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June 5, 1985

REGION V FILE

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U S NUCLEAR REGULATORY COMMISSION  
1450 MARIA LANE SUITE 210  
WALNUT CREEK CA 94596

DOCKET 50-312  
LICENSE NO. DPR-54  
SPECIAL REPORT NO. 85-05

A District employee has interviewed an additional family with a considerable ingestion of aquatic foods from the Clay Creek, Hadseville Creek, and Laguna Creek areas.

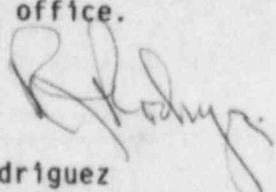
The family was interviewed on April 11, 1985. A preliminary evaluation of the potential radiological exposure to the family was performed and the calculated exposure to the adult exceeded the limits of 40 CFR 190.

The District then made arrangements to perform a whole body count on the adult and the count was conducted on April 30, 1985. The whole body count revealed no activity other than naturally occurring potassium.

By performing reverse calculations using the minimum detectable activity of the whole body count, an upper bound envelope of the radiological exposure was determined. The upper bound calculations indicate that the maximum exposure the adult could have received resulting from their ingestion of aquatic foods is 6 mrem to the Adult Total Body and 2 mrem to the Adult Liver.

These values do not exceed the limits of 40 CFR 190.

The enclosed report details the above mentioned calculations. If there are any questions concerning this report, please contact Mr. Ed Bradley at the District office.

  
R. J. Rodriguez  
Assistant General Manager  
Nuclear

Enclosure

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ATTACHMENT A

URANIUM FUEL CYCLE DOSE EVALUATION

ON FAMILY "Z<sub>10</sub>"

1. Introduction

An additional fisherman recently came to the attention of the District. The individual was interviewed April 11, 1985 and given a whole body count at Helgeson Scientific Services in Pleasanton, Ca, April 30, 1985. This family is now identified as "Z<sub>10</sub>".

This report discusses the details of the calculations evaluating the potential radiological exposure to "Z<sub>10</sub>" via the ingestion of aquatic foods and from shoreline recreational activities. The whole body count results are also discussed.

2. Concentrations of Radionuclides in the Environment Downstream of Rancho Seco

The concentrations of radionuclides in the aquatic environment downstream of the Rancho Seco Nuclear Generating Station Unit No. 1 are reported in UCID-20295 and UCID-20298 (references 2 and 3). The concentrations in these reports were used in this report and are provided in Tables 1 and 2.

3. Radiological Dose Conversion Factors

The radiological dose conversion factors used in the following calculations are the same as those used in the LADTAP II computer code (reference 4) and are provided in this report in Tables 3 and 4.

4. Interview Result with Family "Z<sub>10</sub>"

The results of the interview with family "Z<sub>10</sub>" are included in Table 5. The father is the only member of the family that hunts and fishes and consumes aquatic foods and wildlife. The entire family, however, does consume the berries.

The father consumed approximately 11.3 kg of sunfish, 18.1 kg of bass, and 4.5 kg of frog legs collected at locations 0.5, 2.4, and 2.9 km downstream during 1984. The father spent approximately 1,000 hours fishing and 50 hours hunting along the stream. The fishing was done while standing in the stream so the 1,000 hours was also included under swimming.

5. Exposure Calculations

The Adult Total Body and Adult Liver are the two highest exposure groups in these calculations and are the only calculations included in this report.

The details of the calculated radiological exposure resulting from the consumption of fish is included in Table 6.

It is calculated that the father ingested approximately 91.6 nCi of Cs-134 and 197 nCi of Cs-137 via fish consumption. This would result in an Adult Total Body exposure of 25.1 mrem and an Adult Liver exposure of 35.0 mrem.

The details of the calculated radiological exposure resulting from the consumption of frog legs is included in Table 7. For the purposes of these calculations, the radionuclide concentrations in frog legs are assumed to equal the radionuclide concentrations in sunfish. It is calculated that the father ingested approximately 12.7 nCi of Cs-134 and 26.5 nCi of Cs-137 via frog leg consumption. This would result in an Adult Total Body exposure of 3.42 mrem and an Adult Liver exposure of 4.76 mrem.

The details of the calculated radiological exposure resulting from shoreline exposure to streambed sediments is included in Table 8. The calculations are independent of age category and result in a Total Body exposure of 4.40 mrem.

The details of the calculated radiological exposure resulting from swimming is included in Table 9. These calculations are truly a first order approximation of the potential exposure due to the assumptions necessary to perform the calculation. An average radionuclide concentration was determined based upon the total amount of radionuclides released in liquid effluents during 1984 and the total water released from the site from 1/1/84 to 9/30/84. The calculations indicate a Total Body dose of only 0.10 mrem.

#### 6. Discussion of the Exposure Calculations

The NRC regulations in 10 CFR 20.405(c)(1) link the District to the EPA regulations of 40 CFR 190 which require uranium fuel cycle operations to be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent does not exceed 25 mrem to the Total Body, 75 mrem to the Thyroid, and 25 mrem to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials to the general environment.

The calculations enclosed in this report indicated that the adult ingested 104 nCi of Cs-134 and 224 nCi of Cs-137 which resulted in a calculated Adult Total Body exposure of 33.0 mrem and a calculated Adult Liver exposure of 39.8 mrem. The District recognizes that these calculations exceed the limits of 40 CFR 190.

#### 7. Discussion of Whole Body Counts

On April 30, 1985, the father in family "Z<sub>10</sub>" was given a whole body count at Helgeson Scientific Services in Pleasanton, California. The results showed no activity other than naturally occurring potassium. Helgeson uses a standard method for determining the minimum detectable activity (MDA) and assumes a "standard man" of 70 kg containing 120 nCi

of naturally occurring K-40 and 5 nCi of Cs-137 resulting from atmospheric atomic bomb testing. Helgeson states that the MDA is 6.3 nCi of Cs-134 and 2.5 nCi of Cs-137. A summary of the following calculations is provided in Table 10.

From reference 5, it is observed that cesium exhibits an age dependent biological half life which results in an age dependent effective half life. The effective half life for the Adult for Cs-134 and Cs-137 are presented in Table 10.

## 7.1 Expectation of Observing a Body Burden Based Upon Ingestion Data

The information obtained from the interview coupled with the observed radionuclide concentrations in aquatic foods leads to an expectation of an observable body burden (quantity of radionuclide in the body) from a whole body count.

It was determined by follow-up telephone conversations that "Z<sub>10</sub>" started collecting and consuming aquatic foods around 1/1/84 and ended collection and consumption around 12/31/84. Using the total estimated radionuclide ingested values based upon the consumption of fish and frog legs (Tables 6 and 7), the average ingestion rate for "Z<sub>10</sub>" would be 2.85 E-01 nCi/day Cs-134 and 6.11 E-01 nCi/day Cs-137 over the 366 day period (1/1/84 to 12/31/84).

$$A = \frac{I}{\lambda} (1 - e^{-\lambda t}) \quad (\text{Equation 1})$$

$$A = A_0 e^{-\lambda t} \quad (\text{Equation 2})$$

A = Activity (nCi) in individual at time t (day)  
 A<sub>0</sub> = Activity (nCi) in individual on 12/31/84  
 I = Rate of ingestion (nCi/day)  
 λ = Decay constant (day<sup>-1</sup>)

By using Equation 1 to calculate the estimated body burden on 12/31/84 and then using Equation 2 to calculate the estimated body burden on 4/30/85, one would expect to see a body burden of 16.4 nCi Cs-134 and 43.1 nCi Cs-137 in the "Z<sub>10</sub>" Adult. These estimated body burden values based upon the consumption data are well within the detection capability of the Helgeson equipment for the Adult, however, no activity other than naturally occurring potassium was observed.

## 7.2 Maximum Ingestion Dose Based Upon MDA Body Burden

The whole body count indicates that the estimate of aquatic foods may have been too high. However, a clean whole body count does not preclude the fact that no ingestion occurred, only that if an ingestion of radionuclides occurred, it has cleared the body and is now less than the MDA of the counting equipment.



As an upper bound calculation, we will assume that "Z<sub>10</sub>" had a body burden equal to the MDA on 4/30/85, calculate the maximum possible ingestion rate using equations 1 and 2, and then calculate the maximum possible ingestion dose. The ingestion dose to "Z<sub>10</sub>" would probably be less than this upper bound calculation value.

By assuming that "Z<sub>10</sub>" had a body burden equal to the MDA on 4/30/85 and by using Equation 2, one can calculate the body burden on 12/31/84 when he stopped eating aquatic foods (see Table 10 for values). This can be considered the maximum activity that could have been in the individual on 12/31/84 and still not detected by a whole body count on 4/30/85 (120 days of clearance prior to whole body count).

The next step is to calculate the rate of consumption that would be necessary from 1/1/84 to 12/31/84 to develop this maximum activity on 12/31/84 that would then not be detectable on a whole body count on 4/30/85. The calculated ingestion rate is provided in Table 10.

Using this rate of ingestion, it is possible to calculate the maximum quantity of ingested radionuclides that could have occurred and still not been able to detect any activity with the whole body count on 4/30/85. These results are also provided in Table 10.

The maximum ingestion dose to "Z<sub>10</sub>" based upon a body burden equal to the MDA at the time of the whole body count is calculated to be a total body dose of 5.77 mrem and a liver dose of 7.34 mrem.

Adding the calculated shoreline and swimming exposure values results in a maximum total dose of 10.3 mrem to the total body and 7.34 mrem to the liver.

### 7.3 Maximum Ingestion Dose Based Upon Cs-137 MDA of WBC And Observed Cs-134/Cs-137 Ratio of Aquatic Foods Ingestion.

The WBC analysis indicates that there could possibly be three times the ingestion of Cs-134 than Cs-137 based upon the MDA of the WBC. However, the environmental data show that the ingestion of Cs-134 would be less than 50% the ingestion of Cs-137 based upon the ingestion of aquatic foods.

Using the WBC sensitivity for Cs-137 and the observed Cs-134/Cs-137 ratio of aquatic food ingestion leads one to compute a maximum ingestion of 6.07 nCi of Cs-134 and 13.0 nCi of Cs-137. The maximum ingestion dose to "Z<sub>10</sub>" based upon this information is then computed to be 1.66 mrem to the total body and 2.31 mrem to the liver.

Adding the calculated shoreline and swimming exposure values results in a maximum total dose of 6.16 mrem to the total body and 2.31 mrem to the liver.

## 8. Conclusion

The calculated radiological exposure to "Z<sub>10</sub>" is based upon an estimate of the consumption of aquatic foods, known radionuclide concentrations in fish, and assumed radionuclide concentrations in frog legs. This calculated exposure is 33 mrem to the Adult Total Body and 40 mrem to the Adult Liver.

An evaluation of the consumption data would indicate that given a 366 day ingestion period followed by a 120 day clearance period, the expected body burden of the Adult is well within the detection capability of the whole body counter, however, no activity other than naturally occurring potassium was observed.

The evaluation of the whole body counts and the observed Cs-134/Cs-137 ratio in aquatic foods indicate that the maximum radiological exposure that could have occurred over this same period of time is 6 mrem to the Adult Total Body and 2 mrem to the Adult Liver.

The District therefore concludes that the limits of 40 CFR 190 have not been exceeded for family "Z<sub>10</sub>".

TABLE 1  
FISH RADIONUCLIDE CONCENTRATION  
(pCi/gm)

<u>Downstream Distance (km)</u>	<u>Cs-134</u>			<u>Cs-137</u>		
	<u>Sunfish</u>	<u>Bass</u>	<u>Catfish</u>	<u>Sunfish</u>	<u>Bass</u>	<u>Catfish</u>
0.5	5.48	2.23	9.41 E-01	11.45	5.00	2.52
2.4	3.48	1.57	6.67 E-01	7.27	3.50	1.82
2.9	3.09	1.43	6.09 E-01	6.45	3.19	1.67
4.0	2.37	1.16	4.99 E-01	4.96	2.60	1.39
6.5	1.30	7.31 E-01	3.18 E-01	2.73	1.63	9.05 E-01
7.3	1.08	6.30 E-01	2.75 E-01	2.25	1.40	7.89 E-01
10.0	5.65 E-01	3.81 E-01	1.69 E-01	1.18	8.46 E-01	4.97 E-01
12.0	3.51 E-01	2.63 E-01	1.17 E-01	7.33 E-01	5.82 E-01	3.53 E-01
12.5	3.11 E-01	2.40 E-01	1.07 E-01	6.50 E-01	5.30 E-01	3.24 E-01
13.0	2.76 E-01	2.18 E-01	9.79 E-02	5.77 E-01	4.83 E-01	2.98 E-01
18.0	8.36 E-02	8.61 E-02	3.96 E-02	1.75 E-01	1.90 E-01	1.27 E-01

Sunfish

$$\text{Cs-134} = 6.17 \text{ e }^{-0.239D}$$

$$\text{Cs-137} = 12.9 \text{ e }^{-0.239D}$$

Bass

$$\text{Cs-134} = 2.45 \text{ e }^{-0.186D}$$

$$\text{Cs-137} = 5.49 \text{ e }^{-0.187D}$$

Catfish

$$\text{Cs-134} = 1.03 \text{ e }^{-0.181D}$$

$$\text{Cs-137} = 2.75 \text{ e }^{-0.171D}$$

D = Downstream distance in km.  
Cs = Cesium concentrations in pCi/gm wet weight.



TABLE 2  
STREAM SEDIMENT CONCENTRATIONS  
(mCi/km<sup>2</sup>)

<u>Downstream Distance (km)</u>	<u>Cs-134</u>	<u>Cs-137</u>
0.5	6.85 E+02	1.46 E+03
2.4	4.18 E+02	8.89 E+02
2.9	3.67 E+02	7.81 E+02
6.5	1.44 E+02	3.06 E+02
7.3	1.17 E+02	2.49 E+02
12.0	3.45 E+01	7.33 E+01
12.5	3.03 E+01	6.44 E+01
13.0	2.66 E+01	5.65 E+01
18.0	7.24	1.54 E+01

$$Cs-134 = (0.47) 1660 e^{-0.26D}$$

$$Cs-137 = 1660 e^{-0.26D}$$

D = Downstream distance in km.  
Cs = Stream sediment inventory mCi/km<sup>2</sup>.

Additional nuclide concentrations at 0.5 km downstream:

Mn-54	5.50 E+01	mCi/km <sup>2</sup>
Co-58	4.10 E+01	mCi/km <sup>2</sup>
Co-60	5.30 E+02	mCi/km <sup>2</sup>
Ag-110m	1.80 E+01	mCi/km <sup>2</sup>

TABLE 3

INGESTION DOSE FACTORS  
(mrem/pCi ingested)

	<u>Total Body</u>	<u>Bone</u>	<u>Liver</u>	<u>Thyroid</u>	<u>Kidney</u>	<u>Lung</u>	<u>GI-LLI</u>
Adult							
Cs-134	1.21 E-04	6.22 E-05	1.48 E-04	0.0	4.79 E-05	1.59 E-05	2.59 E-06
Cs-137	7.14 E-05	7.97 E-05	1.09 E-04	0.0	3.70 E-05	1.23 E-05	2.11 E-06
Teenager							
Cs-134	9.14 E-05	8.37 E-05	1.97 E-04	0.0	6.26 E-05	2.39 E-05	2.45 E-06
Cs-137	5.19 E-05	1.12 E-04	1.49 E-04	0.0	5.07 E-05	1.97 E-05	2.12 E-06
Child							
Cs-134	8.10 E-05	2.34 E-04	3.84 E-04	0.0	1.19 E-04	4.27 E-05	2.07 E-06
Cs-137	4.62 E-05	3.27 E-04	3.13 E-04	0.0	1.02 E-04	3.67 E-05	1.96 E-06

SHORELINE EXPOSURE FACTORS  
(mrem/hr)/(pCi/m<sup>2</sup>)

	<u>Total Body</u>	<u>Skin</u>
Cs-134	1.20 E-08	1.40 E-08
Cs-137	4.20 E-09	4.90 E-09
Mn-54	5.80 E-09	6.80 E-09
Co-58	7.00 E-09	8.20 E-09
Co-60	1.70 E-08	2.00 E-08
Ag-110m	1.80 E-08	2.10 E-08

TABLE 4

IMMERSION DOSE FACTORS FOR SWIMMING IN CONTAMINATED WATER  
(mrem/hr) / (pCi/liter)

	<u>Total Body</u>
H-3	0.0
Na-24	7.80 E-06
Mn-54	1.50 E-06
Co-58	1.80 E-06
Co-60	4.60 E-06
Nb-95	0.0
Ag-110m	4.90 E-06
I-131	7.80 E-07
I-133	9.60 E-07
I-135	0.0
Cs-134	2.90 E-06
Cs-136	4.10 E-06
Cs-137	1.00 E-06

TABLE 5

USER: Z10

	<u>Adult</u>	<u>Teenager</u>	<u>Child</u>	<u>Infant</u>	<u>Comments</u>
Number in Family	(2)	(2)	(2)	-	
Aquatic Foods (kg/yr)					
sunfish	11.3	-	-	-	
bass	18.1	-	-	-	
catfish	-	-	-	-	
frog legs	4.5	-	-	-	
crayfish	-	-	-	-	
Wildlife (kg/yr)					
duck	-	-	-	-	
geese	-	-	-	-	
pheasant	4.1	-	-	-	
dove	2.3	-	-	-	
rabbit	7.7	-	-	-	
Shoreline (hr/yr)					
fishing	1000	-	-	-	
hunting	50	-	-	-	
swimming	1000	-	-	-	
boating	-	-	-	-	
irrigation	-	-	-	-	
Other					
water	-	-	-	-	
beef	-	-	-	-	
berries	0.8	0.8	0.8	-	

Notes: Father is the only family member who eats aquatic foods and wildlife.  
 80% sunfish caught 0.5 km downstream.  
 5% sunfish caught 2.4 km downstream.  
 15% sunfish caught 2.9 km downstream.  
 80% bass caught 0.5 km downstream.  
 10% bass caught 2.9 km downstream.  
 10% bass caught in Hadselville Creek approximately 0.5 km upstream of Clay Creek confluence.  
 45% frogs caught 0.5 km downstream.  
 10% frogs caught 0.5-2.4 km downstream.  
 45% frogs caught in pond approximately 0.5 km north of Clay Creek approximately 1.0 km downstream.  
 80% hunting and fishing done 0.5 km downstream.  
 20% hunting and fishing done 2.9 km downstream.

TABLE 6  
FISH CONSUMPTION CALCULATION

<u>Fish</u>	<u>Location Downstream (km)</u>	<u>Nuclide Concentration (pCi/gm)</u>		<u>Consumption (%/100)      (gm)</u>		<u>Ingestion (pCi)</u>	<u>Adult Total Body (mrem)</u>	<u>Adult Liver (mrem)</u>
Sunfish	0.5	Cs-134	5.48	0.80	1.13 E+04	4.95 E+04	5.99	7.33
		Cs-137	11.45			1.04 E+05	7.39	11.3
	2.4	Cs-134	3.48	0.05	1.13 E+04	1.97 E+03	2.38 E-01	2.91 E-01
		Cs-137	7.27			4.11 E+03	2.93 E-01	4.48 E-01
	2.9	Cs-134	3.09	0.15	1.13 E+04	5.24 E+03	6.34 E-01	7.75 E-01
		Cs-137	6.45			1.09 E+04	7.81 E-01	1.19
Bass	0.5	Cs-134	2.23	0.80	1.81 E+04	3.23 E+04	3.91	4.78
		Cs-137	5.00			7.24 E+04	5.17	7.89
	2.9	Cs-134	1.43	0.10	1.81 E+04	2.59 E+03	3.13 E-01	3.83 E-01
		Cs-137	3.19			5.77 E+03	4.12 E-01	6.29 E-01

Total dose calculated from fish consumption (mrem)	25.1	35.0
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Total nuclide ingestion Cs-134	9.16 E+04 pCi
Cs-137	1.97 E+05 pCi



TABLE 7  
FROG LEG CONSUMPTION CALCULATION(1)

Location Downstream (km)	Nuclide Concentration (pCi/gm)		Consumption (%/100)      (gm)		Ingestion (pCi)	Adult Total Body (mrem)	Adult Liver (mrem)
0.5	Cs-134	5.48	0.45	4.5 E+03	1.11 E+04	1.34	1.64
	Cs-137	11.45			2.32 E+04	1.66	2.53
2.4	Cs-134	3.48	0.10	4.5 E+03	1.57 E+03	1.89 E-01	2.32 E-01
	Cs-137	7.27			3.27 E+03	<u>2.34 E-01</u>	<u>3.57 E-01</u>
Total dose calculated from frog leg consumption (mrem)						3.42	4.76
Total nuclide ingestion Cs-134						1.27 E+04 pCi	
Cs-137						2.65 E+04 pCi	

(1) Frog leg radionuclide concentrations are assumed to equal the sunfish concentrations.

TABLE 8  
SHORELINE EXPOSURE CALCULATION

<u>Location Downstream (km)</u>	<u>Nuclide Concentration (mCi/km<sup>2</sup>)</u>		<u>Hours</u>	<u>Total Body Dose<sup>(1)</sup> (mrem)</u>
0.5	Cs-134	6.85 E+02	840	1.38
	Cs-137	1.46 E+03	840	1.03
	Mn-54	5.5 E+01	840	5.36 E-02
	Co-58	4.1 E+01	840	4.82 E-02
	Co-60	5.3 E+02	840	1.51
	Ag-110m	1.8 E+01	840	5.44 E-02
2.9	Cs-134	3.67 E+02	210	1.85 E-01
	Cs-137	7.81 E+02	210	<u>1.38 E-01</u>
Total calculated dose (mrem)				4.40

(1) Shorewidth factor = 0.2

TABLE 9  
SWIMMING CALCULATION

<u>Nuclide</u>	<u>Curies<sup>(1)</sup></u>	<u>Average Concentration<sup>(2)</sup></u> <u>(pCi/liter)</u>	<u>Total Body Dose</u> <u>(mrem)</u>
H-3	2.98 E+02	3.10 E+04	0.0
Na-24	5.95 E-04	6.19 E-02	4.83 E-04
Mn-54	2.45 E-03	2.55 E-01	3.83 E-04
Co-58	1.15 E-02	1.20	2.16 E-03
Co-60	1.94 E-02	2.02	9.29 E-03
Nb-95	1.26 E-04	1.31 E-02	0.0
Ag-110m	1.45 E-03	1.51 E-01	7.40 E-04
I-131	1.24 E-01	1.29 E+01	1.01 E-02
I-133	1.71 E-02	1.78	1.71 E-03
I-135	1.87 E-03	1.94 E-01	0.0
Cs-134	1.53 E-01	1.59 E+01	4.61 E-02
Cs-136	4.28 E-03	4.45 E-01	1.82 E-03
Cs-137	3.01 E-01	3.13 E+01	<u>3.13 E-02</u>
Total calculated dose (mrem)			1.04 E-01

(1) Total amount of radionuclide released from Rancho Seco during 1984.

- (2) - Total water released from Rancho Seco from 1/1/84 through 9/30/84  
9.62 E+09 liters.  
- Dilution water added 7.3 km downstream from Folsom South Canal is not  
considered.  
- Irrigation water removed 0.5 to 7.3 km downstream is not considered.  
- No stream bed sediment interaction assumed.

TABLE 10  
WHOLE BODY COUNT CALCULATIONS

		<u>Cs-134</u>	<u>Cs-137</u>
Biological Half Life	$T_{BIO}(\text{days})$	115	115
Effective Half Life	$T_{EFF}(\text{days})$	99.75	113.8
Decay Constant	$\lambda_{EFF} (\text{days}^{-1})$	6.949 E-03	6.091 E-03
Whole Body Count			
Minimum Detectable Activity (MDA)		6.3	2.5
(nCi)			

EXPECTATION OF OBSERVING A BODY BURDEN BASED UPON INGESTION DATA

Total Ingested (nCi)	104	224
Ingestion Rate I nCi/(day)	2.85 E-01	6.11 E-01
Expected Body Burden on 4/30/85 (nCi)	16.4	43.1

MAXIMUM DOSE BASED UPON MDA BODY BURDEN

Maximum Body Burden on 12/31/84 (nCi)	14.5	5.19
Maximum Ingestion Rate (nCi/day)	1.09 E-01	3.54 E-02
Maximum Ingestion (nCi)	40.0	13.0
Maximum Whole Body Dose (mrem)	4.84	0.93
Maximum Liver Dose (mrem)	5.93	1.41
Maximum Ingestion Dose (mrem)		
Whole Body	5.77	
Liver	7.34	

## REFERENCES

1. "Fancho Seco Liquid Effluent Pathway Aquatic and Terrestrial Dietary Survey Report" UCID-20267, November 30, 1984.
2. "Concentration of Radionuclides In Fresh Water Fish Downstream of Rancho Seco Nuclear Generating Plant" UCID-20295, December 27, 1984.
3. "Radionuclides in Sediments Collected Downstream from the Rancho Seco Nuclear Power Generating Station" UCID-20298, January 17, 1985.
4. "User's Manual for LADTAPII - A Computer Program for Calculating Radiation Exposure to Man from Routine Release of Nuclear Reactor Liquid Effluents" NUREG/CR-1276, May 1980.
5. "Age-Specific Radiation Dose Commitment Factors For A One-Year Chronic Intake" NUREG 0172, November 1977.