ISR Exhibit to Rebuttal Testimony of Dr. François J. Lemay

Cost of decontamination at Surry based on assumptions contained in NUREG/CR-3673

In its testimony (A81), NRC and Sandia stated (A81) that the cost of decontamination was discussed in NUREG/CR-3673 (NRC000058). On page 4-14, 4-15 and 4-18 the authors of NUREG/CR-3673 write:

> Recently, much attention has been given to the potential effectiveness and costs of decontamination techniques after LWR accident releases [Wa82, Li83, Os83]. The experimental data which exist concerning the effectiveness of decontamination techniques are dependent on radionuclides, particle sizes, and the chemical forms characteristic of deposited material. Little data exist which are directly applicable to the small particle sizes (~0.1-10 µm) and soluble materials which are anticipated in releases from most severe LWR accidents. The cost and effectiveness estimates for decontamination contain large uncertainties, and results of future experimentation with decontamination techniques should be used to update models for decontamination.
>
> The cost estimates used in this study for various levels of decontamination effort in an area are taken from a detailed review of decontamination effectiveness and costs performed at Sandia National Laboratories (SNL) [Os84].
>
> Table 4.4
> Decontamination Cost and Effectiveness Values for Non-Farm Areas [Os84]

Dose Rate Reduction Factor After Decontamination	Approximate Costs ($/person)	Fraction of Cost for Paid Labor	Worker Dose Reduction Factor (Estimated Worker Dose/Dose From Continuous Exposure
(f)	(DRf)	(RLf)	(WRf)
3	2600	0.7	0.33
15	6900	0.5	0.33
20	7400	0.5	0.33

NUREG/CR-3673 cites reference [Os84] as:

Ostmeyer, R.M., and G.E. Runkle, An Assessment of Decontamination Costs and Effectiveness for Accident Radiological Releases. Albuquerque, N.M.: Sandia National Laboratories, to be published.

The discussion continues on pages 4-19 and 4-20 and in Table 4.1 of NUREG/CR-3673:

> The total man-years of effort required for the decontamination program in each area is estimated using:
>
> $$DMY = \frac{Cd1}{DW} \qquad (4.8)$$
>
> where
>
> DMY = the total man-years of effort required in area,
> DW = the average cost of decontamination labor ($/man-year)
> Cd1 = the portion of decontamination program costs for labor
>
> The average cost of decontamination labor is estimated to be ~$30,000 per man-year in this study (~$10/hour for a 56 hour work week). This cost is estimated based on costs for military and disaster relief personnel. The total man-years of effort required is used to estimate the number of decontamination workers required to complete the decontamination program in a specified program duration:
>
> $$Nd = \frac{DMY}{td} \qquad (4.9)$$
>
> where
> Nd = the number of decontamination workers required to complete the program in the estimated program duration (number of workers)
> td = specified average time required to complete the decontamination effort (years)

Pages 6-24 to 6-25 of NUREG/CR-3673 contain the following description, related to Siting Source Term (SST)-1, a most severe accident:

> Additional attributes of SST1 accident consequences estimated in the new economic model are shown in Table 6.7. The implementation of population protective measures (including decontamination, interdiction, and relocation) results in a factor-of-four reduction in total population dose incurred in the first 100 years after accident occurrence. The dose to decontamination workers during the decontamination period is estimated to be about 2% of the total population dose incurred in this period. A total of ~11,000 man-years of effort is involved in the decontamination program to reduce population exposure from the accident. Based on a mean time to completion of 90 days for the decontamination efforts, this program would require a work force of ~46,000 men. Clearly, a large decontamination program after a severe reactor accident would have some important beneficial economic impacts in an affected area. *However, manpower*

limitations may force an extended period for completion of the offsite decontamination program after large releases of radioactive material. [emphasis added]

Table 6.7 – Comparison of offsite cost estimates from CRAC2 and new models, conditional on SST1 accident release, Surry #2 plant.

Cost Component	CRAC2 Mean Costs	New Model Mean Costs
Evacuation	$\$3.0\times10^{6}$	$\$4.5\times10^{6}$
Emergency Phase Relocation	-	$\$2.3\times10^{7}$
Intermediate Phase Relocation	-	$\$8.6\times10^{7}$
Agricultural Product Disposal	$\$8.0\times10^{7}$	$\$9.1\times10^{7}$
Population Relocation		
During Decontamination	-	$\$9.3\times10^{7}$
Land and Property Decontamination	$\$4.2\times10^{8}$	$\$6.6\times10^{8}$
Land and Property Interdiction	$\$1.9\times10^{8}$	$\$1.6\times10^{8}$
Interdicted Population Relocation	$\$4.9\times10^{7}$	$\$2.6\times10^{7}$
Offsite Health Effects	-	$\$1.5\times10^{8}$
Total Offsite Costs	$\$7.4\times10^{8}$	$\$1.1\times10^{9}$

Other Attributes Estimated in New Model		
Total Population Dose Incurred, 0-100 Years	1.4×10^{7}	Person-Rem
Total Population Dose Avoided by Protective Measures	4.1×10^{7}	Person-Rem
Decontamination Worker Dose	2.8×10^{8}	Person-Rem
Labor Required for Decontamination Program	1.1×10^{4}	Person-Years
Number of Decontamination Workers Required for Completion of Program in 90 Days	4.6×10^{4}	Persons

The number of persons needed for decontamination is calculated in NUREG/CR-3673 from the data in Table 4.4 and Table 6.7 and equations 4.8, 4.9 as follows:

$$Cd1 = RLf \times Cd$$

$$DMY = \frac{Cd1}{DW}$$

$$Nd = \frac{DMY}{td}$$

When expressed in words, these equations are

Labor Cost of Decontamination = RLf (0.5) × Cost of Decontamination ($\$6.6\times10^8$)

$$\text{Number of Person-Years} = \frac{\text{Labor Cost of Decontamination } (\$3.3\times10^8)}{\text{Annual salary of worker } (\$30{,}000)}$$

$$\text{Number of Workers} = \frac{\text{Number of Person-Years } (1.1\times10^4)}{\text{Duration of Decontamination (fraction of year = 90 d / 365 d)}}$$

$$= 4.6\times10^4 \text{ workers}$$

In Table 4.4 of NUREG/CR-3673, the costs are calculated for 1982. When adjusted for CPI the costs of decontamination per person are consistent with the value contained in Sample Problem A. The values quoted in NUREG/CR-3673 are therefore consistent with the MACCS2 methodology used by Entergy in its cost calculation.

ISR's calculation of the Cost of Decontamination at Indian Point Unit 2 assuming the validity of the methodology in NUREG/CR3673

ISR used the population-dependent decontamination cost from the Entergy MACCS2 output file to calculate the number of workers that would be required to decontaminate the non-farm areas, assuming the validity of the NUREG/CR3673 methodology . The MACCS2 output file provided by Entergy (conbi2NS-noE-NmetEC.OUT),for the Early High scenario, contains the following mean costs:

TOTAL ECONOMIC COSTS	2.05E+11
POP.-DEPENDENT COSTS	2.05E+11
FARM-DEPENDENT COSTS	3.92E+08
POP.-DEPENDENT DECONTAMINATION COST	4.41E+10
FARM-DEPENDENT DECONTAMINATION COST	3.41E+07
POP.-DEPENDENT INTERDICTION COST	1.46E+11
FARM-DEPENDENT INTERDICTION COST	3.04E+08
POP.-DEPENDENT CONDEMNATION COST	1.48E+10

FARM-DEPENDENT CONDEMNATION COST	1.26E+07
EMERGENCY PHASE COST	2.16E+08

ISR adjusted the the annual salary of workers by the CPI (ENT000461) from 1982 to 2005 in order to have a consistent cost basis:

$$\text{DW (2005\$)} = \text{DW (1982\$)} \times \frac{\text{CPI (2005)}}{\text{CPI (1982)}} = \$30{,}000 \times \frac{195.3}{96.5} = \$60{,}715$$

Using the same equations as NUREG/CR-3673, ISR calculated the following:

Labor Cost of Decontamination = RLf (0.5) × Cost of Decontamination ($\$4.41\times10^{10}$)

$$\text{Number of Person-Years} = \frac{\text{Labor Cost of Decontamination } (\$2.2\times10^{10})}{\text{Annual salary of worker } (\$60{,}715)}$$

$$\text{Number of Workers} = \frac{\text{Number of Person-Years } (3.62\times10^{5})}{\text{Duration of Decontamination (fraction of year = 90 d / 365 d)}}$$

$$= 1.5\times10^{6} \text{ workers required for decontamination}$$