UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PENNSYLVANIA POWER & LIGHT COMPANY	)	
	)	
and	)	Docket Nos. 50-387
	)	50-388
ALLEGHENY ELECTRIC COOPERATIVE INC.	)	
	)	
(Susquehanna Steam Electric Station,	)	
Units 1 and 2)	)	

AFFIDAVIT OF FRAZIER L. BRONSON
IN SUPPORT OF PARTIAL SUMMARY DISPOSITION OF
CONTENTION 2 (RADIOACTIVE DOSES)

County of Philadelphia) : ss.
Commonwealth of Pennsylvania)

Frazier L. Bronson, being duly sworn, deposes and says as follows:

1. I am Vice President, Nuclear Services Division, Radiation Management Corporation ("RMC"). My business address is 3508 Market Street, Philadelphia, Pennsylvania. A summary of my professional qualifications and experience was attached as Exhibit "A" to my Affidavit dated June 15, 1981 in Support of Applicants' Motion for Summary Disposition of Contention 5(a) in this proceeding.

DS03
s
1/1

2. RMC was responsible for the estimation on behalf of Applicants of the radioactive doses that will be imparted upon the public due to the operation of the Susquehanna Steam Electric Station ("Susquehanna"). The purposes of my Affidavit are to discuss how the releases of radioactive matter from Susquehanna into the atmosphere and the Susquehanna River will be translated into potential radioactive doses and to set forth the magnitude of those doses, particularly those for cesium-137 and cobalt-60 (both of which are singled out in Contention 2). My Affidavit is based on the release estimates provided by Bechtel Corporation and included in Applicants' Environmental Report ("ER") for Susquehanna and is also based on the release rates specified in the Affidavit dated August 4, 1981, of John C. Dodds in Support of Partial Summary Disposition of Contention 2 in this proceeding.

3. The radiation doses attributable to the releases from Susquehanna were estimated utilizing the methods and assumptions in Regulatory Guide 1.109 (Rev. 0), March 1976, published by the NRC Staff ("Staff") [1].[1] The Staff commissioned the development of pathway and internal dosimetry models to permit the pre-operational prediction of the dispersion of radioactive effluents from nuclear power plants into the atmosphere and water bodies, their transport to man through various exposure pathways, and the resulting radiation doses.

---

1 References are listed at the end of this Affidavit.

A set of pathways and internal dosimetry models was developed for the Staff by Battelle Pacific Northwest Laboratories in the mid 1970's; these models are described in Regulatory Guide 1.109, and have been put in the form of computer codes widely used by the nuclear industry. The Staff regards these models and codes as acceptable for calculating the radiological impact of plant operation on individuals and populations and determining compliance with Appendix I to 10 CFR Part 50, and recommends their use by license applicants [1].

Doses From Gaseous Pathways

4. There are several exposure pathways to man resulting from atmospheric release of radionuclides. Some of them result in external exposures: submersion in air and exposure to radionuclides deposited on the ground. Other pathways result in internal doses: inhalation of radionuclides, or ingestion of radionuclides deposited in water, crops or vegetation. Radionuclides reach crops and vegetation through direct deposition and through root uptake. Man is exposed by eating such crops or vegetation, or by consuming milk and meat products from animals who have eaten such crops or vegetation.

5. The annual radiation doses resulting from the calculated radioactive gases and/or particulate releases from Susquehanna were estimated for individuals at distances up to 50 miles from the plant site and for the population in the contiguous 48 States utilizing the GASPAR computer code, which

is one of the above mentioned codes developed for the Staff to calculate radiation doses to individuals and populations due to releases from nuclear power plants. The GASPAR code model assumes as sources a semi-infinite cloud that originates from an elevated stack, and another source located at ground level, both emanating continuously for a period of one year. A semi-infinite cloud has a radius as large as the range of the radiation in question in air. Radioactive decay is considered so that, as the cloud moves away from the release point, the total radioactivity decreases. Also, as the cloud moves away, it becomes larger as the gases disperse, mix and dilute in the surrounding air, thus reducing the concentration of radioactive materials.

6. For radioactive gases that are inhaled, the dose to the lung is calculated separately. Similarly, for short range beta particles, the dose to the skin is calculated separately from the dose to the whole body from penetrating radiation.

7. In order to compute the effects of particulate materials contained in the cloud, the population is divided by age group into infant, child, teenager and adult, to account for size and activity or inhalation rate.[2] Particulate material is also depleted from the cloud by a variety of

---

2 As explained in my Affidavit in Support of Summary Disposition of Contention 5(a), para. 7, n.2, the fetus is not the critical age group for either inhalation or ingestion doses.

mechanical methods such as settling and impingement. For inhaled particulate radioactive materials, doses to six critical organs (bone, liver, thyroid, kidney, lung and gastro-intestinal tract) and whole-body doses are calculated.

8. Because of the deposition of particulate radioactive material on the ground, a ground plane source is assumed to be created and to contribute a dose to each organ. The average quantity on the ground is the calculated value after fifteen years of plant operation.[3]

9. Doses due to food that may be contaminated are also computed. The contribution from each source (green leafy vegetation, all other vegetation, milk and meat) to each organ is estimated separately.

10. Once the GASPAR code estimates the amount of a radionuclide that reaches each organ of an individual, the code converts that exposure to a radioactive dose.

11. Dose conversions for inhaled radioactivity are derived by multiplying the average breathing rate for each age group by the local concentration computed from the release rate (curies per second) from the facility and the local diffusion coefficient in sec/m^3. The inhaled radioactivity is assumed to translocate within the body to various organs according to the model given in ICRP Publication 2 [3]. Some fraction of the inhaled material is translocated to the organ of interest.

---

3 Fifteen years represents the mid-point of a plant's operating life; use of a fifteen year value approximates the average deposition over the operating life of the facility [1].

This material builds up in that organ and simultaneously is removed by radiological decay and biological elimination. Eventually an equilibrium condition is reached and this maximum concentration in the organ is used to calculate the organ dose. A similar computational process is utilized with respect to ingested radioactive matter.

12. The dose to the organ is calculated based on the organ mass and radius and the effective energy deposited in the organ from all of the radiations emitted per disintegration by the specific radionuclide. The energy deposited in the whole organ is modified by the assigned quality factor, Q. The ICRP in Publication 2 issued in 1959 recommended use of a quality factor of 1.7 for the weak beta and gamma radiation. This value was used for the computation performed for PP&L. See my Affidavit dated June 15, 1981 in Support of Summary Disposition of Contention 5(c) at para. 7.

13. To summarize, we used the GASPAR code to compute the dose to individuals at distances up to 50 miles from the Susquehanna site, and throughout the contiguous 48 States. Average annual wind speeds for each of 16 sectors surrounding the plant were used. As the cloud of radioactive material moves away from the facility, the gas disperses, radioactivity decays and particulates are deposited on the ground. The dose to the individual from immersion in the radioactive cloud and from standing on contaminated soil is calculated. Since a person immersed in the cloud will breathe it, the dose to the

lungs is calculated from inhaled materials. People and animals may feed on vegetation contaminated by deposition. The dose to people is the sum of that produced directly by the consumption of vegetables and that resulting indirectly from consumption of milk and meat from animals grazing on contaminated pastures. The input parameters used in calculating individual doses from gaseous effluents from Susquehanna, and the results of these dose computations, are summarized in Tables 5.2-25 and 5.2-26, respectively, of Section 5 of the Susquehanna ER. These tables are attached as Exhibits "A" and "B" hereto.

14. In my opinion, the computed doses set forth in Table 5.2-26 (Exhibit B) represent conservatively high estimates of the radioactive doses that will be received by members of the public due to gaseous releases from the Susquehanna facility.

Doses From Liquid Pathways

15. Another of the above referenced computer codes developed for the Staff, LADTAP, was used to calculate the annual radioactive doses to individuals from releases of radionuclides to waterways, and specifically to the Susquehanna River

16. The following are the principal liquid pathways through which radioactive doses may be received by individuals outside the plant: (1) drinking water; (2) aquatic foods; (3) exposure from deposition at the shoreline; (4) exposure from

swimming or boating; and (5) irrigation of crops. Each of these potential pathways is included in the LADTAP model.

17. The dose to an individual from any of these pathways is modified by several factors, including: (a) Usage, which (as the case may be) is either the exposure time or the intake rate for the particular individual. Usage is age-adjusted and is specific for a particular pathway. (b) Dilution, measured at the point where water or aquatic foods are taken from the river. (c) Effluent flow rate and release rate of each radionuclide. (d) Reconcentration of the nuclide in aquatic organisms in the food chain. (e) Radioactive decay of the nuclide from the time it is released until it is ingested or the individual is exposed to it. (f) For shoreline exposures, the buildup of longer-lived isotopes on the shore and the shore width. All of these factors are recognized and incorporated into LADTAP.

18. Doses from foods grown on land irrigated with contaminated water are also calculated. The deposition rate of radioactive material depends on the concentration and the irrigation rate. For vegetation, the activity in the edible portion of the crop is calculated for each species of plant. For cattle grazing on irrigated pasture, a further correction is made for the time of exposure to the contaminated feed.

19. Doses from meat and milk from the irrigation pathway depend not only on the contamination of forage but also on the level of radioactivity in the animals' drinking water.

The drinking water may or may not be from the irrigation water source and may not be contaminated. In addition, the decay from harvest to human consumption is also taken into account. Tritium doses from irrigation water are calculated separately and added to the other doses.

20. Dilution of the material in the waterway is based on Regulatory Guide 1.113 [2]. Regulatory Guide 1.113 discusses in detail the equations used for dilution and dispersion in the river, as well as water use factors that affect dilution or mixing and sediment uptake and transport.

21. To summarize, LADTAP computes the dose to an individual who is exposed to radioactive effluents in water. Accepted dilution models are used to calculate dilution to the point of use. Radioactive decay is considered as is bioaccumulation or reconcentration, and direct exposure to contaminated water and shoreline. Doses are calculated for infant, child, teenager, and adult[4] for each nuclide, in the same six organs plus whole-body doses considered for gaseous releases. Pathways in the model include drinking the water, swimming and boating, shoreline recreation, eating irrigated foods and consuming meat and animal products from animals fed irrigated vegetation or provided with drinking water from the contaminated source. The dose is computed in the same manner described in paras. 10-12 above for gaseous effluents.

---

4 See n.2, <u>supra</u>.

22. Tables 5.2-23, 5.2-24, 5.2-33 and 5.2-34 of the Susquehanna ER, attached as Exhibits "D" through "G" hereto, give the input parameters used in the calculation of individual doses from liquid effluents from Susquehanna, and summarize the maximum individual doses and those to the population within 50 miles of the plant and to the population in the contiguous 48 States attributable to the liquid pathway for Susquehanna radioactive releases. It is my opinion that the computed doses in those tables are conservatively high.

Doses From All Pathways

23. Tables 5.2-33 through 5.2-35 of the Susquehanna ER, attached as Exhibits "F" through "H" hereto, summarize the calculated combined population doses within a 50 mile radius of the Susquehanna facility and to the population in the contiguous 48 States as a result of gaseous and liquid effluents from Susquehanna. As can be seen from Table 5.2-35 (Exhibit H), the total whole-body doses attributable to all radioactive effluents from Susquehanna are 6.0 man-rem to the 50 mile-radius population and 21 man-rem to the entire population of the contiguous United States. Again, I believe these dose estimates to be conservatively high.[5]

---

5 A report entitled "Radioecological Assessment of the Wyhl Nuclear Power Plant" [4], and commonly known as "the Heidelberg Report", was prepared at the University of Heidelberg, West Germany, to assess the doses from the releases from the Wyhl pressurized water reactor. The Heidelberg Report was referenced in intervenor Environmental Coalition on Nuclear Power's "Additional Responses to Applicant and Staff Inter-

(continued next page)

Details of Dose Computation

Doses from cesium-137 and cobalt-60 in drinking water

24. The radioactive doses associated with the release of cesium-137 and cobalt-60 into the Susquehanna River

---

(continued)
rogatories as Directed by the Board Memorandum of March 27, 1980," dated May 1, 1980, at pp. 6-9, as suggesting that higher doses than those derived from Regulatory Guide 1.109 models might be appropriate. The Heidelberg Report uses essentially the same environmental models described in Regulatory Guide 1.109, but utilizes some values for model parameters which are much higher than the values used by the NRC. As a result, the doses computed in the report are much higher (by factors of 10 to 10,000) than the doses calculated using the NRC parameter values.

A review of the Heidelberg report by the NRC Staff [5] demonstrates that the dose computations in the Heidelberg Report are erroneous for a number of reasons, including:

1. The measured releases of radionuclides in the vicinity of reactors operating in the United States, are much less than the values used in the Heidelberg Report, and the measured environmental concentrations of the most significant radionuclides near reactors in the U.S. are much less than those assumed in the Heidelberg Report;

2. The values used in the Heidelberg Report for several critical parameters in the models are equal to or higher than the highest values derived from the references cited in the Report. Although it is possible to have an actual measured value that is higher than the average for one particular parameter at a nuclear reactor site, it is unlikely that all other actual parameter values will also be maximized for that site at the same time;

3. The Heidelberg Report values for some critical parameters are unsubstantiated. For instance, the kidney ingestion dose conversion factor for cesium-137 is 40 times higher than the value used by NRC and that given by the International Commission on Radiation Protection [3, 6].

For these and other reasons discussed in detail in the NRC Staff's analysis of the Heidelberg Report, that Report grossly overstates the doses that will be produced by the effluents from a plant such as Susquehanna, as is demonstrated by the much lower measured concentrations of radionuclides in vegetation, meat and milk in the vicinity of reactors in the United States.

were computed utilizing the LADTAP program and making very conservative (on the high side) assumptions as to site-specific parameters. For example, it was assumed that each of the 9000 residents of Danville, a municipality that derives its drinking water from the Susquehanna River, drinks 2 liters of river water per day. The computation was based on a concentration of 3.9×10^{-3} pCi/liter of cesium-137 and 1.5×10^{-3} pCi/liter of cobalt-60 at the Danville intake structure. See Susquehanna ER, Table 5.2-3, attached as Exhibit "C" hereto, and Affidavit of John C. Dodds, dated August 4, 1981, in Support of Partial Summary Disposition of Contention 2 at paras. 8-10.

25. A simplified form of the generalized dose equation for calculating radiation doses to man via liquid effluent pathways is [1]:

$$R_{aipj} = C_{ip} * U_{ap} * D_{aipj}$$

where: R_{aipj} is the annual dose to organ (j) of an individual of age group (a) from nuclide (i) via pathway (p) in mrem/yr.

C_{ip} is the concentration of nuclide (i) in the media of pathway (p) in pCi/l. The concentrations in environmental media of interest can be estimated from the mixing ratio, the discharge flow, and the radionuclide release rate.

D_{aipj} is the dose factor, specific to age group (a), radionuclide (i), pathway (p), and organ (j). It represents the dose due to the intake of a radionuclide in mrem/pCi. Dose factors for internal exposure via ingestion are provided in Appendix E, Tables E-11, 12, 13 and 14 of Regulatory Guide 1.109. Appendix E also provides further discussion of the data, models, and assumptions used.

U_{ap} is the intake rate associated with pathway (p) for age group (a).

26. For cesium-137, $C_{ip} = 3.9 \times 10^{-3}$ pCi/liter; U_{ap} = 730 liters/year (2 liters/day); $D_{aipj} = 7.14 \times 10^{-5}$ mrem/pCi. Therefore, the dose for cesium-137 is 2.03×10^{-4} mrem/year.

27. For cobalt-60, $C_{ip} = 1.5 \times 10^{-3}$ pCi/liter; U_{ap} = 730 liters/year; $D_{aipj} = 4.72 \times 10^{-6}$ mrem/pCi. See Exhibit C. Therefore, the dose for cobalt-60 is 2.07×10^{-4} mrem/year.

28. The total combined dose to a resident of Danville attributable to cesium-137 and cobalt-60 in his drinking water is 4.1×10^{-4} mrem/year. I believe this value to represent a conservatively high estimate of the radioactive doses to the Danville residents from releases of those radionuclides with the liquid effluents from Susquehanna.

Frazier L. Bronson

Frazier L. Bronson

Sworn to and subscribed before me this 25th day of August, 1981.

Notary Public

PRISCILLA DAVIS
Notary Public, Phila., Phila. Co.
My Commission Expires Feb. 25, 1985

References

1. Office of Standards Development, U.S. Nuclear Regulatory Commission, "Regulatory Guide 1.109 -- 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" (Rev. 0, March 1976).

2. Office of Standards Development, U.S. Nuclear Regulatory Commission, "Regulatory Guide 1.113--Estimating Aquatic Dispersion of Effluents From Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I" (Rev. 0, May 1976)

3. International Commission on Radiation Protection, "Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication 2, Pergamon Press, New York (1959).

4. Department of Environmental Protection, University of Heidelberg, Germany, "Radioecological Assessment of the Wyhl Nuclear Power Plant," NRC Translation 520 (May 1978, Rev. July 1979).

5. Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, "Staff Review of 'Radioecological Assessment of the Wyhl Nuclear Power Plant'", NUREG-0668 (June 1980).

6. International Commission on Radiation Protection, "Limits for Intake of Radionuclides by Workers", ICRP Publication 30, Part 1, Pergamon Press, New York (1978).

TABLE 5.2-25

INPUT PARAMETERS USED IN THE CALCULATION OF INDIVIDUAL DOSES TO MAN FROM GASEOUS EFFLUENTS OF SUSQUEHANNA SES

	CRITICAL BOUNDARY LOCATION	CRITICAL VEGETABLE GARDEN	CRITICAL DAIRY FARM
LOCATION	South-west boundary of site	West vegetable garden	North-west dairy farm
Distance from vents	0.379 miles	0.7 miles	0.7 miles
Transit time	0.09 hours	0.10 hours	0.13 hours
X/Q (normal)	2.1E-5 sec/m^3	1.4E-5 sec/m^3	3.9E-6 sec/m^3
X/Q (depleted)	1.9E-5 sec/m^3	1.2E-5 sec/m^3	3.6E-6 sec/m^3
Deposition	4.2E-8 1/m^2	2.1E-8 1/m^2	7.8E-9 1/m^2
Occupancy	8766 hr/yr	8766 hr/yr	8766 hr/yr
Leafy vegetable consumption	0	26 kg/yr	0
Other vegetable consumption	0	520 kg/yr	0
Milk consumption	0	0	330 l/yr
Meat consumption	0	0	0
Inhalation usage	1900 m^3/yr	2700 m^3/yr	1900 m^3/yr
Critical age group	infant	child	infant

TABLE 5.2-26

CALCULATED MAXIMUM INDIVIDUAL DOSES* TO MAN RESULTING
FROM GASEOUS EFFLUENTS OF SUSQUEHANNA SES
(PER UNIT)

LOCATION IS SOUTHWEST BOUNDARY OF SITE (MAXIMUM) - CRITICAL AGE GROUP IS INFANT

Beta air dose = 8.97 mrad/yr
Gamma air dose = 6.78 mrad/yr

		DOSES IN MREM/YR							
NUCLIDES	PATHWAY	TOTAL BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
NOBLE GASES	SUBMERSION	4.38	4.38	4.38	4.38	4.38	4.38	4.47	9.63
IODINE AND** PARTICULATES	GROUND SHINE	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05
	INHALATION	0.04	0.03	0.01	0.04	0.02	2.82	0.04	0.03
	TOTAL FOR IODINE AND PARTICULATE	0.08	0.07	0.05	0.08	0.06	2.86	0.08	0.08

* Dose are to maximum individual using input in Table 5.2-25

** Include C-14 and tritium.

TABLE 5.2-26 (Cont.)

CALCULATED MAXIMUM INDIVIDUAL DOSES* TO MAN RESULTING
FROM GASEOUS EFFLUENTS OF SUSQUEHANNA SES
(PER UNIT)

LOCATION IS WEST SECTOR VEGETABLE GARDEN - CRITICAL AGE GROUP IS CHILD

Beta air dose = 5.96 mrad/yr
Gamma air dose = 4.48 mrad/yr

		DOSES IN MREM/YR							
NUCLIDES	PATHWAY	TOTAL BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
NOBLE GASES	SUBMERSION	2.89	2.89	2.89	2.89	2.89	2.89	2.95	6.37
IODINE AND** PARTICULATES	GROUND SHINE	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	VEGETABLE CONSUMPTION	2.81	2.81	2.68	2.82	0.77	3.54	2.81	2.81
	INHALATION	0.02	0.02	0.01	0.02	0.02	1.09	0.02	0.02
	TOTAL FOR IODINE AND PARTICULATES	2.85	2.85	2.71	2.86	0.81	4.65	2.85	2.85

* Dose are to maximum individual u[illegible]t in Table 5.2-25
** Include C-14 and tritium.

TABLE 5.2-26 (Cont.)

CALCULATED MAXIMUM INDIVIDUAL DOSES* TO MAN RESULTING
FROM GASEOUS EFFLUENTS OF SUSQUEHANNA SES
(PER UNIT)

LOCATION IS NORTH-WEST SECTOR DAIRY FARM - CRITICAL AGE GROUP IS INFANT

Beta air dose = 1.65 mrad/yr
Gamma air dose = 1.22 mrad/yr

		DOSES IN MREM/YR							
NUCLIDES	PATHWAY	TOTAL BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
NOBLE GASES	SUBMERSION	0.79	0.79	0.79	0.79	0.79	0.79	0.79	1.74
IODINE AND** PARTICULATES	GROUND SHINE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	MILK	0.80	0.80	0.79	0.82	0.11	4.93	0.80	0.80
	INHALATION	0.01	0.01	0.00	0.01	0.00	0.53	0.01	0.01
	TOTAL FOR IODINE AND PARTICULATES	0.83	0.82	0.80	0.84	0.12	5.47	0.82	0.82

* Dose are to maximum individual using input in Table 5.2-25

** Include C-14 and tritium.

TABLE 5.2-3

EXPECTED CONCENTRATIONS OF RADIONUCLIDES IN UNTREATED DRINKING WATER AT THREE SUPPLIERS DOWNSTREAM OF SUSQUEHANNA SES (PER UNIT)

NUCLIDES	LOCATION (Concentrations* in pCi/l)		
	DANVILLE	SUNBURY	SHAMOKIN DAM
DILUTION FACTOR	321	93.5**	361
TRANSIT TIME (Hours)	13.8	52.2**	21.6
Na-24	3.5E-04	2.1E-04	2.2E-04
P-32	4.6E-05	1.5E-04	4.0E-05
Cr-51	1.3E-03	4.4E-03	1.2E-03
Mn-54	1.7E-04	5.9E-04	1.5E-04
Mn-56	1.3E-06	1.4E-10	1.4E-07
Fe-55	3.3E-04	1.1E-03	2.9E-04
Fe-59	9.2E-06	3.1E-05	8.2E-06
Co-58	6.8E-04	2.3E-03	6.0E-04
Co-60	1.5E-03	5.2E-03	1.3E-03
Ni-65	6.5E-09	5.8E-13	6.7E-10
Cu-64	8.8E-04	3.7E-04	5.1E-04
Zn-65	6.6E-05	2.2E-04	5.8E-05
Zn-69m	6.9E-05	3.5E-05	4.1E-05
Zn-69	1.7E-12	0.0E-01	0.0E-01
W-187	2.1E-05	2.4E-05	1.5E-05
Np-237	1.3E-03	4.5E-03	1.2E-03
Br-83	4.1E-08	2.1E-12	3.8E-09
Sr-89	2.9E-05	9.8E-05	2.6E-05
Sr-90	1.6E-06	5.4E-06	1.4E-06
Sr-91	6.2E-05	1.3E-05	3.1E-05
Y-91	1.7E-05	5.7E-05	1.5E-05
Sr-92	3.8E-07	7.1E-11	4.6E-08
Y-92	3.9E-06	7.3E-09	7.5E-07
Y-93	7.3E-05	1.8E-05	3.8E-05
Zr-95	1.5E-06	5.2E-06	1.4E-06
Nb-95	1.5E-06	5.1E-06	1.4E-06
Mo-99	2.9E-04	6.6E-04	2.3E-04
Tc-99m	8.1E-05	3.4E-06	2.9E-05
Ru-103	2.8E-05	9.2E-05	2.4E-05
Ru-105	1.9E-06	1.6E-08	4.9E-07
Rh-105	2.0E-05	3.2E-05	1.5E-05
Te-129m	1.1E-05	3.6E-05	9.5E-06
Te-129	1.7E-12	0.0E-01	1.5E-14
Te-131m	8.6E-06	1.2E-05	6.4E-06
I-131	1.9E-02	5.5E-02	1.6E-02
Te-132	1.2E-06	3.0E-06	1.0E-06
I-132	2.7E-07	8.2E-12	2.3E-08
I-133	1.5E-03	1.5E-03	1.0E-03
Cs-134	2.0E-03	7.0E-03	1.8E-03
I-135	1.0E-04	6.2E-06	4.0E-05
Cs-136	3.8E-05	1.2E-04	3.4E-05
Cs-137	3.9E-03	1.3E-02	3.5E-03
Ba-139	2.4E-10	0.0E-01	4.3E-12
Ba-140	9.0E-05	2.8E-04	7.9E-05
La-140	1.9E-05	3.4E-05	1.5E-05
La-141	3.7E-07	1.3E-09	8.2E-08
Ce-141	9.2E-06	3.0E-05	8.1E-06
La-142	6.1E-10	0.0E-01	1.6E-11
Ce-143	2.7E-06	4.2E-06	2.1E-06
Pr-143	8.9E-06	2.8E-05	7.8E-06
H-3	9.4E-01	3.2E 00	8.3E-01

* Drinking water includes 12 hour decay time in processing.

** Dilution and transit time are for August and September - the months facility is operational.

TABLE 5.2-23

INPUT PARAMETERS USED IN THE CALCULATION OF INDIVIDUAL DOSES TO MAN FROM LIQUID EFFLUENTS OF SUSQUEHANNA SES

	PATHWAY		
	CONSUMPTION OF AQUATIC BIOTA	SHORELINE EXPOSURE	DRINKING WATER
LOCATION	EDGE OF INITIAL MIXING ZONE	EDGE OF INITIAL MIXING ZONE	DANVILLE
DILUTION FACTOR	5.0	5.0	321.0
TRANSIT TIME	25.0 hr	1.0 hr	25.8 hr
USAGE	21.0 kg/yr	12.0 hr/yr	730 l/yr
SHORE WIDTH FACTOR	-	0.2	-

EXHIBIT D

TABLE 5.2-24

CALCULATED MAXIMUM INDIVIDUAL DOSES* TO MAN RESULTING FROM LIQUID EFFLUENTS OF SUSQUEHANNA SES (PER UNIT)

	DOSES (mrem/yr)							
PATHWAY	SKIN	BONE	LIVER	TOTAL BODY	THYROID	KIDNEY	LUNG	GI-LLI
CONSUMPTION OF FISH	0.00E 0	2.39E 0	2.05E 0	1.47E 0	7.49E-1	6.62E-1	2.19E-1	1.90E-1
DRINKING	0.00E 0	4.04E-4	7.20E-4	5.35E-4	2.70E-2	4.16E-4	1.59E-4	2.23E-4
SHORELINE	2.04E-3	1.73E-3	1.73E-3	1.73E-3	1.73E-3	1.73E-3	1.73E-3	1.73E-3
TOTAL	2.04E-3	2.39E 0	2.05E 0	1.47E 0	7.78E-1	6.64E-1	2.21E-1	1.92E-1

* Doses are to maximum individual using input in Table 5.2-23 and are for the adult.

TABLE 5.2-33

CALCULATED POPULATION DOSES TO THE POPULATION WITHIN A 50-MILE RADIUS OF SUSQUEHANNA SES RESULTING FROM BOTH LIQUID AND GASEOUS EFFLUENTS

		DOSES IN MAN-REM/YEAR							
EFFLUENT	PATHWAY	TOTAL BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
Liquid	Fish consumption	4.7E-2	4.9E-3	8.1E-2	8.2E-2	1.6E-2	2.0E-2	9.1E-3	-
	Drinking	3.3E-3	1.3E-3	3.6E-3	5.6E-3	2.5E-3	2.0E-1	1.1E-3	-
	Shoreline	4.5E-3	-	-	-	-	4.5E-3	-	4.5E-3
	Boating	3.9E-6	-	-	-	-	3.9E-6	-	-
Gaseous	Submersion	3.2E 0	3.2E 0	3.2E 0	3.2E 0	3.2E 0	3.2E 0	3.3E 0	9.3E 0
	Ground shine	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.8E-2
	Inhalation	7.9E-2	7.8E-2	5.9E-3	8.6E-2	8.5E-2	2.2E 0	8.0E-2	7.5E-2
	Vegetables	2.0E 0	2.0E 0	4.7E 0	2.0E 0	1.3E 0	2.3E 0	2.0E 0	2.0E 0
	Cows milk	4.8E-1	4.8E-1	9.8E-1	4.8E-1	2.8E-1	1.6E 0	4.8E-1	4.8E-1
	Meat	1.1E-1	1.1E-1	3.8E-1	1.1E-1	8.8E-2	1.3E-1	1.1E-1	1.1E-1

TABLE 5.2-34

CALCULATED POPULATION DOSES TO THE CONTIGUOUS POPULATION OF THE UNITED STATES RESULTING FROM BOTH LIQUID AND GASEOUS EFFLUENTS FROM SUSQUEHANNA SES

DOSES IN MAN-REM/YEAR

EFFLUENT	PATHWAY	TOTAL BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
LIQUID	Fish consumption	4.7E-2	4.9E-3	8.1E-2	8.2E-2	1.6E-2	2.0E-2	9.1E-3	-
	Drinking	2.2E-2	8.5E-3	2.4E-2	3.7E-2	1.7E-2	1.3E 0	7.6E-3	-
	Shoreline	4.5E-3	-	-	-	-	4.5E-3	-	4.5E-3
	Boating	3.9E-6	-	-	-	-	3.9E-6	-	-
GASEOUS	Submersion	4.0E 0	4.0E 0	4.0E 0	4.0E 0	4.0E 0	4.0E 0	4.2E 0	1.3E 1
	Ground Shine	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.2E-2	3.8E-2
	Inhalation	1.1E-1	1.1E-1	5.9E-3	1.1E-1	1.1E-1	2.2E 0	1.1E-1	7.5E-2
	Vegetables	8.5E 0	8.5E 0	3.6E 1	8.5E 0	7.7E 0	8.7E 0	8.5E 0	2.0E 0
	Cows milk	3.2E 0	3.2E 0	1.3E 1	3.2E 0	2.8E 0	5.5E 0	3.2E 0	9.9E-1
	Meat	5.1E 0	5.1E 0	2.5E 1	5.1E 0	5.1E 0	5.1E 0	5.1E 0	1.1E-1

TABLE 5.2-35

SUMMARY OF CALCULATED POPULATION DOSES

	TOTAL BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
Total 50 mile Population	6.0E 0	5.9E 0	9.4E 0	6.0E 0	5.0E 0	9.7E 0	6.0E 0	1.2E 1
Total U.S Population	2.1E 1	2.1E 1	7.8E 1	2.1E 1	2.0E 1	2.7E 1	2.1E 1	1.6E 1