit a reliable quantitative statistical inference. It does, however, suggest that significant environmental impacts caused by accidents are very unlikely to occur over time periods of a few decades.

Melting or severe degradation of reactor fuel has occurred in only one of these units, during the accident at Three Mile Island Unit 2 (TMI-2) on March 28, 1979. In addition to the release of a few million curies of xenon-133, it has been estimated that approximately 15 Ci of radioiodine were also released to the environment at TMI-2 (Rogovin). This amount represents an extremely minute fraction of the total radioiodine inventory present in the reactor at the time of the accident. No other radioactive fission products were released in measurable quantity.

It has been estimated that the maximum cumulative offsite radiation dose to an individual was less than 100 millirems (Rogovin, President's Commission). The total population exposure has been estimated to be in the range from about 1000 to 3000 person-rems. This exposure could produce between none and one additional fatal cancer over the lifetime of the population. The same population receives each year from natural background radiation about 240,000 person-rems, and approximately a half-million cancers are expected to develop in this group over its lifetime (ibid), primarily from causes other than radiation. Trace quantities (barely above the limit of detectability) of radioiodine were found in a few samples of milk produced in the area. No other food or water supplies were impacted.

Accidents at nuclear power plants have also caused occupational injuries and a few fatalities but none attributed to radiation exposure. Individual worker exposures have ranged up to about 4 rems as a direct consequence of accidents, but the collective worker exposure levels (person-rems) are a small fraction of the exposures experienced during normal routine operations that average about 440 to 1300 person-rems in a PWR and 740 to 1650 person-rems in a BWR per reactor-year.

Accidents have also occurred at other nuclear reactor facilities in the United States and in other countries (Bertini, Marsh). Because of inherent differences in design, construction, operation, and purpose of most of these other facilities, their accident record has only indirect relevance to current nuclear power plants. Melting of reactor fuel occurred in at least seven of these accidents, including the one in 1966 at the Enrico Fermi Atomic Power Plant Unit 1. This was a sodium-cooled fast breeder demonstration reactor designed to generate 61 MWe. The damages were repaired and the reactor reached full power in 4 years following the accident. It operated successfully and completed its mission in 1973. This accident did not release any radioactivity to the environment.

A reactor accident in 1957 at Windscale, England, released a significant quantity of radioiodine, approximately 20,000 Ci, to the environment. This reactor, which was not operated to generate electricity, used air rather than water to cool the uranium fuel. During a special operation to heat the large amount of graphite in this reactor, the fuel overheated and radioiodine and noble gases were released directly to the atmosphere from a 123-m (405-ft) stack. Milk produced in a 518-km^2 (200-mi^2) area around the facility was impounded for up to 44 days. This kind of accident cannot occur in water-cooled reactors like Palo Verde, however.

5.9.2.4 Mitigation of Accident Consequences

Pursuant to the Atomic Energy Act of 1954, the Nuclear Regulatory Commission has conducted a safety evaluation of the application to operate PVNGS. Although this evaluation contains more detailed information on plant design, the principal design features are presented in the following section.

(1) <u>Design Features</u>

PVNGS contains features designed to prevent accidental release of radioactive fission products from the fuel and to lessen the consequences should such a release occur. Many of the design and operating specifications of these features are derived from the analysis of postulated events known as design-basis accidents. These accident preventive and mitigative features are collectively referred to as engineered safety features (ESF). The possibilities or probabilities of failure of these systems is incorporated in the assessments discussed in Section 5.9.2.5(2).

Each steel-lined, prestressed, posttensioned concrete containment is a passive mitigating system which is designed to minimize accidental radioactivity releases to the environment. Safety injection systems are incorporated to provide cooling water to the reactor core during an accident to prevent or minimize fuel damage.

The containment spray system is designed to spray cool water into the containment atmosphere, providing heat-removal capability inside the containment following steam release in accidents and helping to prevent containment failure due to overpressure. The spray water also contains an additive (hydrazine) which will chemically react with any airborne radioiodine to remove it from the containment atmosphere and prevent its release to the environment.

All the mechanical systems mentioned above are supplied with emergency power from onsite diesel generators in the event that normal offsite station power is interrupted.

The fuel-handling building for each unit also has accident-mitigating systems. The safety-grade ventilation system contains both charcoal and high-efficiency particulate filters. This ventilation system is also designed to keep the area around the spent-fuel pool below the prevailing barometric pressure during fuel-handling operations so that outleakage will not occur through building openings. If radioactivity were to be released into the building, it would be drawn through the ventilation system, and any radioactive iodine and particulate fission pro-ducts would be removed from the flow stream before exhausting to the outdoor atmosphere.

There are features of the plant that are necessary for its power-generation function that can also play a role in mitigating certain accident consequences. For example, the main condenser, although not classified as an ESF, can act to mitigate the consequences of accidents involving leakage from the primary to the secondary side of the steam generators (such as steam generator-tube ruptures). If normal offsite power is maintained and the turbine bypass system is operable, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or atmospheric dump valves can significantly reduce the amount of radioactivity released to the environment. In this case, the fission-product-removal capability of the normally operating waste gas treatment system would come into play.

Much more extensive discussions of the PVNGS safety features and characteristics may be found in the applicant's FSAR. The staff evaluation of these features are addressed in the SER. In addition, the implementation of the lessons learned from the TMI-2 accident--in the form of improvements in design, and procedures and operator training--will significantly reduce the likelihood of a degraded core accident which could result in large releases of fission products to the containment. Specifically, the applicant will be required to meet those TMI-related requirements specified in NUREG-0737. As noted in Section 5.9.2.5(7), no credit has been taken for these actions and improvements in discussing the radiological risk of accidents.

(2) Site Features

The NRC reactor site criteria, 10 CFR Part 100, require that the site for every power reactor have certain characteristics that tend to reduce the risk and potential impact of accidents. The discussion that follows briefly describes the Palo Verde site characteristics and how they meet these requirements.

First, the site has an exclusion area, as required by 10 CFR Part 100. The exclusion area, located within the 1640-ha (4050-acre) site, is owned by the applicant. The minimum distance from the edge of the Unit 3 containment building to the exclusion area boundary is 871 m (2857 ft). There are no residents within the exclusion area. Material submitted by the applicant states that the appli-cant ow.s all surface rights in the exclusion area, but does not own all mineral rights. The applicant has stated that it has the authority, required by Part 100, to determine all activities in this area. There are no activities unrelated to plant operation that occur within the exclusion area except for the activity associated with the construction of Units 2 and 3. There are no public roads, railways, or waterways traversing the exclusion area.

Second, beyond and surrounding the exclusion area is a low population zone (LPZ), also required by 10 CFR Part 100. The LPZ for the Palo Verde site is a circular area with a 6400-m (21,000-ft) radius, measured from the center of the Unit 2 containment building. Within this zone, the applicant must ensure that there is a reasonable probability that appropriate protective measures could be taken on behalf of the residents and other members of the public in the event of a serious accident. The population density of the LPZ is very low and is expected to remain that way for the life of the plant. There are no industrial, commercial, or institutional facilities in the LPZ now or planned for the future.

There are very few transient personnel within 10 mi of the site, and these are mostly migrant farm workers. In case of a radiological emergency, the applicant has made arrangements to carry out protective actions, including evacuation of personnel in the vicinity of the nuclear plant. For further details, see the section below on Emergency Preparedness.

Third, 10 CFR Part 100 also requires that the distance from the reactor to the nearest boundary of a densely populated area containing more than about 25,000 residents be at least one-and-one-third times the distance from the reactor to the outer boundary of the LPZ. Because accidents of greater potential hazards than those commonly postulated as representing an upper limit are conceivable, although highly improbable, it was considered desirable to add the population center distance requirement in Part 100 to provide for protection against exces-sive exposure doses to people in large centers. Sun City (with a 1977 population of 43,500 persons), with its closest boundary about 58 km (36 mi) east-northeast, has been currently designated as the nearest population center. The contiguous communities of Avondale and Goodyear, about 50 km (31 mi) east of the site, are projected to become the nearest population center by about 1995. The current as well as the projected population center distance is at least one-and-one-third times the LPZ outer radius. The major city within 80 km (50 mi) of the Palo Verde site is the urbanized area of Phoenix, Arizona, whose center is located about 72 km (45 mi) east, with a 1980 population of 772,884. Current population densities within 48 km (30 mi) of the site are about 17.6 persons/km^2 (11 persons per mi^2) and are projected to reach about 61 persons per km^2 (38 persons per mi^2) during the life of the plant.

The safety evaluation of the Palo Verde site has also included a review of potential external hazards (activities offsite that might adversely affect the operation of the plant and cause an accident). This review encompassed nearby industrial, transportation, and military facilities that might create explo-sive, missile, toxic gas, or similar hazards. The risk to the Palo Verde facility from such hazards has been found to be negligibly small. A more detailed discussion of the compliance with the Commission's siting criteria and the consideration of external hazards are given in the staff's Safety Evaluation Report.

(3) Emergency Preparedness

Emergency preparedness plans including protective action measures for the Palo Verde facility and environs are in an advanced but not yet fully completed stage. In accordance with the provisions of 10 CFR Section 50.47, effective November 3, 1980, no operating license will be issued to the applicant unless a finding is made by the NRC that the state of onsite and offsite emergency preparedness provides reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Among the standards that must be met by these plans are provisions for two emergency planning zones (EPZ). A plume exposure pathway EPZ of about 16 km (10 mi) in radius and an ingestion exposure pathway EPZ of about 80 km (50 mi) in radius are required. Other standards include appropriate ranges of protective actions for each of these zones, provisions for dissemination to the public of basic emergency planning information, provisions for rapid notification of the public during a serious reactor emergency, and methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences in the EPZs of a radiological emergency condition.

NRC findings will be based upon a review of the Federal Emergency Management Agency (FEMA) findings and determinations as to whether state and local government emergency plans are adequate and capable of being implemented, and on the NRC assessment as to whether the applicant's onsite plans are adequate and capable of being implemented. NRC staff findings are reported in the staff's Safety Evaluation Report. Although the presence of adequate and tested emergency plans cannot prevent the occurrence of an accident, it is the judgment of the staff that such plans can and will substantially mitigate the consequences to the public if one should occur.

5.9.2.5 Accident Risk and Impact Assessment

(1) Design-Basis Accidents

As a means of ensuring that certain features of the PVNGS meet acceptable design and performance criteria, both the applicant and the staff have analyzed the potential consequences of a number of postulated accidents. Some of these could lead to significant releases of radioactive materials to the environment and calculations have been performed to estimate the potential radiological consequences to persons offsite. For each postulated initiating event, the potential radiological consequences cover a considerable range of values, depending upon the particular course taken by the accident and the conditions, including wind direction and weather prevalent during the accident.

In the safety analysis and evaluation of the PVNGS, three categories of accidents have been considered. These categories are based upon their probability of occurrence and include (a) incidents of moderate frequency (events that can reasonably be expected to occur during any year of operation), (b) infrequent accidents (events that might occur once during the lifetime of the plant), and (c) limiting faults (accidents not expected to occur but that have the potential for significant releases of radioactivity). The radiological consequences of incidents in the first category, also called anticipated operational occurences, are discussed in Section 5.9.1. Some of the initiating events postulated in the second and third categories for the PVNGS are shown in Table 5.11. These events are designated design-basis accidents in that specific design and operating features as described above in Section 5.9.2.4(1) are provided to limit their potential radiological consequences. Approximate radiation doses to the whole body that might be received by a person at the boundary of the plant exclusion area during the first 2 hours of the accidents are also shown in the table. The inhalation doses to the thyroid of a hypothetical child located at the exclusion area boundary during entire durations of these accidents were calculated by the applicant and are also shown in the table. The results shown in the table reflect the expectation that engineered safety and operating features designed to mitigate the consequences of the postulated accidents would function as intended. An important implication of this expectation is that the releases considered are limited to noble gases and radioiodines and that any other radioactive materials (for example, in particulate form) are not expected to be released. The results are also quasi-probabilistic in nature in the sense that the meteorological dispersion conditions are taken to be neither the best nor the worst for the site, but rather are an average value determined by actual site measurements. In order to contrast the results of these calculations with those using more pessimistic, or conservative, assumptions described below, the doses shown in Table 5.11 are sometimes referred to as "realistic" doses.

Table 5.11 Approximate radiation doses from design-basis accidents at exclusion area boundary

	Dose (rem)	
Accident Type	Whole body	Child thyroid
Infrequent accidents		
Waste gas tank failure	0.07	< 0.0004
Small-break LOCA[1]	0.04	< 0.0003
Steam generator tube rupture[2]	0.02	< 0.004
Fuel-handling accident	0.07	0.002
Limiting faults		
Main steamline break	< 0.0005	< 0.00004
Control rod ejection	0.04	0.8
Large-break LOCA	0.4	8.0

[1]LOCA-Loss of Coolant Accident; the TMI-2 accident was one kind of a small-break LOCA.

[2]See NUREG-0651 for descriptions of three steam generator tube rupture accidents that have occurred in the United States.

Population exposures calculated by the applicant for these events range from a small fraction of a person-rem to about 770 person-rems for the population within 80 km (50 mi) of the PVNGS. These calculations for both individual and population exposures indicate that the risk of incurring any adverse health effects as a consequence of these events is exceedingly small. By comparison with the estimates of radiological impact for normal operations shown in Section 5.9.1, the staff also concludes that radiation exposures from design-basis accidents are roughly comparable to the exposures to individuals and the population from normal station operations over the expected lifetime of the plant.

The staff is carrying out calculations to estimate the potential upper bounds for individual exposures from the same initiating accidents in Table 5.11 for the purpose of implementing the provisions of 10 CFR Part 100. For these calculations, much more pessimistic (conservative or worst case) assumptions are made as to the course taken by the accident and the prevailing conditions. These assumptions include much larger amounts of radioactive material released by the initiating events, additional single failures in equipment, operation of ESFs in a degraded mode,* and very poor meteorological dispersion conditions. A license to operate the plant will not be given unless the results of these calculations would show that for these events the exposures are not expected to exceed 25 rems to the whole body and 300 rems to the thyroid of any individual at the exclusion area boundary over a period of 2 hr. For calculation of the thyroid dose, it will be assumed that an individual is located at a point on the exclusion area boundary where the radioiodine concentration in the plume has its highest value and inhales at a breathing rate characteristic of a person jogging for a period of 2 hr. The health risk to an individual receiving 300 rems to the thyroid is the potential appearance of benign or malignant thyroid nodules in about 1 out of 10 cases, and the development of a fatal thyroid cancer in about 4 out of 1,000 cases.

None of the calculations of the impacts of design-basis accidents described in this section takes into consideration possible reductions in individual or population exposures as a result of taking any protective actions.

(2) Probabilistic Assessment of Severe Accidents

In this and the following three sections, there is a discussion of the probabilities and consequences of accidents of greater severity than the design-basis accidents discussed in the previous section. As a class, they are considered less likely to occur, but their consequences could be more severe, both for the plant itself and for the environment. These severe accidents, heretofore frequently called Class 9 accidents, can be distinguished from design-basis accidents in two primary respects: they involve substantial

*The containment structure, however, is assumed to prevent leakage in excess of that which can be demonstrated by testing, as provided in 10 CFR Section 100.11(a).

physical deterioration of the fuel in the reactor core, including overheating to the point of melting, and they involve deterioration of the capability of the containment structure to perform its intended function of limiting the release of radioactive materials to the environment.

The assessment methodology employed is that described in the Reactor Safety Study (RSS) which was published in 1975.* However, the sets of accident sequences that were found in the RSS to be the dominant contributors to the risk in the prototype PWR (Westinghouse-designed Surry Unit 1) have recently been updated ("rebaselined") (NUREG-0715). The rebaselining has been done largely to incorporate peer group comments (NUREG/CR-0400) and better data and analytical techniques resulting from research and development after the publication of the RSS. Entailed in the rebaselining effort was the evaluation of the individual dominant accident sequences--as they are understood to evolve. The earlier technique of grouping a number of accident sequences into the encompassing "Release Categories" as was done in the RSS has been largely (but not completely) eliminated.

The PVNGS units are Combustion Engineering-designed PWRs having similar design and operating characteristics to the RSS prototype PWR. Therefore, the present assessment for PVNGS has used as its starting point the rebaselined accident sequences and release categories referred to above, and more fully described in Appendix E. Characteristics of the sequences (and release categories) used (all of which involve partial to complete melting of the reactor core) are shown in Table 5.12. Sequences initiated by natural phenomena such as tornadoes, floods, or seismic events and those that could be initiated by deliberate acts of sabotage are not included in these event sequences. The radiological consequences of such events would not be different in kind from those which have been treated. Moreover, it is the staff's judgment, based upon design requirements of 10 CFR Part 50, Appendix A, relating to effects of natural phenomena, and safeguards requirements of 10 CFR Part 73, that these events do not contribute significantly to risk.

Calculated probability per reactor-year associated with each accident sequence (or release category) used is shown in the second column in Table 5.12. As in the RSS, there are substantial uncertainties in these probabilities. This is due, in part, to difficulties associated with the quantification of human error and to inadequacies in the data base on failure rates of individual plant components that were used to calculate the probabilities (NUREG/CR-0400). The probability of accident sequences from the Surry plant were used to give a perspective of the societal risk at PVNGS because, although the probabilities of particular accident sequences may be substantially different and even improved for PVNGS the overall effect of all sequences taken together is likely to be within the uncertainties (see Section 5.7.2.5(7) for discussion of uncertainties in risk estimates).

*Because this report has been the subject of considerable controversy, a discussion of the uncertainties surrounding it is provided in Section 5.9.2.5(7).

Table 5.12 Summary of atmospheric releases in hypothetical accident sequences in a PWR (rebaselined)

Accident sequence or sequence group[b]	Probability (reactor-yr^{-1})	Fraction of core inventory released[a]						
		Xe-Kr	I	Cs-Rb	Te-Sb	Ba-Sr	Ru[c]	La[d]
Event V	2.0×10^{-6}	1.0	0.7	0.8	0.4	0.1	0.04	0.006
TMLB'	3.0×10^{-6}	1.0	0.3	0.4	0.2	0.04	0.02	0.002
PWR3	3.0×10^{-6}	0.8	0.2	0.2	0.3	0.02	0.03	0.003
PWR7	4.0×10^{-5}	6×10^{-3}	4×10^{-5}	1×10^{-5}	2×10^{-5}	1×10^{-6}	1×10^{-6}	2×10^{-7}

[a]Background on the isotope groups and release mechanisms is presented in Appendix VII, WASH 1400.[70]

[b]See Appendix F for description of the accident sequences and Release Categories.

[c]Includes Ru, Rh, Co, Mo, Tc.

[d]Includes Y, La, Zr, Nb, Ce, Pr, Nd, Np, Pu, Am, Cm.

Note: Please refer to Section 5.9.2.5(7) for a discussion of uncertainties in risk estimates.

The magnitudes (curies) of radioactivity release for each accident sequence or release category are obtained by multiplying the release fractions shown in Table 5.12 by the amounts that would be present in the core at the time of the hypothetical accident. These are shown in Table 5.10 for a PVNGS unit at the core thermal power level of 3817 MWt.

The potential radiological consequences of these releases have been calculated by the consequence model used in the RSS adapted and modified as described below to apply to a specific site. The essential elements are shown in schematic form in Figure 5.2. Environmental parameters specific to the PVNGS site have been used and include the following:

- meteorological data for the site representing a full year of consecutive hourly measurements and seasonal variations

- projected population for the year 2000 extending throughout regions of 80-km (50-mi) and 563-km (350-mi) radius from the site

- the habitable land fraction within the 563-km (350-mi) radius

- land-use statistics, on a statewide basis, including farm land values, farm product values including dairy production, and growing season information,

  for the State of Arizona and each surrounding state within the 563-km (350-mi) region

To obtain a probability distribution of consequences, the calculations are performed assuming the occurrence of each accident-release sequence at each of 91 different "start" times throughout a 1-year period. Each calculation utilizes the site-specific hourly meteorological data and seasonal information for the time period following each "start" time. The consequence model also contains provisions for incorporating the consequence reduction benefits of evacuation, relocation, and other protective actions. Early evacuation and relocation of people would considerably reduce the exposure from the radioactive cloud and the contaminated ground in the wake of the cloud passage. The evacuation model used (see Appendix F) has been revised from that used in the RSS for better site-specific application. The quantitative characteristics of the evacuation model used for the Palo Verde site are best-estimate values made by the staff and partly based upon evacuation time estimates submitted by the applicant. There may be some people near a site who may not be notified or who will choose not to evacuate. (However, there will be planning for essentially complete notification of even those with impaired sight and/or hearing, or those in remote living situations.) Also, near the PVNGS, there are three schools, where special equipment or personnel may be needed to facilitate evacuation. They are the Palo Verde, Arlington, and Ruth Fisher schools. Because of this, actual evacuation effectiveness could be greater or less than that characterized but would not be expected to be very much less.

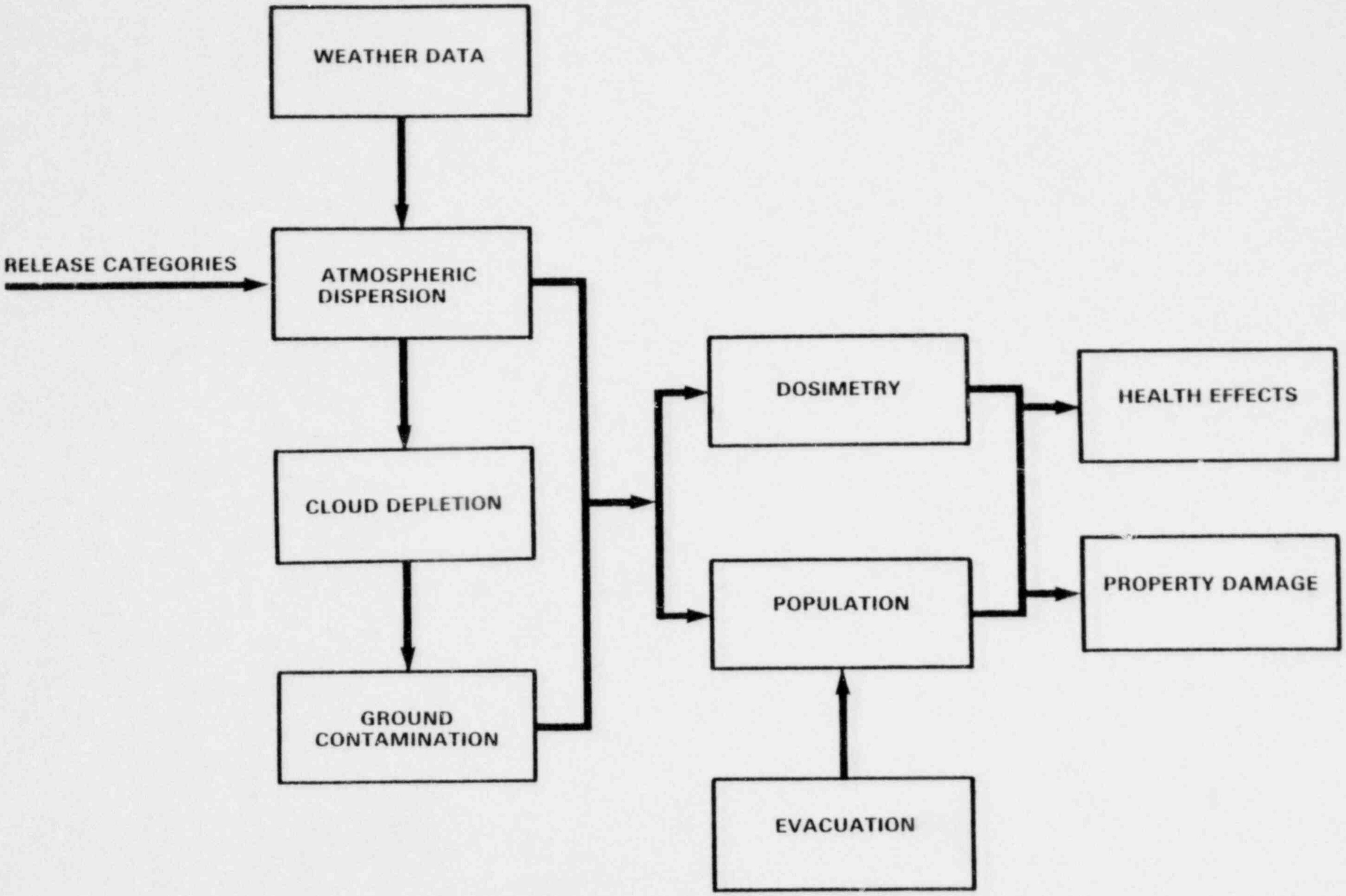

Figure 5.2 Schematic outline of consequences model

The other protective actions include: (a) either complete denial of use (interdiction) or permitting use only at a sufficiently later time after appropriate decontamination of food stuffs such as crops and milk, (b) decontamination of severely contaminated environment (land and property) when it is considered to be economically feasible to lower the levels of contamination to protective action guide (PAG) levels, and (c) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels reduce to such values by radioactive decay and weathering so that land and property can be economically decontaminated as in (b) above. These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment.

Early evacuation of people within and early relocation of people from regions outside (see Appendix F) the plume exposure pathway EPZ and other protective actions as mentioned above are considered as essential sequels to serious nuclear reactor accidents involving significant release of radioactivity to the atmosphere. Therefore, the results shown for the PVNGS reactors (Table 5.13) include the benefits of these protective actions.

There are also uncertainties in the estimates of consequences and the error bounds may be as large as they are for the probabilities. It is the judgment of the staff, however, that it is more likely that the calculated results are overestimates of consequences rather than underestimates.

The results of the calculations using this consequence model are radiological doses to individuals and to populations, health effects that might result from these exposures, costs of implementing protective actions, and costs associated with property damage by radioactive contamination.

(3) Dose and Health Impacts of Atmospheric Releases

The results of the calculations of dose and health impacts performed for the PVNGS are presented in the form of probability distributions in Figures 5.3 through 5.6 and are included in Table 5.13. All of the accident sequences and release categories shown in Table 5.12 contribute to the results, the consequences of each being weighted by its associated probability.

Figure 5.3 shows the probability distributions for the number of persons who might receive whole-body doses equal to or greater than 200 rems and 25 rems, and thyroid doses equal to or greater than 300 rems from early exposure,* all on a per-reactor-year basis. The 200-rem whole-body dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole-body (which has been identified earlier as the lower limit for a clinically observable physiological effect in nearly all people) and 300-rem thyroid figures correspond to the Commission's guideline values for reactor siting in 10 CFR Part 100.

---

*Early exposure to an individual includes external doses from the radioactive cloud and the contaminated ground, and the dose from internally deposited radionuclides from inhalation of contaminated air during the cloud passage. Other pathways of exposure are excluded.

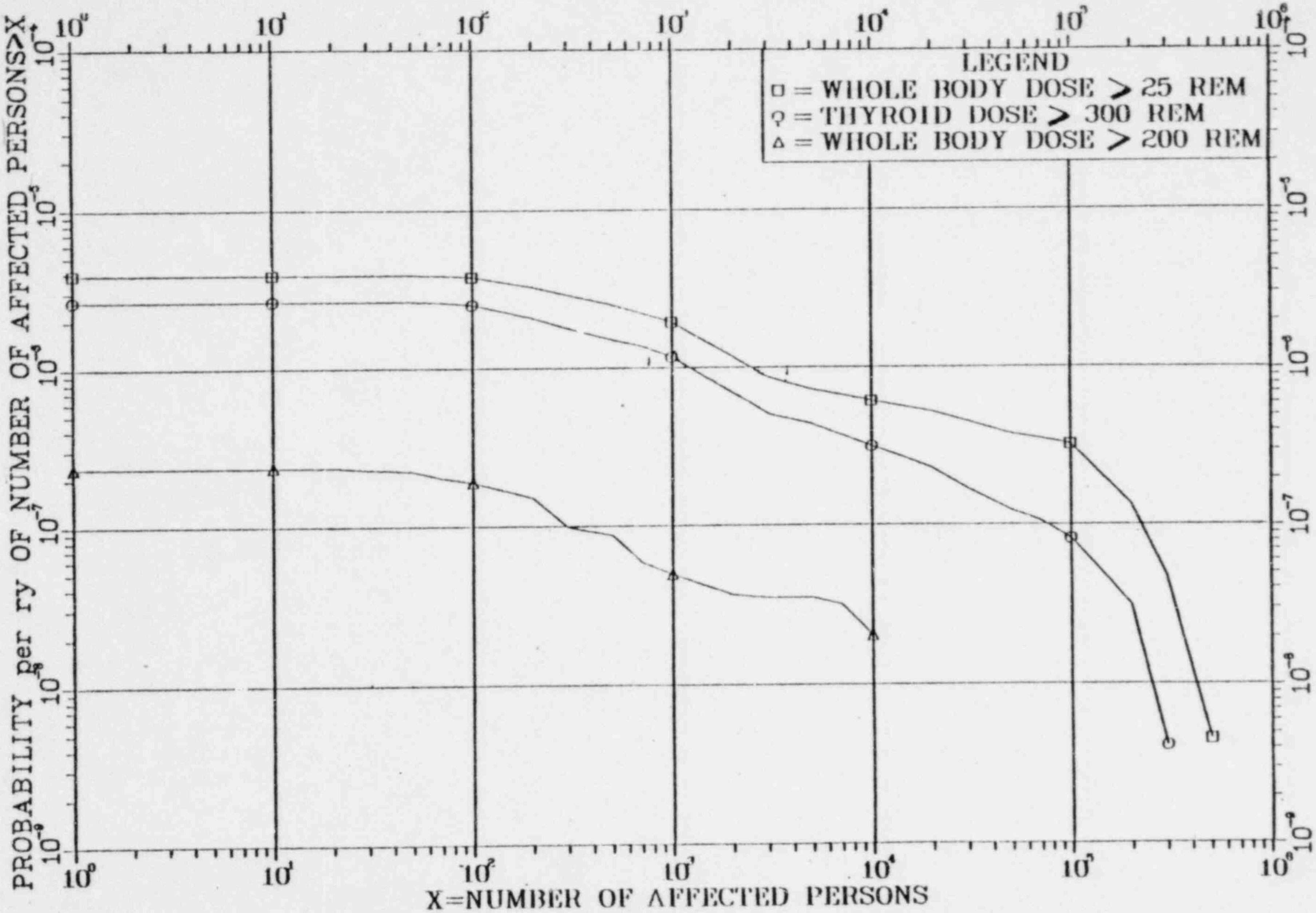

Figure 5.3 Probability distributions of individual dose impacts (see Section 5.9.2.5(7) for discussion of uncertainties in risk estimates)

The figure shows in the left-hand portion that there are approximately 4 chances in 1,000,000 (4×10^{-6}) per reactor-year that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that the three curves run almost parallel in horizontal lines initially shows that if one person were to receive such doses, the chances are about the same that several tens to hundreds would be so exposed. The chances of larger numbers of persons being exposed at those levels are seen to be considerably smaller. For example, the chances are about 2 in 100,000,000 (2×10^{-8}) that 10,000 or more people might receive doses of 200 rems or greater. A majority of the exposures reflected in this figure would be expected to occur to persons within a 72-km (45-mi) radius of the plant. Virtually all would occur within a 160-km (100-mi) radius.

Figure 5.4 shows the probability distributions for the total population exposure in person-rems (that is, the probability per reactor-year that the total population exposure will equal or exceed the values given. Most of the population exposure up to 10 million person-rems would occur within 50 mi, but the more severe releases (as in the first two accident sequences in Table 5.12) would result in exposure to persons beyond the 50-mi range as shown.

For perspective, population doses shown in Figure 5.4 may be compared with the annual average dose to the population within 50 mi of the Palo Verde site due to natural background radiation of 130,000 person-rems, and to the anticipated annual population dose to the general public from normal station operation of 210 person-rems (excluding plant workers) (see Appendix C, Table C-6).

Figure 5.5 shows the probability distribution for acute fatalities (see Appendix G), representing radiation injuries that would produce fatalities within about year after exposure. Virtually all of the acute fatalities would be expected to occur within the 32-km (20-mi) radius. The results of the calculations shown in this figure and in Table 5.13 reflect the effect of evacuation within the 10-mi plume exposure pathway EPZ only. For the very low probability accidents having the potential for causing radiation exposures above the threshold for acute fatality at distances beyond 16.1 km (10 mi), it would be realistic to expect that authorities would evacuate persons at all distances at which such exposures might occur. Acute fatality consequences would, therefore, reasonably be expected to be very much less than the numbers shown. (Figure F-1 of Appendix F illustrates the potential benefits of evacuation within 24 km (15 mi). Calculations predict zero acute fatality for evacuation within 32 km (20 mi).)

Figure 5.6 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population and the population within 81 km (50 mi) are shown separately. Further, the fatal, latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs.

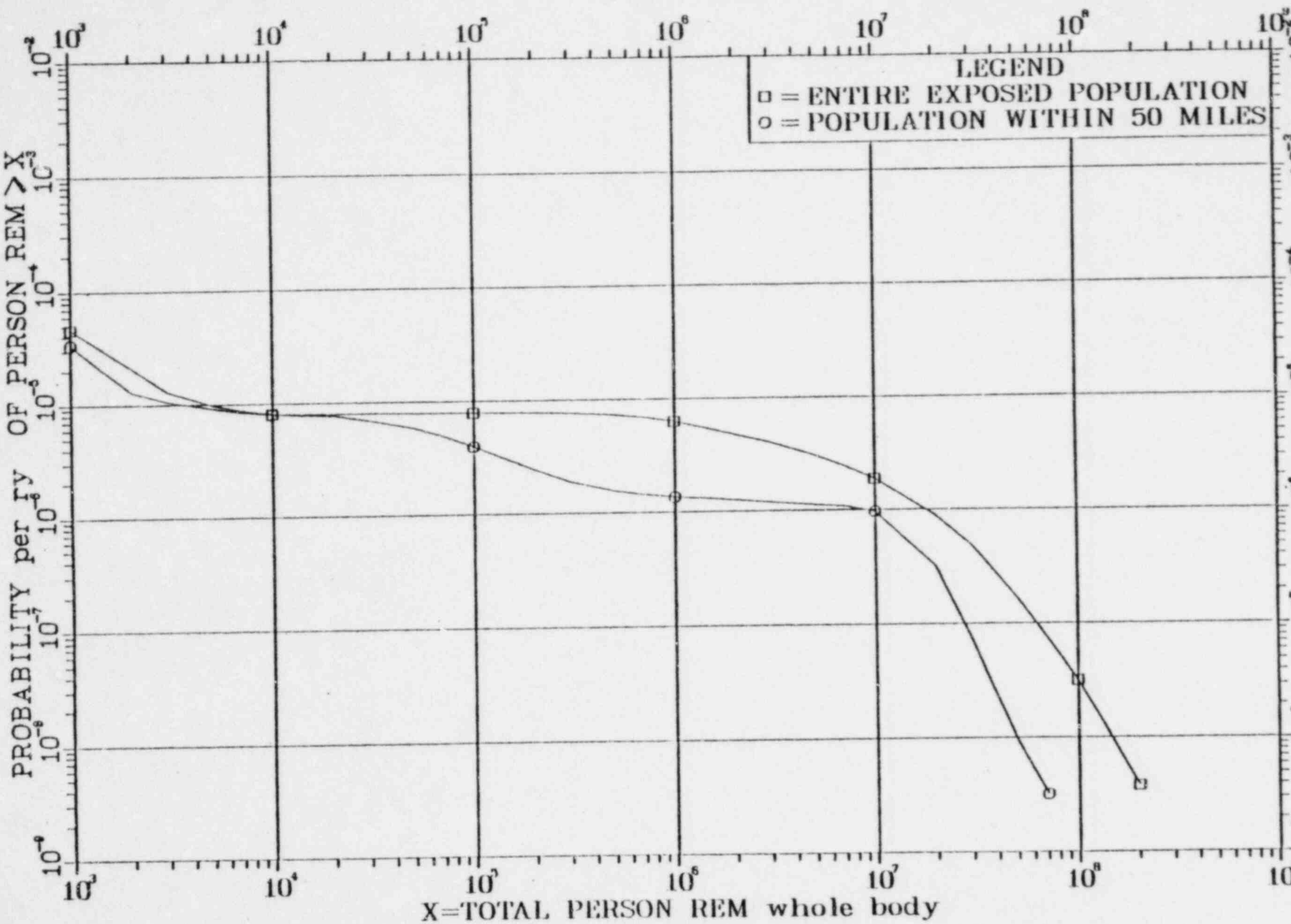

Figure 5.4 Probability of distributions of population exposures (see Section 5.9.2.5(7) for discussion of uncertainties in risk estimates)

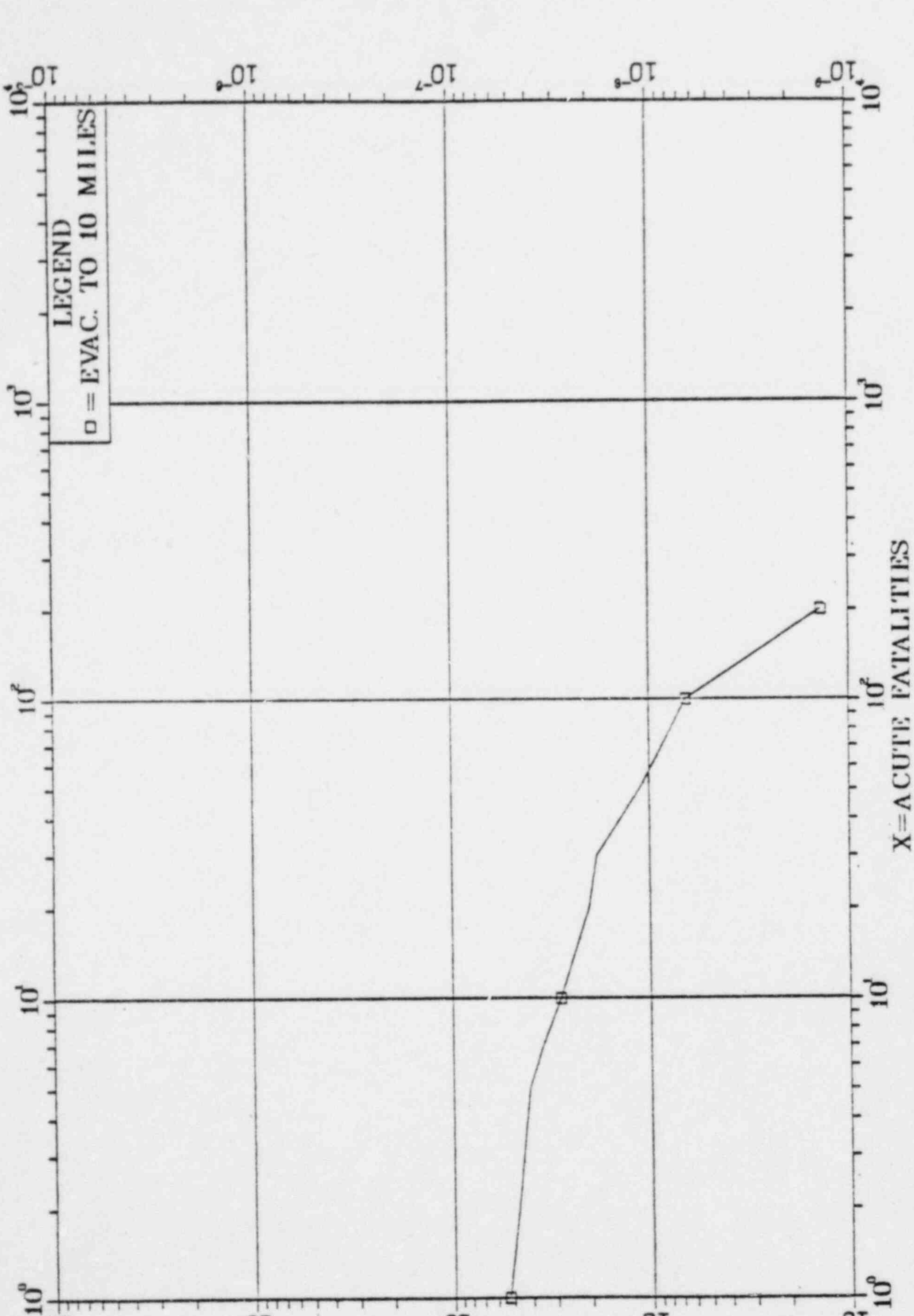

Figure 5.5 Probability distribution of acute fatalities (see Section 5.9.2.5(7) for discussion of risk estimates)

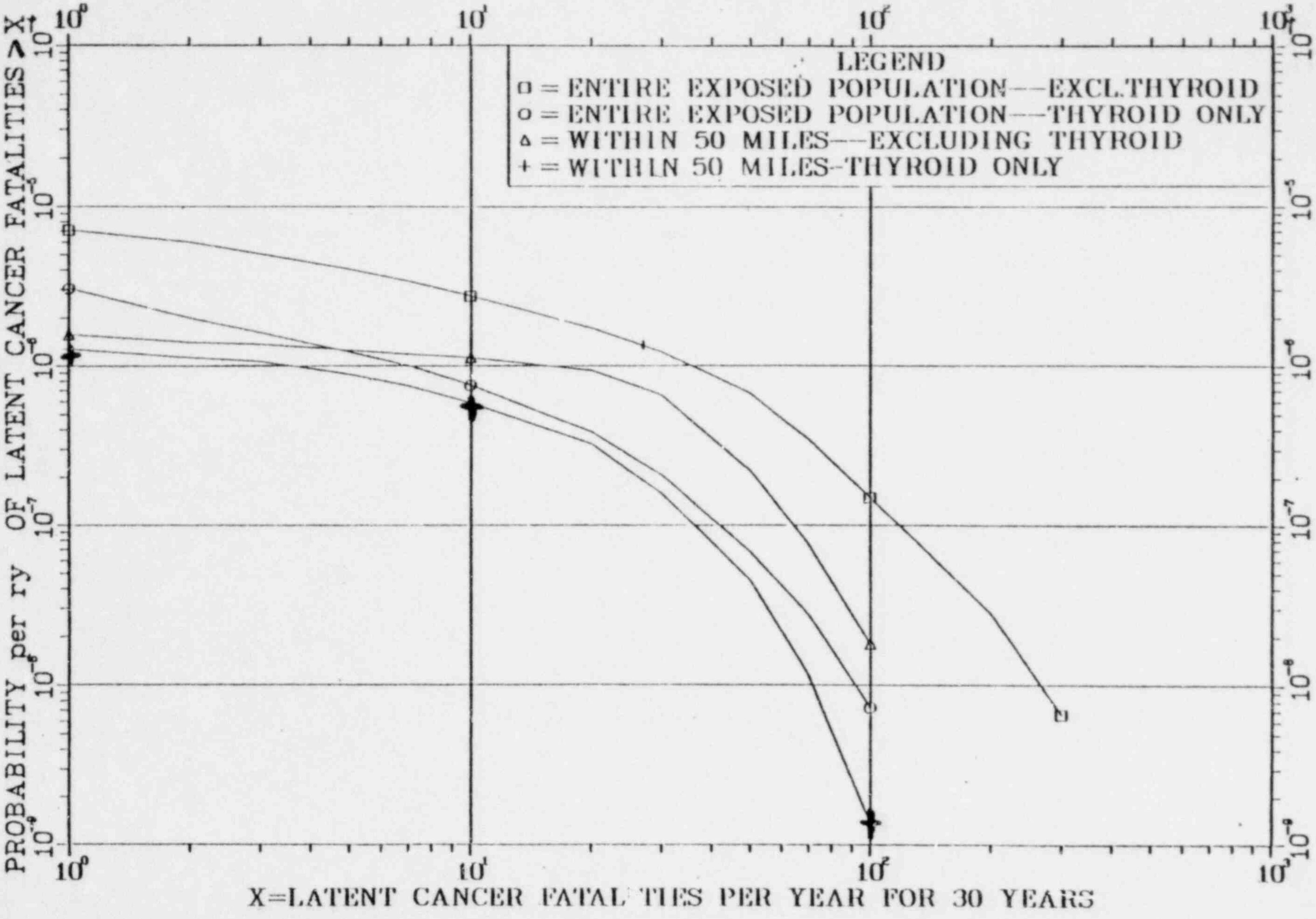

Figure 5.6 Probability distributions of cancer fatalities (see Section 5.9.2.5(7) for discussion of uncertainties in risk estimates)

Table 5.13 Summary of environmental impacts and probabilities

Probability of impact per reactor-year	Persons exposed over 200 rems	Persons exposed over 25 rems	Acute fatalities	Population exposure, millions of person-rems 50 mi/total	Latent[a] cancers, 50 mi/total	Cost of offsite mitigating actions, $ millions
10^{-4}	0	0	0	0/0	0/0	0
10^{-5}	0	0	0	0.004/0.005	0/0	0.9
5×10^{-6}	0	0	0	0.064/1.5	0/90	82
10^{-6}	0	2,500	0	10/20	425/1,130	450
10^{-7}	300	220,000	<1	27/60	3,000/4,830	2,600
10^{-8}	20,000	440,000	57	50/130	2,100/2,700[b]	5,000
Related figure	5.9	5.9	5.11	5.10	5.12	5.13

[a]Includes cancers of all organs. Thirty times the values shown in Figure 5.6 are shown in this column, reflecting the 30-yr period over which cancers might occur. Genetic effects would be approximately twice the number of latent cancers.

[b]Thyroid cancers only. Cancers of all other organs do not contribute at this probability level.

Note: See Section 5.9.2.5(7) for a discussion of uncertainties in risk estimates

(4) Economic and Societal Impacts

As noted in Section 5.9.2.2, the various measures for avoidance of adverse health effects including those due to residual radioactive contamination in the environment are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts for the Palo Verde facility and environs have also been made. Unlike the radiation exposure and health effect impacts discussed above, impacts associated with adverse health effects avoidance are more readily transformed into economic impacts.

The results are shown in Figure 5.7 as the probability distribution for the cost of offsite mitigating actions in Figure 5.7 and are included in Table 5.12. The factors contributing to these estimated costs include the following:

- evacuation costs
- value of crops contaminated and condemned
- value of milk contaminated and condemned
- costs of decontamination of property where practical
- indirect costs due to loss of use of property and incomes derived there from

The last-named cost would derive from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 5.7 shows that at the extreme end of the accident spectrum these costs could exceed several billion dollars but that the probability that this would occur is exceedingly small, less than one chance in a million per reactor-year. Additional economic impacts that can be monetized include costs of decontamination of the facility itself and the costs of replacement power. Probability distributions for these impacts have not been calculated but they are included in the discussion of risk considerations in Section 5.9.2.5(6) below.

(5) Releases to Groundwater

As identified in Section 5.9.2.2(2), accidental releases of radioactivity to groundwater could provide a pathway of public radiation exposure and environmental contamination. Consideration has been given to the potential environmental impact of this pathway for the Palo Verde station. The principal contributors to the risk are the core melt accidents associated with the evaluated accident sequences and release categories. The penetration of the basemat of the containment buildings can release molten core debris to the strata beneath the station. Soluble radionuclides in this debris can be leached and transported with groundwater to downgradient domestic wells used for drinking. In pressurized water reactors, such as the Palo Verde units,

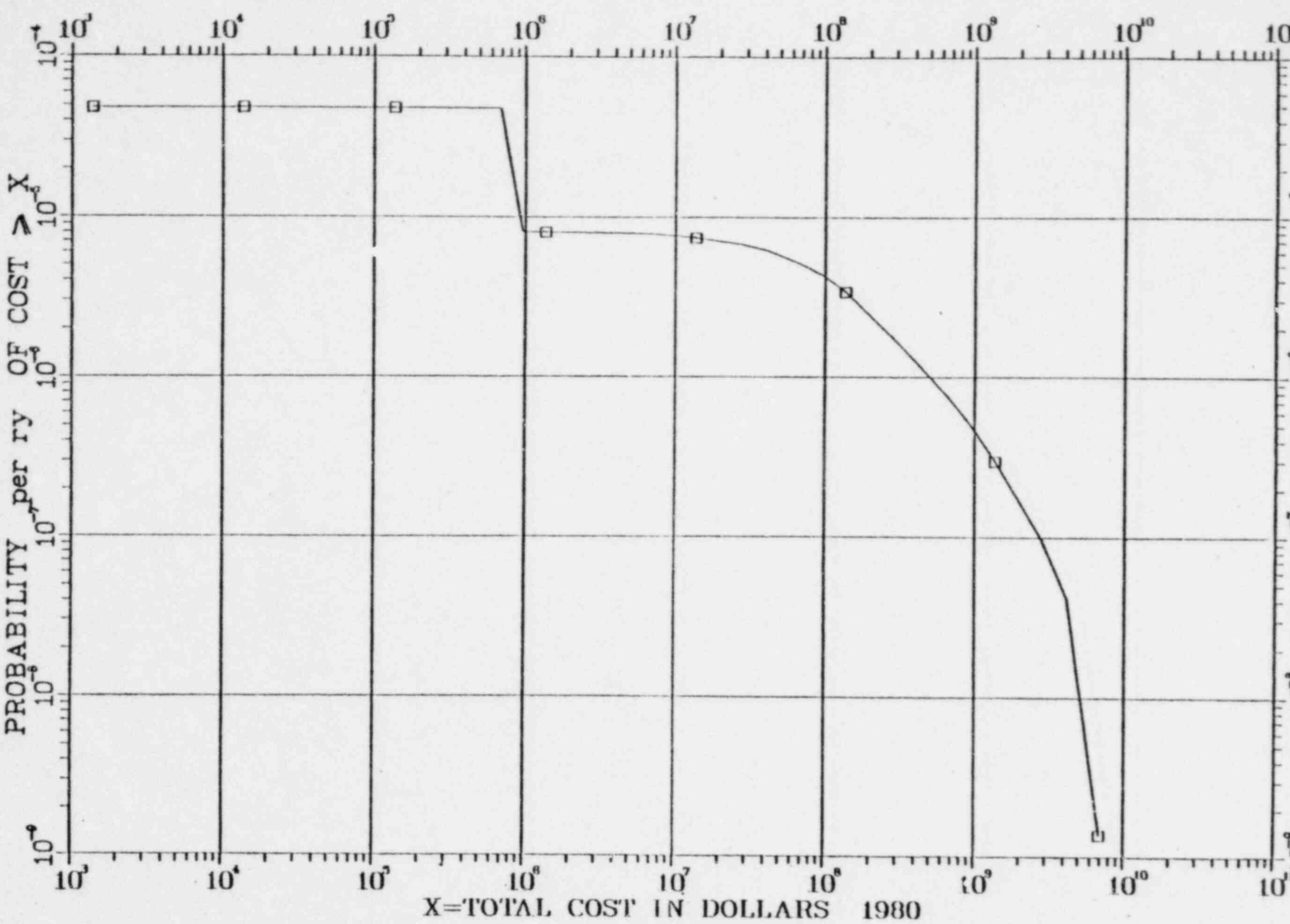

Figure 5.7 Probability distribution of mitigation measures cost (see Section 5.9.2.5(7) for discussion of uncertainties in risk estimates)

there is an additional opportunity for groundwater contamination due to the release of contaminated sump water to the ground through a breach in the containment.

An analysis of the potential consequences of a liquid pathway release of radioactivity for generic sites was presented in the "Liquid Pathway Generic Study" (LPGS) (NUREG-0440). The LPGS compared the risk of accidents involving the liquid pathway (drinking water, irrigation, aquatic food, swimming, and shoreline usage) for four conventional, generic land-based nuclear plants and a floating nuclear plant (for which the nuclear reactors would be mounted on a barge and moored in a water body). Parameters for the land-based sites were chosen to represent averages for a wide range of real sites and are thus "typical," but represented no real site in particular.

The discussion in this section is an analysis to determine whether or not the Palo Verde site liquid pathway consequences would be unique when compared to land-based sites considered in the LPGS.

The Palo Verde station is located in the Lower Hassayampa-Centennial ground water basin. There are three major sedimentary hydrologic units underlying the site (FSAR):

(1) The Upper Alluvial Unit consists primarily of fluvial silty and gravelly sand with discontinuous clay and silty clay lenses. This unit extends to a depth of about 30 to 60 ft (9 to 18 m) beneath the site.

(2) The Middle Fine Grained Unit consists of massive, continuous layers of clay and silty clay, with discontinuous lenses of clayey silt, clayey sand, and the silty sand. The thickness of this unit at the site is about 250 ft (76 m).

(3) The Lower Coarse Grained Unit consists of variably cemented conglomerate of volcanic flow, tuff, and sandstone.

The Lower Coarse Grained Unit has groundwater under artesian conditions and is the regional aquifer. The Middle Fine Grained Unit serves as an effective aquiclude isolating the Upper Alluvial Unit from the regional aquifer. Groundwater exists under water table conditions in the Upper Alluvial Unit.

The PVNGS is located in an area that was under intensive irrigation from 1950 to 1975. Water which infiltrated the soil formed a large perched groundwater mound. Since the cessation of irrigation in 1975, the mound has decayed slowly by flowing radially outward from the center in the Upper Alluvial Unit. The staff estimates that vertical percolation through the thick aquiclude would be very small.

In the event of a core melt accident, contamination released to the ground would migrate with the radial flow caused by the dissipation of the perched groundwater mound. The staff has conservatively estimated the average radial groundwater velocity to be no greater than 19 ft (6 m) per year. Furthermore, this velocity will be reduced as the mound dissipates. Local recharge of the water table by infiltrating rainfalls or seepage from the evaporation pond, storage pond, and spray ponds is considered to be minor. Contamination flowing in the groundwater could affect only users of groundwater because there are no surface water bodies fed by the water table.

There are approximately 3500 people living within 10 mi of the site (ER). Most, if not all, drinking water is supplied from the deep artesian aquifer which would not be affected by contamination from the plant. Table 5.14 shows a comparison of parameters for the LPGS dry site and the Palo Verde site. Only Sr-90 was considered in the dose comparison because it has been shown in the LPGS that virtually all of the liquid pathway population dose from an assumed core melt accident would be due to this isotope in the dry-site case. It is obvious from this comparison that the Palo Verde site is far superior to the LPGS site in terms of the potential for liquid pathway population doses. The staff estimated that the population dose would be practically zero compared to the LPGS dry-site case.

Table 5.14 Comparison of LPGS dry site and Palo Verde site

Parameter	LPGS dry site	Palo Verde site
Groundwater velocity	2446 ft/yr	19 ft/yr (conservative)
Retardation coefficient	28 for Sr-90	89 for Sr-90 (conservative, see NUREG/CR-0912)
Exclusion boundary distance	1500 ft	2600 ft
Groundwater travel time to exclusion boundary	0.61 yrs	140 yrs
Sr-90 travel time to exclusion boundary	17 yrs	12.5×10^3 yrs
Fraction of Sr-90 reaching exclusion boundary	0.66	~0
Well water usage	10 people/mi^2	11 people/mi^2 (conservative based on population within 10 mi and all water usage from the upper aquifer)

Furthermore, the staff has conservatively estimated that the minimum groundwater travel time from the plant to the site exclusion boundary would be at least 140 years. There are measures which could be taken to inhibit or stop the movement of contaminated groundwater, such as slurry walls or wellpoint dewatering, long before it posed any hazard to water supplies. Thus, the Palo Verde site is not unique in its liquid pathway contribution to risk when compared to other land-based sites in the "Liquid Pathway Generic Study." The

LPGS demonstrated that the individual and population doses for the liquid pathway range from fractions to very small fractions of those that can arise from the airborne pathways.

(6) Risk Considerations

The foregoing discussions have dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Because the ranges of both factors are quite broad, it is also useful to combine them to obtain average measures of environmental risk. Such averages can be particularly instructive as an aid to the comparison of radiological risks associated with accident releases and with normal operational releases.

A common way in which this combination of factors is used to estimate risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a number of consequences expected per unit of time. Such a quantification of risk does not at all mean that there is universal agreement that peoples' attitudes about risk, or what constitutes an acceptable risk, can or should be governed solely by such a measure. At best, it can be a contributing factor to a risk judgment, but not necessarily a decisive factor.

Table 5.15 shows average values of risk associated with population dose, acute fatalities, latent fatalities, and costs for evacuation and other protective actions. These average values are obtained by summing the probabilities multiplied by the consequences over the entire range of distributions. Because the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

Table 5.15 Average values of environmental risks due to accidents per reactor-year*

Environmental risk	Average value
Population exposure	
Person-rems within 50 mi	21
Total person-rems	67
Acute fatalities	0.0000021
Latent cancer fatalities	
All organs excluding thyroid	0.0037
Thyroid only	0.00086
Cost of protective actions and decontamination	$2,260**

*See Section 5.9.2.5(7) for discussions of uncertainties in risk estimates.
**1980 dollars

A comparison of population exposures and latent cancer fatality risks (excluding exposure to the plant personnel) shows that the accident risks are comparable to those for normal operation.

There are no acute fatality nor economic risks associated with protective actions and decontamination for normal releases; therefore, these risks are unique for accidents. For perspective and understanding of the meaning of the acute fatality risk of 0.000002/yr, however, it should be noted that a good approximation of the population at risk is that within about 16 km (10 mi) of the plant, about 25,000 persons in the year 2000. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 5 from motor vehicle accidents, 2 from falls, 1 from drowning, 1 from burns, 0.3 from firearms (CONAES, p 577).

Within the 16-km (10-mi) radius plume exposure pathway EPZ, the calculations show that the best estimate evacuation can reduce the risks of whole body or thyroid exposure and risks of acute or latent cancer fatality to an individual to near zero. For comparison the following risks of fatality per year to an individual living in the United States may be noted (ibid): automobile accident 2.2×10^{-4}, falls 7.7×10^{-5}, drowning 3.1×10^{-5}, burning 2.9×10^{-5}, and firearms 1.2×10^{-5}.

The economic risk associated with evacuation and other protective actions could be compared with property damage costs associated with alternative energy generation technologies. The use of fossil fuels--coal or oil, for example--would emit substantial quantities of sulfur dioxide and nitrogen oxides into the atmosphere, and, among other things, lead to environmental and ecological damage through the phenomenon of acid rain (CONAES, pp.559-560). This effect has not, however, been sufficiently quantified for a useful comparison to be drawn at this time.

There are other economic impacts and risk that can be monetized that are not included in the cost calculations discussed in Section 5.9.2.5(4). These are accident impacts on the facility itself that result in added costs to the public (ratepayers, taxpayers, and/or shareholders). These costs would be for decontamination and repair or replacement of the facility, and for replacement power.

No detailed methodology has been developed for estimating the contributions of an accident to the economic risk to the licensee for decontamination and restoration of the plant. Experience with such costs is currently being accumulated as a result of the Three Mile Island accident. If an accident occurs during the first year of operation of a Palo Verde unit (1984), the economic penalty associated with the initial year of the unit's operation is estimated at $1 billion for decontamination and $600 million for restoration, including replacement of the damaged nuclear fuel. The staff considers the estimate as conservative (high) in that the total costs are assumed to occur during the first year of the accident, whereas in reality the costs would be spread over several years thereafter. Although insurance would cover $300 million of the $1600 million, the insurance is not credited against the $1600 million because the $300 million times the risk probability should theoretically balance the insurance premium. In addition, the staff estimates additional fuel costs of $470 million for replacement power during each year the unit is being restored. This estimate assumes that the energy that would have been forthcoming from the unit (assuming a 60-percent capacity factor) will be replaced primarily by oil-fired generation in the Arizona, Nevada, New Mexico, and California area. Assuming that the nuclear unit does not operate for 8 years, the total additional replacement power costs would be approximately $3.8 billion.

If the probability of sustaining a total loss of the original facility is taken as the sum of the occurrence of a core melt accident (the sum of the probabilities for the categories in Table 5.12), then the probability of a disabling accident happening during each year of a unit's service life is 4.8×10^{-5}. Multiplying the previously estimated costs of $5.4 billion for an accident to a Palo Verde unit during the initial year of its operation by the above 4.8×10^{-5} probability results in an economic risk of approximately $260,000 applicable to a Palo Verde unit during its first year of operation. This is also approximately the economic risk during the second and each subsequent year of operation. Although nuclear units depreciate in value and may operate at reduced capacity factors so that the economic consequences due to an accident become less as the units become older, this reduction is considered to be offset by higher costs of decontamination and restoration of the units in the later years as a result of inflation.

(7) Uncertainties

The foregoing probabilistic and risk assessment discussion has been based on the methodology presented in the Reactor Safety Study which was published in 1975.

In July 1977, the NRC organized an Independent Risk Assessment Review Group to (a) clarify the achievements and limitations of the Reactor Safety Study, (b) assess the peer comments thereon and the responses to the comments, (c) study the current state of such risk assessment methodology, and (d) recommend to the Commission how and whether such methodology can be used in the regulatory and licensing process. The results of this study were issued in September 1978 (NUREG/CR-0400). This report, called the Lewis Report, contains several findings and recommendations concerning the RSS. Some of the more significant findings are summarized below.

- A number of sources, both conservative and nonconservative in the probability calculations in the RSS, were found, which were very difficult to balance. The Review Group was unable to determine whether the overall probability of a core melt given in the RSS was high or low, but the group did conclude that the error bands were understated.

- The methodology, which was an important advance over earlier methodologies that had been applied to reactor risk, was sound.

- It is very difficult to follow the detailed thread of calculations through the RSS. In particular, the Executive Summary is a poor description of the contents of the report, should not be used as such, and has lent itself to misuse in the discussion of reactor risk.

On January 19, 1979 the Commission issued a statement of policy concerning the RSS and the Review Group Report. The Commission accepted the findings of the Review Group.

The accident at Three Mile Island occurred in March 1979 at a time when the accumulated experience record was about 400 reactor-years. It is of interest to note that this was within the range of frequencies estimated by the RSS for an accident of this severity (CONAES, p. 553). It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of reactor accidents like that one, by a significant number of investigative groups both within NRC and outside of it. Actions to improve the safety of nuclear power plants have come out of these investigations, including those from the President's Commission on the Accident at Three Mile Island, and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident" (NUREG-0660, Vol. I) collects the various recommendations of these groups and describes them under the subject areas of: Operational Safety; Siting and Design; Emergency Preparedness and Radiation Effects; Practices and Procedures; and NRC Policy, Organization, and Management. The action plan presents a sequence of actions, some already taken, that will result in a gradually increasing improvement in safety as individual actions are completed. PVNGS is receiving and will receive the benefit of these actions on the schedule indicated in NUREG-0660. The improvement in safety from these actions has not been quantified, however, and the radiological risk of accidents discussed in this chapter does not reflect these improvements.

5.9.2.6 Conclusions

The foregoing sections consider the potential environmental impacts from accidents at the Palo Verde facility. These have covered a broad spectrum of possible accidental releases of radioactive materials into the environment by atmospheric and groundwater pathways. Included in the considerations are postulated design-basis accidents and more severe accident sequences that lead to a severely damaged reactor core or core melt.

The environmental impacts that have been considered include potential radiation exposures to individuals and to the population as a whole, the risk of near- and long-term adverse health effects that such exposures could entail, and the potential economic and societal consequences of accidental contamination of the environment. These impacts could be severe, but the likelihood of their occurrence is judged to be small. This conclusion is based on (1) the fact that considerable experience has been gained with the operation of similar facilities without significant degradation of the environment, (2) the fact that, in order to obtain a license to operate the Palo Verde facility, it must comply with the applicable Commission regulations and requirements, and (3) a probabilistic assessment of the risk based upon the methodology developed in the Reactor Safety Study. The overall assessment of environmental risk of accidents, assuming protective action, shows that it is roughly comparable to the risk from normal operation although accidents have a potential for acute fatalities and economic costs that cannot arise from normal operations. The risks of acute fatality from potential accidents at the site are small in comparison with risks of acute fatality from other human activities in a comparatively sized population.

The staff has concluded that there are no special or unique circumstances about the Palo Verde site and environs that would warrant special mitigation features for the PVNGS.

5.10 Impacts from the Uranium Fuel Cycle

The uranium fuel cycle rule, 10 CFR Part 51.20 (44 FR 45362), reflects the latest information relative to the reprocessing of spent fuel and to radioactive waste management as discussed in NUREG-0116, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," and NUREG-0216, which presents staff responses to comments on NUREG-0116. The rule also considers other environmental factors of the uranium fuel cycle, including aspects of mining and milling, isotopic enrichment, fuel fabrication, and management of low- and high-level wastes. These are described in the AEC report WASH-1248, "Environmental Survey of the Uranium Fuel Cycle." The NRC staff was also directed to develop an explanatory narrative that would convey in understandable terms the significance of releases in the table. The narrative was also to address such important fuel cycle impacts as environmental dose commitments and health effects, socioeconomic impacts, and cumulative impacts, where these are appropriate for generic treatment. This explanatory narrative was published in the Federal Register on March 4,1981 (46 FR 15154-15175). Appendix G to this statement contains a number of sections that address those impacts of the fuel cycle that reasonably appear to have significance for individual reactor licensing sufficient to warrant attention for NEPA purposes.

Table S-3 of the final rule is reproduced in its entirety as Table 5.16 in this statement. Specific categories of natural resource use included in the table relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high- and low-level wastes, and radiation doses from transportation and occupational exposures. The contributions in the table for reprocessing, waste management, and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle); that is, the cycle that results in the greater impact is used.

Appendix G to this statement contains a description of the environmental impact assessment of the uranium fuel cycle as related to the operation of the Palo Verde Nuclear Generating Station. The environmental impacts are based on the values given in Table 5.16 and on an analysis of the radiological impact from radon-222 and technetium-99 releases. The staff has determined that the environmental impact of the station on the U.S. population from radioactive gaseous and liquid releases (including radon and technetium) due to the uranium fuel cycle is insignificant when compared with the impact of natural background

Table 5.16 Uranium fuel cycle environmental data[1] (Summary Table S-3)

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
NATURAL RESOURCES USE		
Land (acres):		
Temporarily committed [2]	100	
Undisturbed area	79	
Disturbed area	22	Equivalent to a 110 MWe coal-fired power plant.
Permanently committed	13	
Overburden moved (millions of MT)	2.8	Equivalent to 95 MWe coal-fired power plant.
Water (millions of gallons):		
Discharged to air	160	=2 percent of model 1,000 MWe LWR with cooling tower.
Discharged to water bodies	11,090	
Discharged to ground	127	
Total	11,377	<4 percent of model 1,000 MWe LWR with once-through cooling.
Fossil fuel:		
Electrical energy (thousands of MW-hour)	323	<5 percent of model 1,000 MWe LWR output.
Equivalent coal (thousands of MT)	118	Equivalent to the consumption of a 45 MWe coal-fired power plant.
Natural gas (millions of scf)	135	<0.4 percent of model 1,000 MWe energy output.
EFFLUENTS—CHEMICAL (MT)		
Gases (including entrainment): [3]		
SO_x	4,400	
NO_x [4]	1,190	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	14	
CO	29.6	
Particulates	1,154	
Other gases:		
F	.67	Principally from UF_6 production, enrichment, and reprocessing. Concentration within range of state standards—below level that has effects on human health.
HC1	.014	
Liquids:		
$SO_4^{=}$	9.9	From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3—600 cfs. NO_3—20 cfs. Fluoride—70 cfs.
NO_3^-	25.8	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.5	
Na^+	12.1	
NH_3	10.0	
Fe	.4	
Tailings solutions (thousands of MT)	240	From mills only—no significant effluents to environment.
Solids	91,000	Principally from mills—no significant effluents to environment.

Table 5.16 (continued)

[Normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116]]

Environmental considerations	Total	Maximum effect per annual fuel requirement or reference reactor year of model 1,000 MWe LWR
EFFLUENTS—RADIOLOGICAL (CURIES)		
Gases (including entrainment):		
Rn-222		Presently under reconsideration by the Commission.
Ra-226	.02	
Th-230	.02	
Uranium	.034	
Tritium (thousands)	16.1	
C-14	24	
Kr-85 (thousands)	400	
Ru-106	.14	Principally from fuel reprocessing plants.
I-129	1.3	
I-131	.83	
Tc-99		Presently under consideration by the Commission.
Fission products and transuranics	.203	
Liquids:		
Uranium and daughters	2.1	Principally from milling—included tailings liquor and returned to ground—no effluents; therefore, no effect on environment.
Ra-226	.0034	From UF_6 production.
Th-230	.0015	
Th-234	.01	From fuel fabrication plants—concentration 10 percent of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Fission and activation products	5.9×10^{-6}	
Solids (buried on site):		
Other than high level (shallow)	11,300	9,100 Ci comes from low level reactor wastes and 1,500 Ci comes from reactor decontamination and decommissioning—buried at land burial facilities. 600 Ci comes from mills—included in tailings returned to ground. Approximately 60 Ci comes from conversion and spent fuel storage. No significant effluent to the environment.
TRU and HLW (deep)	1.1×10^{7}	Buried at Federal Repository.
Effluents—thermal (billions of British thermal units)	4,063	<5 percent of model 1,000 MWe LWR.
Transportation (person-rem):		
Exposure of workers and general public	2.5	
Occupational exposure (person-rem)	22.6	From reprocessing and waste management.

[1] In some cases where no entry appears it is clear from the background documents that the matter was addressed and that, in effect, the Table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at all in the Table. Table S-3 does not include health effects from the effluents described in the Table, or estimates of releases of Radon-222 from the uranium fuel cycle or estimates of Technetium-99 released from waste management or reprocessing activities. These issues may be the subject of litigation in the individual licensing proceedings.

Data supporting this table are given in the "Environmental Survey of the Uranium Fuel Cycle," WASH-1248, April 1974; the "Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supp. 1 to WASH-1248); the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248); and in the record of the final rulemaking pertaining to Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3. The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two fuel cycles (uranium only and no recycle). The contribution from transportation excludes transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of § 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S-3A of WASH-1248.

[2] The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

[3] Estimated effluents based upon combustion of equivalent coal for power generation.

[4] 1.2 percent from natural gas use and process.

radiation.* In addition, the nonradiological impacts of the uranium fuel cycle have been found to be acceptable.

5.11 Decommissioning Impacts**

The staff's assessment of the impacts resulting from the various decommissioning methodologies available for nuclear power plants has been updated from that presented in the FES-CP and is presented in NUREG-0586. This assessment is summarized below.

Decommissioning of a nuclear power reactor does not usually involve environmental impacts that are unique to a specific project. The technology for decommissioning nuclear facilities is well in hand and, although, technical improvements in decommissioning techniques are to be expected, at the present time decommissioning can be performed safely and at reasonable cost. Radiation doses to the public as a result of decommissioning activities should be very small and would come primarily from the transportation of decommissioning waste to waste-burial grounds. Radiation doses to decommissioning workers should be a small fraction of the worker exposure over the operating lifetime of the facility; these doses usually will be well within the occupational-exposure limits imposed by regulatory requirements. Decommissioning costs for reactors are a small fraction of the present-worth commissioning costs.

Decommissioning of nuclear facilities is not an imminent health-and-safety problem. However, planning for decommissioning can affect health and safety as well as cost. Essential to such planning activity are the decommissioning alternative to be used and the timing of decommissioning. Also to be considered are (1) acceptable residual-radioactivity levels for unrestricted use of the facility, (2) financial assurance that funds will be available for performing required decommissioning activities at the end of facility operation (including premature closure), and (3) facilitating decommissioning. Decommissioning of a nuclear facility generally has a positive environmental impact. At the end of facility life, termination of a nuclear license is use of the facility, (2) financial assurance that funds will be available for performing required decommissioning activities at the end of facility operation (including premature closure), and (3) facilitating decommissioning.

*After three days of hearings before the Atomic Safety and Licensing Appeal Board (ASLAB) using the Perkins record in a "lead case" approach, the ASLAB issued a decision on May 13, 1981 (ALAB-640) on the radon-222 release source term for the uranium fuel cycle. The decision, among other matters, produced new source term numbers based on the record developed at the hearings. These new numbers did not differ significantly from those in the Perkins record, which are the values set forth in Table 5.15. Any health effects relative to radon-222 are still under consideration before the ASLAB. Because the source term numbers in ALAB-640 do not differ significantly from those in the Perkins record, the staff continues to conclude that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural background sources. (Subsequent to ALAB-640, a second ASLAB decision (ALAB-654), issued September 11, 1981) permits intervenors a 60-day period to challenge the Perkins record on the potential health effects of radon-222 emissions.

**The material in this section is based on NUREG-0586, "Draft Generic Environmental Statement on Decommissioning Nuclear Facilities."

Decommissioning of a nuclear facility generally has a positive environmental impact. At the end of facility life, termination of a nuclear license is required. Such termination requires decontamination of the facility so that the level of any residual radioactivity remaining in the facility or on the site is low enough to allow either unrestricted use of the facility and the site or recommissioning of the facility as a nuclear or nonnuclear power plant.

Compared to operation requirements, the commitment of resources for decommissioning is generally small. The major environmental impact of decommissioning is the commitment of small amounts of land for the burial of waste. This is in exchange for being able to reuse the facility and site for other nuclear or nonnuclear purposes. Because in many instances (such as at a reactor facility) the land has valuable resource capability, the return of this land to the commercial or public sector is highly desirable. In decommissioning nuclear facilities, the objective of NRC regulatory policy is to ensure that proper and explicit procedures are followed to mitigate any potential for adverse impact on public health and safety or on the environment.

Three alternative methods can be and have been used to decommission reactors. "DECON" is defined as immediate removal of the radioactive materials, thereby reducing radioactivity to levels that would permit the property to be released for unrestricted use. "SAFSTOR" is defined as those activities required to place and maintain a radioactive facility in such condition that (1) the risk to safety is within acceptable bounds and (2) the facility can be safely stored for as long a time as desired and subsequently decontaminated to levels that would permit release of the facility for unrestricted use. SAFSTOR consists of a short period of preparation for safe storage; a safe-storage period of continuing care consisting of security, surveillance, and maintenance (variable length up to 100 years); and a short period of deferred decontamination. Several variations of SAFSTOR are possible. "ENTOMB" means to encase and maintain property in a strong and structurally long-lived material to ensure retention until radioactivity decays to a level acceptable for releasing the facility for unrestricted use. ENTOMB is intended for use where the residual radioactivity will decay to levels permitting unrestricted release of the facility within a reasonable period of time.

Estimated costs of decommissioning vary, depending on the characteristic of the particular reactor and the decommissioning mode chosen. For a large PWR, DECON is estimated to cost $33.3 million (in 1978 dollars). SAFSTOR is estimated to cost $42.8 million with a 30-year safe-storage period, and $41.8 million with a 100-year safe-storage period. ENTOMB is estimated to cost $20.3 million with the pressure vessel and its internals retained and $27.4 million with the pressure vessel and internals removed, plus a $40,000 annual maintenance-and-surveillance cost in both cases.

The NRC staff makes the following preliminary conclusions on decommissioning impacts in NUREG-0586:

> The technical basis exists for performing decommissioning in a safe, efficient, and timely manner. Decommissioning as used here means to safely remove contaminant radioactive material down to residual levels considered acceptable for permitting unrestricted use of a facility and its site. Decommissioning has major beneficial impact because it allows a nuclear facility which no longer has operational value to be made available for unrestricted use. Moreover, making

the facility available for unrestricted use eliminates the potential problems of increased numbers of sites used for the confinement of radioactively contaminated materials, as well as potential health, safety, regulatory, and economic problem; and also releases valuable industrial land that can be reused with great benefit. When properly performed, decommissioning has only minor adverse impacts. These include: an occupational dose burden which is of marginal significance to health and safety and which is a small percent of such burden experienced over the operational life of a facility; a relatively modest cost compared to the net present worth of the commissioning cost; and the irreversible commitment of a small amount of land (primarily for low-level waste) at an appropriate radioactive waste burial facility.

5.12 Emergency Planning Impacts

In connection with the promulgation of the Commission's upgraded emergency planning requirements, the staff issued NUREG-0685, "Environmental Assessment for Effective Changes to 10 CFR Part 50 and Appendix E to 10 CFR Part 50; Emergency Planning Requirements for Nuclear Power Plants" (August 1980). The applicant is currently finalizing the Emergency Plan for PVNGS in accordance with 10 CFR Part 50, as amended July 23, 1980, as well as the recommended criteria contained in NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants."

The staff believes the only noteworthy potential source of impact on the public from emergency planning would be associated with the siren alert system. The test requirements and alarm noise levels are consistent with those used for existing alert systems; therefore, the staff concludes that the noise impacts associated with the siren alert system will be infrequent and insignificant.

The emergency operations facility will be located on site, and, therefore, its construction will not involve any significant additional environmental impacts from the construction impacts considered in the FES-CP.

5.13 References

Material used in the preparation of this section includes the U.S. Nuclear Regulatory Commission publications listed immediately below by publication number as well as the other documents listed following in alphabetical order

U.S. Nuclear Regulatory Commission NUREG Reports

NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976.

NUREG-0116 (Supplement 1 to WASH-1248), "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," October 1976.

NUREG-0216 (Supplement 2 to WASH-1248), "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," March 1977.

NUREG-0340, "Overview of the Reactor Safety Study Consequences Model," October 1977.

NUREG-0440, "Liquid Pathway Generic Study," February 1978.

NUREG-0522, "Draft Environmental Statement Related to Construction of Palo Verde Nuclear Generating Station Units 4 & 5," Docket Ncs. STN 50-592, STN 50-593, April 1979.

NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," January 1981.

NUREG-0651, "Evaluation of Steam Generator Tube Rupture Accidents," March 1980.

NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," February 1980.

NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident," Vol. I, May 1980.

NUREG-0713, "Occupational Radiation Exposure at Commercial Nuclear Power Reactors, 1979." Vol. 2, December 1981.

NUREG-0715, "Task Force Report on Interim Operations of Indian Point," August 1980.

NUREG-0737, "Clarification of TMI Action Plan Requirements," November 1980.

NUREG-0800, "Radiation Protection," in: "Standard Review Plan," Chapter 12, July 1981 (formerly issued as NUREG-75/087.

NUREG-75/104, "Reactor Safety Study--An Assessment," WASH-1400, October 1975.

NUREG/CR-0400, "Risk Assessment Review Group Report to the U.S. Nuclear Regulatory Commission," September 1978.

NUREG/CR 0912, "Geosciences Data Base for Modeling a Nuclear Waste Repository," January 1981.

U.S. Nuclear Regulatory Commission, Office of Inspection and Enforcement (IE)

Inspection Reports Nos. 50-528/80-21, 50-529/80-21, and 50-530/80-21, December 8-10, 1980.

U.S. Nuclear Regulatory Commission Regulatory Guides

1.21, Revision 1, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," June 1974.

1.109, Revision 1, "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," October 1977.

4.1, Revision 1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," April 1975.

8.8, Revision 3, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable," June 1978.

Other Items

Adams, A. P., and B. A. Lewis, "Microbial Aerosols from Cooling Towers and Cooling Sprays: A Pilot Study," Argonne National Laboratory, ANL/ES-83, November 1979.

Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR I), "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences/National Research Council, November 1972.

Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR III), "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," National Academy of Sciences/National Research Council, July 1980.

American Cancer Society, "Cancer Facts and Figures 1979," 1978.

Bertini, H. W, and others, "Descriptions of Selected Accidents that Have Occurred at Nuclear Reactor Facilities," Nuclear Safety Information Center, Oak Ridge National Laboratory, ORNL/NSIC-176, April 1980.

Blair, Benham, and Affiliates, preparers, "Final Environmental Assessment Report, Clearing of Phreatophytic Vegetation from the Salt and Gila Rivers, 91st Avenue to Gillespie Dam, Maricopa County, Arizona," for Flood Control District of Maricopa County, Phoenix, December 1981.

Blaylock, B. G., and J. P. Witherspoon, "Radiation Doses and Effects Estimated for Aquatic Biota Exposed to Radioactive Releases from LWR Fuel-Cycle Facilities," Nuclear Safety, 17:351, 1976.

Bureau of Land Management, Phoenix, and U.S. Nuclear Regulatory Commission, "Final Environmental Statement, Palo Verde-Devers 500 kV Transmission Line," February 1979.

Carnow, B., and others, "Health Effects of Aerosols Emitted from an Activated Sludge Plant," U.S. Environmental Protection Agency, EPA-600/1-79-019, May 1979.

Carson, J. E., "Atmospheric Impacts of Evaporative Cooling Systems," Argonne National Laboratory, ANL/ES-53, Argonne, IL, 1976.

Champion, E. R., C. H. Goodman, and P. R. Slawson, "Field Study of Mechanical-Draft Cooling Tower Plume Behavior," paper presented at Waste Heat Management and Utilization Conference, Miami Beach, FL, May 1977.

Clark, C. S., and others, "Health Effects of Occupational Exposure to Wastewater," in: "Wastewater Aerosols and Disease," Proceedings of a Symposium held in Cincinnati, Ohio, September 19-21, U.S. Environmental Protection Agency, EPA-600/9-80-028, December 1980.

Committee on Nuclear and Alternative Energy Systems (CONAES), "Energy in Transition 1985 - 2010," Final Committee Report, National Research Council, 1979, Chapter 9, pp 517-534.

Dean, R. B., "Assessment of Disease Rates Among Sewer Workers in Copenhagen, Denmark," U.S. Environmental Protection Agency, EPA-600/1-78-007, January 1978.

Dickey, J. B., and others, "The Operating Debut of the Round Mechanical-Draft Cooling Tower," Proceedings of the American Power Conference, 37:582-590, 1975.

Dominguez, L. B., Supervisor, Enteric Foodborne/Waterborne Disease Control, Arizona Department of Health Services, letter to Janis Kerrigan, Licensing Project Manager, U.S. Nuclear Regulatory Commission, April 6, 1981.

Edison Electric Institute, "Electric Power Plant Environmental Noise Guide," 1978.

Englesson G. A., and H. C. Hu, "Non-water Quality Impacts of Closed-Cycle Cooling Systems and the Interaction of Stack Gas and Cooling Tower Plumes," U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, EPA-600/7-79-090, Research Triangle Park, NC, 1979.

Electric Power Research Institute, "Biological Effects of High Voltage Electric Fields: An Update," EPRI Report EA-1123, July 1979.

Fannin, K. F., and others, "Health Effects of a Wastewater Treatment System," U.S. Environmental Protection Agency, EPA-600/1-78-062, October 1978.

Fletcher, J. L., "Effects of Noise on Wildlife and Other Animals," U.S. Environmental Protection Agency, NTID 300.5, 1971.

Fletcher, J. L., and R. G. Busnell, "Effects of Noise on Wildlife," Academic Press, New York, 1978.

Gartside, P. S., and others, "Interim Report on a Mortality Study of Former Employees of the Metropolitan Sanitary District of Greater Chicago," in: "Wastewater Aerosols and Disease," Proceedings of a Symposium held in Cincinnati, Ohio, September 19-21, U.S. Environmental Protection Agency, EPA-600/9-80-028, December 1980.

Gray, D. H. and C. Penessis, "Engineering Properties of Sludge Ash," _Journal of the Water Pollution Control Federation_, 44(5):847-858, May 1972.

Halpenny, L. C., and S. D. Clark, "1977 Supplement to Water Balance Investigations of River Bed, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Arizona," Water Development Corp., Tucson, 1977.

Halpenny, L. C., and D. K. Greene, "Water Balance Investigations of River Bed, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Arizona," Water Development Corp., Tucson, 1975.

Hanna, S. R., "Atmospheric Effects of Energy Generation," National Oceanic and Atmospheric Administration, Oak Ridge, TN, ATDL Contribution No. 77/9, June 1978.

Hanna, S. R., "Meteorological Effects of the Mechanical-Draft Cooling Towers of the Oak Ridge Gaseous Diffusion Plant," in: "Cooling Tower Environment 1974," U.S. Energy Research and Development Administration Symposium Series, CONF-740302, pp. 291-306, 1975.

Hinson, C. S., memorandum to W. E. Kreger, U.S. Nuclear Regulatory Commission, "Preliminary LWR Exposure Data for 1980," May 28, 1981.

International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, January 1977.

Jain, S. C., and J. F. Kennedy, "Modeling Near-Field Behavior of Mechanical Draft Cooling Tower Plumes," in: "Cooling Tower Environment-1978," Water Resources Research Center, University of Maryland, College Park, May 1978.

Johnson, D. E., and others, "Environmental Monitoring of a Wastewater Treatment Plant," U.S. Environmental Protection Agency, EPA-600/1-79-027, August 1979.

Johnson, D. E., and others, "Health Implications of Sewage Treatment Facilities," U.S. Environmental Protection Agency, EPA-600/1-78-032, May 1978.
Keys, W. B., "Construction of Linings for Reservoirs, Tanks, and Pollution Control Facilities," John Wiley & Sons, New York, 1977.

Kennedy, J. F., and H. Fordyce, "Plume Recirculation and Interference in Mechanical-Draft Cooling Towers," in: "Cooling Tower Environment-1974," U.S. Energy Research and Development Administration Symposium Series, CONF-740302, pp. 58-87, 1975.

Land, C. E., Science 209, 1197, September 12, 1980.

Lester, G. C., and D. W. Fraser, "Legionellosis-Legionnaires' Disease; Pontiac Fever," in: "Medical Clinics of North America Symposium on Infectious Lung Diseases," May 1980, reprinted by the U.S. Department of Health and Human Services.

MAG 208 Point Source Plan Revision, Eastside Area Analysis, Local vs. Regional, James Fulton, Consultant; John Carrolo Engineers; Dibble and Associates; September 1981

Maricopa Association of Governments, "208 Water Quality Management Program," Phoenix, 1979.

National Council on Radiation Protection and Measurements, "Review of the Current State of Radiation Protection Philosophy," NCRP Report No. 43, January 1975.

Parker, D. S., and others, "Lime Use in Wastewater Treatment: Design and Cost Data," USEPA Report, EPA-600/2-75-038, October 1975.

Policastro, A. J., and others, "Investigation of Mathematical Models for Cooling-Tower Plumes and Drift," paper presented at Winter Meeting, American Nuclear Society, San Francisco, November 11-19, 1979.

President's Commission on the Accident at Three Mile Island, "Report," October 1979, Commission Findings B, Health Effects.

Rogovin, Mitchell, Director, "Three Mile Island - A Report to the Commissioners and the Public," Vol. I, Nuclear Regulatory Commission Special Inquiry Group, January 1980, Summary Section 9.

Rylander, R., and M. Lundholm, "Responses to Wastewater Exposure with Reference to Endotoxin," in: "Wastewater Aerosols and Disease," Proceedings of a Symposium held in Cincinnati, Ohio, September 19-21, U.S. Environmental Protection Agency, EPA-600/9-80-028, December 1980.

Sekla, L., and others, "Sewage Treatment Plant Workers and Their Environment: A Health Study," in: "Wastewater Aerosols and Disease," Proceedings of a Symposium held in Cincinnati, Ohio, September 19-21, U.S. Environmental Protection Agency, EPA-600/9-80-028, December 1980.

Shuval, H. I., and B. Fattal, "Epidemiological Study of Wastewater Irrigation in Kibbutzim in Israel," in: "Wastewater Aerosols and Disease," Proceedings of a Symposium held in Cincinnati, Ohio, September 19-21, 1979, U.S. Environmental Protection Agency, EPA-600/9-80-028, December 1980.

Steyler, R., "Flow Projection Comparison, MAG 208 Study vs. Phoenix Wastewater Division Projection in MGD," August 26, 1981.

Tedesco, R. L., NRC, letter to E. E. VanBrunt, Jr., Arizona Public Service Co., August 10, 1981.

Title 10 Code of Federal Regulations Part 20, "Standards for Protection Against Radiation," January 1981.

Title 10 Code of Federal Regulations Part 50, "Domestic Licensing of Production and Utilization Facilities," January 1981.

Title 40 Code of Federal Regulations Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," January 1981.

Tyndall, R. L., E. L. Dominque and L. L. Muldraw, "Presence of Pathogenic Microorganisms in Power Plant Cooling Waters--Annual Report for 1980," Oak Ridge National Laboratory, May 1981.

WASH-1248, U.S. Atomic Energy Commission, "Environmental Survey of the Uranium Fuel Cycle," April 1974.

United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources and Effects of Ionizing Radiation," 1977.

U.S. Department of Energy, Office of Electric Energy Systems, "Project Resumes--Biological Effects From Electric Fields Associated with High Voltage Transmission Lines--Contractors Review, November 18-19, 1980."

U.S. Environmental Protection Agency (EPA), "Final Environmental Impact Statement on the Maricopa Association of Governments Point Source Metro Phoenix 208 Wastewater Management Plan," July 1979.

U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA-550/9-74-004, March 1974.

U.S. Fish and Wildlife Service, Albuquerque, letter to to Col. Gwynn Teaque, U.S. Army Corps of Engineers, Los Angeles, February 6, 1981.

Western Savings and Loan Association, Marketing Research Department, "Forecast 1981," 1981.

6 EVALUATION OF THE PROPOSED ACTION

6.1 Unavoidable Adverse Environmental Effects

The staff has reassessed the physical, social, and economic impacts that can be attributed to operation of PVNGS. Such impacts, beneficial or adverse, are summarized in Table 6.1. Because the station is currently under construction, many of the expected adverse impacts of the construction phase are evident. The applicant is committed to an ongoing program of restoration and redress of the station site, which will be completed after the termination of the construction period.

At the present time the staff foresees no impacts of a magnitude requiring mitigating actions. However:

(1) Before engaging in additional construction or operational activities that may result in a significant adverse environmental impact that was not evaluated or that is significantly greater than that evaluated in this statement, the applicant shall provide written notification of such activities to the Director of the Office of Nuclear Reactor Regulation and shall receive written approval from that office before proceeding with such activities.

(2) The applicant shall carry out the environmental monitoring programs outlined in Section 5 of this statement as modified and approved by the staff and implemented in the environmental protection plan that will be incorporated in the operating licenses for PVNGS.

(3) If adverse environmental effects or evidence of irreversible environmental damage are detected during the operating life of the station, the applicant shall provide the staff with an analysis of the problem and a proposed course of action to alleviate it.

6.2 Irreversible and Irretrievable Commitments of Resources

There has been no change in the staff's assessment of this impact since the earlier review, except that the continuing escalation of costs has increased the dollar value of the materials used for constructing and fueling the station.

6.3 Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

There have been no signficant changes in the staff's preconstruction evaluation of the relationship between environmental effects of short-term uses

Table 6.1 Benefit/cost summary for PVNGS Units 1, 2, and 3

Benefit/cost	Magnitude or reference[1]	Staff assessment of benefit/cost[2]
BENEFITS		
Primary		
Electrical energy (Sec. 2.2)	20 x 10^9 kWh/yr	Large
Additional generating capacity (Sec. 2.4)	3810 MWe	Large
Reduced generating costs (Sec. 2.2)	$1530 million (1987$)	Large
Diversity of fuel supply (Sec. 2.3)	Sec. 2.3	Small
Secondary		
Annual taxes (Sec. 5.8.2)	$126 million (1986$)	Small
Employment (Sec. 5.8.1)	844 full-time jobs	Small
Annual payroll (Sec. 5.8.1)	$27.7 million (1986$)	Small
Annual local purchases (Sec. 5.8.1)	$18.9 million (1986$)	Small
COSTS		
Economic		
Fuel (Sec. 2.2 and 6.4.2)	10.5 mill/kWh (1987$)	NA[3]
Operation and maintenance (Sec. 2.2 and 6.4.2)	3.5 mill/kWh (1987$)	NA
Decommissioning (Sec. 6.4.2; ER-OL, Sec. 5.8.1)	$195 million (3 units) (1980$)	Small
Socioeconomic		
Historic and prehistoric sites (Sec. 5.7)	Sec. 5.7	NA
Labor force interaction with local infrastructure (Sec. 5.8.4)	Sec. 5.8	Small
Nonradiological Environmental		
Resources committed		
Land (Sec. 4.2.2 and 5.2)	1640 ha	Small
Water (Sec. 4.3.2)	1.7 x 10^8 m^3/yr	Moderate
Uranium (fuel) (NUREG-0480)	17,000 MT U^3O^8 (3 units)	Small
Other materials and supplies	FES-CP, Sec. 10.3.4	Small

[1],[2],[3] See notes at end of table.

Table 6.1 (continued)

Benefit/cost	Magnitude or reference[1]	Staff assessment of benefit/cost[2]
Aquatic resources		
Consumption		
Surface water (Sec. 4.2.3)	2.6×10^7 m^3/yr	Moderate
Groundwater	Sec. 5.3.1	Small
Groundwater level drawdown	Sec. 5.3.1	Small
Surface water contamination	No discharge	NA
Ecological	Sec. 5.5.2	Small
Terrestrial resources		
Fog (Sec. 5.4)	Sec. 5.4.1	Small
Drift (Sec. 5.4.1 and 5.5.1)	260 kg/day	Small
Ecological (Sec. 5.5.1) (includes riparian habitat)	Sec. 5.5.1	Small
Meteorology and air quality		
Offsite air temperature and humidity	Sec. 5.4.1	Small
Combustion exhaust gases (Sec. 5.4.2 and 4.2.6.1	Sec. 5.4.2	Small
Fugitive dust (Sec. 5.4.2 and 4.3.3.2)	Sec. 5.4.2	Small
Radiological Environmental		
General population	Sec. 5.9	Small
Workers	Sec. 5.9	Small
Transportation of fuel and waste	Sec. 5.9	Small
Biota other than man	Sec. 5.9	Small
Uranium fuel cycle	Sec. 5.10	Small
Accident risk	Sec. 5.9	Small

[1]Where a particular unit of measure for a benefit/cost category has not been specified in this statement, or where an estimate of the magnitude of the benefit/cost under consideration has not been made, the reader is directed to the appropriate section for further information.

[2]Subjective measure of costs and benefits are assigned by reviewers, where quantification is not possible: Small--impacts that, in the reviewers' judgments, are of such minor nature, based on currently available information, that they do not warrant detailed investigations or considerations of mitigative actions; Moderate--impacts that, in the reviewers' judgments, are likely to be clearly evident (mitigation alternatives are usually considered for moderate impacts); Large--impacts that, in the reviewers' judgments, represent either a severe penalty or a major benefit. Acceptance requires that large negative impacts should be more than offset by other overriding project considerations.

[3]Not applicable.

(construction and operation of the station) and long-term productivity (FES-CP, Section 10.2). The conclusion that the dedication of resources for a nuclear generating station at the Palo Verde site is consistent with the balancing of short- and long-term objectives for use of the environment is still valid.

6.4. Benefit-Cost Summary

6.4.1 Benefits

The primary benefits to be derived from operation of the PVNGS Units 1, 2, and 3 include about 20 billion kWh of baseload electrical energy that the station will be able to produce annually (this projection assumes operation at an average 60-percent capacity factor) (Section 2.2). Another primary benefit will be the improved reliability of the participants' system brought about by the addition of 3810 MWe of generating capacity to the system (Section 2.4), as well as the saving of about $500 million in production costs per unit per year (Section 2.2). Finally, the operation of PVNGS will increase the diversity of fuel supply of the participants' system by providing baseload generating capacity using a fuel type other than the gas and oil presently used (Section 2.3).

Secondary benefits arising from operation of PVNGS include wages paid to 844 operating personnel (about $27.7 million per year beginning in 1986) and taxes paid to state and local political subdivisions (Sections 5.8.1 and 5.8.2). The taxes are estimated to be about $126 million per year in every year of operation. The taxing bodies receiving a majority of these funds would be

Ruth Fisher Elementary School District, Maricopa County Junior College District, Arlington Elementary School District, Buckeye Union High School District, Maricopa County, and the State of Arizona.

6.4.2 Costs

6.4.2.1 Economic

The economic costs associated with station operation include fuel costs and operation and maintenance costs which for 1987, the first full year all units are to be operating commercially, are 10.5 mills/kWh (Table 2.2) and 3.5 mills/kWh in 1987 dollars, respectively. The cost of decommissioning is a small additional cost of station operation. The applicant's estimate of the cost for decommissioning each unit is about $65 million in 1980 dollars (modified from ER-OL, Section 5.8.1, to reflect 1980 dollars).

6.4.2.2 Socioeconomic

No significant socioeconomic costs are expected from either the operation of the station or the number of operating personnel and their families living in the area (Section 5.8.4).

6.4.2.3 Environmental

Nonradiological

The nonradiological environmental costs of land-use, water-use, and ecological effects previously estimated in the FES-CP (Sections 5.1 through 5.3, and 5.5 through 5.6) have been reestimated on the basis of new information and have been found not to have increased (Sections 5.2 through 5.6).

Radiological

The radiological environmental costs resulting from operation of PVNGS Units 1, 2, and 3 have been reestimated on the basis of new information in the following areas: dose to the general public; occupational dose; dose to the public and workers due to transportation of radioactive material; dose to biota subsequently consumed by man; and dose associated with the uranium fuel cycle. These costs are summarized below.

The risks to the general population as a result of the radioactive effluents from PVNGS are a very small fraction of the estimated occurrence of cancer deaths in the U.S. population and genetic disorders in future generations of the U.S. population as a result of each year of exposure to natural-background radiation. Therefore, the staff concludes that the health impact to the general public due to routine operation of the station will be undetectable (Section 5.9).

Assuming that the average annual dose commitment per nuclear worker at PVNGS will be in the same range as that at similarly sized PWRs, the staff estimates an average annual worker dose of about 31 person-rems/yr (Section 5.9). In terms of job-related fatalities, the staff concludes that the risk to the average nuclear plant worker is within the range of risks associated with other occupations, and is acceptable (Section 5.9).

The transportation dose to workers and the public is specified in Table 5.7. This dose is small and is not considered significant in comparison to the natural-background dose (Section 5.9).

Based on studies of radiation exposure to biota other than man, there have been no cases of exposures that can be considered significant in terms of harm to the species or that approach the exposure limits to members of the public permitted by 10 CFR Part 20. Evidence to date indicates that no other living organisms are more radiosensitive than man. No measurable radiological impact on populations of biota is expected as a result of routine operation of PVNGS (Section 5.9).

The data on the uranium fuel cycle provided in Table 5.14 include maximum recycle-option impacts for each element of the fuel cycle. Thus, the staff's conclusions as to acceptability of the environmental costs of the fuel cycle are not affected by the specific fuel cycle selected (Section 5.10).

6.4.3 Conclusions

As a result of the analysis and review of potential environmental, technical, economic, and social impacts, the staff has been able to forecast more accurately the effects of operation of PVNGS Units 1, 2, and 3. No new information has been obtained that alters the overall balancing of the benefits versus the environmental costs of station operation. Consequently, the staff has determined that the station will most likely operate with only minimal environmental impact. The staff finds that the primary benefits of minimizing system production costs and increasing baseload generating capacity by 3810 MWe greatly outweigh the environmental, social, and economic costs. Benefits and costs are summarized in Table 6.1.

7 LIST OF CONTRIBUTORS

U.S. Nuclear Regulatory Commission

G. Gears	Environmental review coordinator, terrestrial resources
E. Licitra	Project manager
L. O'Reilly	Radiological assessment
E. Markee	Meteorology and accident analysis
R. Gonzales	Hydrology and accident analysis
A. Brauner	Siting analysis and accident analysis
M. Kaltman	Socioeconomics and cultural resources
J. Lehr	Water quality, nonradioactive waste systems, noise
S. Feld	Economic impacts
M. Wohl	Accident analysis

Argonne National Laboratory

V. Harris	Project leader, nonradioactive waste systems, water quality
L. Busch	Need for power, benefit/cost analysis, alternatives
J. Carson	Air quality, cooling-tower effects
P. Denise	Socioeconomics, land use
J. DePue	Editor (ANL input)
G. Marmer	Noise, plant engineering.
W. Marr	Need for power, benefit-cost analysis, alternatives
W. Pfanenstiel	Health effects
L. Soholt	Ecology

8 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE DRAFT ENVIRONMENTAL STATEMENT WERE SENT

Advisory Council on Historic Preservation
Council on Environmental Quality
Department of Agriculture, Soil Conservation Service
Department of Commerce
Department of Energy
Department of Health and Human Services
Department of Housing and Urban Development
Department of the Army, Corps of Engineers
Department of the Interior
Department of Transportation
Environmental Protection Agency
Federal Aviation Administration

Arizona Atomic Energy Commission (now Arizona Radiation Regulatory Agency)
Arizona Department of Health Services
County Commissioners, Maricopa County, Arizona
Maricopa Bureau of Air Pollution Control
Office of the Governor, State of Arizona

9 STAFF RESPONSES TO COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

Pursuant to 10 CFR Part 51, the "Draft Environmental Statement Related to the Operation of Palo Verde Nuclear Generating Station, Units 1, 2, and 3" was transmitted, with a request for comments, to the agencies and organizations, listed in Section 8.

Comments on the DES were received from:

Arizona Game and Fish Department (AGFD)
Arizona Office of Economic Planning and Development (AOEPD)
  Arizona Department of Health Service (ADHS)
  AORCC
  Department of Health Services (EHS)
  Maricopa Association of Government (MAG)
Arizona Public Service Company (APS)
Arizona Radiation Regulatory Agency (ARRA)
Arizona State Parks (ASP)
John F. Doherty (JFD)
Federal Emergency Management Agency (FEMA)
Sharon Harrington (SH)
Maricopa County Department of Planning and Development (MAR)
Janet D. Mitchell (JDM)
Myron L. Scott (MLS)
U.S. Department of Agriculture, Economic and Statistical Service
U.S. Department of Agriculture, Forest Service (FS)
U.S. Department of the Army (DOA)
U.S. Department of Health and Human Service, Bureau of Radiological Health (DHHS)
U.S. Department of the Interior (DOI)
U.S. Department of Transportation (DOT)
U.S. Environmental Protection Agency (EPA)

The comment letters are reproduced in this statement in Appendix I.

The comments from MAG, FEMA, FS, AORCC, EHS, ASP, and DOA did not require a staff response either because these agencies or individuals had no comments or because their comments indicated agreement with the Draft Environmental Statement. The remaining comments did require a staff response. The staff's consideration of these comments and its disposition of the issues involved are reflected in part by revised text in the pertinent sections of this Final Environmental Statement and in part by the following discussions. These discussions are generally keyed to the body of the statement; for example, subsection 9.5.9.1 in this section contains the staff's response to comments on subsection 5.9.1 in the Draft Environmental Statement. The comments are referenced by use of the abbreviations indicated above, by the individual comment number noted in the margins of the comment letters shown in Appendix I, and by the page numbers in Appendix I on which copies of the comments appear.

9.1 Title, Summary and Conclusions, Foreword, and Introduction

JDM-1 (Page I-26)*

Diversion of a portion of the 91st Avenue sewage effluent to PVNGS will reduce the total amounts of pathogens and chemical toxins discharged directly into the Gila River, theoretically reducing the chance for human exposure and the resulting public health risks. Although the amount of pathogens and chemical toxins in the diverted portion of the sewage effluent will also be reduced during (1) pipeline transport to PVNGS, (2) tertiary treatment, and (3) onsite storage, these reductions will have no effect on public health risks near the 91st Avenue sewage treatment plant. However, the combined actions of diversion and treatment at PVNGS will reduce the total environmental burden of pathogens and chemical toxins. Item 4k of the Summary and Conclusions has been revised accordingly.

MLS-0 (Pages I-28, 29, 30)

These comments deal with the availability of the DES, a prehearing conference, and an ACRS subcommittee meeting; they are not related to the content of the DES. Therefore, these comments have been responded to by a separate letter.

SH-6 (Page I-23)

Capabilities of contractors, such as the Bechtel Power Corporation, to design and construct is not an environmental issue. However, design and construction activities for nuclear power plants are monitored by NRC inspectors. Based on the results of those inspections for PVNGS, there is no basis for concluding that the record of Bechtel is questionable.

9.2 Purpose and Need for Action

JDM-2 (Page I-26)

Between 50-60 percent of electricity in the six participants' systems are for industrial or commercial use, not residential. Growth in population, particularly in the so-called Sun Belt, is not the major component of input data to econometric forecasting systems.

Some of the individual systems' demand forecasts were based on historical analysis, while others were based on combinations of demographic studies and econometrics. The staff analyzed the approaches taken by APS, as lead applicant, in forecasting demand for all participants for the next decade and found the results to be reasonable. However, there is a large potential for error when projections are made of average annual rate of growth (AARG) of peak demand or electricity sales for a project such as PVNGS, where six utility systems are involved. Recent estimates for these systems, given in Supplement 3 to the ER-OL (dated August 1981) show an AARG for peak demand for the years 1981-1990 of 3.1 percent for all participants' systems. The AARG for demand in participants' systems for the decade 1980-1980 was 4.9 percent; the variation in annual AARG ranged from 0.4 percent in 1974 to 12 percent in 1971. For the years 1975-1980,

*See also Section 9.4.3.2, response to JDM-5.

applicants' systems have shown an AARG of 4.6 percent in demand but the annual AARG has steadily declined from 7.6 percent in 1976 to 3.5 percent in 1980.

9.4 Project Description and Affected Environment

9.4.2.4 Cooling System

APS-1 (Page I-11)

The text has been revised to reflect this comment.

9.4.2.5 Radioactive-Waste-Management Systems

JDM-3 (Page I-26)

"Wet" solid wastes are those wastes that are removed from liquid streams during processing by liquid radwaste treatment systems and that require solidification prior to shipment. Information on "wet" solid wastes is given in Section 11.2.3 of the Safety Evaluation Report for Palo Verde (NUREG-0857, November 1981).

EPA-2 (Page I-40)

Section 5.9.1.2 discusses the operating standards of 40 CFR Part 190. As stated there, the staff concludes that PVNGS is capable of operating within those standards. All applicable regulations, including 40 CFR Part 190, will be enforced.

ARRA-1 (Page I-16)

As stated in Section 4.2.5, the estimated volumes of solid wastes are based on several years of data on actual shipments of solid wastes from several operating PWRs. The data show that the volume of "wet" solid waste generally is proportional to reactor power, but the volume is influenced by the waste treatment systems used and by other factors. The expected volume of "wet" solid waste reported was determined using this experience data. This value, 510 m^3 (18,000 ft^3) per year per unit, is the staff's best estimate of the "wet" solid waste volume after solidification of spent resin wastes and concentrated evaporator bottoms.

The data from operating PWRs show that the volumes of "dry" solid wastes shipped generally are independent of reactor power. There are no data from PWRs using incineration for volume reduction. Much of the "dry" solid waste volumes reported in the data base were compacted waste. The staff has used the available data on the volumes of waste shipped to burial grounds from operating reactors to estimate the volume of "dry" solid waste that will be generated. The actual volume may be higher or lower than the estimate, depending on conditions and practices at Palo Verde, but the value of 340 m^3 (12,000 ft^3) per year per unit is the staff's best estimate.

The NRC, in its low level waste volume reduction Policy Statement of October 16, 1981, is encouraging all licensees to minimize the volumes of low level radioactive waste generated by their facility operation. The Policy Statement recommended the adoption of certain administrative controls and the evaluation of advanced volume reduction equipment to achieve reductions of waste volumes. Because of this policy and the incentives provided by limited burial ground space and the costs associated with waste processing, handling, shipment, and disposal, the Commission believes that significant reductions in the volumes of waste generated per reactor site are feasible in future years. However, the staff's lack of information on future volume reduction activities at Palo Verde prevents it from making more accurate estimates of waste volumes to be used for planning purposes.

EPA-12 (Page I-42) and MAR-2 (Page I-24)

The current disposal method for solid wastes is discussed in Section 4.2.5.

For future disposal of those wastes, the State of Arizona is exploring both an interstate compact storage facility with five other Western States (Rocky Mountain Group) and possible disposal sites in Arizona. If those wastes need to be stored at the PVNGS site until a disposal site becomes available, the contribution to annual exposures would not be significant and the total exposures due to the operation of PVNGS would still be within the values presented in Appendix C.

9.4.2.6 Nonradioactive-Waste-Management Systems

EPA-13 (Page I-42)

As described in Section 4.2.6.1, the natural evaporation rate in the area greatly exceeds the rate at which waste water will be added. Staff calculations indicate that during much of the year, the liquid surface will cover only a small area of the evaporation pond near the discharge orifice. In Section 4.2.4.1, the permeability of the evaporation pond is given as 10^{-10} cm/sec. The depth of the aquifer will also decrease the probability of aquifer contamination. In addition, to ensure that no deterioration of offsite groundwater quality occurs as a result of PVNGS operation, the applicant will monitor groundwater quality at leak detection collection points and monitoring wells, and will continuously maintain the integrity of the liner, as described in Section 5.3.2.3. Thus the staff concludes that operation of the onsite evaporation pond should not have a measurable effect on groundwater quality.

9.4.2.8 Water Conveyance System

MLS-2 (Page I-30) and SH-2 (Page I-22)

In designing the pipeline which conveys effluent from the Phoenix 91st Avenue sewage treatment plant to the PVNGS, the effect of scour on the Hassayampa River channel bottom was considered. The pipeline is located below any expected scour so that there is a minimum of 9 m (28 ft) of ground cover between the river bottom and the top of the pipeline. Therefore, flooding on the Hassayampa River will have no effect on the pipeline.

9.4.3.1 Hydrology

JDM-4 (Page I-26)

Generally a water level decline in a deep aquifer, such as the regional aquifer at Palo Verde, is undesirable because it can result in land subsidence and ground cracking. It can also result in lower water availability and higher pumping costs. At Palo Verde, there is no physical evidence or published information to indicate that any subsidence has occurred within an 8-km (5-mi) radius of the plant as a result of the localized groundwater level decline that occurred between 1950 and 1975. Likewise, a rise in the regional aquifer should have no effect as far as subsidence is concerned. A higher ground water level, however, should benefit the applicant slightly because of expected lower pumping costs in obtaining ground water for the plant's domestic water supply.

9.4.3.2 Water Quality

JDM-5 (Page I-26)

In Appendix I determinations, the staff does not take into consideration possible reduction of prior impacts. Because PVNGS has no liquid releases, there can be no impact or population dose as a result of routine plant operation.

Prior to construction of the PVNGS, sewage effluent from the Phoenix 91st Avenue sewage treatment plant was discharged into the Salt River. A small portion of this discharge was used instream for fish and wildlife enhancement. A larger portion was diverted for agricultural purposes. The remaining effluent flowed varying distances downstream before infiltrating into the riverbed.

With operation of the PVNGS, some of the effluent from the 91st Avenue plant will flow by pipeline for use as cooling water at the station. This will reduce the amount of 91st Avenue plant effluent that will be discharged to the Salt River and will, therefore, reduce the amount available for infiltration into the ground.

Groundwater reserves in the region consist of an extensive regional aquifer of 1035-1425 km^2 (400-550 mi^2). Recharge of this aquifer is principally the result of underflow from the upper Hassayampa Valley. Recharge from stream infiltration, if any, comprises only a small fraction of the natural recharge. Because stream infiltration is only a small part of the total recharge of the regional aquifer, a reduction in the amount of effluent available to infiltrate into the ground will have an insignificant effect on the amount of water that reaches the groundwater resource. Based on this, the staff concludes that if there is any radioactive contamination in the effluent from the 91st Avenue plant, any decrease in the amount which reaches the groundwater resource due to less effluent being available to infiltrate into the ground will also be insignificant.

9.4.3.4 Ecology

DOI-2 (Page I-36)

Section 4.3.4 has been revised to reflect this comment.

SH-E (Page I-22)

The PVNGS facility has not disturbed or in any way disfigured any national forests, as suggested by this comment. PVNGS is situated on land formerly utilized for agricultural purposes.

9.4.3.6 Historic and Archeological Sites

APS-2 (Page I-11)

The comment is correct, and the staff has revised the text (Section 4.3.6).

MLS-3 (Page I-30)

See revised text in Section 4.3.6.

9.5 Environmental Consequences and Mitigating Actions

9.5.2 Site Land Use

APS-3 (Page I-11)

The text has been revised to reflect this comment.

9.5.3.1 Water Use

AGFD-1, 2 (Page I-1)

Statements in Section 5.3.1.1 concerning AGFD's usage of committed effluent have been revised to reflect AGFD's comments.

APS-4 (Page I-11)

The staff's evaluation of sewage effluent availability (Section 5.3.1.1) has been revised to reflect the updated projections provided by the applicant in Supplement 4 to the PVNGS ER-OL.

APS-5 (Pages I-11, 12, 13)

The text following Table 5.3 has been rewritten to reflect more current information which has become available since the DES-OL was published. The rewritten text, however, differs from that suggested by the applicant. Although the applicant states, in Comment APS-5, that the Arizona Game and Fish Department (AGFD) has abandoned its attempt to perfect its right to 9×10^6 m^3/yr (7,3000 acre-ft/ yr) of sewage effluent under Arizona state law as an instream use for fish and wildlife enhancement, the AGFD in its comments on the DES-OL stated that it is utilizing its commitment and intends to do so in the future. Because of this apparent contradiction, the staff, in its analysis of sewage effluent availability, conservatively assumed that 9×10^6 m^3/yr of the effluent discharge from the 91st Avenue Plant will not be available for use except by the AGFD. In addition, the applicant states that according to the Benson-Allison decree, the Buckeye Irrigation District (BID), has a right to 80 miners inches of constant flow (80 miners inches is equivalent to about 0.056 m^3 (2 ft^3) per second), which reaches its headworks. Based on Halpenny (1975), the staff concludes that the Benson-Allison decree granted the BID a right to 80 miners inches of constant flow per quarter section (65 ha (160 acres)) of irrigated land.

APS-6 (Page I-13)

One of the values in Table 5.4 corresponding to the PVNGS usage for three units is 8.33 × 10^7 m^3 (67,500 acre-ft). This value is incorrect. The correct number should be 7.91 × 10^7 m^3 (64,100 acre-ft). The applicant states that the correct value should be 63,750 acre-ft based on information contained in Section 4.2.3 of the DES. It is not clear to the staff how this value was calculated because in Section 4.2.3, the PVNGS water usage is shown as 2.6 × 10^7 m^3/unit (21,350 acre-ft/unit). For three units, the amount should be 7.8 × 10^7 m^3 (64,050 acre-ft) (21,350 x 3). This is the same value used by the staff, except that it was rounded off to 7.91 × 10^7 m^3 64,100 acre-ft.

APS-7 (Page I-13)

The staff agrees with this comment. Accordingly, statement has been deleted.

MAR-1 (Page I-24)

It is the staff's position (Section 5.3.1) that there will be sufficient water provided by sewage effluent and that no additional sources of cooling water will be needed.

SH-D (Page I-22)

The staff is unaware of any request that the applicant may have made for water from the the Central Arizona Project. The sources of water already identified by the applicant are adequate for operation of the PVNGS. As explained in Section 5.3.1.1, all of the cooling water needed by the PVNGS will be obtained from the Cities of Phoenix and Tolleson. Water for domestic purposes will be pumped from the regional aquifer. The staff has determined that these two sources of water are adequate for station operation.

9.5.3.2 Water Quality

ADHS-1, 3 (Page I-5)

Section 5.3.2.1 has been revised to refer to these comments.

ADHS-2 (Page I-5)

Section 5.3.2.3 has been revised to reflect this comment.

9.5.4.2 Emissions and Dust

APS-8 (Page I-14)

As stated in Section 5.4.2, particulate concentrations in air on leaving the towers are expected to be approximately equal to the 24-hour National Ambient Air Quality Standard (NAAQS) for total suspended particulates. However, the ground level concentration in air is expected to be at least a factor of 100 less than the concentration at the release height. Therefore, no violation of the NAAQS at ground level is anticipated.

9.5.5 Wastewater Diversion

AGFD-3 (Page I-2)

The staff agrees that a reduction of flow through this stretch of the Gila River would lead to a reduction in wildlife habitat (as noted in Section 5.5.1.2) and that this would have an adverse effect on wildlife dependent upon this habitat. A more definitive analyses of impacts on wildlife and wildlife habitat requires detailed data on the value of dependence of the habitat and upon the quantity of the effluent that flows through the stretch of the Gila River below 91st Avenue. Continued growth in the Phoenix area and consequent increases in sewage effluent from the 91st Avenue Sewage Treatment Plant could return the flow regime in the river to current levels, allowing flow-dependent habitat to recover. The timing and likelihood of such recovery is dependent upon the actual magnitude of future growth in the area.

In addition, it is difficult to determine how the proposed clearing of up to 1600 ha of riparian habitat between Gillespie Dam and 91st Avenue for flood control purposes will interact with reductions in effluent flow (see Blair). If clearing takes place, the ultimate effect of reducing effluent flow may be to inhibit the establishment of preferred species of vegetation. Reduced flow may also inhibit the reinvasion of tamarisk (salt cedar) into the river's floodplain.

The staff has analyzed this loss in the FES-CP (Sections 5.5.1.1 and 10.3.3) and again analyzed it in the DES-OL and finds that this impact is acceptable in an overall cost-benefit analysis of the PVNGS project (Section 6.1, Table 6.1).

9.5.8 Socioeconomics

SH-A (Page I-22) and MLS-5 (Page I-30)

Section 5.8 of the provides an analysis of the socioeconomic impacts of station operation.

DOT-1 (Page I-38)

Section 5.8.4 has been revised to reflect this comment.

MLS-7 (Page I-30)

The staff does not contemplate civil liberties problems regarding plant security during normal operation of PVNGS. This conclusion is based on experience gained during the application of a comprehensive security program during more than 30 years of protecting restricted data and, more recently, in protecting commercial nuclear power plants. These programs include the use of armed guards and security clearances for employees and have been implemented without violation of the fundamental rights of individuals.

MAR-3 (Pages I-24 and 25)

The assumption that the "site is a growth generator which attracts new growth and development" is not proven. The staff is not aware of any studies that indicate power stations as the causal factor in community growth. In fact, the uniform pricing structure within service areas suggests that economic activities would be indifferent with respect to location within the service area, everything else being equal. When other factors are not equal, economic units, including households, will consider a "market basket" of factors--time and cost of travel, taxes, quality of services, capital investment--in making a locational decision. Development that occurs in nuclear plant communities is usually found in previously established areas that offer services and amenities. Unless the station's boundary areas were already settled and already contained desirable services, there is no reason to expect growth and development in those areas.

The comment proposes a very expensive set of recommendations (increase in site boundaries and purchase of development rights) for an assumed set of circumstances. The staff believes that a more cost-effective approach would involve a review and revision, where necessary, of county zoning, capital improvement budgets and program, site plan, and real estate tax policies.

9.5.8.3 Offsite Land Use

DOI-3 (Pages I-36 and 37)

The nearest boundary of an Indian reservation is more than 35 km (20 mi) from the site boundary of PVNGS. Should evidence of irreversible environmental damage or adverse environmental effects be detected that could affect reservation lands, the Bureau of Indian Affairs will be contacted concerning the proposed course of action to alleviate the problem.

9.5.9 Radiological Impacts

DHHS-4b (Page I-35)

The monitoring of accident releases is not an environemental statement issue. The staff's evaluation of monitoring accident releases is presented in the Safety Evaluation Report for PVNGS (NUREG-0857, dated November 1981).

EPA-3a (Page I-40)

The intent of Section 5.9 is to summarize which regulations nuclear power plants must comply with to be allowed to operate. The section quoted with regard to 10 CFR Part 20, "Radiation Protection Standards," does apply to nuclear power plants.

10 CFR 20.2 defines the scope of this regulation as: "The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed to the regulations in Parts 30 through 35, 40, or 70 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter."

EPA-3b (Page I-40)

This section of the text has been clarified in the FES.

EPA-2 (Page I-40)

See staff response under Section 9.4.2.5 above.

9.5.9.1 Radiological Impacts from Routine Operation

JDM-6 (Page I-27) and APS-9 (Page I-14)

The sentence in paragraph 5.9.1.1.1 should have said that the occupational doses for each unit at PVNGS "could average as much as 3 times this value over the life of the plant." While the average annual dose at each PVNGS unit is projected to be 440 person-rems, this annual dose could average as much as 1300 person-rems (or roughly 3 x 440) over the life of the plant in the event of unusually high special maintenance doses.

The 1300 person-rem upper range value was derived from the doses of a plant built within the last 8 years and is a valid number for estimating the upper range annual doses of new operating units. While it is true that new plants are designed to higher standards and should, theoretically, have lower annual operating doses, the annual doses of some recently built plants have equaled or exceeded the annual does reported by much older plants. The lower generating capacities and smaller physical sizes of some of the early plants have been contributing factors to their lower annual doses. Therefore, the 1300 person-rem upper range value for PWRs is applicable to new as well as old PWRs, and is an acceptable estimate for an upper end dose projection.

The 440 person-rem average value does not take into consideration APS design and operation ALARA programs that are considered in the analysis in the SER.

APS-10, 11, 12 (Page I-14)

The text of the FES has been revised to include these points.

DHHS-1, 2, 4, 5 (Pages I-34 and 35)

These comments do not require formal comment.

EPA-4 (Page I-41)

The 50-year period used in the dose commitment reflects the remaining life expectancy of the average individual in the population today who may be exposed to radiation originating in a nuclear power plant.

EPA-5 (Page I-41)

The NRC values quoted in the DES are based on an 80,000 person-rem dose and a risk estimator of 135 fatal cancers per 1,000,000 person-rems. For further discussion on this, refer to Section 5.9.1.2 of the FES.

EPA-6 (Part I-41)

As stated in Section 5.9.1.1.2, in the subsection entitled "Direct Radiation for PWRs," direct radiation levels in unrestricted areas from sources within a PWR are generally small. These radiation levels may vary with time depending on a plant's operating characteristics, but under all circumstances the applicant will be required, by 10 CFR 20.105, to maintain doses to individuals in unrestricted areas, from direct sources of radiation within the plant, below 25 mrem/year. The document referenced in the comment refers to a specific circumstance where radiation levels exceeded background prior to corrective action. Nonetheless, in general, direct radiation levels in unrestricted areas from PWRs are small. In all circumstances, no individual in unrestricted areas may receive in excess of 25 mrems/year.

EPA-7 (Page I-41)

40 CFR 190 requires that the total quantity of krypton-85 released to the environment from the entire uranium fuel cycle during normal operation must not exceed 50,000 curies per gigawatt-year of electrical energy produced by the fuel cycle. Because this situation will never arise at PVNGS, there is no need to address the issue relating to krypton standard in the FES.

EPA-8 (Page I-41)

A footnote explaining the definition of D/Q has been added to Table 5.8.

ARRA-2 (Page I-16)

In analyzing the contributions of various isotopes to specific organs from ground deposition and/or inhalation, the majority of the dose comes from iodine in the thyroid and carbon-14 in the bone. This section of the text has been changed to effect this clarification.

EPA-11 (Page I-42)

The staff has considered the incremental organ dose from radioiodine, particulates, carbon-14, and tritium as a result of an additional release of 57 millicuries/year of iodine-131 resulting from the use of sewage effluent in the cooling system at the PVNGS. Conservatively assuming that all of this material is released into the atmosphere, the staff estimates that the calculated organ dose of 6 millirems/year thyroid as a result of the operation of the station would not increase significantly (<10%). Because of the difficulties in making such estimates, the applicant is currently to moniting and will continue to monitor this potential pathway at the operational stage to ensure that the releases remain within the staff's ALARA design objectives.

MAR-4 (Page I-25)

A preservice and inservice inspection program for structural components is an NRC safety requirement that will be implemented for PVNGS. An environmental monitoring program will also be implemented during the life of the plant. Such programs are in addition to the NRC's own inspection activities, which have not been reduced as a result of cutbacks in other government agencies.

ARRA-6 (Page I-17)

In doing the anlysis of exposure due to potential pathways, the staff analyzes the major food pathways. Although cottonseed oil is a component of cooking oils, exposure to the population from this pathway would not be the dominant nor a significant pathway. Those estimates from the pathway are significantly less than the other pathways discussed in the DES, such as vegetation and milk.

9.5.9.2 Postulated Accidents

APS-13 (Page I-14)

The inventories used are renormalized from Reactor Safety Study (RSS) (WASH-1400) inventories, which were generated for a core power level of 3200 Mwt. It was assumed in generating the RSS inventories that one-third of the core contained fuel with 1-year burnup, the second third contained fuel with 2-year burnup, and the remaining third contained fuel with 3-year burnup.

SH-C (Page I-22)

Design basis accidents (DBAs) are postulated for the purpose of reactor safety system design. They are not judged to be significant contributors to the risks because the safety systems have been designed to mitigate the consequences of such accidents. Therefore, the DBAs have not been subjected to the same level of probabilistic analysis as the more severe accidents analyzed in the DES.

ARRA-3 (Page I-16)

The basis for the average cost of protective action and decontamination ($2260) is described in Appendix VI, Section 12 (Economic Model) of the Reactor Safety Study (NUREG 75/014). The analyses performed to obtain this average cost (1980 dollars) incorporate the spread of a radionuclide-containing plume and its effects on residents and property. Intermediate monetary costs calculated in the analyses are those for decontamination of farm fields, residences, businesses, and public areas. Resident relocation costs and costs of milk denial and nondairy-product denial are also included.

APS-15 (Page I-14)

Use of the station minimum (871 m) EAB distance rather than the Unit 1 EAB distance will not affect the calculated DBA consequences, because relative concentrations (χ/Qs) for 871 m were utilized in determining these consequences.

SH-1 (Page I-22)

The plant structures are designed according to the requirements of Regulatory Guide 1.76, which incorporates information on nationwide and regional statistics on tornadic winds.

APS-17 (Page I-15)

The staff agrees that replacement fuel cost should be based on the projected energy mix within the area, but not in proportion to the energy mix. The more efficient energy sources will be based loaded even with the nuclear generator in operation. These units cannot take on more load if the nuclear unit is not operating, and therefore the replacement energy must come from the less efficient units that are not fully loaded. Staff projections show that most of the coal and natural gas generation will be base loaded, so that the replacement energy must come principally from oil-fired generation.

In computing the replacement power cost, the staff has credited the decreased nuclear fuel usage as reflected by the term "additional" fuel costs appearing in the DES.

DOT-2 (Page I-38)

An evacuation time estimate study has been performed and the results are to be integrated into the protective action decision-making methodology.

DHHS-3a (Page I-35)

Introduction of radionuclides into the liquid pathway as a result of a core-melt accident will require considerable time (days to months). As a result, provisions for an expanded groundwater monitoring program can be made on an ad hoc basis. The applicant's provisions for emergency laboratory support, emergency environmental monitoring, and use of state and Federal monitoring capabilities provide a sufficient basis on which to institute such a program in a timely manner.

SH-3 (Page I-22) and MLS-1 (Page I-30)

Those construction materials which would be potentially vulnerable to the effects of the desert climate, particularly intense sunlight, are stored indoors, most often in a large site warehouse. In addition, components and equipment for PVNGS that are safety related will be environmentally qualified to postulated accident conditions whose effects are more severe when compared to the effects of a desert climate.

APS-16 (Page I-14)

The difference between the staff's determination of groundwater velocity and that of the applicant is not because the DES ignores actual perched mound water elevation as is stated in the comment. It is due to the difference in the assumptions made regarding the elevation of the perched water mound. The applicant assumed that the groundwater elevation beneath the station was at the design water elevation of 280 m (921 ft). In Section 2.4.13.5 of the FSAR, the applicant states: "The groundwater level beneath each unit is predicted to remain well below its respective design groundwater elevation during the 40-year plant life." Based on this statement, the staff concluded that a groundwater level somewhat lower than the design level would be more appropriate for use in determining groundwater velocity. The elevation used by the staff was obtained from Figure 2.4-30 of the FSAR.

EPA-9 (Page I-41) and APS-14 (I-14)

The text has been revised to reflect these comments.

SH-4 (Page I-23)

Emergency preparedness, including communications during an emergency, is a safety-related matter currently under review by the NRC staff. The current status of this review is presented in Section 13.3 and Appendix C to Supplement to the staff's Safety Evaluation Report, dated February 1982 (see availability statement on the inside front cover of this report).

EPA-11 (Page I-42)

The routing of contaminated steam to the condenser would not be undertaken without offsite power to operate the cooling water pumps. The onsite standby power source is not sized to sustain the addition of such a relatively large load.

SH-5 (Page I-23)

Evaluation of the emergency core cooling system (ECCS) to mitigate the potential loss of primary coolant is within the safety review scope of the NRC staff. This evaluation is presented in Section 6.3 of the staff's Safety Evaluation Reports for Palo Verde and CESSAR, both dated November 1981. Because the ECCS includes the capability to recirculate through the core, via the containment sump, primary coolant that would leave the primary system in the event of a break, availability of cooling water is not limited to 3-1/2 hours.

DOI-1 (Page I-36)

The staff's analysis of core-melt accident liquid pathway consequences conservatively includes all groundwater users in the region, for wells screened in the regional aquifer or the perched water table aquifer. Vertical seepage from the perched water table to the regional aquifer will be minimal. Most groundwater movement will be radially away from the center of the perched mound.

In order to conclusively prove that the liquid pathway consequences are negligible even for a postulated direct contamination of the regional aquifer, the staff has repeated its analysis comparing the LPGS dry site to the Palo Verde site, using transport characteristics typical of the regional aquifer instead of the perched water table. The staff's original conclusions remain unchanged, because calculated doses are still a very small fraction of those predicted for the LPGS dry site.

EPA-1 (Page I-40)

The applicant has submitted his proposed emergency plan for PVNGS. The proposed plan has been reviewed by the staff as part of its safety review and the applicant is currently revising the plan in response to staff comments. The State of Arizona has also submitted its emergency plan to FEMA for review. A full-power license will not be issued to PVNGS until acceptable emergency plans are in place.

9.5.10 Impacts from the Uranium Fuel Cycle

SH-7 (Page I-23) and MLS-4 (Page I-30)

Section 5.10 and Appendix G reflect the latest information on the uranium fuel cycle, including environmental data (Table 5.15 of the DES). The rights of specific Native Americans in respect to the development of specific uranium resources are properly the subject of environmental statements that are required in connection with any such proposed development.

9.5.11 Decomissioning Impacts

ARRA-5 (Page I-16)

The applicant indicates that the costs of decommissiong will constitute one element of the total cost of service. The precise manner in which decommissioning costs are accounted for, including the costs to be recovered from the respective customers of the participants, will be decided ultimately by those Federal, state, and local agencies having jurisdiction over the rates charged by the participants.

MLS- 6 (Page I-30)

As stated in Section 5.11, the assessment of decommissioning impacts has been updated from that assessment in the FES-CP and is based on a generic assessment by the NRC staff that is presented in NUREG-0586, "Draft Generic Environmental Statement on Decommissioning Nuclear Facilities."

9.5.12 Emergency Planning Impacts

ARRA-4 (Page I-16)

The staff does not believe that this statement should be either deleted or rewritten.

9.6 Evaluation of the Proposed Action

9.6.1 Unavoidable Adverse Environmental Effects

JDM-9 (Page I-27)

Taxes, employment, and payroll, listed as benefits in Table 6.1, are labeled as "secondary" benefits only because they are the result of power generation. Power generation is considered the primary benefit by the staff, as indicated in Table 6.1. The staff fails to see a relationship between Section 5.10 and the economic benefits shown in Table 6.1. No cost attribution is visible to the staff as a result of identifying taxes, employment, or payroll as benefits.

JDM-7 (Page I-27)

The environmental analyses carried out in Section 5 are based upon calculations and appropriate methods of environmental impact assessment that involve various assumptions, and are therefore a cause for an unknown degree of uncertainty. Accordingly, the staff requires monitoring programs.

JDM-8 (Page I-27)

The NRC staff's limited monitoring programs are either based upon comparisons to background (normal) levels or comparisons to preoperationsl levels. In many case, the monitoring programs involve a qualitative assessment by the licensee followed by NRC notification. Mitigative actions during operation will depend upon NRC and licensee assessments.

9.C Examples of Site-Specific Dose-Assessment Calculations

JDM-10 (Page I-27)

Table C-6, entitled "Annual total-body population dose commitments, year 2000, Palo Verde Units 1, 2, and 3" (p. C-11 DES), represents the dose received by the total U.S. population, in units of person-rems and not the dose to the population within 80 km. A complete discussion of the computational models used to calculate the doses from gaseous effluents to the maximally exposed individual, the general population, and the population within 80 km of Palo Verde can be found in NUREG-0597, "User's Guide to GASPAR Code," U.S. Nuclear Regulatory Commission, 1980.

9.G Impacts of the Uranium Fuel Cycle

JFD-1 (Page I-20)

Section 5.9.3.1 of the FES, entitled "Radiological Impacts on Humans," discusses the risk to both the maximally exposed individual and to the general population from the routine operation of PVNGS.

JFD-2 (Part I-20)

The Advisory Committee on the Biological Effects of Ionizing Radiations (BEIR III), in the report entitled "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," points out that for some sites and types of cancers (for example, lung) the incidence is fairly well approximated by mortality. Therefore, the values quoted in Appendix G on cancer deaths can be used as an approximation for the incidence of lung cancer from radon-222.

JFD-3, 4 (Page I-20)

The text in Appendix G has been revised to include these points.

JFD-5 (Page I-20)

For additional discussion of the impact of radon, refer to NUREG-0757, "Radon Releases from Uranium Minning and Milling and their Calculated Health Effects," U.S. Nuclear Regulatory Commission, 1980.

DHHS-4a, (Page I-35)

These comments do not require formal response.

SH-B (Page I-22)

The radiological effects and disposal of transuranic wastes, which include plutonium 239, are addressed in Table 5.15, Section 5.10, and Appendix G.

APPENDIX A

FINAL ENVIRONMENTAL STATEMENT - CONSTRUCTION PHASE - PALO VERDE NUCLEAR GENERATING STATION UNITS 1, 2, AND 3 (PROVIDED IN THE DES ONLY)

APPENDIX B

LETTER FROM THE U.S. DEPARTMENT OF THE INTERI`R,
FISH AND WILDLIFE SERVICE,
CONCERNING ENDANGERED SPECIES IN THE PVNGS AREA

IN REPLY REFER TO:

SE

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

February 6, 1981

Mr. Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

This is in reply to your letter of January 23, 1981, which requested information about species which are listed or proposed to be listed as threatened or endangered, as provided by the Endangered Species Act. Your area of interest is the Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3, Maricopa County, Arizona.

As provided by Section 7(c)(1) of the Endangered Species Act, the Fish and Wildlife Service is required to furnish a list of those species, both proposed and listed, that may be affected by Federal construction activities. I partially agree with your interpretation of Section 7 (c) of the Act, as amended. You need not prepare a biological assessment for those parts of the PVNGS under construction prior to the 1978 amendments, but a biological assessment is required for construction begun after enactment of the 1978 amendments.

Upon receipt of the Fish and Wildlife Service's species list, the Federal agency authorizing, funding or carrying out the construction action is required to conduct a biological assessment for the purpose of identifying listed and proposed species which are likely to be affected by such action.

The biological assessment shall be completed within 180 days after receipt of the species list, unless it is mutually agreed to extend this period. If the assessment is not initiated within 90 days after receipt of the species list, I suggest its accuracy be verified before conducting the assessment.

Biological assessments should include as a minimum:

1) an on-site inspection of the area affected by the proposed activity or program, which may include a detailed survey of the area to determine if species are present and whether suitable habitat exists for either expanding the existing population or potential reintroductions of populations;

2) interview recognized experts on the species at issue, including the Fish and Wildlife Service, State conservation departments, universities, and others who may have data not yet found in scientific literature;

3) review literature and other scientific data to determine the species distribution, habitat needs, and other biological requirements;

4) review and analyze the effects of the proposal on the species, in terms of individuals and populations, including consideration of the cumulative effects of the proposal on the species and its habitat;

5) analyze alternative actions that may provide conservation actions;

6) other relevant information;

7) report documenting the assessment results.

For purposes of providing interim guidance, the Fish and Wildlife Service considers construction projects to be any major Federal action authorized, funded or carried out by a Federal agency which significantly affects the quality of the human environment and which is designed primarily to result in the building or erection of man-made structures such as dams, buildings, roads, pipelines, channels, and the like.

If the biological assessment indicates the proposed project may affect listed species, the formal consultation process shall be initiated by writing to the Regional Director, Region 2, U.S. Fish and Wildlife Service, P.O. Box 1306, Albuquerque, New Mexico 87103. If no effect is evident, there is no need for further consultation. I would, however, appreciate the opportunity to review your biological assessment.

In addition, the Act (Sec. 7(c)(1)) now requires Federal agencies to confer with the Service on any agency action which is likely to jeopardize the continued existence of any species proposed to be listed as endangered or threatened or adversely modify critical habitat proposed to be designated for such species. The purpose of this requirement is to identify and resolve at the early planning stage of an action, all potential conflicts between the action and the respective species and critical habitat. The informal consultation process can accomplish this requirement.

The attached sheet provides information on listed species which may occur in the area of interest. If you have need of further assistance, please call the Endangered Species Office at (505) 766-3972 or FTS 474-3972.

Sincerely yours,

Acting
Assistant Regional Director

Attachments

cc: Phoenix Area Office (SE), Phoenix, Arizona
Phoenix Field Office (ES), Phoenix, Arizona

Palo Verde Nuclear Generating Station
Maricopa County, Arizona

LISTED SPECIES

Peregrine falcon (Falco peregrinus anatum) - occurs in areas with rocky, steep cliffs, preferably near water where bird prey concentrat:. Peregrines are also found in forest and grassland areas.

Bald eagle (Haliaeetus leucocephalus) - nests near water and requires trees or rock cliffs for nest sites. Eagles winter along reservoirs and rivers; fish are its primary food.

Yuma clapper rail (Rallus longirostris yumanensis) - occurs in shallow, fresh or brackish water marshes containing dense stands of cattails and/or tule. Feeding occurs in shallow water and on adjacent mud flats.

PROPOSED SPECIES

None.

CRITICAL HABITAT

None.

APPENDIX C

EXAMPLES OF SITE-SPECIFIC DOSE-ASSESSMENT CALCULATIONS

CONTENTS

LIST OF TABLES

APPENDIX C

EXAMPLES OF SITE-SPECIFIC DOSE-ASSESSMENT CALCULATIONS

1. Calculational Approach

As mentioned in the text, the quantities of radioactive material that may be released annually from the Palo Verde Nuclear Generating Station are estimated on the basis of the description of the radwaste systems in the applicant's ER and FSAR and by using the calculational model and parameters developed by the NRC staff in NUREG-0017. These estimated effluent release values for normal operation, including anticipated operational occurrences, along with the applicant's site and environmental data in the ER and in subsequent answers to NRC staff questions, are used in the calculation of radiation doses and dose commitments.

The models and considerations for environmental pathways that lead to estimates of radiation doses and dose commitments to individual members of the public near the plant and of cumulative doses and dose commitments to the entire population within an 80-km (50-mi) radius of the plant as a result of plant operations are discussed in detail in Regulatory Guide 1.109. Use of these models, with additional assumptions for environmental pathways that lead to exposure to the general population outside the 80-km radius, is described in Appendix D of this statement.

The calculations performed by the staff for the releases to the atmosphere provide total integrated dose commitments to the entire population within 80 km of the station based on the projected population distribution in the year 2000. The dose commitments represent the total dose that would be received over a 50-yr period, following the intake of radioactivity for 1 yr under the conditions existing 15 years after the station begins operation (that is, the mid-point of station operation). For younger persons, changes in organ mass and metabolic parameters with age after the initial intake of radioactivity have been considered.

2. Dose Commitments from Radioactive Effluent Releases

The NRC staff estimates of the expected gaseous and particulate releases (listed in Table C-1), along with the site meteorological considerations (discussed in Section 2.4 summarized in Table C-2), were used to estimate radiation doses and dose commitments for airborne effluents. Individual receptor locations and pathway locations considered for the maximally exposed individual in these calculations are listed in Table C-3.

Annual average relative concentration (χ/Q) and relative deposition (D/Q) values were calculated using the straight-line Gaussian atmospheric dispersion model described in Regulatory Guide 1.111. Diffusion coefficients appropriate for a desert site were incorporated into the dispersion model. Based on information presented by the applicant comparing the straight-line model with a time-dependent, segmented-plume model for the Palo Verde site, the results of the straight-line model were adjusted to reflect spatial and temporal variations in airflow. All releases were considered to be ground level with mixing in the turbulent wake of plant structures. Intermittent releases from the reactor building vent were evaluated using the methodology described in NUREG-0324. Five years (August 1973 - August 1978) of onsite meteorological data were used for this evaluation. Wind speed and direction data were based on measurements at the 10-m (33-ft) level and atmospheric stability was defined by the vertical temperature gradient measured between the 10-m (30-ft) and 60-m (200-ft) levels.

(a) Radiation Dose Commitments to Individual Members of the Public

As explained in the text, calculations are made for a hypothetical individual member of the public (the "maximally exposed individual") who would be expected to receive the highest radiation dose from all appropriate pathways. This method tends to overestimate the doses because assumptions are made that would be difficult for a real individual to fulfill.

Individual receptor locations and pathway locations considered for the maximally exposed individual are listed in Table C-3. The estimated dose commitments to the individual who is subject to maximum exposure at selected offsite locations from airborne releases of radioiodine and particulates are listed in Tables C-4 and C-5. The maximum annual total body and skin dose to a hypothetical individual and the maximum beta and gamma air dose at the site boundary are presented in Tables C-4 and C-5.

The maximally exposed individual is assumed to consume well above average quantities of the potentially affected foods and to spend more time at potentially affected locations than the average person, as indicated in Tables E-4 and E-5 of Regulatory Guide 1.109.

(b) Cumulative Dose Commitments to the General Population

Annual radiation dose commitments from airborne radioactive releases from the PVNGS are estimated for two populations in the year 2000: (1) all members of the general public within 80 km (50 mi) of the station (Table C-5) and (2) the entire U.S. population (Table C-6). Dose commitments beyond 80 km are based on the assumptions discussed in Appendix D. For perspective, annual background radiation doses are given in the tables for both populations.

3. References

U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Regulatory Guide 1.109, Revision 1, October 1977.

U.S. Nuclear Regulatory Commission, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," NUREG-0017, April 1976.

U.S. Nuclear Regulatory Commission, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Reactors," Regulatory Guide 1.111, Revision 1, July 1977.

U.S. Nuclear Regulatory Commission, "χOQ DOQ Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," NUREG-0324, draft report, September 1977.

Table C-1 Calculated releases of radioactive materials in gaseous effluents from Palo Verde Units 1, 2, and 3 (Ci/yr per unit)

Nuclide	Plant vent stack (Continuous)	Air ejector exhaust (Continuous)	Turbine bldg. vent (Continuous)	Plant vent stack* (Intermittent)	Total
Ar-41	25	**	**	**	25
Kr-83m	2	**	**	**	2
Kr-85m	21	1	**	**	22
Kr-85	110	2	**	700	810
Kr-87	5	**	**	**	5
Kr-88	28	3	**	**	31
Kr-89	**	**	**	**	**
Xe-131m	81	1	**	**	82
Xe-133m	140	3	**	**	140
Xe-133	12,000	240	**	**	13,000
Xe-135m	**	**	**	**	**
Xe-135	107	5	**	**	110
Xe-137	**	**	**	**	**
Xe-138	**	**	**	**	**
		Total Noble Gases			14,000
Mn-54	.0004	***	***	.00005	.0005
Fe-59	.0001	***	***	.00002	.0002
Co-58	.001	***	***	.0002	.002
Co-60	.0006	***	***	.00007	.0007
Sr-89	.00003	***	***	.000003	.00004
Sr-90	.000006	***	***	.0000006	.000006
Cs-134	.0004	***	***	.00005	.0005
Cs-137	.0004	***	***	.00008	.0008
		Total Particulates			.005
I-131	.07	.008	.0004	**	.08
I-133	.07	.01	.0006	**	.08
H-3	1,500	-	-	-	1500
C-14	1	**	**	7	8

*Intermittent release, 15 8-hr releases per year from waste gas decay tanks.
**Less than 1 Ci/yr for noble gases and C-14 and less than 10-4 Ci/yr for iodines.
***Less than 1 percent of total for this nuclide.

Table C-2 Summary of atmospheric dispersion factors (χ/Q) and relative deposition values for maximum site boundary and receptor locations near PVNGS Units 1, 2, and 3*

Location**	Source***	χ/Q (m/s^3)	Dispersion Parameters: χ/Q (decayed)**** (m/s^3)	χ/Q (decayed-depleted)**** (m/s^3)	D/Q (m^{-2})
Unit 1					
Nearest site boundary (1.48 km, SW)	A	6.46×10^{-6}	6.41×10^{-6}	5.67×10^{-6}	4.74×10^{-9}
	B	2.89×10^{-5}	2.87×10^{-5}	2.54×10^{-5}	2.12×10^{-8}
	C	6.46×10^{-6}	5.41×10^{-6}	5.67×10^{-6}	4.74×10^{-9}
	D	6.46×10^{-6}	6.41×10^{-6}	5.67×10^{-6}	4.74×10^{-9}
Nearest residence and garden (2.52 km, N)	A	3.99×10^{-6}	3.94×10^{-6}	3.39×10^{-6}	3.54×10^{-9}
	B	1.55×10^{-5}	1.53×10^{-5}	1.32×10^{-5}	1.37×10^{-8}
	C	3.99×10^{-6}	3.94×10^{-6}	3.39×10^{-6}	3.54×10^{-9}
	D	3.99×10^{-6}	3.94×10^{-6}	3.39×10^{-6}	3.54×10^{-9}
Nearest milk cow (4.83 km, N)	A	1.98×10^{-6}	1.93×10^{-6}	1.56×10^{-6}	1.06×10^{-9}
	B	8.01×10^{-6}	7.82×10^{-6}	6.32×10^{-6}	4.28×10^{-9}
	C	1.98×10^{-6}	1.93×10^{-6}	1.56×10^{-6}	1.06×10^{-9}
	D	1.98×10^{-6}	1.93×10^{-6}	1.56×10^{-6}	1.06×10^{-9}
Unit 2					
Nearest site boundary (1.83 km, SSW)	A	7.40×10^{-6}	7.34×10^{-6}	6.41×10^{-6}	4.22×10^{-9}
	B	2.80×10^{-5}	2.77×10^{-5}	2.42×10^{-5}	1.59×10^{-8}
	C	7.40×10^{-6}	7.34×10^{-6}	6.41×10^{-6}	4.22×10^{-9}
	D	7.40×10^{-6}	7.34×10^{-6}	6.41×10^{-6}	4.22×10^{-9}
Nearest residence and garden (2.64 km, N)	A	3.65×10^{-6}	3.60×10^{-6}	3.07×10^{-6}	2.94×10^{-9}
	B	1.36×10^{-5}	1.35×10^{-5}	1.15×10^{-5}	1.10×10^{-8}
	C	3.65×10^{-6}	3.60×10^{-6}	3.07×10^{-6}	2.94×10^{-9}
	D	3.65×10^{-6}	3.60×10^{-6}	3.07×10^{-6}	2.94×10^{-9}
Nearest milk cow (5.07 km, N)	A	1.87×10^{-6}	1.82×10^{-6}	1.47×10^{-6}	9.67×10^{-10}
	B	7.53×10^{-6}	7.34×10^{-6}	5.90×10^{-6}	3.89×10^{-9}
	C	1.87×10^{-6}	1.82×10^{-6}	1.47×10^{-6}	9.67×10^{-10}
	D	1.87×10^{-6}	1.82×10^{-6}	1.47×10^{-6}	9.67×10^{-10}

Table C-2 (Continued)

Location**	Source***	χ/Q (m/s^3)	Dispersion χ/Q (decayed)**** (m/s^3)	Parameters χ/Q (decayed-depleted)**** (m/s^3)	D/Q (m^{-2})
Nearest site boundary (1.6 km, SSW)	A	8.24×10^{-6}	8.18×10^{-6}	7.20×10^{-6}	5.22×10^{-9}
	B	3.13×10^{-5}	3.11×10^{-5}	2.74×10^{-5}	3.42×10^{-8}
	C	8.24×10^{-6}	8.18×10^{-6}	7.20×10^{-6}	5.22×10^{-9}
	D	8.24×10^{-6}	8.18×10^{-6}	7.20×10^{-6}	5.22×10^{-9}
Nearest residence and garden (4.7 km, SSW)	A	3.49×10^{-6}	3.42×10^{-6}	2.77×10^{-6}	9.69×10^{-10}
	B	1.31×10^{-5}	1.28×10^{-5}	1.03×10^{-5}	3.62×10^{-9}
	C	3.49×10^{-6}	3.42×10^{-6}	2.77×10^{-6}	9.69×10^{-10}
	D	3.49×10^{-6}	3.42×10^{-6}	2.77×10^{-6}	9.69×10^{-10}
Nearest milk cow (6.92 km, SSW)	A	2.40×10^{-6}	2.33×10^{-6}	1.81×10^{-6}	5.17×10^{-10}
	B	8.79×10^{-6}	8.52×10^{-6}	6.62×10^{-6}	1.89×10^{-9}
	C	2.40×10^{-6}	2.33×10^{-6}	1.81×10^{-6}	5.17×10^{-10}
	D	2.40×10^{-6}	2.33×10^{-6}	1.81×10^{-6}	5.17×10^{-10}

*The values presented in this table are corrected for radioactive decay and cloud depletion from deposition, where appropriate, in accordance with Regulatory Guide 1.111, Revision 1, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors," July 1977.

**"Nearest" refers to that type of location where the highest radiation dose is expected to occur from all appropriate pathways.

***Sources:
- A - Reactor building vent, ground level continuous release
- B - Reactor building vent, ground level intermittent release, 15 releases per year, 8 hours each release
- C - Air ejector vent, ground level continuous release
- D - Turbine building vent, ground level continuous release

****For a discussion of χ/Q (decayed) and χ/Q (decayed-depleted) refer to a NRC draft document by F. Sagend and J. Goll, "XOQDOQ-Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations", 1976.

Table C-3 Nearest pathway locations used for maximum individual dose commitments for Palo Verde Units 1, 2, and 3

Location	Sector	Distance (mi)
Nearest site boundary*	SW of Unit 1	1.48
	SSW of Unit 2	1.83
	SSW of Unit 3	1.60
Nearest residence and garden**	N of Unit 1	2.52
	N of Unit 2	2.64
	SSW of Unit 3	4.70
Nearest milk cow	N of Unit 1	4.83
	N of Unit 2	5.07
	SSW of Unit 3	6.92

*Beta and gamma air doses, total body doses, and skin doses from noble gases are determined at site boundaries in the sector where the maximum potential value is likely to occur.

**Dose pathways including inhalation of atmospheric radio-activity, exposure to deposited radionuclides, and submersion in gaseous radioactivity are evaluated at residences. This particular location includes doses from vegetable consumption as well.

Table C-4 Annual dose commitments to a maximally exposed individual near PVNGS

Location	Pathway	Doses (mrems/yr per unit, except as noted)			
UNIT 1					
		Noble gases in gaseous effluents			
		Total body	Skin	Gamma air dose (mrads/yr per unit)	Beta air dose (mrads/yr per unit)
Nearest site boundary* (SW 1.48 km)	Direct radiation from plume	0.66	2.7	1.1	4.2
		Iodine and particulates in gaseous effluents**			
		Total body	Organ		
Nearest*** site boundary (SW 1.48 km)	Ground deposition	0.0058(T)	0.0058(T) (thyroid)		
	Inhalation	0.39(T)	0.68(T) (thyroid)		
Nearest garden and residence (N 2.25 km)	Ground deposition	0.0041(C)	0.0041(C) (thyroid)		
	Inhalation	0.21(C)	0.41(C) (thyroid)		
	Vegetable consumption	1.7(C)	1.8(C) (thyroid)		
Nearest milk cow (N 4.83 km)	Ground deposition	0.0013(C)	0.0013(C) (thyroid)		
	Inhalation	0.11(C)	0.20(C) (thyroid)		
	Vegetable consumption	0.82(C)	0.87(C) (thyroid)		
	Milk consumption	0.34(C)	0.47(C) (thyroid)		
UNIT 2					
		Noble gases in gaseous effluents			
		Total body	Skin	Gamma air dose (mrads/yr per unit)	Beta air dose (mrads/yr per unit)
Nearest site boundary* (SSW 1.83 km)	Direct radiation from plume	0.75	2.9	1.3	4.5
		Iodine and particulates in gaseous effluents**			
		Total body	Organ		
Nearest*** site boundary (SSW 1.83 km)	Ground deposition	0.0049(T)	0.0049(T) (thyroid)		
	Inhalation	0.45(T)	0.75(T) (tnyroid)		
Nearest residence and garden (N 2.64 km)	Ground deposition	0.0034(C)	0.0034(C) (thyroid)		
	Inhalation	1.5(C)	0.36(C) (thyroid)		
	Vegetable consumption	0.2(C)	1.6(C) (thyroid)		
Nearest milk cow (N 5.07 km)	Ground deposition	0.0014(C)	0.0014(C) (thyroid)		
	Inhalation	0.1(C)	0.18(C) (thyroid)		
	Vegetable consumption	0.78(C)	0.54(C) (thyroid)		
	Milk consumption	0.32(C)	0.43(C) (thyroid)		

Table C-4 (Continued)

Location	Pathway	Doses (mrems/yr per unit, except as noted)			
UNIT 3					
		Noble gases in gaseous effluents			
		Total body	Skin	Gamma air dose (mrads/yr per unit)	Beta air dose (mrads/yr per unit)
Nearest site boundary* (SSW 1.6 km)	Direct radiation from plume	0.84	3.2	1.4	5.1
		Iodine and particulates in gaseous effluents**			
		Total body	Organ		
Nearest*** site boundary (SSW 1.6 km)	Ground deposition	0.84(T)	0.84(T) (thyroid)		
	Inhalation	0.5(T)	0.87(T) (thyroid)		
Nearest residence and garden (SSW 4.7 km)	Ground deposition	0.0011(C)	0.0011(C) (thyroid)		
	Inhalation	0.21(C)	0.36(C) (thyroid)		
	Vegetable consumption	1.5(C)	1.5(C) (thyroid)		
Nearest milk cow (SSW 6.92 km)	Ground deposition	0.00059(C)	0.00059(C) (thyroid)		
	Inhalation	0.13(C)	0.24(C) (thyroid)		
	Vegetable consumption	0.99(C)	1.0(C) (thyroid)		
	Milk consumption	0.41(C)	0.47(C) (thyroid)		

*"Nearest" refers to that site boundary location where the highest radiation doses as a result of gaseous effluents have been estimated to occur.

**Doses are for the age group and organ that results in the highest cumulative dose for the location: T=teen, C=child, I=infant. Calculations were made for these age groups and for the following organs: gastrointestinal-tract, bone, liver, kidney, thyroid, lung, and skin.

***"Nearest" refers to the location where the highest radiation dose to an individual from all applicable pathways has been estimated.

Table C-3 Calculated Appendix I dose commitments to a maximally exposed individual and to the population from operation of Palo Verde Units 1, 2, and 3

	Annual Dose per Reactor Unit	
	Individual	
	App I Design Objectives*	Calculated Doses**
UNIT 1		
Liquid effluents		
Dose to total body from all pathways	3 mrems	NA
Dose to any organ from all pathways	10 mrems	NA
Noble-gas effluents		
Gamma dose in air	10 mrads	1.1 mrads
Beta dose in air	20 mrads	4.2 mrads
Dose to total body of an individual	5 mrems	0.66 mrems
Dose to skin of an individual	15 mrems	2.7 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	2.20 mrems
	Population within 80 km	
	Total Body (person-rems)	Thyroid (person-rems)
Natural-background radiation.	130,000	-
Liquid effluents	NA	NA
Noble-gas effluents	2.7	2.7
Radioiodine and particulates	32.0	44.0
UNIT 2		
Liquid effluents		
Dose to total body from all pathways	3 mrems	NA
Dose to any organ from all pathways	10 mrems	NA
Noble-gas effluents		
Gamma dose in air	10 mrads	1.3 mrads
Beta dose in air	20 mrads	4.5 mrads
Dose to total body of an individual	5 mrems	0.75 mrems
Dose to skin of an individual	15 mrems	2.9 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	2.0 mrems
	Population within 80 km	
	Total Body (person-rems)	Thyroid (person-rems)
Natural-background radiation.	130,000	-
Liquid effluents	NA	NA
Noble-gas effluents	2.7	2.7
Radioiodine and particulates	32.0	44.0

Table C-5 (Continued)

	Annual Dose per Reactor Unit	
	Individual	
	App I Design Objectives*	Calculated Doses**
UNIT 3		
Liquid effluents		
Dose to total body from all pathways	3 mrems	NA
Dose to any organ from all pathways	10 mrems	NA
Noble-gas effluents (at site boundary)		
Gamma dose in air	10 mrads	1.4 mrads
Beta dose in air	20 mrads	5.1 mrads
Dose to total body of an individual	5 mrems	0.84 mrems
Dose to skin of an individual	15 mrems	3.2 mrems
Radioiodines and particulates***		
Dose to any organ from all pathways	15 mrems	1.9 mrems
	Population within 80 km	
	Total Body (person-rems)	Thyroid (person-rems)
Natural-background radiation.	130,000	-
Liquid effluents	NA	NA
Noble-gas effluents	2.7	2.7
Radioiodine and particulates	32.0	44.0

*Design Objectives from Sections II.A, II.B, II.C, and II.D of Appendix I, 10 CFR Part 50, consider doses to maximally exposed individual and to population per reactor unit.

**Numerical values in this column were obtained by summing appropriate values in Table C-4. Locations resulting in maximum doses are represented here.

***Carbon-14 and tritium have been added to this category.

."Natural Radiation Exposure in the United States," U.S. Environmental Protection Agency, ORP-SID-72-1, June 1972; using the average background dose for Arizona of 117 mrem/yr and the year 2000 projected population of 1.1×10^6.

Table C-6 Annual total-body population dose commitments, year 2000, Palo Verde Units 1, 2, and 3

Category	U.S. population dose commitment, person-rems/yr
Natural background radiation*	26,000,000*
Palo Verde Units 1, 2, and 3 (combined) operation	
Plant workers	1,300
General public	
Liquid effluents**	NA
Gaseous effluents	338
Transportation of fuel and waste	9

*Using the average U.S. background dose (100 mrems/yr) and year 2000 projected U.S. population from "Population Estimates and Projections," Series II, U.S. Department of Commerce, Bureau of the Census, Series P-25, No. 541, February 1975.

**80-km (50-mi) population dose.

APPENDIX D

NEPA POPULATION-DOSE ASSESSMENT

APPENDIX D

NEPA POPULATION-DOSE ASSESSMENT

Population-dose commitments are calculated for all individuals living within 80 km (50 mi) of the Palo Verde Nuclear Generating Station, employing the same models used for individual doses (see Regulatory Guide 1.109, Revision 1), for the purpose of meeting the "as low as reasonably achievable" (ALARA) requirements of 10 CFR, Part 50, Appendix I. In addition, dose commitments to the population residing beyond the 80-km region which are associated with the export of food crops produced within the 80-km region and with the atmospheric and hydrospheric transport of the more mobile effluent species--such as noble gases, tritium, and carbon-14--are taken into consideration for the purpose of meeting the requirements of the National Environmental Policy Act, 1969 (NEPA). This appendix describes the methods used to make these NEPA population dose estimates.

1. Iodines and Particulates Released to the Atmosphere

Effluent nuclides in this category deposit onto the ground as the effluent moves downwind; thus the concentration of these nuclides remaining in the plume is continuously being reduced. Within 80 km of the facility, the deposition model in Regulatory Guide 1.111, Revision 1 is used in conjunction with the dose models in Regulatory Guide 1.109, Revision 1. Site-specific data concerning production and consumption of foods within 80 km of the reactor are used. For estimates of population doses beyond 80 km, it is assumed that excess food not consumed within the 80-km area will be consumed by the population beyond 80 km. It is further assumed that none, or very few, of the particulates released from the facility will be transported beyond the 80-km, distance; thus they will make no significant contribution to the population dose outside the 80-km region except by export of food crops. This assumption was tested and found to be reasonable for the Palo Verde station.

2. Noble Gases, Carbon-14, and Tritium Released to the Atmosphere

For locations within 80 km (50 mi) of the reactor facility, exposures to these effluents are calculated with a constant mean wind-direction model according to the guidance provided in Regulatory Guide 1.111, Revision 1 and the dose models described in Regulatory Guide 1.109, Revision 1. For estimating the dose commitment from these radionuclides to the U.S. population residing beyond the 80-km region, two dispersion regimes are considered. These are referred to as the first-pass dispersion regime and the world-wide dispersion regime. The model for the first-pass dispersion regime estimates the dose commitment to the population from the radioactive plume as it leaves the facility and drifts across the continental U.S. toward the northeastern corner of the U.S. The model for the world-wide dispersion regime estimates the dose commitment to the U.S. population after the released radionuclides mix uniformly in the world's atmosphere or oceans.

First-Pass Dispersion

For estimating the dose commitment to the U.S. population residing beyond the 80-km region as a result of the first pass of radioactive pollutants, it is assumed that the pollutants disperse in the lateral and vertical directions along the plume path. The direction of movement of the plume is assumed to be from the facility toward the northeast corner of the U.S. The extent of vertical dispersion is assumed to be limited by the ground plane and the stable atmospheric layer aloft, the height of which determines the mixing depth. The shape of such a plume geometry can be visualized as a right cylindrical wedge whose height is equal to the mixing depth. Under the assumption of constant population density, the population dose associated with such a plume geometry is independent of the extent of lateral dispersion; it is dependent only on the mixing depth and other nongeometrical-related factors (NUREG-0597). The mixing depth is estimated to be 1000 m and a uniform population density of 62 persons/km^2 is assumed along the plume path with an average plume transport velocity of 2 m/s.

The total-body population dose commitment from the first-pass of radioactive effluents is due principally to (1) external exposure from gamma-emitting noble gases and (2) internal exposure from inhalation of air containing tritium and from ingestion of food containing carbon-14 and tritium.

World-Wide Dispersion

For estimating the dose commitment to the U.S. population after the first-pass, world-wide dispersion is assumed. Nondepositing radionuclides with half-lives greater than 1 year are considered. Noble gases and carbon-14 are assumed to mix uniformly in the world's atmosphere (3.8×10^{18} m^3), and radioactive decay is taken into consideration. The world-wide dispersion model estimates the activity of each nuclide at the end of a 15-year release period (midpoint of reactor life) and estimates the annual population dose commitment at that point in time, taking into consideration radioactive decay and physical removal mechanisms (for example, C-14 is gradually removed to the world's oceans). The total-body population dose commitment from the noble gases is due mainly to external exposure from gamma-emitting nuclides, while from carbon-14 it is due mainly to internal exposure from ingestion of food containing carbon-14.

The population dose commitment due to tritium releases is estimated in a manner similar to that for carbon-14, except that after the first- pass, all of the tritium is assumed to be immediately distributed in the world's circulating water volume (2.7×10^{16} m^3) including the top 75 m of the seas and oceans, as well as the rivers and atmospheric moisture. The concentration of tritium in the world's circulating water is estimated at the point in time after 15 years of releases have occurred, taking into consideration radioactive decay; the population dose commitment estimates are based on the incremental concentration at that point in time. The total-body population dose commitment from tritium is due mainly to internal exposure from the consumption of food.

4. References

Title 10 of the Code of Federal Regulations Part 50, "Domestic Licensing of Production and Utilization Facilities," January 1981.

U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I." Regulatory Guide 1.109, Revision 1, U.S. October 1977.

U.S. Nuclear Regulatory Commission, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Reactors," Regulatory Guide 1.111, Revision 1, July 1977.

U.S. Nuclear Regulatory Commission, "User's Guide to GASPAR Code," NUREG-0597, June 1980.

APPENDIX E

REBASELINING OF THE RSS RESULTS FOR PWRs

APPENDIX E

REBASELINING OF THE RSS RESULTS FOR PWRs

The results of the Reactor Safety Study (RSS) have been updated. The update was done largely to incorporate results of research and development conducted after the October 1975 publication of the RSS and to provide a baseline against which the risk associated with various light-water-cooled reactors (LWRs) could be consistently compared.

Primarily, the rebaselined RSS results reflect use of advanced modeling of the processes involved in meltdown accidents (that is, the MARCH computer code modeling for transient- and LOCA-initiated sequences and the CORRAL code used for calculating magnitudes of release accompanying various accident sequences). These codes* have led to a capability to predict the transient- and small-LOCA initiated sequences that is considerably advanced beyond what existed at the time the RSS was completed. The advanced accident process models (MARCH and CORRAL) produced some changes in staff estimates of the release magnitudes from various accident sequences in WASH-1400. These changes primarily involved release magnitudes for the iodine, cesium, and tellurium families of isotopes. In general, a decrease in the iodines was predicted for many of the dominant accident sequences, while some increases in the release magnitudes for the cesium and tellurium isotopes were predicted.

Entailed in this rebaselining effort was the evaluation of individual dominant accident sequences as they are understood to evolve rather than the technique of grouping large numbers of accident sequences into encompassing, but synthetic, release categories as was done in WASH-1400. The rebaselining of the RSS also eliminated the "smoothing technique" that was criticized in the report by the Risk Assessment Review Group (sometimes known as the Lewis Report, NUREG/CR-0400, September 1978).

In both of the RSS designs (pressurized water reactors and boiling water reactors, PWRs and BWRs), the likelihood of an accident sequence leading to the occurrence of a steam explosion (a) in the reactor vessel was decreased. This was done to reflect both experimental and calculational indications that such explosions are unlikely to occur in those sequences involving small size LOCAs and transients because of the high pressures and temperatures expected to exist within the reactor coolant system during these scenarios. Furthermore, if such an explosion were to occur, there are indications that it would be unlikely to produce as much energy and the massive missile-caused breach of containment as was postulated in WASH-1400.

*It should be noted that the MARCH code was used on a number of scenarios in connection with the TMI-2 recovery efforts and for post-TMI-2 investigations to explore possible alternative scenarios that TMI-2 could have experienced.

For rebaselining of the RSS-PWR design, the release magnitudes for the risk dominating sequences (such as Event V, TMLB' δ, γ, and S_2C-δ, described later) were explicitly calculated and used in the consequence modeling, rather than being lumped into release categories as was done in WASH-1400. The rebaselining led to a small decrease in the predicted risk to an individual of early fatality or latent cancer fatality relative to the origin- RSS-PWR predictions. This result is believed to be largely attributable to the decreased likelihood of occurrence for sequences involving severe steam explosions (α) that breached containment. In WASH-1400, the sequences involving severe steam explosions (α) were artificially elevated in their risk significance (that is, made more likely) by use of the "smoothing technique."

In summary, the rebaselining of the RSS results led to small overall differences from the predictions in WASH-1400. It should be recognized that these small differences due to the rebaselining efforts are likely to be far outweighed by the uncertainties associated with such analyses.

The accident sequences which are expected to dominate risk from the RSS-PWR design are described below. These sequences are assumed to represent the approximate accident risks from the PVNGS PWR design. Accident sequences are designated by strings of identification characters in the same manner as in the RSS. Each of the characters represents a failure in one or more of the important plant systems or features that ultimately would result in melting of the reactor core and a significant release of radioactive materials from containment.*

Event V (Interfacing System LOCA)

During the RSS a potentially large risk contributor was identified due to the configuration of the multiple check valve barriers used to separate the high pressure reactor coolant system from the low design pressure portions of the emergency core cooling system (ECCS) (that is, the low pressure injection subsystem - LPIS). If these valve barriers were to fail in various modes, such as leak-rupture or rupture-rupture, and suddenly exposed the LPIS to high overpressures and dynamic loadings, the RSS judged that a high probability of LPIS rupture would exist. Because the LPIS is largely located outside of containment, the Event V scenario would be a LOCA that bypassed containment and those mitigating features (for example, sprays) within containment. The RSS assumed that if the rupture of LPIS did not entirely fail the LPIS makeup function (which would ultimately be needed to prevent core damage), the LOCA environment (flooding, steam) would. Predictions of the release magnitude and consequences associated with Event V have indicated that this scenario represents one of the largest risk contributors from the RSS-PWR design. The NRC has recognized this RSS finding and has taken steps to reduce the probability of occurrence of Event V scenarios in both existing and future LWR designs by requiring periodic surveillance testing of the interfacing valves to ensure that these valves are properly functioning as pressure boundary isolation barriers during plant operations. Accordingly, Event V predictions for the RSS-PWR are likely to be conservative relative to the design and operation of the PVNGS PWRs.

*For additional information detail see Appendix V of "Reactor Safety Study," WASH-1400, NUREG-75/014, October 1975.

TMLB'-δ, γ

This sequence essentially considers the loss and nonrestoration of all ac power sources available to the plant, along with an independent failure of the steam turbine driven auxiliary feedwater train which would be required to operate to remove shutdown heat from the reactor core. The transient event is initiated by loss of offsite power sources which would result in plant trip (scram) and the loss of the normal way that the plant removes heat from the reactor core (that is, via the power conversion system consisting of the turbine, condenser, the condenser cooling system, and the main feedwater and condensate delivery system that supplies water to the steam generators). This initiating event would then demand operation of the standby onsite emergency power supplies (two diesel generators) and the standby auxiliary feedwater system, two trains of which are electrically driven by either onsite or offsite power. With failure and nonrestoration of ac power and the failure of the steam turbine-driven auxiliary feedwater train to remove shutdown heat, the core would ultimately uncover and melt. If restoration of ac power were not successful during (or following) melt, the containment heat removal and fission product mitigating systems would not be operational to prevent the ultimate overpressure (δ, γ) failure of containment and a rather large, energetic release of activity from the containment. Next to the Event V sequence, TMLB'δ, γ is predicted to dominate the overall accident risks in the RSS-PWR design.

S_2C-δ (PWR 3)

In the RSS the S_2C-δ sequence was placed into PWR release Category 3, and it actually dominated all other sequences in Category 3 in terms of probability and release magnitudes. The rebaselining entailed explicit calculations of the consequences from S_2C-δ, and the results indicated that it was next in overall risk importance following Event V and TMLB'δ, γ.

The S_2C-δ sequence included a rather complex series of dependencies and interactions that are believed to be somewhat unique to the containment systems (subatmospheric) employed in the RSS-PWR design.

In essence, the S_2C-δ sequence included a small LOCA occurring in a specific region of the plant (reactor vessel cavity), failure of the recirculating containment heat removal systems (CSRS-F) because of a dependence on water draining to the recirculation sump from the LOCA, and a resulting dependence imposed on the quench spray injection system (CSIS-C) to provide water to the sump. The failure of the CSIS(C) resulted in eventual overpressure failure of containment (δ) due to the loss of CSRS(F). Given the overpressure failure of containment, the RSS assumed that the ECCS functions would be lost either due to the cavitation of ECCS pumps or from the rather severe mechanical loads that could result from the overpressure failure of containment. The core was then assumed to melt in a breached containment leading to a significant release of radioactive materials.

Approximately 20 percent of the iodines and 20 percent of the alkali metals present in the core at the time of release would be released to the atmosphere. Most of the release would occur over a period of about 1.5 hours. The release of radioactive material from containment would be caused by the sweeping action of gases generated by the reaction of the molten fuel with concrete. Because these gases would be initially heated by contact with the melt, the rate of sensible energy release to the atmosphere would be moderately high.

PWR 7

This is the same as the PWR release Category 7 of the original RSS which was made up of several sequences such as S_2D-ε (the dominant contributor to the risk in this category), S_1D-ε, S_2H-ε, S_1H-ε, AD-ε, AH-ε, TML-ε, and TKQ-ε. All of these sequences involved a containment basemat melt-through as the containment failure mode. With exception of TML-ε and TKQ-ε, all involve the potential failure of the emergency core cooling system following occurrence of a LOCA, with the containment ESFs continuing to operate as designed until the basemat was penetrated. Containment sprays would operate to reduce the containment temperature and pressure as well as the amount of airborne radioactivity. The containment barrier would retain its integrity until the molten core proceeded to melt through the concrete containment basemat. The radioactive materials would be released into the ground, with some leakage to the atmosphere occurring upward through the ground. Most of the release would occur continuously over a period of about 10 hours. The release would include approximately 0.002 percent of the iodines and 0.001 percent of alkali metals present in the core at the time of release. Because leakage from containment to the atmosphere would be low and gases escaping through the ground would be cooled by contact with the soil, the energy release rate would be very low.

APPENDIX F

CONSEQUENCE MODELING CONSIDERATIONS

APPENDIX F

CONSEQUENCE MODELING CONSIDERATIONS

1. Evacuation Model

"Evacuation," used in the context of offsite emergency response in the event of a substantial amount of radioactivity release to the atmosphere in a reactor accident, denotes an early and expeditious movement of people to avoid exposure to the passing radioactive cloud and/or to acute ground contamination in the wake of the cloud passage. It should be distinguished from "relocation," which denotes a postaccident response to reduce exposure to long-term ground contamination. The Reactor Safety Study (RSS) consequence model contains provision for incorporating radiological consequence reduction benefits of public evacuation. Benefits of a properly planned and expeditiously carried out public evacuation would be well manifested in reduction of acute health effects associated with early exposure; namely, in the number of cases of acute fatality (see Section 2 below) and acute radiation sickness that would require hospitalization. The evacuation model originally used in the RSS consequence model is described in WASH-1400 as well as in NUREG-0340. However, the evacuation model used herein is a modified version (SAND 78-0092) of the RSS model and is, to a certain extent, site-emergency-planning oriented.

The model utilizes a circular area with a specified radius, with the reactor at the center. For the purposes of the analysis, the results of which are presented in Section 5.9.2, this radius was chosen to be the 16 km (10 mi) corresponding to the plume exposure pathway emergency planning zone (EPZ).

The modified version is briefly outlined below:

The model uses a circular area with a specified radius (such as a 10-mi) plume exposure pathway Emergency Planning Zone (EPZ), with the reactor at the center. It is assumed that people living within portions of this area would evacuate if an accident should occur involving imminent or actual release of significant quantities of radioactivity to the atmosphere.

Significant atmospheric releases of radioactivity would in general be preceded by 1 or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the release of radioactivity from the containment building). For the purpose of calculation of radiological exposure, the model assumes that all people who live in a fan-shaped area (fanning out downwind from the reactor) within the circular zone with downwind direction as its median--that is, those people who would potentially be under the radioactive cloud that would develop following the release--would leave their residences after lapse of a specified amount of delay time* and then evacuate. The delay time is reckoned from the beginning of the warning time, and is the sum of the time required by the reactor operators to notify the responsible authorities; time required by the authorities to interpret the data, decide to evacuate, and direct the people to evacuate; and time required for the people to mobilize and get under way.

The model assumes that while each evacuee is leaving the area, he/she moves radially out and in the downwind direction with an average effective speed (obtained by dividing the zone radius by the average time taken to clear the zone after the delay time) over a fixed distance* from the evacuee's starting point.

This distance is selected to be 15 mi (which is 5 mi more than the 10-mi plume exposure pathway EPZ radius). After reaching the end of the travel distance, the evacuee is assumed to receive no further radiation exposure.

The model incorporates a finite length of the radioactive cloud in the downwind direction that would be determined by the product of the duration over which the atmospheric release would take place and the average windspeed during the release. It is assumed that the front and the back of the cloud formed would move with an equal speed which would be the same as the prevailing windspeed; therefore, its length would remain constant at its initial value. At any time after the release, the concentration of radioactivity is assumed to be uniform over the length of the cloud. If the delay time were less than the warning time, then all evacuees would have a head-start; that is, the cloud would be trailing behind the evacuees initially. On the other hand, if the delay time were more than the warning time, then depending on initial locations of the evacuees there are possibilities that (a) an evacuee would still have a head-start, or (b) the cloud would be already overhead when an evacuee starts out to leave, or (c) an evacuee would be initially trailing behind the cloud. However, this initial picture of cloud-people disposition would change as the evacuees travel depending on the relative speeds and positions between the cloud and people. It may become possible that the cloud and an evacuee would overtake one another one or more number of times before the evacuee would reach his or her destination. In the model, the radial position of an evacuating person, while stationary or in transit, is compared to the front and the back of the airborne radionuclides. The model calculates the time periods during which people are exposed to radionuclides on the ground while they are stationary and while they are evacuating. Because radionuclides would be deposited continually from the cloud as it passed a given location, a person while under the cloud would be exposed to ground contamination less concentrated than if the cloud had completely passed. To account for this, at least in part, the revised model assumes that persons are exposed to the total ground contamination concentration calculated to exist after complete passage of the cloud, when they are completely passed by the cloud; to one-half the

---

*Assumed to be a constant value, which would be the same for all evacuees.

calculated concentration when they are anywhere under the cloud; and to no concentration when they are in front of the cloud. The model provides for use of different values of the shielding protection factors for exposure from airborne radioactivity and contaminated ground, and the breathing rates for stationary and moving evacuees during delay and transit periods. Different values of the shielding protection factors for exposure from airborne radioactivity and from ground contamination have been used.

Results shown in Section 5.9.2.5 for accidents involving significant release of radioactivity to the atmosphere were based on the assumption that all people within the 10-mi plume exposure pathway EPZ would evacuate as per the evacuation scenario described above. The staff does not expect that detailed characterization of the evacuation from any special facility near a plant site, where everyone may not be quickly evacuated, would significantly alter the conclusions. As a reasonable emergency measure for the Palo Verde site, it was also assumed that all people beyond the evacuation distance and within 25 mi of the reactor who would be exposed to the contaminated ground would be relocated after passage of the plume. For those people within the 10-to-25-mi zone, a reasonable relocation time span of 4 hours* has been assumed, during which each person is assumed to receive additional exposure to the ground contamination. Beyond the 25-mi distance the usual assumption of the RSS consequence model regarding the period of ground exposure was used--which is that if the calculated ground dose to the total marrow over a 7-day period would exceed 200 rems, then this high dose rate would be detected by actual field measurements following the plume passage, and people from those regions would then be relocated immediately. For this situation the model limits the period of ground dose calculation to 24 hours; otherwise, the period of ground exposure is limited to 7 days for calculation of early dose.

It is also realistic to expect that authorities would evacuate persons at distances from the site where exposures above the threshold for causing acute fatalities could occur regardless of the plume exposure pathway EPZ distance. Figure F-1 illustrates the reduction in acute fatalities that can occur by extending evacuation to a larger distance, such as 15 mi, from the Palo Verde site. Calculation shows that if the evacuation distance is increased to 20 mi, there would be no acute fatalities at all probability levels for this site. Also illustrated in Figure F-1 is a pessimistic case for which no early evacuation is assumed and all persons are assumed to be exposed for the first 24 hours following an accident and are then relocated.

The model has the same provision for calculation of the economic cost associated with implementation of evacuation as in the original RSS model. For this purpose, the model assumes that for atmospheric releases of duration 3 hours

---

*Because of policy changes and new requirements since the DES, the delay time, evacuation speed, and relocation time given here are different from those used in the calculations for the DES (the previous values for these items were not presented explicitly in the DES).

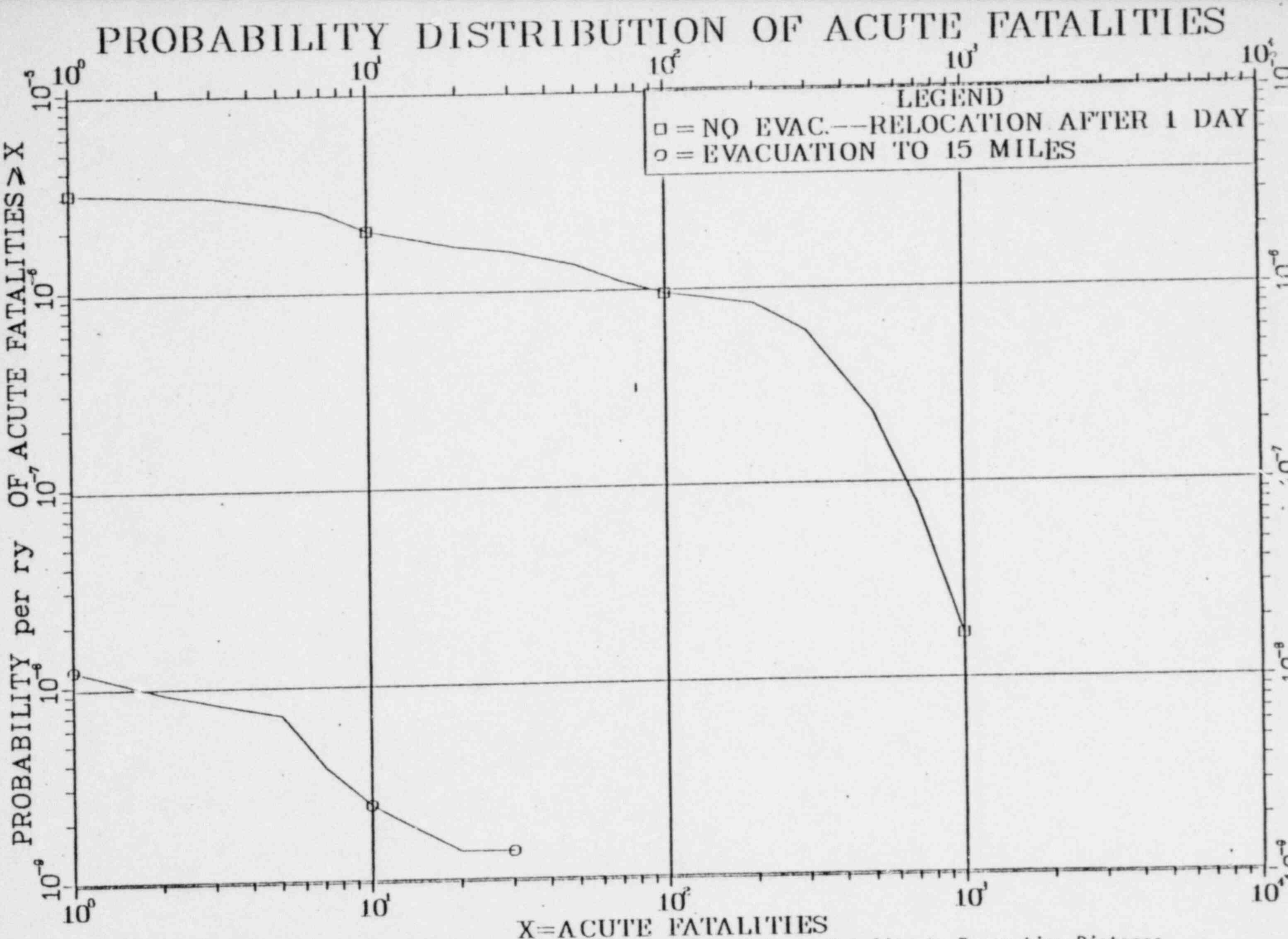

Figure F.1 Sensitivity of Probability Distribution of Acute Fatality to Evacuation Distance.
Note 1: For evacuation of 20 miles no fatality is predicted.
Note 2: Please see Section 5.9.2.5(7) for uncertainties in risk estimates.

or less, all people living within a circular area of 5-mi radius centered at the reactor plus all people within a 45° angular sector within the plume exposure pathway EPZ and centered on the downwind direction will be evacuated and temporarily relocated. However, if the duration of release would exceed 3 hours, the cost of evacuation is based on the assumption that all people within the entire plume exposure pathway EPZ would be evacuated and temporarily relocated. For either of these situations, the cost of evacuation and relocation is assumed to be $125 (1980 dollars) per person, which includes cost of food and temporary shelter for a period of 1 week.

2. Early Health Effects Model

The medical advisors to the Reactor Safety Study proposed three alternative dose-mortality relationships that can be used to estimate the number of acute or early fatalities that might result in an exposed population. These alternatives characterize different degrees of post-exposure medical treatment from "none," to "supportive," to "heroric"; they are more fully described in NUREG-0340.

The calculational estimates of the acute fatality risks presented in Section 5.9.2.5 and Section 1 of this appendix used the dose-mortality relationship that is based upon the supportive treatment alternative. This implies the availability of medical care facilities and services for those exposed in excess of about 200 rems. At the extreme low probability end of the spectrum (that is, at the one chance in one hundred million per reactor-year level), the number of persons involved might exceed the capacity of facilities for such services, in which case the number of acute fatalities might have been somewhat underestimated. To gain perspective on this element of uncertainty, the staff has also performed calculations using the most pessimistic dose-mortality relationship based upon no medical treatment and using identical assumptions regarding early evacuation and early relocation as made in Section 5.9.2.5. This shows no increase in acute fatalities at the one chance in one million per reactor-year level, an increase from 57 to 350 acute fatalities at the one chance in one hundred million per reactor-year level (see Table 5.13), and an overall 10-fold increase in annual risk of acute fatalities (see Table 5.15).

3. References

Sandia Laboratories, "A Model of Public Evacuation for Atmospheric Radiological Releases," SAND 78-0092, June 1978.

U.S. Nuclear Reglatory Commission, "Reactor Safety Study," WASH-1400 (NUREG-75/014), October 1975.

U.S. Nuclear Regulatory Commission, "Overview of the Reactor Safety Study Consequences Model," NUREG-0340, October 1977.

APPENDIX G

IMPACTS OF THE URANIUM FUEL CYCLE

APPENDIX G

IMPACTS OF THE URANIUM FUEL CYCLE

The following assessment of the environmental impacts of the fuel cycle as related to the operation of the proposed project is based on the values given in Table S-3 (reproduced in Section 5.10 as Table 5.16) and the NRC staff's analysis of the radiological impact from radon releases. For the sake of consistency, the analysis of fuel cycle impacts has been cast in terms of a model 1000-MWe light-water-cooled reactor (LWR) operating at an annual capacity factor of 80 percent. In the following review and evaluation of the environmental impacts of the fuel cycle, the staff's analysis and conclusions would not be altered if the analysis were to be based on the net electrical power output of the Palo Verde Nuclear Generating Station.

1. Land Use

The total annual land requirement for the fuel cycle supporting a model 1000-MWe LWR is about 460,000 m^2 (113 acres). Approximately 53,000 m^2 (13 acres) per year are permanently committed land, and 405,000 m^2 (100 acres) per year are temporarily committed. (A "temporary" land commitment is a commitment for the life of the specific fuel cycle plant, such as a mill, enrichment plant, or succeeding plants. On abandonment or decommissioning of the plant, such land can be used for any purpose. "Permanent" commitments represent land that may not be released for use after plant shutdown and/or decommissioning.) Of the 405,000 m^2 per year of temporarily committed land, 320,000 m^2 are undisturbed and 90,000 m^2 are disturbed. Considering common classes of land use in the United States,* fuel cycle land use requirements to support the model 1000-MWe LWR do not represent a significant impact.

2. Water Use

The principal water use requirement for the fuel cycle supporting a model 1000-MWe LWR is that required to remove waste heat from the power stations supplying electrical energy to the enrichment step of this cycle. Of the total annual requirement of 43 x 10^6 m^3 (11.4 x 10^9 gal), about 42 x 10^6 m^3 are required for this purpose, assuming that these plants use once-through cooling. Other water uses involve the discharge to air (for example, evaporation losses in process cooling) of about 0.6 x 10^6 m^3 (16 x 10^7 gal) per year and water discharged to the ground (such as mine drainage) of about 0.5 x 10^6 m^3 per year.

*A coal-fired plant of 1000-MWe capacity using strip-mined coal requires the disturbance of about 810,000 m^2 (200 acres) per year for fuel alone.

On a thermal effluent basis, annual discharges from the nuclear fuel cycle are about 4 percent of the model 1000-MWe LWR using once-through cooling. The consumptive water use of 0.6 x 10^6 m^3 per year is about 2 percent of the model 1000-MWe LWR using cooling towers. The maximum consumptive water use (assuming that all plants supplying electrical energy to the nuclear fuel cycle used cooling towers) would be about 6 percent of the model 1000-MWe LWR using cooling towers. Under this condition, thermal effluents would be negligible. The staff finds that these combinations of thermal loadings and water consumption are acceptable relative to the water use and thermal discharges of the station.

3. Fossil Fuel Consumption

Electrical energy and process heat are required during various phases of the fuel cycle process. The electrical energy is usually produced by the combustion of fossil fuel at conventional power plants. Electrical energy associated with the fuel cycle represents about 5 percent of the annual electrical power production of the model 1000-MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, would be less than 0.3 percent of the electrical output from the model plant. The staff finds that the direct and indirect consumptions of electrical energy for fuel cycle operations are small and acceptable relative to the net power production of the station.

4. Chemical Effluents

The quantities of chemical, gaseous, and particulate effluents associated with fuel cycle processes are given in Table S-3. The principal species are SO_x NO_x, and the particulates. Judging from data in the seventh annual Council on Environmental Quality report, the NRC staff finds that these emissions constitute an extremely small additional atmospheric loading in comparison with these emissions from the stationery fuel-combustion and transportation sectors in the United States, that is, about 0.02 percent of the annual national releases for each of these species. The staff believes such small increases in releases of these pollutants are acceptable.

Liquid chemical effluents produced in fuel cycle processes are related to fuel enrichment, fabrication, and reprocessing operations and may be released to receiving waters. These effluents are usually present in dilute concentrations such that only small amounts of dilution water are required to reach levels of concentration that are within established standards. Table S-3 specifies the flow of dilution water required for specific constituents. Additionally, all liquid discharges into the navigable waters of the United States from plants associated with the fuel cycle operations will be subject to requirements and limitations set forth in the NPDES permit.

Tailings solutions and solids are generated during the milling process. These solutions and solids are not released in quantities sufficient to have a significant impact on the environment.

5. Radioactive Effluents

Radioactive effluents estimated to be released to the environment from reprocessing and waste management activities and certain other phases of the fuel cycle process are set forth in Table S-3. Using these data, the staff has calculated the 100-year involuntary environmental dose commitment* to the U.S. population. It is estimated from these calculations that the overall involuntary total-body gaseous dose commitment to the U.S. population from the fuel cycle (excluding reactor releases and the dose commitment due to radon-222 and technetium-99) would be approximately 400 person-rems for each year of operation of the model 1000-MWe LWR (reference reactor year or RRY). Based on Table S-3 values, the additional involuntary total-body-dose commitments to the U.S. population from radioactive liquid effluents (excluding technetium-99) due to all fuel cycle operations other than reactor operation would be approximately 100 person-rems per year of operation. Thus the estimated involuntary 100-year environmental dose commitment to the U.S. population from radioactive gaseous and liquid releases due to these portions of the fuel cycle is approximately 500 person-rems (whole-body) per RRY.

At this time Table S-3 does not address the radiological impacts associated with radon-222 and technetium-99 releases. Principal radon releases occur during mining and milling operations and as emissions from mill tailings, whereas principal technetium-99 releases occur from gaseous diffusion enrichment facilities. The staff has determined that radon-222 releases from these operations for each year of operation of the model 1000-MWe LWR are as given in Table G-1.

The staff has calculated population dose commitments for these sources of radon-222 using the RABGAD computer code described in Appendix A of Vol. 3, Chap. IV, Sec. J, of NUREG-0002. The results of these calculations for mining and milling activities before tailings stabilization are listed in Table G-2.

When added to the 500 person-rems total-body dose commitment for the balance of the fuel cycle, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is approximately 640 person-rems. Over this period of time, this dose is equivalent to 0.00002 percent of the natural-background total-body dose of about 3 billion person-rems to the U.S. population.** The staff has considered the health effects associated with the releases of radon-222, including both the short-term effects of mining, milling, and active tailings, and the potential long-term effects from unreclaimed open-pit mines and stabilized tailings. The staff has assumed that after completion of active mining underground mines will be sealed, returning releases of radon-222

*The environmental dose commitment (EDC) is the integrated population dose for 100 years; that is, it represents the sum of the annual population doses for a total of 100 years. The population dose varies with time, and it is not practical to calculate this dose for every year.

**Based on the annual average natural background individual dose commitment of 100 millirems and a stabilized U.S. population of 300 million.

Table G-1 Radon releases from mining and milling operations and mill/tailings for each year of operation of the model 100-MWe LWR

Radon source	Quantity released
Mining**	4060 Ci
Milling and tailings*** (during active mining)	780 Ci
Inactive tailings*** (before stabilization)	350 Ci
Stabilized tailings*** (several hundred years)	1 to 10 Ci/year
Stabilized tailings*** (after several hundred years)	110 Ci/year

*After three days of hearings before the Atomic Safety and Licensing Appeal Board (ASLAB) using the Perkins record in a "lead case" approach, the ASLAB issued a decision on May 13, 1981 (ALAB-640) on the radon-222 release source term for the uranium fuel cycle. The decision, among other matters, produced new source term numbers based on the record developed at the hearings. These new numbers did not differ significantly from those in the Perkins record which are the values set forth in this table. Any health effects relative to radon-222 are still under consideration before the ASLAB. Because the source term numbers in ALAB-640 do not differ significantly from those in the Perkins record, the staff continues to conclude that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural background sources. Subsequent to ALAB-640, a second ASLAB decision (ALAB-654, issued September 11, 1981) permits intervenors a 60-day period to challenge the Perkins record on the potential health effects of radon-222 emissions. (See page G-4.)

**R. Wilde, NRC transcript of direct testimony given "In the Matter of Duke Power Company Company (Perkins Nuclear Station), Docket No. 50-488, April 17, 1978.

***P. Magno, NRC transcript of direct testimony given "In the Matter of Duke Power Company (Perkins Nuclear Station)," Docket No. 50-488, April 17, 1978.

to background levels. For purposes of providing an upper bound impact assessment, the staff has assumed that open-pit mines will be unreclaimed and has calculated that if all ore were produced from open pit mines, releases from them would be 110 Ci per RRY. However, because the distribution of uranium ore reserves available by conventional mining methods is 66 percent underground and 34 percent open pit (Department of Energy), the staff has further assumed that uranium to fuel LWRs will be produced by conventional mining methods in these proportions. This means that long-term releases from unreclaimed open-pit mines will be 0.34 x 110 or 37 Ci per year per RRY.

Table G-2 Estimated 100-year environmental dose commitment per year of operation of the model 1000-MWe LWR

		Dosage (person-rems)		
Radon Source	Radon-222 releases(Ci)	Total body	Bone	Lung (bronchial epithelium)
Mining	4100	110	2800	2300
Milling and active tailings	1100	29	750	620
Total	5200	140	3600	2900

Based on the above, the radon released from unreclaimed open-pit mines over 100- and 1000-year periods would be about 3700 Ci and 37,000 Ci per RRY respectively. The total dose commitments for a 100-to-1000-year period would be as follows:

Table G-3 Total dose commitments for 100-to-1000-yr period

		Population dose commitments (person-rems)		
Time span (years)	Radon-222 Releases(Ci)	Total body	Bone	Lung (bronchial epithelium)
100	3,700	96	2,500	2,000
500	19,000	480	13,000	11,000
1,000	37,000	960	25,000	20,000

The above dose commitments represent a worst case situation in that no mitigating circumstances are assumed. However, state and Federal laws currently require reclamation of strip and open-pit coal mines, and it is very probable that similar reclamation will be required for uranium open-pit mines. If so, long-term releases from such mines should approach background levels.

For long-term radon releases from stabilized tailings piles, the staff has assumed that these tailings would emit, per RRY, 1 Ci per year for 100 years, 10 Ci per year for the next 400 years, and 100 Ci per year for periods beyond 500 years. With these assumptions, the cumulative radon-222 release from stabilized tailings piles per RRY would be 100 Ci in 100 years and 4090 Ci in 500 years and 53,800 Ci in 1000 years (Gotchy). The total-body, bone, and bronchial epithelium dose commitments for these periods are as follows:

Table G-4 Total-body, bone, and bronchial epithelium dose commitmets for 100, 500, and 1000 years

		Population dose commitments (person-rems)		
Time span (years)	Radon-222 Releases(Ci)	Total body	Bone	Lung (bronchial epithelium)
100	100	2.6	68	56
500	4,090	110	2,800	2,300
1,000	53,800	1,400	37,000	30,000

If risk estimators of 135, 6.9, and 22 cancer deaths per million person-rems for total-body, bone, and lung exposures, respectively, are used, the estimated risk of cancer mortality resulting from mining, milling, and active tailings emissions of radon-222 is about 0.11 cancer fatalities per RRY. When this risk from radon-222 emissions from stabilized tailings over a 100-year release period is added, the estimated risk of cancer mortality over a 100-year period is unchanged. Similarly, a risk of about 1.2 cancer fatalities is estimated over a 1000-year release period per RRY. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon induced cancer fatalities per RRY range as follows: 0.11 to 0.19 fatalities for a 100-year period, 0.19 to 0.57 fatalities for a 500-year period, and 1.2 to 2.0 fatalities for a 1000-year period.

The estimated risk of genetic defects from mining, milling, and active tailings is even lower. Using a risk estimator of 258 potential cases of all forms of genetic disorders per million person-rems, the staff estimates about 0.04 genetic disorders per RRY may occur. When potential radon releases from reclaimed and unreclaimed open-pit mines are included, the overall risks of radon-induced genetic disorders per RRY range as follows:

0.04 to 0.06 genetic disorders for a 100-year prriod
0.07 to 0.16 genetic disorders for a 500-year period
0.29 to 0.40 genetic disorders for a 1000-year period

To illustrate: a single-model 1000-MWe LWR operating at an 80-percent capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1000 years; and to induce between 1.2 and 1.8 genetic disorders in 100 years, 2.1 and 4.8 in 500 years, and 8.7 and 12.0 in 1000 years as a result of releases of radon-222.

These doses and predicted health effects have been compared with those that can be expected from natural-background emissions of radon-222. Using data from the National Council on Radiation Protection (NCRP), the staff calculated the average radon-222 concentration in air in the contiguous United States to be about 150 pCi/m^3, which the NCRP estimates will result in an annual dose to the bronchial epithelium of 450 millirems. For a stabilized future U.S. population of 300 million, this represents a total lung dose commitment of 135 million person-rems per year. If the same risk estimator of 22 lung cancer fatalities per million person-lung-rems used to predict cancer fatalities for the model 1000 MWe LWR is used, estimated lung cancer fatalities alone from background radon-222 in the air can be calculated to be about 3000 per year or 300,000 to 3,000,000 lung cancer deaths over periods of 100 to 1000 years respectively.

The staff is currently in the process of formulating a specific model for analyzing the potential impact and health effects from the release of technetium-99 during the fuel cycle. However, for the interim period until the model is completed, the staff has calculated that the potential 100-year environmental dose commitment to the U.S. population from the release of Tc-99 should not exceed 100 person-rems per RRY. These calculations are based on the gaseous and the hydrological pathway model systems described in NUREG-0002, Vol. 3, Chapter IV, Sec. J, Appendix A. When added to the 640 person-rem total-body dose commitment for the balance of the fuel cycle, including radon-222, the overall estimated total-body involuntary 100-year environmental dose commitment to the U.S. population from the fuel cycle for the model 1000-MWe LWR is about 740 person-rems. Over this period of time, this dose is equivalent to 0.00002 percent of the natural-background total-body dose of about three billion person-rems to the U.S. population.*

The staff also considered the potential health effects associated with this release of technetium-99 (Tc-99). Using the modeling systems described in NUREG-0002, the major risks from Tc-99 are from exposure of the gastrointestinal tract and kidney, although there is a small risk from total-body exposure. Using organ-specific risk estimators, these individual organ risks can be converted to total-body risk equivalent doses. Then, by using the total-body risk estimator of 135 cancer deaths per million person-rems, the estimated risk of cancer mortality due to technetium-99 releases from the nuclear fuel cycle is about 0.01 cancer fatality per RRY over the subsequent 100 to 1000 years.

In addition to the radon and technetium related potential health effects from the fuel cycle, other nuclides produced in the cycle, such as carbon-14, will contribute to population exposures. It is estimated that 0.08 to 0.12 additional cancer deaths may occur per RRY (assuming that no cure or prevention of cancer is ever developed) over the next 100 to 1000 years, respectively, from exposures to these other nuclides.

The latter exposures can also be compared with those from naturally occurring terrestrial and cosmic-ray sources. These average about 100 millirems. Therefore, for a stable future population of 300 million persons, the whole-body dose commitment would be about 30 million person-rems per year, or 3 billion person-rems and 30 billion person-rems for periods of 100 and 1000 years respectively. These natural-background dose commitments could produce about 400,000 and 4,000,000 cancer deaths during the same time periods. From the above analysis, the NRC staff concludes that both the dose commitments and health effects of the uranium fuel cycle are insignificant when compared to dose commitments and potential health effects to the U.S. population resulting from all natural-background sources.

*Based on an annual average natural-background individual dose commitment of 100 mrems and a stablilized U.S. population of 300 million.

6. Radioactive Wastes

The quantities of buried radioactive waste material (low-level, high-level, and transuranic wastes) associated with the uranium fuel cycle are specified in Table S-3. For low-level waste disposal at land burial facilities, the Commission notes in Table S-3 that there will be no significant radioactive releases to the environment. The Commission notes that high-level and transuranic wastes are to be buried at a Federal Repository and that no release to the environment is associated with such disposal. NUREG-0116, which provides background and context for the high-level and transuranic Table S-3 values established by the Commission, indicates that these high-level and transuranic wastes will be buried and will not be released to the biosphere. No radiological environmental impact is anticipated from such disposal.

7. Occupational Dose

The annual occupational dose attributable to all phases of the fuel cycle for the model 1000-MWe LWR is about 200 person-rems. The NRC staff concludes that this occupational dose will not have a significant environmental impact.

8. Transportation

The transportation dose to workers and the public is specified in Table S-3. This dose is small and is not considered significant in comparison to the natural-background dose.

9. Fuel Cycle

The staff's analysis of the uranium fuel cycle did not depend on the selected fuel cycle (no recycle or uranium-only recycle), because the data provided in Table S-3 include maximum recycle option impact for each element of the fuel cycle. Thus the staff's conclusions as to acceptability of the environmental impacts of the fuel cycle are not affected by the specific fuel cycle selected.

10. References

Council on Environmental Quality, "The Seventh Annual Report of the Council on Environmental Quality," Figs. 11-27 and 11-28, pp. 238-239, September 1976.

Gotchy, R., testimony from "In the Matter of Duke Power Company (Perkins Nuclear Station)," U.S. Nuclear Regulatory Commission, Docket No. 50-488, filed April 17, 1978.

National Council on Radiation Protection and Measurements (NCRP), "Natural Background Radiation in the United States," NCRP Publication No. 45, November 1975.

U.S. Department of Energy, "Statistical Data of the Uranium Industry," GJO-100(8-78), January 1978.

U.S. Nuclear Regulatory Commission, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0116 (Supplement 1 to WASH-1248), October 1976.

U.S. Nuclear Regulatory Commission, "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light-Water-Cooled Reactors," NUREG-0002, August 1976.

APPENDIX H

LETTER FROM STATE HISTORIC PRESERVATION OFFICER

ASP

RECEIVED FEB 9 1982 US NUCLEAR REGULATORY COMMISSION DOCUMENT MANAGEMENT BR TIDC

February 3, 1982

ARIZONA STATE PARKS

1688 WEST ADAMS STREET
PHOENIX, ARIZONA 85007
TELEPHONE 602-255-4174

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Palo Verde Nuclear Generating Station, Units 1, 2 and 3
DRAFT ENVIRONMENTAL STATEMENT
re: operational licensing
Arizona Public Service Company, et al.
NRC

Dear Director:

I have reviewed the Draft Environmental Statement prepared by the NRC for this proposed Federal action and have the following comments relative to the project's compliance with the historic preservation requirements for Federally licensed undertakings:

1. This office was consulted during the planning phases of the various features of the project and the necessary cultural resource surveys, evaluations, and avoidance/mitigation plans were carried out by the applicant.

   Our records indicate consultation over several years with the Arizona Public Service and Salt River Project utility companies, the Bureau of Land Management, and the Nuclear Regulatory Commission regarding the various features of the project.

2. I am satisfied that the project has not adversely affected any significant cultural resources. The combination of complete site avoidance through project re-design and the recovery of data from those sites that could not be avoided has provided for the preservation of cultural resources that might otherwise have been adversely affected by the project.

3. Therefore, in my opinion, licensing the operation of the Palo Verde Nuclear Generating Station, Units 1, 2 and 3, should have no adverse effect on any significant cultural resources.

C002 B:10

The continued cooperation of the NRC with this office in complying with historic preservation requirements pursuant to the Advisory Council's regulations (36 CFR Part 800) is appreciated. If we can assist further, please let us know.

Sincerely,

Frank B. Fryman
Archaeologist & Compliance Coordinator

for Ann A. Pritzlaff
State Historic Preservation Officer

FBF:mes

APPENDIX I

PUBLIC COMMENTS ON THIS STATEMENT

ARIZONA GAME & FISH DEPARTMENT

2222 West Greenway Road Phoenix, Arizona 85023 942-3000

December 15, 1981

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

RE: Draft Environmental Statement - Operation of Palo Verde Nuclear Generating Station; NUREG-0841

Dear Sir:

Our Department has reviewed the "Draft Environmental Statement related to the operation of Palo Verde Nuclear Generating Station Units 1, 2, and 3" and we submit the following comments.

On page 5-3 the following statement appears in a discussion of commitments on the sewage effluent:

> At the present time, however, only the BID is utilizing its commitment. The AGFD has abandoned its wildlife project, and the WCL facilities were washed out by flood waters in 1978"

The Arizona Game and Fish Department commitment of 7300 acre/feet of sewage effluent ensures the survival of a diverse riparian plant community downstream from the 91st Avenue treatment plant. Therefore, our Department is utilizing this commitment and we intend to continue to do so. AGFD 1

The Arizona Game and Fish Department has not abandoned any wildlife project along the Gila River. Furthermore, our Department has no intentions of abandoning any wildlife project in this area. AGFD 2

C002 s 1/0

On page 5-10 the following statement appears:

> "The staff concludes, based on the estimates given in Section 5.3.1 that diversion of wastewater for PVNGS and Buckeye Irrigation District could result in a reduction of high quality wildlife habitat in Segment B in 1986, and anticipates that most of the riparian habitat would recover by the year 2000 when water flow will achieve nearly 100 percent of 1980 levels."

AGFD 3

Our Department believes that any significant reduction in the riparian plant communities along this stretch of the Gila River will create substantial adverse impacts to the wildlife which depend on this habitat. We further believe that the Draft Environmental Statement is grossly inadequate in its description of impacts to wildlife and wildlife habitat.

Thank you for the opportunity to submit comments on this document.

Sincerely,

Bud Bristow, Director

William E. Werner

William E. Werner
Habitat Specialist
Region IV, Yuma

WEW:kh

cc: Planning and Evaluation Branch, Phoenix

ARIZONA

OFFICE
OF THE
GOVERNOR
BRUCE BABBITT

OFFICE OF
ECONOMIC PLANNING AND DEVELOPMENT

Larry Landry, Director • (602) 255-5371 • General Offices of OEPAD • 4th Floor

RECEIVED
JAN 27 1982
US NUCLEAR REGULATORY COMMISSION
DOCUMENT MANAGEMENT BR
TIDC

MEMORANDUM

TO: Applicant

FROM: Arizona State Clearinghouse

DATE: JAN 20 1982

RE: Comment After Signoff

Enclosed is a copy of a response, concerning the attached project, which was received by us after our Signoff to you.

A copy of the response is to be forwarded to the Federal Agency.

C002
B
1/1

8201290263 820120
PDR ADOCK 05000528
D PDR

Mailing Address: Executive Tower Room 505 • 1700 West Washington • Phoenix, Arizona 85007

Major

SIGNOFF

OMB Approval No. 29–R0218

FEDERAL ASSISTANCE

2. Applicant's application — a. Number: — b. Date: 19 Year Month Day

3. State application identifier — a. Number: AZ 81-80-0067 — b. Date Assigned: Year month day 19 81 11 18

1. Type Of Action (Mark appropriate box)
- ☐ Preapplication
- ☐ Application
- ☐ Notification Of Intent (Opt.)
- ☐ Report Of Federal Action

Leave Blank: DEC 23 1981 — Valerie Manning

4. Legal Applicant/Recipient
- a. Applicant Name: U.S. Nuclear Regulatory Commission
- b. Organization Unit: Off. of Nuclear Reactor Regulation
- c. Street/P.O. Box:
- d. City: Washington
- e. County: Mar
- f. State: D.C.
- g. Zip Code: 20555
- h. Contact Person (Name & telephone no.): Frank J. Miraglia, Chief Licensing Branch No. 3

5. Federal Employer Identification No.

6. Program (From Federal Catalog)
- a. Number: 77•999
- b. Title: unknown

U.S. Nuclear Regulatory Comm.

7. Title and description of applicant's project: Draft Environmental Statement related to the operation of Palo Verde Nuclear Generating Station, Units 1, 2, & 3 Docket Nos. STN50-528, STN 50-529, & STN 50-530 NUREG-0841

The proposed action is the issuance of operating licenses to the Arizona Public Service Co for the startup & operation of the Palo Verde Nuclear Generating Station, Units 1, 2, & 3, located in Maricopa Co., about 24 km west of Buckeye, AZ.

8. Type of applicant/recipient
A–State; B–Interstate; C–Substate District; D–County; E–City; F–School District; G–Special Purpose District; H–Community Action Agency; I–Higher Educational Institution; J–Indian Tribe; K–Other
(Specify): Fed. Agency — Enter appropriate letter: K

9. Type of assistance
A–Basic Grant; B–Supplemental Grant; C–Loan; D–Insurance; E–Other — Enter appropriate letter(s): e

10. Area of project impact (Names of cities, counties, states, etc.): west of Buckeye, Maricopa Co., Arizona

11. Estimated number of persons benefiting:

12. Type of application
A–New; B–Renewal; C–Revision; D–Continuation; E–Augmentation — Enter appropriate letter: a

13. Proposed Funding

a. Federal	$	.00
b. Applicant		.00
c. State		.00
d. Local		.00
e. Other		.00
f. Total	$	.00

14. Congressional Districts Of: a. Applicant — b. Project: mul.

15. Type of change (For 12c or 12e)
A–Increase Dollars; B–Decrease Dollars; C–Increase Duration; D–Decrease Duration; E–Cancellation; F–Other Specify:
Enter appropriate letter(s):

16. Project Start Date Year month day 19

17. Project Duration Months

18. Estimated date to be submitted to federal agency Year month date 19

19. Existing federal identification number

20. Federal agency to receive request (Name, city, state, zip code)

21. Remarks added ☐Yes ☐No

22. The Applicant Certifies That
a. To the best of my knowledge and belief, data in this preapplication/application are true and correct, the document has been duly authorized by the governing body of the applicant and the applicant will comply with the attached assurances if the assistance is approved.
b. If required by OMB Circular A-95 this application was submitted, pursuant to instructions therein, to appropriate clearinghouses and all responses are attached:

	No response	Response attached
(1) Arizona State Clearinghouse	☐	☒
(2) Region I Clearinghouse (MAG)	☐	☒
(3)	☐	☐

23. Certifying representative — a. Typed name and title — b. Signature — c. Date signed Year month day 19

24. Agency name

25. Application received Year month day 19

26. Organizational Unit

27. Administrative office

28. Federal application identification

29. Address

30. Federal grant identification

31. Action taken
- ☐ a. Awarded
- ☐ b. Rejected
- ☐ c. Returned for amendment
- ☐ d. Deferred
- ☐ e. Withdrawn

32. Funding

a. Federal	$	.00
b. Applicant		.00
c. State		.00
d. Local		.00
e. Other		.00
f. Total	$	.00

33. Action date Year month day 19

34. Starting date Year month day 19

35. Contact for additional information (Name and telephone number)

36. Ending date Year month day 19

37. Remarks added ☐Yes ☐No

38. Federal agency A–95 action
a. In taking above action, any comments received from clearinghouses were considered. If agency response is due under provisions of Part 1, OMB Circular A-95, it has been or is being made.
b. Federal Agency A-95 Official (Name and telephone number)

424-101

Standard Form 424 Page 1 (10-75)
Prescribed by GSA, Federal Management Circular 74-7

81800067

RECEIVED DEC 1981 ENVIRONMENTAL HEALTH

ARIZONA DEPARTMENT OF HEALTH SERVICES

REF: HW 0856

Inter-Office Memorandum

TO: Pam Williamson,
Technical Advisor

DATE: December 8, 1981

THRU:

FROM: William H. Williams, Manager WHW.
Hazardous Waste Section

RE: Draft Environmental Statement - Palo Verde Nuclear Generating Station

The Bureau of Waste Control has reviewed the subject material and has the following concerns:

1. The on-site landfill will require approval by the Solid Waste Section.
2. Proposed testing (noted in section 5.3.2.3) should be by standard "EP toxicity" method. Terminology used in the report is not clear.
3. The liquid waste evaporation pond will require approval/permits from either of two sections in BWC depending on the nature of the waste.

WHW:pk

major

Janis

SIGNOFF

OMB Approval No. 29–R0218

FEDERAL ASSISTANCE

2. Applicant's application — a. Number — b. Date 19 Year Month Day

3. State application identifier — a. Number AZ 81-80-0067 — b. Date Assigned 19 81 11 18 (Year month day)

1. Type Of Action (Mark appropriate box): ☐ Preapplication ☐ Application ☐ Notification Of Intent (Opt.) ☐ Report Of Federal Action

Leave Blank: DEC 23 1981 — Valerie Manning

4. Legal Applicant/Recipient
- a. Applicant Name: U.S. Nuclear Regulatory Commission
- b. Organization Unit: Off. of Nuclear Reactor Regulation
- c. Street/P.O. Box:
- d. City: Washington — e. County: Mar
- f. State: D.C. — g. Zip Code: 20555
- h. Contact Person (Name & telephone no.): Frank J. Miraglia, Chief Licensing Branch No. 3

5. Federal Employer Identification No.

6. Program (From Federal Catalog)
- a. Number: 77•999
- b. Title: unknown

U.S. Nuclear Regulatory Comm.

7. Title and description of applicant's project: Draft Environmental Statement related to the operation of Palo Verde Nuclear Generating Station, Units 1, 2, & 3 Docket Nos. STN50-528, STN 50-529, & STN 50-530 NUREG-0841

The proposed action is the issuance of operating licenses to the Arizona Public Service Co for the startup & operation of the Palo Verde Nuclear Generating Station, Units 1, 2, & 3, located in Maricopa Co., about 24 km west of Buckeye, AZ.

8. Type of applicant/recipient
A–State, B–Interstate, C–Substate District, D–County, E–City, F–School District, G–Special Purpose District, H–Community Action Agency, I–Higher Educational Institution, J–Indian Tribe, K–Other

(Specify): Fed. Agency — Enter appropriate letter: K

9. Type of assistance
A–Basic Grant, B–Supplemental Grant, C–Loan, D–Insurance, E–Other — Enter appropriate letter(s): e

10. Area of project impact (Names of cities, counties, states, etc.): west of Buckeye, Maricopa Co., Arizona

11. Estimated number of persons benefiting

12. Type of application
A–New, B–Renewal, C–Revision, D–Continuation, E–Augmentation — Enter appropriate letter: a

13. Proposed Funding

a. Federal	$	.00
b. Applicant		.00
c. State		.00
d. Local		.00
e. Other		.00
f. Total	$	.00

14. Congressional Districts Of: a. Applicant — b. Project: mul.

15. Type of change (For 12c or 12e)
A–Increase Dollars, B–Decrease Dollars, C–Increase Duration, D–Decrease Duration, E–Cancellation, F–Other Specify: — Enter appropriate letter(s)

16. Project Start Date (Year month day) 19

17. Project Duration — Months

18. Estimated date to be submitted to federal agency (Year month date) 19

19. Existing federal identification number

20. Federal agency to receive request (Name, city, state, zip code)

21. Remarks added ☐ Yes ☐ No

Section I - Applicant / Recipient Data

22. The Applicant Certifies That
a. To the best of my knowledge and belief, data in this preapplication/application are true and correct, the document has been duly authorized by the governing body of the applicant and the applicant will comply with the attached assurances if the assistance is approved.
b. If required by OMB Circular A-95 this application was submitted, pursuant to instructions therein, to appropriate clearinghouses and all responses are attached:

	No response	Response attached
(1) Arizona State Clearinghouse	☐	☒
(2) Region I Clearinghouse (MAG)	☐	☒
(3)	☐	☐

23. Certifying representative — a. Typed name and title — b. Signature — c. Date signed (Year month day) 19

Section II - Certification

24. Agency name

25. Application received (Year month day) 19

26. Organizational Unit

27. Administrative office

28. Federal application identification

29. Address

30. Federal grant identification

31. Action taken
- ☐ a. Awarded
- ☐ b. Rejected
- ☐ c. Returned for amendment
- ☐ d. Deferred
- ☐ e. Withdrawn

32. Funding

a. Federal	$	.00
b. Applicant		.00
c. State		.00
d. Local		.00
e. Other		.00
f. Total	$	.00

33. Action date (Year month day) 19

34. Starting date (Year month day) 19

35. Contact for additional information (Name and telephone number)

36. Ending date (Year month day) 19

37. Remarks added ☐ Yes ☐ No

C002 S 0/1

38. Federal agency A–95 action
a. In taking above action, any comments received from clearinghouses were considered. If agency response is due under provisions of Part 1, OMB Circular A-95, it has been or is being made.
b. Federal Agency A-95 Official (Name and telephone number)

Section III - Federal Agency Action

8201070007 811223
PDR ADOCK 05000528
PDR

Standard Form 424 Page 1 (10-75)
Prescribed by GSA, Federal Management Circular 74-7

...... to be completed by Reviewing Agency

TO:

Mary Alice Bivens, Director
State Liaison Officer
AORCC
1333 W. Camelback, Suite 206
Phoenix, AZ 85013

State Application Identifier (SAI)

NOV 18 1981 State AZ No. 81-80-0067

Game & Fish
Archaeological Research
Energy
Health
Water
AORCC
Land
Parks

Region I

FROM: Arizona State Clearinghouse
1700 West Washington Street, Room 505
Phoenix, Arizona 85007

This project is referred to you for review and comment. Please evaluate as to the following questions. After completion, return THIS FORM AND ONE XEROX COPY to the Clearinghouse no later than 17 WORKING DAYS from the date noted above. Please contact the Clearinghouse at 255-5004 if you need further information or additional time for review.

☒ No comment on this project ☐ Proposal is supported as written ☐ Comments as indicated below

1. Is project consistent with your agency goals and objectives? ☐ Yes ☐ No ☐ Not Relative to this agency

2. Does project contribute to statewide and/or areawide goals and objectives of which you are familiar? ☐ Yes ☐ No

3. Is there overlap or duplication with other state agency or local responsibilities and/or goals and objectives? ☐ Yes ☐ No

4. Will project have an adverse effect on existing programs with your agency or within project impact area? ☐ Yes ☐ No

5. Does project violate any rules or regulations of your agency? ☐ Yes ☐ No

6. Does project adequately address the intended effects on target population? ☐ Yes ☐ No

7. Is project in accord with existing applicable laws, rules or regulations with which you are familiar? ☐ Yes ☐ No

Additional Comments (Use back of sheet, if necessary):

RECEIVED
NOV 20 1981
AORCC

Reviewers Signature Mary Alice Bivens

Date 11/20/81

Title Dir. SLO

Telephone

... to be completed by Reviewing Agency

TO:

Dr. James Sarn, M.D., Director
Department of Health Services
1740 West Adams Street
Phoenix, AZ 85007

FROM: Arizona State Clearinghouse
1700 West Washington Street, Room 505
Phoenix, Arizona 85007

State Application Identifier (SAI)

NOV 18 1981 State AZ No. 81-80-0067

Game & Fish
Archaeological Research
Energy
Health
Water
AORCC
Land
Parks

Region I

This project is referred to you for review and comment. Please evaluate as to the following questions. After completion, return THIS FORM AND ONE XEROX COPY to the Clearinghouse no later than 17 WORKING DAYS from the date noted above. Please contact the Clearinghouse at 255-5004 if you need further information or additional time for review.

☒ No comment on this project ☐ Proposal is supported as written ☐ Comments as indicated below

1. Is project consistent with your agency goals and objectives? ☐ Yes ☐ No ☐ Not Relative to this agency

2. Does project contribute to statewide and/or areawide goals and objectives of which you are familiar? ☐ Yes ☐ No

3. Is there overlap or duplication with other state agency or local responsibilities and/or goals and objectives? ☐ Yes ☐ No

4. Will project have an adverse effect on existing programs with your agency or within project impact area? ☐ Yes ☐ No

5. Does project violate any rules or regulations of your agency? ☐ Yes ☐ No

6. Does project adequately address the intended effects on target population? ☐ Yes ☐ No

7. Is project in accord with existing applicable laws, rules or regulations with which you are familiar? ☐ Yes ☐ No

Additional Comments (Use back of sheet, if necessary):

Reviewers Signature Pamela Williamson Date 12/8/81

Title EHS / ADHS Telephone 1134

...to be completed by reviewing agency Request Chase, McCain

TO: 12/11/81

State Application Identifier (SAI)

NOV 18 1981 State AZ No. 81-80-0067

John J. DeBolske, Exec. Dir.
Maricopa Association of
Government
1820 W. Washington St.
Phoenix, AZ 85007 1113

Game & Fish
Archaeological Research
Energy
Health
Water
AORCC
Land
Parks

FROM: Arizona State Clearinghouse
1700 West Washington Street, Room 505
Phoenix, Arizona 85007

Region I

This project is referred to you for review and comment. Please evaluate as to the following questions. After completion, return THIS FORM AND ONE XEROX COPY to the Clearinghouse no later than 17 WORKING DAYS from the date noted above. Please contact the Clearinghouse at 255-5004 if you need further information or additional time for review.

☑ No comment on this project ☐ Proposal is supported as written ☐ Comments as indicated below

1. Is project consistent with your agency goals and objectives? ☐ Yes ☐ No ☐ Not Relative to this agency

2. Does project contribute to statewide and/or areawide goals and objectives of which you are familiar? ☐ Yes ☐ No

3. Is there overlap or duplication with other state agency or local responsibilities and/or goals and objectives? ☐ Yes ☐ No

4. Will project have an adverse effect on existing programs with your agency or within project impact area? ☐ Yes ☐ No

5. Does project violate any rules or regulations of your agency? ☐ Yes ☐ No

6. Does project adequately address the intended effects on target population? ☐ Yes ☐ No

7. Is project in accord with existing applicable laws, rules or regulations with which you are familiar? ☐ Yes ☐ No

Additional Comments (Use back of sheet, if necessary):

Reviewers Signature Jack Tevlin _______ Date 12/18/81

Title Staff Asst. I-9 _______ Telephone _______

ARIZONA PUBLIC SERVICE COMPANY

STA. ________

P.O. BOX 21666 - PHOENIX, ARIZONA 85036

December 15, 1981
ANPP-19700 - JMA/JRM

Mr. Frank A. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Comments on Draft Environmental Statement
Palo Verde Nuclear Generating Station,
Units 1, 2 and 3

Dear Mr. Miraglia:

Our comments on the subject Draft Environmental Statement are attached.

Thank you for the opportunity to comment.

Very truly yours,

E. E. Van Brunt, Jr.
APS Vice President
Nuclear Projects
ANPP Project Director

EEVBJr/JRM/sam

cc: [redacted]
P. Hourihan
R. Greenfield

SECTION	PAGE		COMMENT
4.2.4.1	4-3	APS-1	Permeability should read 10^{-10} cm/sec.
4.3.6	4-15	APS-2	This section states "there are no historic properties... located on or near the PVNGS site" nor "in or near the water conveyance pipeline." The word "registered" should be inserted prior to the word historic in both cases for clarification as there were historic properties; however, they were not registered.
5.2	5-1	APS-3	In the first sentence the word "than" should be inserted after the word "larger."
5.3.1.1	5-1	APS-4	Projections of sewage effluent have been updated since the development of the information supplied for the DES-OL. Reference should be made to the PVNGS ER-OL Supplement 4 for updated data on sewage effluent projections.
5.3.1.1	5-3	APS-5	It is suggested that the text following Table 5.2 be rewritten as follows:

"By having senior rights to these effluent quantities these three users are entitled to $4.75 \times 10^7 M^3$/year (38,500 acre-feet/year) of sewage effluent discharged from the 91st Avenue plant. This is not to say that these quantities are delivered first every calendar year, but daily, weekly and monthly flows are reserved for their use which would amount to the annual totals expressed above. The BID, therefore, has a right to divert under an agreement with the City of Phoenix an amount equal to 2,500 acre-feet/month to satisfy its 30,000 acre-feet per year. The Arizona Game and Fish Department had an understanding with the City of Phoenix which calls for the delivery of 6.52 MGD of effluent to the Salt River channel for an annual equivalent of 7,300 acre-feet. However, AGFD has abandoned its attempt to perfect this right under Arizona State law as an instream use for fish and wildlife enhancement. The WCL facilities ceased to exist as a result of flooding in 1978, and therefore effluent deliveries under this contract no longer exist.

The BID, under a 1919 amendment to the Benson vs. Allison court decree, has water rights in the Salt River which go beyond that under contract with the City of Phoenix. The decree states that BID has rights to 80 miner's inches (40 miner's inches=approximately 1 cfs) of constand flow which reaches its headworks. This amount of water is above and beyond the 30,000 acre-feet per year which is covered under the contract with the City of Phoenix

SECTION	PAGE	COMMENT

APS-5 (cont'd)

Because BID and Phoenix have not been in-tertied by any conveyance system, the delivery point of the 30,000 acre-feet has been into the Salt River channel. However, with the construction of the Palo Verde pipeline and agreements between Arizona Public Service and BID for rights-of-way for this line, BID arranged for pipeline capacity to deliver its 30,000 acre-feet under contract by this means.

The amount of sewage effluent that will be available in 1986 for use by the BID, assuming the AGFD and WCL do not utilize their commitments, is shown in Table 5.3.

Table 5.3 Sewage effluent available for use by the Buckeye Irrigation District in 1986, in acre-feet.

	COE-EPA '79 Proj.	Phoenix '79 Proj.	MAG '81 Proj.	Phoenix '81 Proj.
Projected Flows from the 91st Avenue Plant	118,000	131,600	118,023	150,300
PVNGS Projected Use	64,100	64,050	64,050	64,050
Sewage effluent available for BID use from 91st Avenue Plant*	53,900	67,550	53,973	86,250

*Represents both contracted 30,000 acre-feet from Phoenix and potential stream diversions.

The annual water requirement of the BID is approximately 130,000 acre-feet per year. During a five year period from 1972 to 1977, the BID diverted on the average of 82,000 acre-feet per year from the Gila River at the Buckeye Heading. This figure reflects the availability of water in the Gila River from all sources upstream, and BID's contractual commitment from the City of Phoenix which was delivered to the river channel. Of the 82,000 acre-feet the source of 14,500 acre-feet was assumed to be made up of water discharged into the river bed from the Salt River Project feeder ditch.

SECTION	PAGE		COMMENT
		APS-5 (Cont'd)	The balance, or 67,500 acre-feet, is therefore assumed to be effluent from the 91st avenue and 23rd Avenue Plants (EPA, 1979). Taking the Phoenix 1981 projections from Table 5.3, there will be 56,250 acre-feet of effluent discharged into the river from the 91st Avenue Plant, in conjunction with the 30,000 acre-feet which would be delivered via the Palo Verde pipeline for BID's use, for a total of 86,250 acre-feet. Therefore, there would be sufficient effluent available to meet BID's 1972-1977 average use during the critical period of 1986. If, instead, the MAG 1981 projections prove to be accurate, there will be 23,973 acre-feet of effluent in the Gila River from the 91st Avenue Plant subject to BID's diversion and the 30,000 acre-feet deliverable through the Palo Verde pipeline, for a total of 53,973 acre-feet which is 15,527 acre-feet short of BID's average yearly diversion between 1972-1977. However, BID may continue to divert any and all waters flowing into the river at its head-gate up to the specified limits noted earlier in the Benson vs. Allison decree. A portion, if not all, of the shortfall may be made up from discharges made into the Salt River bed further upstream from the 23rd Avenue Plant and/or from pumped groundwater. It stands to reason that BID will continue to maximize its legal diversion of surface water flows from the Salt and Gila Rivers to forego the cost and use of its groundwater supplies. The above discussion assumes that BID will continue to have a like number of acres under irrigation as it does presently."
5.3.1.1	5-4	APS-6	Table 5.4 as depicted is somewhat confusing, especially the figures presented for PVNGS usage for 3 units. Of the three numbers representing Palo Verde usage in this Table, not one reflects the quantity now calculated as our estimated use from Section 4.2.3. of 63,750 AF. The result is that the report now has four figures representing cooling water at PVNGS.
		APS-7	The last sentence on this page is also somewhat misleading. There will not be more water available in the Salt and Gila Rivers as a result of the Arizona Game and Fish and Water Conservation Laboratory not using their commitments. Conceptually these uses were "in-stream" uses and not effluent water diverted from the stream channel.

SECTION	PAGE		COMMENT
5.4.2	5-8	APS-8	The top paragraph is misleading because the 24-hr. NAAQS for that suspended particulates is for ground level concentration. The 260 ug/m^3 mentioned is the concentration in air at the elevation of the tower.
5.9.1.1.1	5-21	APS-9	Occupational doses are overestimated. The statement that occupational doses "could average as much as 3 to 4 times" the 440 man rem average established by NUREG-0713 is not consistent with the 1300 man rem upper limit noted in the NUREG (and noted in the DES). The 440 man rem average is also inconsistent with the SER and FSAR. No credit is given to APS design and operation ALARA Programs.
5.9.1.1.1	5-22	APS-10	Construction worker exposures are principally due to the refueling water tank and gasecus effluents. Nitrogen-16 sources in the turbines are not significant dose contributors at PWR's.
5.9.1.1.2	5-22	APS-11	N-16 is not a dominant source.
5.9.1.4.1	5-23, 29	APS-12	Table 5-8 (1) Under "Direct Radiation" the inaccessible sector is WNW now NW. (2) Under Drinking (well), samples are taken from surrounding residences not communities. (3) Under Milk, direction should be 7 mi. ENE not 6 mi. east.
	5-33, 34	APS-13	Table 5.9 Inventories are significiantly low. Inconsistent with ER-OL Table 7.1-2.
5.9.2.1 (1)	5-37	APS-14	PVNGS Uses water sprays rather than cooling fans for post-accident containment heat removal. The spray additive is hydrazine, not sodium hydroxide.
5.9.2.4 (2)	5-38	APS-15	Although the minimum distance from Unit 1 to the EAB is 1,037 meters, the EAB is only 871 meters from Unit 3 (west sector).
5.9.2.5 (5)	5-55	APS-16	The radial groundwater velocity of 19 ft/yr exceeds FSAR analysis of 8.2 ft/yr. The DES ignores actual perched mound water elevation.

SECTION	PAGE		COMMENT
5.9.2.5 (6)	5-58	APS-17	Replacement fuel cost should be based upon participant's projected energy mix. The choice of oil-fired replacement power overestimates the cost. It appears that the replacement core cost has been counted twice. There should be a credit for decreased nuclear fuel cost against replacement fuel cost such that replacement fuel cost represents only the incremental cost of using more costly generation methods.

ARIZONA
RADIATION REGULATORY AGENCY

Bruce Babbitt
Governor
Charles F. Tedford
Director

925 South 52nd Street, Suite #2 • Tempe, Arizona 85281 • (602) 255-4845

January 29, 1982

Docket Nos. 50-528
50-529
and 50-530

Mr. Frank J. Miraglia, Chief
Licensing Branch #3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

The recent correspondence dated January 28, 1982, requesting comments on the "Draft Environmental Statement" related to the operation of Palo Verde Nuclear Generating Station Units 1, 2, 3 has been received. I should note for the record this is the first official document received by this agency regarding the aforementioned request. Mr. Licitra called during the earlier part of January and solicited the Agency's overdue comments to correspondence supposedly received during October, 1980. The Agency never received this correspondence. Accordingly, please note the correct address.

The following comments are considered germane to the review:

1. Page 4-4, Section 4.2.5: Radioactive Waste Management Systems. The last paragraph, line 5, states : approximately 18,000 cubic feet of "wet" solid wastes and 12,000 cubic feet of "dry" solid wastes will be shipped off-site annually from each unit to a licensed burial site. The NRC staff is requested to project a realistic estimate of total cubic feet of waste per reactor after compaction, incineration, and concentration have occurred. The guesstimate will prove useful in the projection of future Low Level Waste volume requirements.

2. Page 5-25, Sec. 5.9.1.1.2: Emergency Planning. The first paragraph, last sentence : "Why are concentrations of I_2 in the thyroid and C-14 in bone of particular significance here?" An explanation is in order, particularly regarding the use of the word "here."

3. Page 5-57, Table 5.4. The basis for the average cost of protective action and decontamination of $2,600 should be amplified and explained.

4. Page 5-65, Sec. 5.12, 2nd paragraph, first sentence. The suggestion is to delete or rewrite. The second sentence clarifies meaning and can stand by itself.

5. Page 5-65, Section 5.11: Decommissioning Impacts. The second paragraph addresses the estimated decommissioning, SAFSTOR, ENTOMB, and annual maintenance and surveillance costs. What mechanism has been established to collect and accrue these funds?

C002
B
1/0

6. General comment: Cotton is one of Arizona's principal crops and is grown in Maricopa County. Cottonseed oil is a component of cooking oils. No note of this could be found in the DES. This point should be addressed.

To summarize, I must state that the document was impressive with regard to detail, accuracy, and completeness. The NRC is to be commended for a fine effort.

Sincerely,

Charles F. Tedford

Charles F. Tedford
Director

CFT:clp

cc: George Britton
Office of the Governor

ARIZONA
STATE
PARKS

1688 WEST ADAMS STREET
PHOENIX, ARIZONA 85007
TELEPHONE 602-255-4174

February 3, 1982

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Palo Verde Nuclear Generating
Station, Units 1, 2 and 3
DRAFT ENVIRONMENTAL STATEMENT
re: operational licensing
Arizona Public Service Company, et al.
NRC

Dear Director:

I have reviewed the Draft Environmental Statement prepared by the NRC for this proposed Federal action and have the following comments relative to the project's compliance with the historic preservation requirements for Federally licensed undertakings:

1. This office was consulted during the planning phases of the various features of the project and the necessary cultural resource surveys, evaluations, and avoidance/mitigation plans were carried out by the applicant.

   Our records indicate consultation over several years with the Arizona Public Service and Salt River Project utility companies, the Bureau of Land Management, and the Nuclear Regulatory Commission regarding the various features of the project.

2. I am satisfied that the project has not adversely affected any significant cultural resources. The combination of complete site avoidance through project re-design and the recovery of data from those sites that could not be avoided has provided for the preservation of cultural resources that might otherwise have been adversely affected by the project.

3. Therefore, in my opinion, licensing the operation of the Palo Verde Nuclear Generating Station, Units 1, 2 and 3, should have no adverse effect on any significant cultural resources.

The continued cooperation of the NRC with this office in complying with historic preservation requirements pursuant to the Advisory Council's regulations (36 CFR Part 800) is appreciated. If we can assist further, please let us know.

Sincerely,

Frank B. Fryman
Archaeologist & Compliance Coordinator

for Ann A. Pritzlaff
State Historic Preservation Officer

FBF:mes

bcc: Emanuel Licitra

December 14, 1981

4327 Alconbury
Houston, Tx. 77021

Mr. Chase R. Stephens
Docketing & Service Branch
U. S. Nuclear Regulatory Commission
Washington D. C. 20555

RE: COMMENTS ON NUREG-0841, DRAFT ENVIRONMENTAL STATEMENT, RELATED TO THE OPERATION OF PALO VERDE NUCLEAR GENERATING STATION, UNITS 1,2, and 3.

To whom it may concern:

Below are my comments on the DES, provided recently on my request.

Doherty Comment 1

In Appendix C, the following statement occurs, "To illustrate: a single-model 1000-MWe LWR operating at an 80-percent capacity factor for 30 years would be predicted to induce between 3.3 and 5.7 cancer fatalities in 100 years, 5.7 and 17 in 500 years, and 36 and 60 in 1,000 years as a result of releases of radon-222." This is the clearest explaination of radon from the fuel cycle on human beings. The FES should contain:

JFD-1 a) The range of fatalities for the project at the expected capacity factor for 40 years from cancer, for those years;

JFD-2 b) The range of cancers which do not kill their victims induced by radon-222 at the expected capacity factor for 40 years from the fuel cycle, for those years;

JFD-3 c) The range of number of birth defects induced by radon-222 fuel cycle activity for the project for 40 years for those years at the expected capacity factor; and

JFD-4 d) The range of fatal birth defects induced by radon-222 fuel cycle activity for the project for 40 years at the expected capacity factor, for 100 years, 500 years and 1000 years.

JFD-5 That is, the effect of radon-222 on humans should be explained more fully than it is in the DES. Thank you for the opportunity to comment.

John F. Doherty

John F. Doherty

RECEIVED
DEC 24 1981

C002
S1/0

8112280311 811
PDR ADOCK 0500
D PDR

Federal Emergency Management Agency
Washington, D.C. 20472

JAN 22 1982

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Re: Draft EIS for Pallo Verdi

Dear Sir:

In response to a telephone inquiry from Emmanuel Licitra of your office, please be advised that we have no comments on the Draft Environmental Impact Statement for Pallo Verdi.

Sincerely,

[signature]

for Spence W. Perry
Associate General Counsel
National Security & Preparedness
Division
Office of General Counsel

C002
B/0

'81 DEC 23 A11

Sharon Harrington
1838 S. 80th Place
Mesa, Arizona 85208

December 17, 1981

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Gentlemen:

I am responding to this letter by December 21, 1981, requesting more time to review this draft environmental statement. I did not receive it in time to make a full study of it, and I believe many residents of Maricopa County have no idea it is even out.

SH-A I do not believe the draft environmental statement sent to me addresses the social and economic cost involved with the operation of the Palo Verde Nuclear Generating Station. Nor does it address radiological effects because it does not attempt to solve the SH-B issue of waste disposal of the highly radioactive plutonium 239 that will be produced by Palo Verde.

SH-C I do not believe Arizona Public Service has considered the likeliness of station accidents and their consequences.

SH-D The fact that APS has just requested water from the Central Arizona Project shows how it has already begun to interfer with our state water requirements. We do not need Palo Verde taking any water from the residents of this state. We have a crisis with water in Arizona without Palo Verde. It will only stand to get worse when and if Palo Verde goes on line.

SH-E It offends me that APS said there was nothing scenic on the land. Four thousand acres of the National Palo Verde Forest was, to say the least, scenic and beautiful before APS disfigured the land.

To get to the real fears Palo Verde is presenting, the lack of study and inspection dealing with this nuclear plant are most offensive. The following concerns are some of the issues the NRC needs to address:

1. No study of tornadic winds that have occured in this area in the past.

2. Water convenance rosses Hasayampa which frequently floods.

3. No study of intense summer heat on construction materials.

Sharon Harrington
1838 S. 80th Place
Mesa, Arizona 85208

December 17, 1981

4. Lack of in-house link support systems; no hot line in case of emergency. Same setup occured at Three Mile Island!

5. Only $3\frac{1}{2}$ hours of primary cooling water available if system fails.

6. The record of Becthel Construction Co. is questionable, and should be thoroughly investigated.

7. No study of native American rights concerning ur nium mining and milling occuring on reservations, dealing with the construction of nuclear power plants, has been done by the NRC.

In closing, I would like to say that the Valley of the Sun newspapers indicated that the hearings with APS before the NRC would be open to public comment. However, I was told at the hearing by the Chairman of the Committee that they were not intended to be open to public comment, that they were only dealing with technical issues at that time.

Are there any plans by the NRC to allow for better public format in future hearings with APS?

Very truly yours,

Sharon Harrington

Sharon Harrington

MARICOPA COUNTY DEPARTMENT OF PLANNING AND DEVELOPMENT
111 S. 3rd. Avenue, Room 300, Phoenix, Arizona 85003 – Phone (602) 262-3201

MARICOPA COUNTY ARIZONA

January 19, 1982

Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

We are in receipt of the Draft Environmental Statement for the operation of Palo Verde Nuclear Generating Station (Docket STN 50-528-529-530). Our staff has had the opportunity to review the statement and we encourage further investigation of the following areas:

1) The Rio Salado as a potential water source

The Rio Salado Development District located at 141 East Palm Lane, Suite 202, in Phoenix, Arizona 85004 is a potential source of cooling water. The District, which covers 40 miles of floodplain between the Granite Reef Dam and the confluence of the Gila and Agua Fria Rivers, hopes to control water as it flows through the Salt River. This is a potential source of cooling water which should be fully investigated.

2) The ultimate disposition of radioactive wastes

The onsite storage and ultimate disposition of radioactive materials are not adequately addressed in the report. The State of Arizona is presently struggling with the issue of hazardous waste disposal. Radioactive waste disposal is among the issues that are not resolved. If the plant begins operation before an acceptable disposal site for radioactive wastes can be found, then provisions must be made for the long term on-site storage of radioactive wastes.

The report states that all radioactive wastes will be solid and will be ultimately shipped off-site annually to a licensed burial site. Where is the site?

3) Control over neighboring properties

The Palo Verde site is a growth generator which attracts new growth and development. While over 1,500 acres of land have been acquired for the Power Station site most of that land is

C002
B
1/0

south of the generating facilities. Privately owned and controlled lands are found approximately 3,800 feet north of reactor #1. It is recommended that the project site boundary be expanded to the north and at least one mile in all directions from the reactor. It also is recommended that the development rights of neighboring properties be acquired to assure compatible land uses.

4) Comprehensive Ongoing Inspections

Most large public utilities, including Arizona Public Service, rely extensively on contractors for the construction of their major facilities. Recent developments such as Diablo Canyon in California and the APS natural gas leak in Arizona suggest that as much attention must be given to construction and maintenance as well as to the planning and design of the project.

A careful pre-operation inspection process coupled with a continuing program of structural and environmental monitoring is necessary to protect the public. With sizeable government cutbacks on the horizon, many people are concerned about the government's ability to conduct thorough inspections of the work performed by private contractors.

I am available to discuss these comments with you.

Sincerely,

DON E. McDANIEL, JR., DIRECTOR
DEPARTMENT OF PLANNING AND DEVELOPMENT

Dudley Onderdonk

Dudley Onderdonk
Principal Planner
Advance Planning Division

DO/na

P.O. Box 654
Citrus Heights, CA 95610
December 16, 1981

DEC 22 1981

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Sir:

I wish to enter the following comments concerning the Draft Environmental Statement related to the operation of Palo Verde Nuclear Generating Station, Units 1,2, and 3, Docket Nos. STN 50-528, STN 50-529, and STN 50-530 (NUREG - 0841) for consideration in the final environmental statement:

JDM-1 SUMMARY AND CONCLUSIONS

Item 4.k (p iv) Add "Any increase in risk to the population near the site is more than offset by the reduction in risk to the population near the 91st Avenue sewage treatment facility or the Salt-Gila River system as the on-site water treatment plant will reduce pathogens by chlorination and other treatment processes and the use of sewage effluent will decrease radiation exposures due to decay prior to ultimate release to the environment."

JDM-2 CHAPTER 2

Paragraph 2.1 (p 2-1) Average annual rate of growth of 3.5% seems low when compared to the population growth of 53.1% between 1970 and 1980 (4.35% per year) as noted in paragraph 4.3.7.3. As population is expected to grow, why isn't electrical demand growth consistent with population? Hasn't growth in electrical demand exceeded 3.5% per year during the last decade? I would think it has been well above 4% per year.

CHAPTER 4

JDM-3 Paragraph 4.2.5 (p 4-4) What are "wet" wastes? Specify that wastes are solidified. (See FES-CP paragraph 3.5.3.)

JDM-4 Paragraph 4.3.1.2 (p 4-11) Is the rise in the regional aquifer harmful or beneficial? Please clarify.

JDM-5 Paragraph 4.3.2.2 (p 4-12) What are radioactivity levels of 91st Avenue sewage treatment facility effluent? Wouldn't PVNGS use of effluent result in decreased population doses since hospital and industrial radwaste will decay prior to re-release at PVNGS? Where is this included in 10 CFR 50 Appendix I evaluation? Can this offset operational transient or steady state releases from the plant? As the effluent is being used for crop irrigation by other users, I would think that a reduction in the ingestion pathway could be quite significant. Does PVNGS operation also lead to reduced contamination of groundwater?

C002
s
1/0

CHAPTER 5

Paragraph 5.9.1.1.1 (p 5-21) How can occupational doses average as much as 3 to 4 times 440 person-rems if the Hinson value is only 1300? Isn't 1300 representative of an old plant, not a new one designed to tougher standards? JDM-6

CHAPTER 6

Paragraph 6.1, Item (2) (p 6-1) Modify to require that the NRC conduct cost benefit analyses of monitoring programs and determine conclusively that the benefit to be gained from monitoring exceeds the cost to the owners or their ratepayers. JDM-7

Paragraph 6.1, Item (3) (p 6-1) Modify to provide a threshold of damage up to which no applicant action is required. Such threshold should be based upon a statistically defensible increment above the nominal, or average, impacts upon the regional ecology described in the FES-CP or the FES-OL, whichever may be greater. Prior to NRC or applicant action to restrict operation or increase applicant's obligations, a cost benefit analysis must be conducted to assure that the potential benefit in mitigating damage does not exceed the withdrawal of benefits normally bestowed by the operation of the plant. JDM-8

Table 6.1 (p 6-2) Why aren't taxes, employment, and payroll benefits of fuel cycle operations included in this table in the same manner in which fuel cycle impacts are included in section 5.10? The DES unfairly attributes a cost without consideration of the benefit. JDM-9

APPENDIX C

Table C-6 (p C-11) Population doses appear to have been calculated by use of non correlated data. An average annual dispersion factor is multiplied by the gaseous releases, converted to dose, and then multiplied by the total population within 80 kilometers. Doesn't population distribution relative to the predominant wind enter into the equation? The Phoenix wind blows east to west. The population lives to the east. Out west is barren desert. There should be a correlation of wind frequency to the population sectors. JDM-10

Please provide me with a copy of the FES so that I may review the manner in which these comments have been addressed.

Sincerely yours,

Janet D. Mitchell

Janet D. Mitchell

December 16, 1981

To: U.S. Nuclear Regulatory Commission
Re: PVNGS Atomic Safety and Licensing Board hearings
Draft E.I.S. on PVNGS Units 1, 2 and 3 (Oct., 1981)

MLS-0

I wish to express my concern over inadequate provision for public participation in the NRC decision-making process on Palo Verde Nuclear Generating Station. Additionally, I wish to file some initial comments on the NRC Draft E.I.S. of October, 1981.

I attended the November 24 Safety and Licensing Board hearings in Phoenix with two companions. We had come primarily as observers; but as the hearings progressed, Sharon Harrington and I felt a need to comment on the proceedings. The Board chairman, Mr. Bender, was cooperative and allowed Ms. Harrington to speak about her concerns, including the difficulties of public participation in highly technical hearings. Mr. Bender offered me the same opportunity, but I preferred to respond in writing.

I share Ms. Harrington's concern that human values should inform any technical decision-making process. For this to occur, the process must be made accessible to non-professionals. The November NRC hearings on PVNGS failed to satisfy this criterion in my opinion.

Advance publicity for the hearings was inadequate. In the local press, the only was a small item in the <u>Phoenix Gazette</u> shortly before the hearings. The specific courtroom location of the November 18 pre-hearing conference was not specified. No address or phone number was given for those seeking additional information on the hearings subject matter. A phone number was given for confirmation of the November 23 and 24 hearings times. But that number was difficult to reach, and the person answering was ill-informed and discourteous. Finally, the article stated that "public statements" could be made at the hearings; but chairman Bender told Ms. Harrington and me that no plans had been made to allow for public comment and that the hearings were purely "technical."

MLS-0 (cont'd)

Similar failure to provide adequate public notice took place regarding issuance of the Draft E.I.S. Notice of availability of that document was limited to a few sources, none of which are widely accessible. Even the state regulatory newsletter failed to provide such notice.

As a result of these experiences, I have little faith remaining in the reliability of the public information provided by the NRC through the local press. Whoever is at fault, those lines of communication appear hopelessly garbled; and I request that you put me on your mailing list or otherwise inform me of upcoming hearings.

This sort of tangling of the channels of communication undercuts public involvement in the NRC decision-making process. Shortly before the temporary suspension of the Diablo Canyon license, an NRC commissioner publicly complained about inadequate public participation in the hearing process. If public notice in California was anything like it has been here, it is easy to see why that was the case. Moreover, genuine public involvement in that process might have eliminated the need for both large-scale public demonstrations against Diablo and the eleventh hour suspension of the plant's license. I believe everyone's interests would be served by increased efforts on your part to improve communication with the general public.

In closing, I wish to set forth several concerns that I feel were inadequately addressed by the Safety and Licensing Board and the Draft E.I.S. As regards matters before the Safety and Licensing Board, I am concerned about the following:

1.) The ability of PVNGS to withstand tornadic winds.
2.) The rather fantastic statement (glossed over by the board) that PVNGS condensation tanks were "designed to be protected against missile" attacks. (A direct hit? How many megatons?!)

MLS-0
(Cont'd)

3.) Apparent inadequacy of in-house and external emergency communications procedures.
4.) Apparently, no provision for emergency loss of feed water to the spray tank cooling system.
5.) Possible civil liberties questions related to accessibility to and inspection of external wells.

Regarding the Draft E.I.S.:

1.) Failure to consider potential effects of the desert climate, particularly intense sunlight, on construction materials.
2.) Possible effects of flash flooding, especially from the Hasayampa, on the water conveyance system inadequately addressed.
3.) The simply inaccurate assertion that: "There are no historic properties, natural areas, or scenic features on or near the PVNGS site."
4.) Inadequate consideration of the socioeconomic impact of the uranium fuel cycle on Native Americans in Northern Arizona.
5.) Questionable analysis, on several points, of socioeconomic impacts of PVNGS on local economy. Failure to adequately assess external costs.
6.) Cursory assessment of decommissioning impacts.
7.) No consideration of socioeconomic impacts of a civil liberties nature resulting from necessary plant security.

Sincerely,

Myron L. Scott

Myron L. Scott
4341 N. 86th St.
Scottsdale, AZ 85251

United States Department of Agriculture

Economics and Statistics Service

Washington, D.C. 20250

November 4, 1981

Mr. Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Miraglia:

Thank you for forwarding the Draft Environmental Statement relating to the startup and operation of the Palo Verde Nuclear Generating Station, Units 1, 2 and 3, located in Maricopa County, west of Buckeye, Arizona.

We have reviewed Docket Nos. STN 50-528, STN 50-529 and STN 50-530 and have no comments.

Sincerely,

Velmar W. Davis

VELMAR W. DAVIS
Associate Director
Natural Resource
Economics Division

C002
s1/0

8111090498 811104
PDR ADOCK 05000528
D PDR

United States Department of Agriculture
Forest Service
Region 3
517 Gold Avenue, SW.
Albuquerque, NM 87102

Reply to: 1950

Date: December 9, 1981

DEC 14 1981

Director, Division of Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Sir:

We have reviewed the Draft Environmental Impact Statement for the Palo Verde Nuclear Generating Station, Units 1, 2, and 3 and have no comment as the proposed administrative action does not affect National Forest System land management programs.

Sincerely,

M. J. HASSELL
Regional Forester

C002
s 1/0

8112160424

D

FS-6200-11(8-80)

DEPARTMENT OF THE ARMY
LOS ANGELES DISTRICT, CORPS OF ENGINEERS
P. O. BOX 2711
LOS ANGELES, CALIFORNIA 90053

SPLED-E

16 DEC 1981

Mr. Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

This is in response to a letter from your office dated 30 October 1981 which requested review and comments on the Draft Environmental Statement (DES) for the Palo Verde Nuclear Generating Station, Units 1,2 and 3, Docket Nos. STN 50-528/529/530.

The proposed plan does not conflict with existing or authorized plans of the Corps of Engineers. We have no comments on the DES.

Thank you for the opportunity to review and comment on this document.

Sincerely,

Robert T. Hall
for NORMAN ARNO
Chief, Engineering Division

M009
s
1/0

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Food and Drug Administration
Rockville MD 20857

DEC 7 1981

RECEIVED JAN 6 1982 US NUCLEAR REGULATORY COMMISSION DOCUMENT MANAGEMENT BR TIDC

Ms. Janis Kerrigan
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Ms. Kerrigan:

The Bureau of Radiological Health staff have reviewed the Draft Environmental Statement (DES) for the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, NUREG-0777, dated October 1981.

In reviewing the DES, we note that (1) the application for a construction permit is dated July 1974, (2) the NRC staff evaluation was issued as a Final Environmental Statement - Construction Phase in September 1975, (3) DHHS comments were provided on the Draft DES - Construction Phase (Appendix A-110, page A-27) June 10, 1975, prior to issuance of the construction permit in May 1976, and (4) as of July 1981, the construction of Unit 1 was about 90 percent complete, Unit 2 was about 65 percent complete, and Unit 3 was about 24 percent complete. The Bureau of Radiological Health staff have reevaluated the public health and safety impacts associated with the proposed operation of the plant and have the following comments to offer:

1. It appears that the dose-design objectives of 10 CFR 50, Appendix I, the operating standards of EPA's 40 CFR 190, and the applicant's radioactive waste management system for the PVNGS units provide adequate assurance that the potential individual and population radiation doses meet current radiation protection standards. It is recognized that there are no liquid effluents, consequently the doses presented in the DES are from the radionuclides expected to be released annually to unrestricted areas in only the gaseous effluents from normal reactor operations.

2. The environmental pathways discussed in Section 5.9.1. and shown schematically in Figure 5.1 cover all emission air pathways that could impact on the population in the environs of the facility. The dose computational methodology and models (Appendix C and D) used in the estimation of radiation doses to individuals near the plant and populations within 80 km of the plant have provided the means to calculate a reasonable estimate of the doses resulting from normal operations and accident situations at the facility. Results of these calculations are shown in Appendix C, Tables C-4, C-5 and C-6, and confirm that the calculated doses meet the design objectives.

C002
S1/0

8201070069 811207
PDR ADOCK 05000528
D PDR

3. The discussion in Section 5.9.2 on postulated accidents is considered to be an adequate assessment of the radiation dose pathways and dose and health impact (Table 5.12) of atmospheric releases. Under normal operation, there is no release of radioactivity to ground water. However, there is a potential for the accidental release of radioactive material into the hydrosphere through contact with ground water. This pathway could lead to population exposure from inhalation or ingestion of contaminated food or water. Even though this event is unlikely, the emergency plan should include provisions for expanding the ground water monitoring program to be prepared for such an accidental release. In particular, the sample collection points should be in the expected pathway and sample analyses should be specific for the radionuclides that are likely to be released. DHHS 3a

Section 5.9.2.4(3) states that the emergency preparedness plan including protective action measures for the Palo Verde facility and environs is in an advanced, but not yet fully developed stage. We will forego further comments on emergency plans, realizing that the process of granting an operating license to the facility will include an adequate review of emergency preparedness (FEMA-NRC Memorandum of Understanding, Regional RAC's, criteria in NUREG-0654). We have representation on the RAC's whose evaluation of the emergency planning relevant to Palo Verde will speak for this agency. DHHS 3b

4. The radiological monitoring program, as presented in Section 5.9.1.4 and summarized in Table 5.8, appears to provide an adequate sampling frequency in the expected critical exposure pathways. The analyses for specific radionuclides are considered sufficiently inclusive to (1) measure the extent of emissions from the plant, and (2) verify that such emissions meet applicable radiation protection standards. DHHS 4a

In view of some of the monitoring problems during the Three Mile Island-2 accident, we suggest the plan be modified to include a section that addresses the problems of monitoring radiohalogens (especially radioiodines) in the presence of radionoble gases. This could be accomplished by reference to FEMA-REP-2, a document on instrumentation systems prepared with considerable input from NRC. DHHS 4b

5. Section 5.10 and Appendix G of this DES contains a description of the environmental impact of the Uranium Fuel Cycle. The environmental effects presented are a reasonable assessment of the population dose commitment and the health effects associated with releases of radon-222 from the uranium fuel cycle. DHHS 5

Thank you for the opportunity to review and comment on this draft document.

Sincerely yours,

John C. Villforth
Director
Bureau of Radiological Health

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 81/2299

RECEIVED JAN 25 1982

JAN 21 1982

Mr. Frank J. Miraglia
Chief, Licensing Branch No. 3
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

50-528

Dear Mr. Miraglia:

We have reviewed the draft environmental impact statement (OLS) for Palo Verde Nuclear Generating Station, Units 1, 2, and 3, Maricopa County, Arizona, and have the following comments.

DOI-1 Groundwater

The environmental report for the construction stage concluded that the Palo Verde Clay was a leaky aquitard (Environmental Report, p. 2.5-8, 2.5-10, 2.5-11). This conclusion was based on the positive head differential between the perched and the regional aquifer water levels and increasing concentrations in dissolved solids toward the centers of heavy withdrawal from the principal regional aquifer, the Lower Coarse-Grained Unit. This change is said to be the result of the variation in degree of recycling of the water as a result of the leakage through the discontinuous lenses of clayey silt, clayey sand, and silty sand of the Middle Fine-Grained Unit (Environmental Report, p. 2.5-30 through 2.5-44, 2.5-9); possibly also the greater difference in head between the aquifers within areas of greatest withdrawal could also hasten leakage. The Environmental Report (p. 2.5-8) also mentions that in the western part of the site the principal regional aquifer is under water-table conditions (that is, no effective confining layer is found). In accord with the foregoing circumstances, the statement's analysis of possible core-melt impacts on ground water should include an evaluation of effects of leakage from the Upper Alluvial Unit into the regional aquifer. It should also address plans for appropriate monitoring of the regional aquifer and remedial action in the event of need.

DOI-2 Ecology

This section states that "This portion of the Gila River, which is within the jurisdiction of the BLM, is presently undergoing an environmental assessment by Federal and State wildlife agencies." The area is actually under multiple jurisdiction. The U.S. Fish and Wildlife Service filed a final environmental impact statement for Clearing of Phreatophytic Vegetation from the Salt and Gila Rivers on Ninety-First Avenue to Gillespie Dam, Maricopa County, Arizona with the Environmental Protection Agency on January 5, 1982.

DOI-3 Reservation Lands

Due to the close proximity of this project to Indian reservations, the Bureau of Indian Affairs (BIA) would like to be kept advised of the proposed environmental monitoring programs outlined in Section 5 of the statement, as modified and approved by the staff, and implemented in the environmental protection plan that will be incorporated in the operating license for Palo Verde Nuclear Generating Station, Units 1, 2, and 3.

8201260184 820121
PDR ADOCK 05000528
D PDR

C002
S.1

Should evidence of irreversible environmental damage or adverse environmental effects be detected during the operating life of the station. It is advisable that you contact the BIA immediately concerning the proposed course of action to alleviate the problem as it affects reservation lands. DOI-3 (Cont'd)

We hope these comments will be helpful to you.

Sincerely,

Bruce Blanchard

Bruce Blanchard, Director
Environmental Project Review

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION NINE

ARIZONA
CALIFORNIA
NEVADA
HAWAII
GUAM
AMERICAN SAMOA

Two Embarcadero Center, Suite 530
San Francisco, California 94111

December 2, 1981

IN REPLY REFER TO
HEP-09

50-528

Mr. Frank J. Miraglia
Chief, Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Miraglia:

We have reviewed the draft environmental impact statement for the operation of the Palo Verde Nuclear Generating Station, Units 1, 2, and 3 in Maricopa County, Arizona, and provide the following comment.

1. Section 5.8.4 on page 5-14 mentions an upgraded highway system from the Phoenix area. This discussion needs to indicate whether this is a reference to the existing highway system or a new highway facility.

2. The EIS text on pages 5-38 and 39 needs to state whether the highway system has been evaluated for its adequacy in accommodating an emergency evacuation of the area. If so, the evaluation results need to be provided; if not, then an evaluation should be conducted and presented in the EIS.

We appreciated this opportunity to review the subject draft EIS and would like to receive a copy of the final statement when it becomes available.

Sincerely yours,

Willis Kisselburg, Jr.

Willis Kisselburg, Jr.
Director, Office of Right-of-Way

DEC 7 1981
U.S. NUCLEAR REGULATORY COMMISSION

C002
s
1/0

8112080266 811202
PDR ADOCK 05000528

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, Ca. 94105

January 12, 1982

JAN 15 1982

Mr. Frank J. Miraglia, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20055

Dear Mr. Mi aglia:

The Environmental Protection Agency (EPA) has received and reviewed the Draft Environmental Impact Statement (DEIS) titled THE OPERATION OF PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, and 3.

The enclosed comments discuss specific areas of concern which our review has shown to be inadequately addressed in the DEIS. These issues include the EPA's standards for radiation levels, emergency response planning, and other factors which warrant further discussic . In addition, our comments address potential seepage from evaporation ponds holding cooling tower effluent.

We appreciate the opportunity to review and comment on the operational phase of Palo Verde Nuclear Generating Station, Units 1, 2, and 3. If you have any questions regarding our comments, or if further information is required, please contact Susan Sakaki, EIS Review Coordinator, at (415) 974-8137 or FTS 454-8137.

Cordially yours,

SONIA F. CROW
Regional Administrator

C002
B
1/1

8201180351 820112
PDR ADOCK 05000528
D PDR

Radiation Comments

1. The DEIS states on page 5-39 that "Emergency preparedness plans including protective action measures for the Palo Verde facility and environs are in an advanced but not yet fully completed stage." The draft plan has not been issued, and EPA is unaware of any activity beyond preliminary planning. Thus, there is no evidence that the critical issues of public safety have yet been addressed, including establishment of planning zones and protective action guides, as well as design of the information network. The EPA assumes that the State of Arizona will have a plan in place by the time Palo Verde Nuclear Generating Station (PVNGS) is scheduled to be ready for operation. The statement, however, as presented in the DEIS, is misleading and should be corrected.

2. Although the radioactive-waste-management systems may be designed to comply with 10 CFR 50.34(a) (Domestic Licensing of Production and Utilization Facilities), we find no statement indicating that 40 CFR 190 (Uranium Fuel Cycle Standard) will be enforced. A statement to this effect should be included in the Final Environmental Impact Statement (FEIS).

EPA-3a

3. The staff's intent in the discussion presented in Section 5 (5.9 Radiological Impacts) is not clear. The discussion of 10 CFR 20 (Radiation Protection Standards) does not apply to the operation of a nuclear power reactor. In fact, the 100 mrem exposure in any 7 consecutive days (page 5-16) would exceed the allowable annual exposure of 25 mrem to the whole body or to any organ, as indicated by 40 CFR 190.

EPA-3b

Further, we recognize that the DEIS incorporates some updated material previously published in 1975 as part of the EIS for the Construction Phase of Palo Verde, Units 1, 2, and 3. Statements regarding doses still require updating (page 5-18). Regulations establishing the Uranium Fuel Cycle Standard (40 CFR 190) have been issued since the previous document was published. "Radioisotopes in the station's effluents that enter restricted areas will produce doses to members of the general public through their radiation at levels similar to the doses from background radiations (cosmic, terrestrial, and internal radiations)," does not appear to reflect the fact that an operating reactor produces doses equivalent to a very small percentage of the natural background. This statement should be clarified.

4. The DEIS uses a dose commitment period of 50 years. This should be changed to reflect a period of 70 years, as used by the EPA mortality-morbidity studies, which more closely matches the population's life expectancy.

5. The occupational dose indicated in the DEIS (pages 5-21) and expressed in 10 CFR 20 is not necessarily satisfactory. The EPA estimates for the year 1975 indicate 130,000 person-rems and 26 premature deaths based on 200 fatal cancers per 1,000,000 person-rems. Thus the fatality incidence rates (now 23) as indicated in Table 5.6 would become 37.

6. Recent findings by the Nuclear Regulatory Commission (NRC) (docket 50-2-6 October 16, 1981) would seem to contradict the statement contained in the DEIS regarding direct radiation for Pressurized Water Reactors (PWR's) (page 5-22). The DEIS indicates that there is virtually no increase in background radiation. It is our understanding that during the operation of San Onofre the exposure adjacent to the reactor is of such a magnitude that would prevent an exposure of 12 microrem per hour from being detected. We note that an increase of 3 microrem per hour for one year is approximately 25 mrem.

7. The DEIS mentions the airborne emissions of krypton (page 5-24) and discusses 40 CFR 190 (page 5-26); however, there is no discussion provided regarding the NRC's responsibilities for limiting the krypton-85 releases to less than 50,000 curies by January 1, 1983. The FEIS should address the need for any controls at Palo Verde to ensure that the krypton standard is not exceeded.

8. The meaning of "D/Q", contained in Table 5.8 should be indicated.

9. The graphics used on page 5-50 should be revised to make the table more readable.

10. The DEIS states on page 5-37, "If normal offsite power is maintained, the ability of the plant to send contaminated steam to the condenser instead of releasing it through the safety valves or atmospheric dump valves can significantly reduce the amount of radioactivity released to the environment." It is not clear why this safety feature cannot be ensured by the use of on-site auxiliary power. The FEIS should clarify this issue.

11. The DEIS indicates that 0.08 Ci/years per unit of iodine-131 will be released (Table C-1, page C-4). The EPA questions whether these calculations represent the PVNGS because of the use of the unique cooling system at the facility and the potential for a site emission of iodine-131 resulting from the use of the sewage effluent. The EPA commented on this issue during the facility construction phase and it would appear that our concerns still have not been addressed. At present, the site could have 240 mCi/year of I-131 released. If an additional 57 mCi/year resulted from the use of sewage effluent, it would represent a significant increase. The ALARA impact of this increase should be addressed in the FEIS.

12. The DEIS does not address the problems related to waste disposal. It is indicated that approximately 1600 curies of solid waste will be shipped off-site annually to a licensed burial site. At this time it is not clear whether the State of Arizona will enter into an interstate compact or provide an approved disposal site. Therefore, the FEIS should address the effect of this material on annual exposures if it cannot be shipped off-site.

Water Quality Comments

EPA-13

The DEIS does not adequately address the potential impacts to groundwater which may result from the evaporation ponds which will hold cooling tower effluent. The DEIS states that "very little water will seep through the evaporation pond liner" (p. 5-5, 5.3.2.1). The Final Environmental Impact Statement (FEIS) should provide documentation to support this statement. In addition to determining seepage volumes from the evaporation ponds, the FEIS should evaluate any impacts to groundwater which may result.