2.1 - General

The Environmental Report should provide the AEC with a general understanding of the ways in which the plant will interact with the environment. A basic knowledge of the existing environment at the proposed location and of the important characteristics and values of the site as it presently exists is necessary to establish a basis for consideration of the environmental impact of the proposed facility. The need for the plant to fulfill power needs in the affected region should also be discussed.

The Washington Public Power System proposes to build Hanford No. 2 on a site leased from the Atomic Energy Commission within the Hanford Reservation in the eastern part of the State of Washington.

Hanford No. 2 consists of a single cycle, forced circulation, boiling water reactor as the steam supply system for a turbine-generator unit with a nominal net electrical output of 1100 megawatts. Heat dissipation from the turbine condensers is provided by an evaporative cooling tower system. Water additions to make up for evaporation losses and blowdown will come from the Columbia River. Radioactive material generated by the reactor will leave the Site almost exclusively either as irradiated fuel elements or as packaged solid wastes. The design objective for both the liquid and gaseous discharges from the plant will be such that 1 the resultant offsite dose does not exceed one percent of 10CFR20 or the proposed limits of 10CFR50 Appendix I during normal operations.

The Site for Hanford No. 2 is a barren desert in a sparsely populated region. The Hanford Reservation has served as a nuclear center since 1943. During this period, comprehensive experience and data concerning environmental and ecological factors in the vicinity of the Site were acquired by the AEC and its contractors and are available to the Supply System. This extensive compilation of baseline information was one of the dominant criteria in the decision to select the Hanford Reservation for the location of Hanford No. 2.

In order to meet forecasted peak and energy requirements of
the Pacific Northwest Hanford No. 2 is scheduled for commercial
operation by September 1977. Hanford No. 2 was advanced from the
1 original schedule when voters of Eugene, Oregon, delayed the nuclear
power plant being planned by the Eugene Water and Electric Board.
Delay in completing Hanford No. 2 beyond fiscal year 1978 could have
a major adverse economic impact on the region in that a net deficit
in peaking capability of 1,748,000 kilowatts and a deficiency of
energy capability amounting to 1,150,000 average kilowatts in that
3 year could be encountered (see Table 2.1.4-2 and Reference 2 in
Section 2.1).

This discussion is treated in greater detail in the following four subsections.

2.1.4 - <u>*Electric Power Supply and Demand*</u>

The specific power needs which this project would meet should be discussed in relation to the present and proposed capacity of the applicant's system and the relationship of the electrical capacity of the proposed facility to the prospective power supply and demand situation of the system, pool, or region involved at the scheduled in-service date of the project. The report also should include a discussion of the consequences of delays in the proposed project. Other alternatives to the project for supplying power should be treated fully under Section 2.5. 3

Hanford No. 2 will be constructed and operated by the Supply System in accordance with an agreement between the Supply System and the Bonneville Power Administration. The Project capability will be purchased under "Net Billing Agreements" between the Supply System, Bonneville and 95 statutory preference customers of Bonneville. Under the Net Billing Agreements, each Participant will assign its share of the Project capability to Bonneville. Payments by the Participants to the Supply System will be credited against the billings made by Bonneville to the Participants for power and certain services. The output of the Project will be added to the other power resources of Bonneville.

The major part of the power supply for the Pacific Northwest has traditionally been from hydroelectric generating resources. The remaining hydro developments in the Pacific Northwest will be peaking generation installations and the area must turn to thermal generation for its base load resources in the immediate future. The combination of hydro peaking and large scale thermal generating plants was found by the Joint Power Planning Council to be the most economic means of producing power to meet the area's anticipate load growth.

To meet expanding electric needs in the Northwest requires 1) an increase in peaking generation, 2) an expansion of power plants to provide baseload energy, and 3) an increase in the capacity of transmission lines to carry power from generation sources to load
3 centers. To meet these requirements optimally, four Northwest private utilities, 104 publicly owned agencies, and BPA, acting in concert as the Joint Power Planning Council, conceived the Hydro-Thermal Power Program. This program has been endorsed by the current and previous Administrations and by the Congress.

The Joint Power Planning Council coordinates the planning of existing and future thermal and hydro resources in the Pacific Northwest.

The utility members of the Joint Power Planning Council have concluded that the "Hydro-Thermal Program" will:

1. Best preserve the environment and natural beauties of the Pacific Northwest.

2. Make efficient and economic use of the Federal Regional Transmission System.

3. Obtain the economies of scale from large thermal generating plants.

4. Coordinate the required large thermal generating plants with existing Pacific Northwest Hydro, both Federal and non-Federal, and the future peaking generation units which will be installed at existing dams, to achieve the most economic and reliable power supply to meet the electric power requirements of the Pacific Northwest.

The first large-scale steam electric generating plant constructed in the Pacific Northwest was the 860,000 kilowatt Hanford No. 1 of the Supply System which was placed in commercial operation on

2.2 - *Environmental Approvals and Consultation*

The Environmental Report should include a listing of all relevant licenses, permits, or other approvals required; the status thereof; and copies of all such documents, if issued, should be appended to the Report.

A discussion of relevant licenses, permits, and other approvals which will be required for Hanford No. 2 and the status of efforts directed toward obtaining such approvals is presented in the following two subsections. Appended hereto as Exhibit II is a copy of the State of Washington legislation pertinent to siting of thermal power plants.

3. There were no losses in preparation of the fish (cooling or long-term freezer storage).

4. An individual consumes as much as 20 kg of fish per year (Reference 18).

5. The total edible weight of sport fish harvested from the Columbia River between the Ringold area and Boardman, Oregon, is not over 1.5×10^4 kg/yr (Reference 18).

Based on the above assumptions, the dose to the individual fisherman would be 8×10^{-4} mrem/yr to his total body. Integrated dose to the population would be 2×10^{-6} man-rem/yr from fish consumption.

Aquatic recreation is a popular pastime in the stretch of the Columbia River below the plant site. Swimming, boating, water skiing and picnicing along the shore or on islands could result in small incremental doses to the local population (Reference 19). Assuming 2
an individual spent 100 hr/yr swimming, 100 hr/yr water skiing or boating, and 500 hr/yr along the shoreline, all near the plant site his total body dose from external exposure would total only 5×10^{-4} mrem/yr.

This dose and others potentially received by such an ardent water sports fan are summarized in Table 2.3.7.3-8.

The population dose received during water recreation activities can be estimated on the basis of the following assumptions.

1. Hours spent in various water sports are those given by Honstead (Reference 19), viz.

10 hrs/yr swimming (immersion)

5 hrs/yr boating and water skiing (surface)

17 hrs/yr on rivershore

2. The population within 50 miles of the Site in the sectors between the NNE and the SW directions, inclusive, are the persons who travel to the Columbia River for their aquatic recreation. This population totaled approximately 120,000 persons in 1970.
3. The dilution offered by the Snake River below Pasco, and the decay during river travel time to southwest Benton County can be ignored. The majority (over 50%) of the exposed population resides in the vicinity of the Tri-Cities (Pasco, Kennewick, and Richland).

Under these conservative assumptions, the integrated population dose from water sports would be 6×10^{-6} man-rem/yr, principally from exposure to the contaminated shoreline.

2 Gaseous Effluents

The gaseous effluent of primary importance for this plant is from the main turbine condenser exhaust system. This off-gas system employs a recombiner-charcoal concept with an assumed input source term of 100,000 μCi/second of a diffusion type mixture of noble gases (after 30 minute decay). The design of this system provides for a decay period sufficient to reduce the expected annual average emission rate to less than 49-59 μCi/second.

In addition to the above release rate of less than 49-59 μCi/second, the following assumptions and associated values were used in defining the environmental effects from this event.

1. Ground level release
2. Meteorology data collected at the Hanford Meteorological Station from January 1955 to July 1961. (Table 2.3.7.3-2 to 7)

3. Population Density to 50 miles for the year 1970. (See Figure 2.3.1.1-4)

The basic mathematical model used to calculate the doses from air submersion is given in the equations that follow.

$$(D)_{x,\theta,d} \doteq 8766 \sum_{I=1}^{n} \overline{\chi}_I \, (DF)_I \qquad (1)$$

Where

$(D)_{x,\theta,d}$ = The annual dose to total body (or skin) of a person located at a point x meters from the source in a direction d, averaged over a sector width of θ radians.

8766 = hours per year

$(DF)_I$ = Dose factor for isotope (I) in units of mrem/hr per pCi/m^3 based on a half-infinite cloud geometry and corrected for the fractional penetration of beta and gamma radiations to the appropriate tissue depth (7×10^{-3} cm for skin and 5 cm for total body). (Reference 22) 2

$$\overline{\chi}_I = \sum_{J=1}^{4} \left(\frac{2}{\pi}\right)^{1/2} \frac{0.01\, f_J\, 10^{12}\, Q'_J}{(\sigma_Z\, \bar{u})_J\, (\theta x)} \left[\exp\left(-\frac{h^2}{2(\sigma_Z)^2_J}\right)\right] \left[\exp\left(-\frac{\lambda_I\, x}{\bar{u}}\right)\right] \qquad (2)$$

Where

χ_I = Annual average concentration (pCi/m^3) of isotope (I) at point (x,θ,d). (Reference 23, pp. 113)

f_J = Percent of time wind blows in direction d under meteorological conditions J.

10^{12} = picocuries per curie

Q'_J = Release rate of Isotope (I) in curies per second

θ = Sector width in radians = $(2\pi/n)$ where (n) is the number of sectors

x = Downwind distance in meters

$\bar{u}_J$ = Average wind speed for meteorological condition (J) in meters per second.

$\frac{x}{\bar{u}_J}$ = Travel time of released material to point (x,θ,d) under meteorological conditions (J) in seconds.

λ_I = Radioactive decay constant for isotope (I).

h = Height of release in meters

2 $(\sigma_Z)_J$ = Standard deviation of vertical dispersion under meteorological condition (J) is calculated from equations given on pp. 141 and 405 of Reference 23.

Equation (1) yields the yearly off-site dose to a person located at point (x,θ,d). The man-rem/yr is determined by multiplying the result of equation (1) by the population density located within the sector of concern. Values of the dose at the point (x,θ,d) are assumed to be applicable to all individuals located in that sector from a distance of $X-\Delta X$ to $X+\Delta X$. The cumulative man-rem for any radial distance presented in Table 2.3.7.3-9 is determined by summing the dose contributions from all sectors for the additional radial distance and adding this to the previous radial man-rem exposures.

Under normal operation a minor contribution to dose at the plant boundary is from direct radiation from the turbine and associated equipment. Other potential contributors are the reactor building,
1 radwaste building, storage tanks, and the off-gas vent.

Dose rate conputations show the direct and scattered shine are

TABLE 2.3.7.3-7

PERCENTAGE FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION AT 200-FOOT LEVEL VS ATMOSPHERIC STABILITY (JANUARY 1955 THROUGH JULY 1961)

ANNUAL

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VAR.	CALM	TOTAL
0 - 3	VS	0.16	0.20	0.14	0.22	0.24	0.41	0.21	0.24	0.20	0.25	0.24	0.46	0.38	0.53	0.41	0.37	0.15	0.56	5.37
	MS	0.19	0.25	0.19	0.22	0.44	0.48	0.22	0.22	0.13	0.17	0.16	0.23	0.29	0.40	0.37	0.41	0.12	0.67	5.17
	N	0.27	0.38	0.28	0.36	0.40	0.47	0.22	0.18	0.13	0.14	0.12	0.23	0.22	0.44	0.50	0.50	0.15	0.50	5.47
	U	0.38	0.65	0.40	0.45	0.36	0.26	0.11	0.22	0.12	0.18	0.10	0.14	0.16	0.30	0.40	0.64	0.49	0.02	5.38
4 - 7	VS	0.18	0.19	0.11	0.15	0.16	0.31	0.22	0.22	0.21	0.35	0.44	0.93	1.03	1.04	0.65	0.35	0.02	0.	6.57
	MS	0.16	0.12	0.12	0.16	0.22	0.40	0.22	0.18	0.18	0.22	0.26	0.46	0.58	0.81	0.49	0.33	0.01	0.	4.92
	N	0.10	0.13	0.10	0.10	0.15	0.25	0.13	0.11	0.07	0.10	0.12	0.18	0.30	0.66	0.31	0.16	0.02	0.	2.98
	U	0.70	0.77	0.43	0.50	0.43	0.56	0.35	0.47	0.46	0.49	0.38	0.39	0.42	1.09	0.97	1.20	0.28	0.	9.88
8 - 12	VS	0.12	0.10	0.08	0.09	0.05	0.14	0.20	0.10	0.11	0.23	0.55	1.07	1.80	1.88	0.55	0.20	0.	0.	7.28
	MS	0.11	0.09	0.02	0.07	0.07	0.19	0.19	0.15	0.21	0.33	0.48	0.90	1.62	1.89	0.35	0.16	0.	0.	6.84
	N	0.06	0.05	0.03	0.03	0.03	0.06	0.06	0.05	0.06	0.08	0.12	0.12	0.36	0.87	0.17	0.09	0.	0.	2.26
	U	0.47	0.35	0.11	0.06	0.07	0.09	0.10	0.12	0.28	0.	0.54	0.33	0.49	1.33	0.47	0.49	0.00	0.	5.91
13 - 18	VS	0.04	0.03	0.02	0.02	0.	0.05	0.08	0.02	0.03	0.11	0.25	0.41	1.05	1.64	0.22	0.07	0.	0.	4.04
	MS	0.08	0.03	0.02	0.01	0.02	0.09	0.13	0.14	0.26	0.60	0.84	1.07	2.81	2.71	0.18	0.12	0.	0.	9.10
	N	0.06	0.01	0.01	0.01	0.00	0.03	0.03	0.05	0.07	0.15	0.20	0.14	0.28	0.51	0.07	0.04	0.	0.	1.66
	U	0.25	0.15	0.04	0.00	0.00	0.03	0.03	0.04	0.19	0.53	0.64	0.26	0.59	1.00	0.10	0.12	0.	0.	3.97
19 - 24	VS	0.	0.	0.00	0.01	0.	0.01	0.01	0.00	0.01	0.02	0.03	0.03	0.04	0.20	0.00	0.00	0.	0.	0.37
	MS	0.03	0.03	0.01	0.00	0.00	0.02	0.07	0.09	0.23	0.56	0.50	0.35	1.37	1.69	0.04	0.01	0.	0.	5.00
	N	0.01	0.02	0.	0.00	0.00	0.01	0.01	0.02	0.07	0.12	0.14	0.05	0.18	0.30	0.01	0.01	0.	0.	0.96
	U	0.06	0.05	0.01	0.00	0.	0.00	0.01	0.01	0.10	0.30	0.44	0.11	0.26	0.60	0.01	0.03	0.	0.	2.00
Over 24	VS	0.	0.00	0.	0.	0.	0.00	0.00	0.01	0.01	0.01	0.01	0.	0.00	0.	0.	0.	0.	0.	0.04
	MS	0.00	0.00	0.	0.	0.	0.01	0.02	0.08	0.33	0.60	0.24	0.08	0.48	0.84	0.01	0.00	0.	0.	2.70
	N	0.00	0.00	0.	0.	0.	0.	0.00	0.02	0.06	0.15	0.07	0.02	0.10	0.27	0.00	0.01	0.	0.	0.71
	U	0.01	0.01	0.	0.	0.	0.	0.	0.01	0.07	0.37	0.27	0.08	0.11	0.48	0.01	0.00	0.	0.	1.41
Totals	VS	0.50	0.52	0.35	0.48	0.45	0.91	0.73	0.59	0.58	0.97	1.52	2.90	4.30	5.29	1.83	0.99	0.17	0.56	23.67
	MS	0.57	0.52	0.36	0.46	0.75	1.19	0.85	0.87	1.35	2.48	2.49	3.09	7.15	8.34	1.45	1.03	0.14	0.67	33.74
	N	0.50	0.59	0.41	0.49	0.59	0.82	0.46	0.43	0.46	0.73	0.77	0.75	1.45	3.06	1.07	0.81	0.17	0.50	14.04
	U	1.85	1.97	0.99	1.02	0.86	0.95	0.61	0.87	1.22	2.47	2.37	1.32	2.02	4.80	1.96	2.48	0.77	0.02	28.55

TABLE 2.3.7.3-8

PROBABLE MAXIMUM DOSE TO AN INDIVIDUAL FROM THE EFFLUENTS RELEASED

AT THE HANFORD NO. 2 NUCLEAR PLANT (mrem/yr)*

Pathway	Annual Exposure	Skin	Total Body	GI Tract	Thyroid	Bone
Air Submersion	8766 hr	1.2×10^{-2}	4×10^{-3}	(4×10^{-3})	(4×10^{-3})	(4×10^{-3})
Drinking Water	438 liters	---	4×10^{-5}	2×10^{-5}	5×10^{-5}	1×10^{-7}
Fish	20 kg	---	8×10^{-4}	1.7×10^{-1}	1.5×10^{-2}	8×10^{-4}
Swimming	100 hr	7×10^{-5}	5×10^{-5}	5×10^{-5}	(5×10^{-5})	(5×10^{-5})
Boating	100 hr	3×10^{-5}	2×10^{-5}	(2×10^{-5})	(2×10^{-5})	(2×10^{-5})
Shoreline Silt	500 hr	5×10^{-4}	4×10^{-4}	(4×10^{-4})	(4×10^{-4})	(4×10^{-4})
Total		0.013	0.005	0.17	0.020	0.005

* Assuming releases listed in Tables 2.3.7.2-1 and 2.3.7.2-2.

TABLE 2.3.7.3-9

INTEGRATED POPULATION TOTAL BODY DOSE FROM SUBMERSION IN AIR CONTAINING RADIONUCLIDES RELEASED FROM THE HANFORD NO. 2 NUCLEAR PLANT

Radial Distance (Miles)	Cumulative Total Body Dose Man-Rem/yr	Cumulative Population-1970	Average Dose Rate mrem/yr per person
4	0	0	0
5	3.2×10^{-5}	20	1.6×10^{-3}
10	3.3×10^{-4}	484	6.9×10^{-4}
20	6.8×10^{-3}	50,268	1.4×10^{-4}
30	1.1×10^{-2}	92,155	1.2×10^{-4}
40	1.1×10^{-2}	121,751	9.3×10^{-5}
50	1.2×10^{-2}	179,592	6.8×10^{-5}

2

yet even in the unlikely event that one of them <u>did</u> occur, the effect on the population would be negligible. 1

From a radiological viewpoint, the nuclear power plant is indeed a good neighbor, one that has a negligible impact on the environment. As indicated earlier, the national average natural background is about 140 mrem/yr, with 100 mrem/yr from the various sources listed in Table 2.3.7.5-1, and the remaining 40 mrem/yr contribution from exposure to building materials. Applying this exposure rate for the 179,600 people residing within 50 miles of 2
the plant in 1970, the calculated integrated population dose from natural background is 25,140 man-rem/yr. In contrast to this dose, the total integrated dose from the liquid and gaseous effluents released from the plant will be only 1.3×10^{-2} man-rem/yr to these same 179,600 people.

TABLE 2.3.7.5-1

DOSE RATES DUE TO EXTERNAL AND INTERNAL IRRADIATION FROM NATURAL SOURCES IN NORMAL AREAS
(Reference 21)

Source	Dose Rates (mrad/yr)*
External Irradiation	
Cosmic rays at sea level	0
Ionizing component	28
Neutrons	0.7
Terrestrial radiation	50
2 Cosmic rays at 20,000 feet	1500
Internal Irradiation	
Potassium-40	20
Rubidium-87	0.3
Carbon-14	1
Radium-226, -228	1
Hydrogen-3 (Tritium)	2
Average total dose to body	100

* Rad is an acronym for radiation absorbed dose. It is the basic unit of absorbed dose of ionizing radiation. A dose of 1 rad means the absorption of 100 ergs of radiation energy per gram of absorbing material. 1 millirad = 0.001 rad. (A roentgen of gamma rays will deposit almost 1 rad in tissue.)

2.5.5 - Alternative Radwaste Systems

The radioactive waste treatment systems are designed to process and dispose of wastes generated during power operation. These radioactive wastes can be either liquid, solid or gaseous. The normal offgas discharge rate will be such that the off-site dose does not exceed one percent of 10CFR20. As much of the water processed through the liquid radwaste system will be retained in the plant as is possible. Occasionally surplus processed water will be discharged from the plant with the blowdown from the cooling towers. The environmental radiation dose due to radioactive material in this discharge will be less than one percent of 10CFR20 limits during normal operation. The overall exposure due to release of radioactivity in both the liquid and gaseous discharges is as low as practicable, as pro- 1
posed in the guidelines of 10CFR50 Appendix I. Radioactive discharges during accident conditions are limited to those permitted by 10CFR100. Solid wastes are packaged in 55 gallon drums or other suitable containers for off-site shipment and disposal.

2.5.5.1 - Present Gaseous Radwaste System

The system being provided for treatment of the gases that are formed inside the fuel elements and in the cooling medium during reactor operation include a building vented release, 30-minute holdup piping, catalytic recombiner and eight low temperature (0°F) charcoal bed adsorbers, as discussed in Subsection 2.3.7. These gases, some of which are radioactive, are carried in a direct cycle boiling water reactor with the steam from the reactor through the turbine into the condenser.

The gases mix with inleaking air in the condensers and this gas-air mixture is continuously removed from the condensers by the air ejector offgas system to maintain vacuum. In this way, radioactive gases are removed continuously from the reactor coolant system. A high temperature catalytic recombiner is used to recombine radiolytically dissociated hydrogen and oxygen from the air ejector system. After chilling to strip the noncondensibles, a period of decay is provided to reduce the radioactivity content of the gas-air mixture prior to reaching the adsorption bed. This decay period is provided by a long length of large diameter pipe.

The charcoal adsorption bed, operating in a constant-temperature vault, will selectively adsorb and delay iodine, xenon and krypton from the bulk carrier gas (principally air). This delay on the charcoal permits essentially all of these gases to decay in place before being released.

A. Alternative Treatment of Gaseous Radwaste

There are several alternative ways to reduce radioactive gaseous
1 discharges from the Hanford No. 2 plant. The estimated releases with various alternative systems were considered and the resultant doses compared with the proposed Appendix I to 10CFR50. This Appendix provides numerical guidance for keeping radioactive effluents to unrestricted areas as low as practicable. A summary description of each alternative system considered and its environmental impact is discussed below. The incremental costs for these various sytems are given in Section 3.1.

No Gaseous Radwaste System

The first alternative system assumes no expenditure to remove radioactivity from the gaseous releases. Based on a General Electric "design basis" fuel leak rate, a total of 75 million curies would be released from the plant each year. This would result in a Site boundary dose of 40,000 mrem/year.

Elevated Release

With the addition of an elevated release this 75 million curies would result in a dose at the Site boundary of 7,000 mrem/year.

30-Minute Holdup Piping Alone

The short-lived radioactive isotopes contained in the gas-air mixture removed from the condensers by the air ejector offgas system will, with sufficient holdup time, decay to very low activity levels prior to being released through the building vent. The holdup piping consists of a long length of pipe which physically provides a length of time for the radioactive fission products to decay before being released to the environment. The gaseous release from the plant would be 3 x 10^6 curies/year and the dose at the Site boundary would 1,200 mrem/year when only the 30-minute holdup piping is provided. This system is shown in Figure 2.5.5.1-1.

Catalytic Recombiners 1

Addition of hydrogen recombiners upstream of the 30-minute holdup piping effectively increases the time for decay of short-lived isotopes by recombining the radiolytic hydrogen and oxygen into water using a catalyst bed. Removal of this radiolytic hydrogen and oxygen reduces the gas volume in the offgas system by about 90 percent, which makes any subsequent holdup system more effective. A factor of approximately six in dose reduction to an individual at the Site boundary is achieved by the addition of hydrogen recombiners.

The hydrogen recombiner system would be installed downstream of the condenser offgas ejector and would exhaust to the holdup pipe. This system is shown schematically in Figure 2.5.5.1-2. This system has been used in similar application at other nuclear plants and is of proven design. However, the resultant off-site dose for design fuel failure conditions would still not meet 10CFR50 Appendix I for this plant.

Charcoal Adsorber System

The hydrogen recombiner system can be augmented by the installation of charcoal adsorbers. The charcoal adsorber system would be installed at the downstream end of the 30-minute holdup pipe and would consist of filters, cooler-condensers, moisture separators, preheaters, and vessels containing the charcoal adsorber material. This system is shown schematically in Figure 2.5.5.1-3.

The charcoal adsorber system increases the effective holdup time for xenon and krypton and thus further reduces the amount of radioactivity which is released from the building vent. Hanford No. 2 studies indicate that the addition of eight charcoal beds (operated at 77°F) to the hydrogen recombiner system would result in a
1 Site boundary dose of 23 mrem/year, and sixteen beds operated at 77°F would result in a Site boundary dose of 1.7 mrem/year.

Charcoal beds have been used in similar applications for nuclear power plants and in other plants in the nuclear industry. Their design performance and reliability have been demonstrated for the type of service that would be required at Hanford No. 2. The following items represent a summary of advantages for the charcoal adsorption system:

i) demonstrated performance on other reactors
ii) delay of short-lived isotopes until activity is minimal
iii) delay of xenon and krypton for long periods
iv) cleans gas by filtration

v) adsorbed gas is released slowly in event of system failure

vi) passive system

Low-Temperature Charcoal Adsorber System

This is the system selected by the Supply System for Hanford No. 2. It incorporates the most desirable features to minimize the off-site dose by increasing the holdup time using refrigeration of eight charcoal beds to about 0°F. Because the adsorption process is a function of temperature, the holdup time is increased on the charcoal beds allowing the xenon and krypton more decay time. The off-site dose is reduced to approximately 0.006 mrem/year for this system.

Absorption by Solvent (ORGDP)

This alternative system removes krypton and xenon from a gas stream by selective absorption in a fluorocarbon solvent. Its main features, when compared to the charcoal adsorption system are:

i) compactness

ii) efficiency better than 99.9 percent for removal of noble gas radioisotopes (which is comparable to a low temperature 1 charcoal system)

The performance and reliability of this type system has not been proven nor applied to nuclear plant service. The only experience to date with the absorption by solvent system has been with bench and pilot plant size systems.

Cryogenic Distillation

This system works by liquifying radioactive gases at low temperatures and storing them while their radioactivity decays. It would be installed downstream of the 30-minute holdup pipe. This scheme is shown schematically in Figure 2.5.5.1-4. Its main features, when compared to the charcoal adsorption system, are:

i) high radioactivity reduction factors achievable (>1000) which is comparable to the low temperature charcoal system

ii) system relatively insensitive to flow change.

Cryogenic systems for producing industrial oxygen were developed 30 to 40 years ago. The application of a cryogenic system to a nuclear plant could have performance problems unrelated to those encountered in other industries.

While the future potential of the cryogenic system may offer advantages, it has not been used for the treatment of radioactive gaseous wastes in large commercial nuclear power plants. As compared to charcoal adsorption systems, the cryogenic system is a rather complicated mechanical system utilizing pumps, compressors, refriger-
1 ation systems, piping, and tanks. The Supply System has concluded that, because of the lack of proven reliability with this type of equipment in this type of service and the complex mechanical systems utilized, the reliability of the cryogenic system would not be as high as that of the charcoal adsorption system. The charcoal adsorption system is essentially a passive system and has been used in radioactive gas treatment for nuclear plants similar in design to Hanford No. 2.

Charcoal Beds with Cryogenic Tail

A combination system utilizing charcoal beds followed by a small cryogenic processing system is a possible alternate to the selected system, but the lack of nuclear industry experience with such a system led to its rejection. The new guides to "as low as practicable" can be met with the simpler and more reliable charcoal bed system alone, and in fact, the release from the low-temperature

Appendix I of 10CFR50. During normal operation the additional radiation doses received by people as a result of the presence of Hanford No. 2 plant is insignificant and there would be no perceptible effect on fish in the Columbia River.

There are also radioactive releases from coal-fired plants which depend on amount of heavy element impurities in the coal and the treatment of stack gases. The coal plant, however, would not have an internal inventory of radioisotopes approaching that of a nuclear plant.

Significant expenditures have been made for the Hanford No. 2 offgas system to remove radioactivity from the gaseous releases. Based on the General Electric design criteria, a total of 75 million curies would be released each year which would result in a dose at the Site boundary of 40,000 mrem/year, if design basis fuel failures were experienced and no money was spent for offgas treatment. With the addition of an elevated release, this 75 million curies would result in a dose at the Site boundary of 7,000 mrem/year. 1

Capital expenditures which the Supply System has made to reduce off-site doses are shown in Table 3.1.2.12-1. The addition of 30 minute holdup piping with the gas released at the building roof would reduce the release per year to 3 x 10^6 curies/year and the dose at Site boundary to 1,200 mrem/year. The addition of G.E. Offgas System at 77°F with eight charcoal beds, 30 minute holdup piping, and the gas released at the building roof would reduce the release rate to 94,000 curies/year and the dose at Site boundary to 23 mrem/year. The use of 16 charcoal beds at 77°F would reduce the release to 16,700 curies per year maximum (with about 4000 curies per year expected), with the dose at the Site boundary of 1.7 mrem per year. 2

TABLE 3.1.2.12-1

<u>Alternate Radwaste Systems</u>

	Item	Release/Year	Site Boundary Dose	Direct Cost*
	1. No Gaseous Radwaste System	75×10^6 curies/year	40,000 mrem/year	0
1	2. Elevated Release	75×10^6 curies/year	7,000 mrem/year	350,000
	3. 30-Minute Holdup Piping Released at Building Roof	3×10^6 curies/year	1,200 mrem/year	200,000
	4. With GE Offgas System 8 Charcoal Beds at 77°F 30-Minute Holdup Piping Released at Building Roof	94,000 curies/year	23 mrem/year	1,560,000
	5. With GE Offgas System 16 Charcoal Beds at 77°F 30-Minute Holdup Piping Released at Building Roof	16,700 curies/year	1.7 mrem/year	1,720,000
2	6. With GE Offgas System 8 Charcoal Beds at 0°F 10-Minute Holdup Piping Released at Building Roof	1545-1860 curies/year	~0.004 mrem/year	1,850,000

* This is direct cost and does not include:

Contingencies and Escalation
1 Engineering and Construction Management
Owner's Direct Cost

The present design utilizes the G.E. Offgas System at 0°F with 8 charcoal beds and 10-minute holdup piping. Gas release at the building roof is reduced to 1545-1860 curies/year which reduces the whole body dose rate at "Site Boundary" to about 0.004 mrem/year.

The Supply System has spent $1,850,000 for the direct cost of equipment with installation on the Offgas System to reduce the off-site dose to 0.004 mrem/year as shown in Figure 3.1.2.12-1.

Liquid effluents may be occasionally discharged into the Columbia River with the blowdown from the Hanford No. 2 plant. Radiation doses to an individual drinking this water in the Tri-Cities, eating Columbia River fish, and participating in water sports immediately downstream of the Hanford No. 2 effluent discharge point were estimated to total only 0.001 mrem/year. These low doses are far below the guidelines of 5 mrem/year proposed in 10CFR50, Appendix I and the 140 mrem/year normally received by an average individual at sea level. In addition, the annual tritium concentration of 0.16 pCi/l is 5000 times less than the normal natural concentration of 800 pCi/l measured in the Columbia River during 1970. The Supply System has allocated a capital expenditure of approximately $1 million to the liquid radwaste system in order to reduce the total dose to the population within 50 miles to 0.001 man-rem/year from all pathways associated with the liquid effluents. 2

Solid wastes from the plant will be packaged in 55 gallon drums or similar suitable containers and when necessary cemented for off-site shipment and disposal. The additional capital cost for cementing and storage of the solid waste handling system is approximately $200 thousand.

Building space for the above equipment is estimated to cost approximately \$2.5 million. The total expenditure that the Supply System has budgeted to reduce off-site doses is \$5.5 million.

3.1.2.13 - <u>Particulate Releases</u>

Burning a ton of coal or a barrel of oil releases a small amount of particulates up the stack. A fossil-fired plant of 1100 MWe would eject about 9 tons of fine particulates per full-load day. Solid waste residue from a coal-fired plant would also require transportation and disposal of about seven hundred tons of ash each day.

3.1.2.14 - <u>Atmospheric Effects</u>

The primary impact of large thermal power plants on the atmos-
phere is the heat and water rejected. The Hanford No. 2 plant will
reject about 2200 MW to the atmosphere at full load. The mechanical
draft cooling tower is not expected to produce ground level fog or
ice in the basin area where the Tri-Cities are located and will not
restrict air traffic at the Pasco Airport due to ceiling height
1 limitations. At higher ground elevations the tower would be expected
to have an effect on roads, railways and transmission lines.
Estimated annual incremental occurrences of fog and ice are:

Highway #240 (18 miles northwest of Site)	12 hours
Transmission Lines	70 hours
Pasco-Spokane Highway (#395) and Northern Pacific Railway (15 miles south of Site)	19 hours
Richland-Benton City Highway (#410) (15 miles south of Site)	26 hours
Hanford Project Highway (11 miles northwest of Site)	21 hours

The increase in humidity in the summertime downwind from the plant will be insignificant. Evaporation from irrigated lands in the Yakima River Valley is about two million gpm in the summertime,

TABLE 3.1.3-1 (Continued)

Benefit & Cost Factors	Current Hanford No. 2 Plant	Alternative Plants: Coal-Fired	Alternative Plants: Oil-Fired	Nuclear Plant With Once-Through Cooling
Impact on Bird Life	Negligible	Negligible	Negligible	Negligible
Radioactive Releases to Columbia River (man-rems/yr) Based on the 1970 population out to 50 miles.	1×10^{-3}	None	None	1×10^{-3}
Radioactive Releases to the Air (man-rems/yr). Based on 1970 population out to 50 miles.	1×10^{-2}	Nearly Zero	Nearly Zero	1×10^{-2}
Particulate Releases (MT/day)	None	9	9	None
Atmospheric Effects	Visible Plume Fogging & Icing Potential	Visible Plume Fogging & Icing Potential	Visible Plume Fogging & Icing Potential	None
New Transmission Lines (Miles)	31	31	31	31
Fuel Transportation	New Fuel - 15 trucks/yr Spent Fuel - 10 casks/yr	1 Train/day	1 Barge/day	New Fuel - 15 Trucks/yr Spent Fuel 10 Casks/yr
Objectionable Aesthetic Value	Cooling Tower	Cooling Tower, tall stack, coal storage, conveyer systems	Cooling Tower, short stack, tank farm, pipe line, oil spills	None
Noise	Quiet	Moderate Noise	Moderate Noise	Quietest
Recreation Benefits	Moderate	Minor	Minor	Moderate
Scientific Benefits	Significant	Moderate	Moderate	Significant
Education Benefits	Significant	Small	Small	Significant

2 1 2

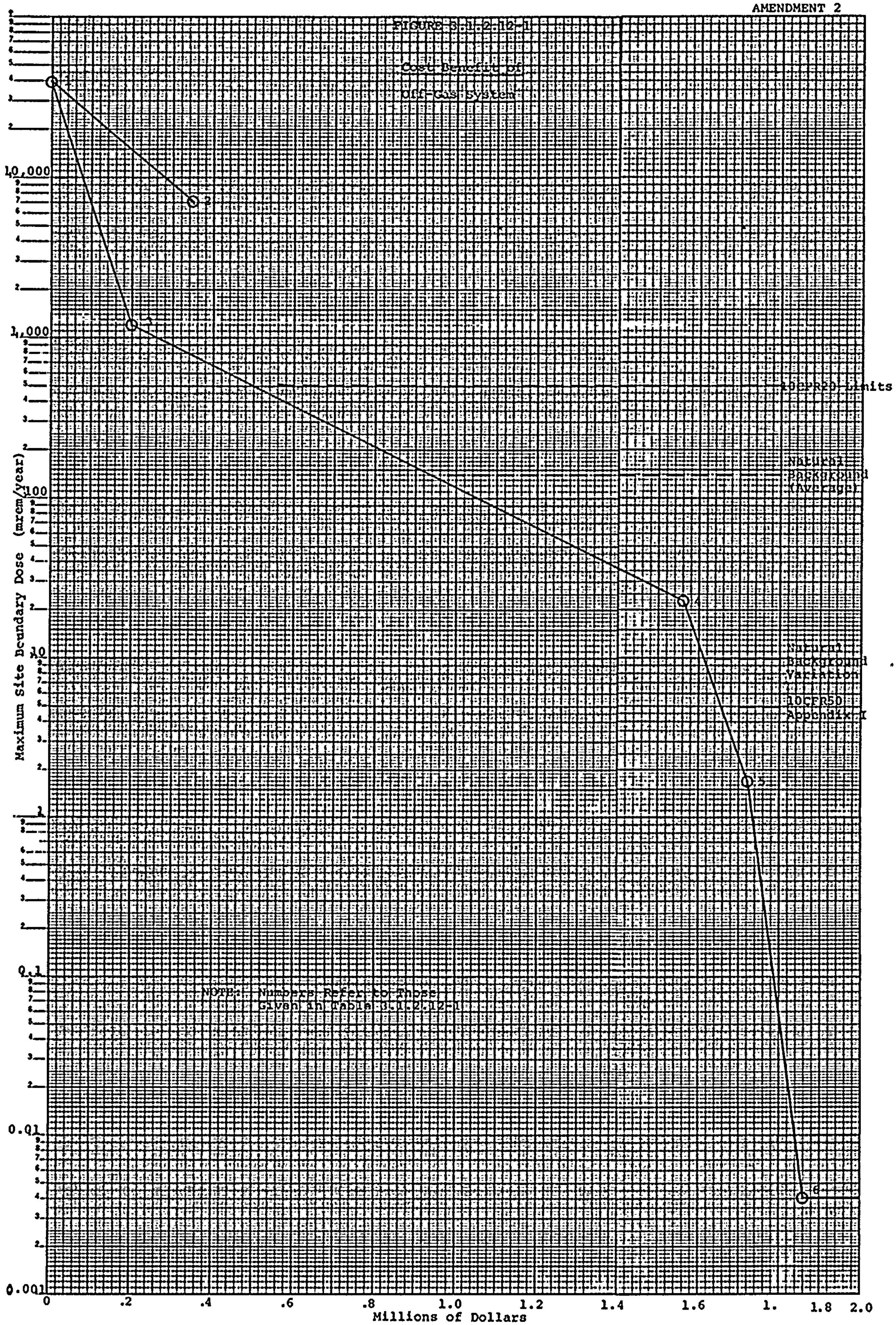
FIGURE 3.1.2.12-1
Cost Benefit of
Off-Gas System
Maximum Site Boundary Dose (mrem/year)
Millions of Dollars
10CFR20 Limits
Natural Background (Average)
Natural Background Variation
10CFR50 Appendix I
NOTE: Numbers Refer to Those Given in Table 3.1.2.12-1

Cloud Gamma Dose Calculation

The following assumptions and associated values were used in defining the environmental effects from this event.

1. Release Height (above grade), 71 meters.
2. Meteorology data collected at the Hanford Meteorological Station from January 1955 to July 1961 (Table 2.3.7.3-2 to 7).
3. Population Density to 50 miles as extrapolated to the year 2015. (See Figure 2.3.1.1-5)

The basic mathematical model used to calculate the whole body exposures is defined in Reference 4 and modified as follows:

$$D_g = \sum_{\substack{\text{Stability} \\ J=1}}^{4} \sum_{\substack{\text{Isotope} \\ I=1}}^{13} \int_Y \int_Z \int_\tau C_1 C_i f_i X_J G_i \, dY dZ d\tau \qquad (1)$$ 2

Where

D_g = Cloud gamma dose (rem)

C_1 = Conversion factor (3.7×10^4 Dis/sec-μCi)

C_i = Flux to dose conversion factor for the i^{th} isotope (rem/sec-γ/cc)

f_i = Number of photons of the i^{th} isotope emitted per disintegration (γ's/dis)

G_i = Dose attenuation kernel for the i^{th} isotope (dimensionless)

$$X_J = \left[\int_Y \frac{f_j Q_i}{2 \pi u \sigma_Y \sigma_Z} \exp\left(-\frac{Z^2}{2\sigma_Z^2} - \frac{Y^2}{2\sigma_Y^2} \right) dY \right] \Big/ \phi R \qquad (2)$$

Where

X_J = Average annual isotopic airborne concentration of the i^{th} isotope (μCi/cc)

f_j = Accumulative frequency for wind speed, stability and sector (dimensionless)

Q_i = Plant release rate of the i^{th} isotope (μCi/sec)

$\sigma_y \sigma_z$ = Horizontal and vertical diffusion coefficients (cm)

u = Wind speed (cm/sec)

Y, Z = Horizontal and vertical distances from plume centerline (cm)

ϕ = Sector angle over which plume is averaged (radians)

R = Distance from release point to detector position (cm)

2 Equation (1) provides the yearly off-site dose to a detector located a distance of R(cm) from the release point and within a sector angle of ϕ radians. The man-rem/yr is determined by multiplying the result of equation (1) by the population density located within the sector of concern as well as by a factor of 0.5 to account for occupancy and shielding effects. Values of sector dose at a distance of R(cm) are assumed to be applicable to all individuals located in that sector from a distance of $R - \Delta R$ to $R + \Delta R$. The cumulative man-rem for any radial distance is determined by summing the dose contributions from all sectors for the additional radial distance and adding this to the previous radial man-rem exposures.

QUESTION 6 (March 1, 1972)

What is the expected dose from atmospheric releases to the individual (mrem/yr) and to the population (man-rem/yr) for the various sectors and radial distances (0-1, 1-2, 2-3, 3-4, 4-5, 5-10, 10-20, 20-30, 30-40, and 40-50 miles) from normal operation of the plant? What is the "site boundary" and/or "maximum boundary? (what location) expected dose to an individual? What is the dose to the individual and the population from drinking water, fish consumption, etc.?

ANSWER

The expected air-submersion doses to the skin and total body versus distance and direction were calculated as previously explained in the answer to Question 2. The results are tabulated in Table II-A and II-B below. Approximately 85% of the total-body dose is from Xe^{133}.

The dose to an individual from the consumption of fish, water, etc., is presented in Section 2.3.7.3-Page 16 of Amendment 2. The cumulative dose is tabulated in Table II-C below.

Table II-A

SKIN DOSE TO INDIVIDUAL, MREM/YEAR

RANGE / SECTOR	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15.0 MI	25.0 MI	35.0 MI	45.0 MI	TOTALS
N	1.01E-01	1.50E-02	6.16E-03	3.47E-03	2.27E-03	9.76E-04	3.20E-04	1.42E-04	8.35E-05	5.61E-05	1.30E-01
NNE	1.04E-01	1.67E-02	6.95E-03	3.88E-03	2.51E-03	1.04E-03	3.31E-04	1.46E-04	8.61E-05	5.79E-05	1.36E-01
NE	1.60E-01	2.74E-02	1.15E-02	6.42E-03	4.12E-03	1.68E-03	5.23E-04	2.31E-04	1.36E-04	9.18E-05	2.12E-01
ENE	1.89E-01	3.36E-02	1.41E-02	7.80E-03	4.98E-03	2.02E-03	6.39E-04	2.86E-04	1.69E-04	1.14E-04	2.53E-01
E	3.02E-01	5.40E-02	2.26E-02	1.25E-02	7.98E-03	3.29E-03	1.07E-03	4.83E-04	2.85E-04	1.92E-04	4.04E-01
ESE	4.63E-01	8.89E-02	3.77E-02	2.08E-02	1.32E-02	5.24E-03	1.64E-03	7.39E-04	4.38E-04	2.95E-04	6.32E-01
SE	5.69E-01	1.07E-01	4.54E-02	2.51E-02	1.59E-02	6.34E-03	1.97E-03	8.85E-04	5.25E-04	3.54E-04	7.72E-01
SSE	2.20E-01	3.45E-02	1.41E-02	7.86E-03	5.09E-03	2.17E-03	7.20E-04	3.23E-04	1.90E-04	1.28E-04	2.85E-01
S	1.63E-01	2.28E-02	9.28E-03	5.20E-03	3.41E-03	1.47E-03	4.88E-04	2.17E-04	1.27E-04	8.55E-05	2.06E-01
SSW	8.91E-02	1.25E-02	5.06E-03	2.82E-03	1.84E-03	7.86E-04	2.58E-04	1.15E-04	6.74E-05	4.52E-05	1.13E-01
SW	9.74E-02	1.30E-02	5.26E-03	2.95E-03	1.94E-03	8.38E-04	2.76E-04	1.22E-04	7.16E-05	4.80E-05	1.22E-01
WSW	6.86E-02	9.09E-03	3.70E-03	2.09E-03	1.38E-03	6.00E-04	1.98E-04	8.80E-05	5.15E-05	3.46E-05	8.58E-02
W	8.79E-02	1.18E-02	4.83E-03	2.74E-03	1.81E-03	7.89E-04	2.62E-04	1.16E-04	6.81E-05	4.57E-05	1.10E-01
WNW	1.04E-01	1.36E-02	5.52E-03	3.14E-03	2.08E-03	9.19E-04	3.06E-04	1.35E-04	7.92E-05	5.32E-05	1.30E-01
NW	1.59E-01	2.25E-02	9.20E-03	5.20E-03	3.42E-03	1.49E-03	4.96E-04	2.21E-04	1.30E-04	8.70E-05	2.01E-01
NNW	1.04E-01	1.60E-02	6.62E-03	3.71E-03	2.42E-03	1.03E-03	3.39E-04	1.51E-04	8.91E-05	5.99E-05	1.34E-01
TOTALS	2.98E+00	4.98E-01	2.08E-01	1.16E-01	7.43E-02	3.07E-02	9.84E-03	4.40E-03	2.60E-03	1.75E-03	3.93E+00

Table II-B

TOTAL BODY DOSE TO INDIVIDUAL, MREM/YEAR

SECTOR \ RANGE	.5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15.0 MI	25.0 MI	35.0 MI	45.0 MI	TOTALS
N	4.59E-02	5.46E-03	1.95E-03	9.96E-04	6.04E-04	2.24E-04	6.30E-05	2.57E-05	1.44E-05	9.32E-06	5.52E-02
NNE	4.83E-02	6.59E-03	2.46E-03	1.26E-03	7.53E-04	2.65E-04	6.86E-05	2.76E-05	1.55E-05	1.00E-05	5.97E-02
NE	7.53E-02	1.14E-02	4.34E-03	2.23E-03	1.33E-03	4.52E-04	1.12E-04	4.50E-05	2.53E-05	1.65E-05	9.52E-02
ENE	8.99E-02	1.42E-02	5.41E-03	2.74E-03	1.61E-03	5.41E-04	1.37E-04	5.63E-05	3.18E-05	2.07E-05	1.15E-01
E	1.43E-01	2.25E-02	8.41E-03	4.21E-03	2.47E-03	8.40E-04	2.26E-04	9.40E-05	5.31E-05	3.45E-05	1.82E-01
ESE	2.24E-01	3.91E-02	1.52E-02	7.69E-03	4.50E-03	1.46E-03	3.63E-04	1.50E-04	8.49E-05	5.54E-05	2.93E-01
SE	2.74E-01	4.68E-02	1.83E-02	9.30E-03	5.47E-03	1.79E-03	4.38E-04	1.79E-04	1.02E-04	6.64E-05	3.56E-01
SSE	1.01E-01	1.33E-02	4.77E-03	2.38E-03	1.41E-03	5.07E-04	1.45E-04	6.04E-05	3.39E-05	2.20E-05	1.24E-01
S	7.34E-02	8.18E-03	2.85E-03	1.44E-03	8.68E-04	3.26E-04	9.47E-05	3.89E-05	2.17E-05	1.41E-05	8.72E-02
SSW	4.04E-02	4.57E-03	1.60E-03	8.01E-04	4.81E-04	1.78E-04	5.06E-05	2.08E-05	1.16E-05	7.52E-06	4.82E-02
SW	4.36E-02	4.53E-03	1.57E-03	7.95E-04	4.84E-04	1.83E-04	5.31E-05	2.17E-05	1.21E-05	7.83E-06	5.12E-02
WSW	3.05E-02	3.09E-03	1.07E-03	5.49E-04	3.37E-04	1.30E-04	3.78E-05	1.55E-05	8.62E-06	5.58E-06	3.58E-02
W	3.91E-02	4.02E-03	1.39E-03	7.14E-04	4.39E-04	1.70E-04	4.98E-05	2.04E-05	1.14E-05	7.37E-06	4.59E-02
WNW	4.59E-02	4.45E-03	1.52E-03	7.82E-04	4.86E-04	1.93E-04	5.72E-05	2.33E-05	1.30E-05	8.41E-06	5.34E-02
NW	7.12E-02	7.87E-03	2.75E-03	1.40E-03	8.54E-04	3.27E-04	9.54E-05	3.92E-05	2.19E-05	1.42E-05	8.46E-02
NNW	4.75E-02	6.03E-03	2.18E-03	1.10E-03	6.63E-04	2.41E-04	6.76E-05	2.79E-05	1.56E-05	1.01E-05	5.78E-02
TOTALS	1.39E+00	2.02E-01	7.57E-02	3.84E-02	2.27E-02	7.83E-03	2.06E-03	8.46E-04	4.76E-04	3.10E-04	1.74E+00

Table II-C

POPULATION DOSE

Pathway	Man-Rem/yr
Drinking Water	1.04×10^{-3}
Fish	1.88×10^{-6}
Swimming	6.7×10^{-7}
Boating	3.3×10^{-7}
Shoreline	5.45×10^{-6}
Total Liquids	1.04×10^{-3}
Air Submersion	1.22×10^{-2}
GRAND TOTAL	1.32×10^{-2}

QUESTION 8 (March 1, 1972)

The predicted noise level of 60-80 dB at 50 feet from the mechanical draft cooling towers would appear to be low, considering that there will be 40 to 48 cells (each with a 200 hp, 28-foot diameter fan). What is the basis for your estimate?

ANSWER

The predicted noise level of 60-80 dB at 50 feet from the mechanical draft cooling towers was a preliminary estimate. Current (draft) tower specifications have noise level limits determined from comparable towers. They are:

> With all fans running at rated load, the combined sound pressure levels, measured at a distance of 50 feet away from any point on the outer casing (measured horizontally) in any direction shall not exceed the following values:

Octave Band Center frequency, Hz	63	125	250	500	1000	2000	4000	8000
Sound Pressure Level decibels re 0.0002 dynes/cm^2	83	77	73	69	66	64	67	70

Responses from tower manufacturers on predicted noise levels are comparable to the preliminary specifications, with one manufacturer below the above values, and another with a maximum dB level of 90.