RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**ER 1-8428**
SRP Section:	**Environmental Report**
Application Section:	**APR1400 Environmental Report**
Date of RAI Issue:	**03/22/2016**

Question No. EIS ACC/SA-2

10 CFR 51.55(a) requires each applicant for a standard design certification under subpart B of 10 CFR Part 52 (i.e., 10 CFR 52.47(b)(2)) to submit with its application a separate document entitled, "Applicant's Environmental Report—Standard Design Certification." The environmental report must address the costs and benefits of severe accident mitigation design alternatives, and the bases for not incorporating severe accident mitigation design alternatives in the design to be certified.

The environmental standard review plan (ESRP) Section 7.2, Severe Accidents, of NUREG 1555 directs the staff to evaluate and independently confirm severe accident risks and analyses presented in an Environmental Report (ER) (i.e., the APR1400 ER, “Applicant’s Environmental Report – Standard Design Certification,” found under ML15006A038 and the proprietary technical report, “Severe Accident Mitigation Design Alternatives (SAMDAs) for the APR1400,’under ML15012A105) of accidents involving radioactive material that can be postulated for the plant under review. The scope of this review should include probability-weighted consequence (i.e., risks) analysis for severe accidents, including dose and socioeconomic risk impacts based on plant specific data in sufficient detail to appropriately evaluate the risks for severe accidents.

The staff requires the following additional information in order to complete its review of the environmental impacts of severe accidents and to ensure appropriate documentation of the applicant’s assessment in the APR1400 Environmental Report.

Provide justification why the use of an older version of the SecPop computer code, which is based on Census 2000 data (SecPop2000), should be acceptable for supporting the severe accident analysis when Census 2010 data is readily available via the latest version of SecPop (SecPop v4.3).

The NRC staff request that any revisions to the ER or supporting technical reports be provided as a markup as part of the response to this RAI.

This RAI is related to the Environmental Audit Information Needs ER-TI-4 (ML15198A023).

Response

The initial development of the APR1400 Level 3 analysis (APR1400-K-P-NR-013902-P) was performed prior to the release of the latest SECPOP program that utilized the 2010 US Census data (Version 4.3.0), “SECPOP (2010)”. The method employed to determine 2030 population data was to begin with a population base year of 2000 and develop growth factors for intervals of 2000 to 2010 using US Census data and projected population growth from 2010 to 2030 from state (VA and NC) population growth estimates. These combined growth factors (2000-2010 multiplied by 2010-2030) were applied to the population grid figures generated by SECPOP2000.

Using the latest version of SECPOP (Version 4.3.0), a comparison was performed to determine the difference between the original reference site population estimate calculated from SECPOP2000 and projected to 2030 to the population estimate calculated from SECPOP (2010) and projected to 2030.

The attached Table 1 contains the results generated from SEPOP (2010) reference site rosette segment population figures. Population estimate growth factors were then calculated for each county identified in the APR1400 Level 3 analysis report. Attached Table 2 lists these counties, the calculated county population growth factors, the latest 2010 census populations, and the 2030 population estimates. The population growth factor was calculated as the ratio of 2030 population divided by the 2010 census population.

The attached Table 3 lists the 2010 to 2030 population growth factors for each rosette segment, determined in the same method as in the APR1400 Level 3 analysis, where each segment's growth factor was then calculated as the sum of the products of each component county area fraction.

The attached Table 4 then shows the SECPOP2000 year 2030 estimated rosette segment populations from the documented APR1400 Level 3 analysis. This was provided for comparison with the attached Table 5, which lists the SECPOP (2010) sensitivity case year 2030 estimated rosette segment populations.

The year 2030 rosette segment population estimates presented in Table 5 were then input into the APR1400 Level 3 analysis WinMACCS site data file. This was the only modification made to the site, and the Base WinMACCS case was recalculated. The results of this calculation are presented in the following tables.

The attached Table 6 documents the percent change in dose for WinMACCS parameter “L-EDEWBODY TOT LIF 0-80.5 km (MEAN)” between the base value documented in the APR1400 Level 3 analysis (APR1400- K- PNR- 013902- P, Section 9.0 - Summary of Results Tables) and the sensitivity case from presented in this RAI response. For this sensitivity case, the use of SECPOP (2010) population data expanded to an estimated population in 2030 showed an increase in the dose parameter value of no more than 3% in any one STC.

The attached Table 7 documents the percent change in economic cost for WinMACCS parameter “ECONOMIC COST MEASURES ($) 0-80.5 km TOTAL ECONOMIC COSTS (MEAN)” between

the base value documented in the APR1400 Level 3 analysis (APR1400- K- PNR- 013902- P, Section 9.0 - Summary of Results Tables) and the sensitivity case from presented in this RAI response. For this sensitivity case, the use of SECPOP (2010) population data expanded to an estimated population in 2030 also showed an increase in economic cost parameter value of no more than 3% in any one STC.

The results in Tables 6 and 7 of this RAI sensitivity case were applied to the calculation of dose and dollars used in the APR1400 SAMDA analysis (APR1400-K-P-NR-013901-P R1) for at power internal events, at power internal flooding, at power internal fire, LPSD internal events, LPSD internal flooding, and LPSD internal fire. The attached Tables 8 through 13 show that for offsite exposure, this sensitivity case increased the dose no more than 3% over the exposure dose documented in the APR1400 SAMDA report. The attached Tables 14 through 19 show that for offsite property damage costs, this sensitivity case also increased the cost no more than 3% over the property damage costs documented in the APR1400 SAMDA report.

These calculations show that though there was an increase in dose and costs associated with the use of SECPOP (2010) population data, the percent difference of the overall impact is nearly negligible and would not change any conclusion presented in the APR1400 Level 3 report or SAMDA analysis.

Therefore, the results and analyses presented in the original analysis remain valid.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Table 1
SECPOP (2010) Reference Site Population

0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Radius	Rosette
0	0	0	0	910	16348	5148	4829	3530	4219	0.0	N
0	0	0	0	830	9340	9958	10294	10812	7324	22.5	NNE
0	0	0	0	137	2800	8062	6960	2990	0	45.0	NE
0	0	0	0	0	6623	10923	1060	270	5195	67.5	ENE
0	0	0	0	0	32246	41704	561	1412	1569	90.0	E
0	0	0	0	0	25225	152126	103870	82763	88627	112.5	ESE
0	0	0	0	0	0	30671	158094	441391	195538	135.0	SE
0	0	0	0	108	555	19036	44900	28231	5530	157.5	SSE
0	37	106	43	304	1060	3222	9581	15840	8359	180.0	S
0	0	0	4	86	205	1186	4738	16647	3836	202.5	SSW
0	0	6	2	257	331	1045	2354	2196	4994	225.0	SW
0	0	0	70	118	569	1341	5627	2844	4220	247.5	WSW
0	0	0	120	58	828	933	3667	61322	41531	270.0	W
0	0	0	2	24	131	925	4078	52478	241990	292.5	WNW
0	0	0	0	429	9642	2413	6470	17144	122387	315.0	NW
0	0	0	0	333	20867	23731	8018	2555	9489	337.5	NNW

Table 2
SECPOP (2010) Census to 2030 Population Estimate Growth Factors

Area	2010-2030 Growth Factor	2010 Census	2030 Projection
Accomack County	1.33	33,164	44,249
Charles City County	1.21	7,256	8,749
Chesterfield County	1.36	316,236	430,266
Dinwiddie County	1.34	28,001	37,563
Essex County	1.16	11,151	12,974
Gloucester County	1.41	36,858	51,824
Greensville County	0.96	12,243	11,808
Hanover County	1.44	99,863	143,959
Henrico County	1.23	306,935	379,041
Isle of Wight County	1.46	35,270	51,629
James City County	1.50	67,009	100,294
King and Queen County	1.09	6,945	7,564
King William County	1.39	15,935	22,227
Lancaster County	1.01	11,391	11,478
Mathews County	1.01	8,978	9,068
Middlesex County	1.20	10,959	13,181
New Kent County	1.60	18,429	29,496
Northampton County	1.29	12,389	15,931
Northumberland County	1.28	12,330	15,821
Prince George County	1.78	35,725	63,420
Richmond County	1.14	9,254	10,512
Southampton County	0.96	18,570	17,795
Surry County	1.16	7,058	8,156
Sussex County	0.92	12,087	11,113
York County	1.33	65,464	86,823
Chesapeake city	1.39	222,209	308,736
Colonial Heights city	1.17	17,411	20,454
Franklin city	1.16	8,582	9,930
Hampton city	1.05	137,436	144,650
Hopewell city	1.06	22,591	23,993
Newport News city	1.01	180,719	183,372
Norfolk city	0.98	242,803	238,927
Petersburg city	0.95	32,420	30,730
Poquoson city	1.05	12,150	12,782
Portsmouth city	1.06	95,535	101,071
Richmond city	0.92	204,214	187,066
Suffolk city	1.79	84,585	151,427
Virginia Beach city	1.13	437,994	493,095
Williamsburg city	1.01	14,068	14,159
Camden County, NC	1.04	9,980	10,364
Currituck County, NC	1.33	23,547	31,324
Gates County, NC	1.28	12,197	15,578
Hertford County, NC	0.97	24,669	23,972
Northampton County, NC	0.86	22,099	19,100
Pasquotank County, NC	1.00	40,661	40,484

Table 3
Population Growth Factors – SECPOP (2010) Year 2030 Estimate

	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Radius
N	1.0	1.16	1.16	1.50	1.50	1.25	1.40	1.17	1.15	1.14	0.0
NNE	1.0	1.16	1.16	1.50	1.50	1.33	1.41	1.37	1.05	1.15	22.5
NE	1.0	1.16	1.16	1.50	1.50	1.33	1.41	1.01	1.01	1.01	45.0
ENE	1.0	1.16	1.16	1.16	1.50	1.33	1.41	1.01	1.01	1.29	67.5
E	1.0	1.16	1.16	1.16	1.50	1.17	1.33	1.05	1.29	1.29	90.0
ESE	1.0	1.16	1.16	1.16	1.01	1.01	1.10	1.05	1.13	1.13	112.5
SE	1.0	1.16	1.16	1.16	1.01	1.01	1.02	1.02	1.18	1.26	135.0
SSE	1.0	1.16	1.46	1.46	1.46	1.46	1.46	1.79	1.51	1.29	157.5
S	1.0	1.16	1.16	1.16	1.16	1.37	1.46	1.63	1.79	1.73	180.0
SSW	1.0	1.16	1.16	1.16	1.16	1.16	1.46	1.21	1.21	1.08	202.5
SW	1.0	1.16	1.16	1.16	1.16	1.16	1.16	0.94	0.94	0.95	225.0
WSW	1.0	1.16	1.16	1.16	1.16	1.16	1.16	0.92	0.92	0.92	247.5
W	1.0	1.16	1.16	1.16	1.16	1.16	1.16	1.78	1.67	1.34	270.0
WNW	1.0	1.16	1.16	1.50	1.50	1.50	1.35	1.38	1.24	1.25	292.5
NW	1.0	1.16	1.16	1.50	1.50	1.50	1.33	1.41	1.49	1.40	315.0
NNW	1.0	1.16	1.16	1.50	1.50	1.50	1.50	1.60	1.30	1.20	337.5

Table 4
SEPOP2000 year 2030 Population Estimate - MACCS INPUT

miles->	1 mi	2 mi	3 mi	4 mi	5 mi	10 mi	20 mi	30 mi	40 mi	50 mi	Direction Total
N	0	0	0	0	411	19648	8194	4708	4095	5089	42,145
NNE	0	0	0	0	3364	12421	11657	12515	11192	7861	59,010
NE	0	7	0	0	0	3631	11491	6741	2994	0	24,864
ENE	0	0	0	0	0	7056	14995	1213	101	5944	29,309
E	0	0	0	0	0	36777	40458	254	1784	1903	81,177
ESE	0	0	0	0	0	28878	171543	100312	95669	100961	497,363
SE	0	0	0	0	0	0	29511	148590	514279	237759	930,140
SSE	0	29	41	0	180	596	24768	61009	43184	6754	136,562
S	0	0	2	249	82	1599	4757	14823	30865	11082	63,459
SSW	0	4	0	147	89	212	2016	5800	21333	4667	34,268
SW	0	0	12	6	104	570	1269	2229	2009	5171	11,371
WSW	0	0	9	55	106	1037	1626	3274	4140	3713	13,961
W	0	0	0	150	168	385	950	4745	91719	57857	155,974
WNW	0	0	0	0	91	316	4062	5907	60384	314108	384,869
NW	0	0	0	0	0	14600	3714	7431	27471	179521	232,738
NNW	0	0	0	0	2035	28885	31637	14081	3126	9983	89,747
Sums	0	40	65	607	6632	156612					
Sums						163955	362649	393631	914347	952374	2,786,956
Annuli						1-10 mi	10-20 mi	20-30 mi	30-40 mi	40-50 mi	1 - 50 mi

* from APR1400-K-PNR-013902-P, Table 5.5.1-5 Projected 2030 Populations Per Segment

Table 5
SEPOP 2010 Year 2030 Population Estimate - MACCS INPUT

miles->	1 mi	2 mi	3 mi	4 mi	5 mi	10 mi	20 mi	30 mi	40 mi	50 mi	Direction Total
N	0	0	0	0	1362	20435	7203	5650	4042	4789	43,480
NNE	0	0	0	0	1242	12387	14001	14082	11331	8386	61,430
NE	0	0	0	0	205	3714	11336	7030	3020	0	25,304
ENE	0	0	0	0	0	8784	15358	1071	273	6680	32,166
E	0	0	0	0	0	37728	55311	590	1816	2018	97,462
ESE	0	0	0	0	0	25595	167034	109322	93175	99777	494,903
SE	0	0	0	0	0	0	31284	161256	522607	246378	961,525
SSE	0	0	0	0	158	812	27865	80382	42629	7106	158,952
S	0	43	122	50	351	1452	4716	15569	28357	14486	65,147
SSW	0	0	0	5	99	237	1736	5733	20060	4131	32,001
SW	0	0	7	2	297	382	1208	2213	2073	4754	10,936
WSW	0	0	0	81	136	658	1550	5174	2615	3880	14,093
W	0	0	0	139	67	957	1078	6510	102193	55818	166,761
WNW	0	0	0	3	36	196	1251	5632	64968	301520	373,605
NW	0	0	0	0	642	14431	3200	9090	25493	171464	224,321
NNW	0	0	0	0	498	31232	35519	12833	3322	11339	94,743
Sums	0	43	129	279	5095	159001					
Sums						164547	379650	442135	927972	942525	2,856,831
Annuli						1-10 mi	10-20 mi	20-30 mi	30-40 mi	40-50 mi	1 - 50 mi

Table 6
WinMACCS Sensitivity of SECPOP Population Estimates on Source Term Category Dose

CET End Point (Release Mode)	*Base (Dose)	RAI-2 SECPOP (2010) to 2013(Dose)	% change in Dose
STC 1	6.34E+04	6.52E+04	3%
STC 2	3.03E+02	3.08E+02	2%
STC 3	9.42E+04	9.66E+04	3%
STC 4	8.00E+04	8.20E+04	2%
STC 5	3.52E+03	3.61E+03	3%
STC 6	1.79E+04	1.84E+04	3%
STC 7	4.48E+04	4.61E+04	3%
STC 8	5.77E+04	5.96E+04	3%
STC 9	1.73E+01	1.75E+01	1%
STC 10	4.17E+01	4.22E+01	1%
STC 11	1.94E+02	1.92E+02	-1%
STC 13	3.31E+04	3.41E+04	3%
STC 14	1.76E+03	1.80E+03	2%
STC 16	5.01E+03	5.17E+03	3%
STC 17	1.20E+02	1.22E+02	2%
STC 18	2.84E+03	2.91E+03	2%
STC 19	5.82E+03	4.46E+03	-26%
STC 20	7.94E+03	8.19E+03	3%
STC 21	7.85E+03	8.11E+03	3%

*Base Dose from APR1400-K-PNR-013902-P, Section 9.0 - Summary of Results Tables

Table 7
WinMACCS Sensitivity of SECPOP Population Estimates on Source Term Category Cost

CET End Point (Release Mode)	*Base ($)	RAI-2 SECPOP (2010) to 2013(Dollars)	% change in $
STC 1	1.86E+10	1.91E+10	3%
STC 2	5.00E+07	5.00E+07	0%
STC 3	2.77E+10	2.85E+10	3%
STC 4	2.09E+10	2.15E+10	3%
STC 5	3.91E+08	3.94E+08	1%
STC 6	4.02E+09	4.13E+09	3%
STC 7	1.00E+10	1.03E+10	3%
STC 8	1.56E+10	1.60E+10	3%
STC 9	3.17E+07	3.18E+07	0%
STC 10	3.01E+07	3.02E+07	0%
STC 11	4.24E+07	4.26E+07	0%
STC 13	5.67E+09	5.80E+09	2%
STC 14	5.86E+07	5.77E+07	-2%
STC 16	3.43E+08	3.41E+08	-1%
STC 17	3.34E+07	3.35E+07	0%
STC 18	1.05E+08	1.02E+08	-3%
STC 19	3.60E+08	3.15E+08	-13%
STC 20	6.68E+08	6.65E+08	0%
STC 21	8.42E+08	8.57E+08	2%

*Base Cost ($) from APR1400-K-PNR-013902-P, Section 9.0 - Summary of Results Tables

Table 8
RAI-SA2 Sensitivity Case
Offsite Exposure By Source Term Category At-Power Internal Events

STC	STC Frequency (per year)	Conditional Person-Sv Offsite Sensitivity SECPOP (2010)	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite		
1	5.33E-08	6.52E+04	6.52E+06	3.48E-01		
2	2.41E-08	3.08E+02	3.08E+04	7.42E-04		
3	5.31E-11	9.66E+04	9.66E+06	5.13E-04		
4	6.49E-11	8.20E+04	8.20E+06	5.32E-04		
5	2.46E-09	3.61E+03	3.61E+05	8.88E-04		
6	1.23E-09	1.84E+04	1.84E+06	2.26E-03		
7	1.14E-08	4.61E+04	4.61E+06	5.26E-02		
8	1.30E-08	5.96E+04	5.96E+06	7.75E-02		
9	3.67E-07	1.75E+01	1.75E+03	6.42E-04		
10	7.64E-07	4.22E+01	4.22E+03	3.22E-03		
11	1.33E-08	1.92E+02	1.92E+04	2.55E-04		
13	1.80E-09	3.41E+04	3.41E+06	6.14E-03		
14	4.28E-11	1.80E+03	1.80E+05	7.70E-06		
16	7.30E-12	5.17E+03	5.17E+05	3.77E-06		
17	2.70E-08	1.22E+02	1.22E+04	3.29E-04		
18	4.19E-10	2.91E+03	2.91E+05	1.22E-04		
19	4.01E-09	4.46E+03	4.46E+05	1.79E-03		
20	1.19E-11	8.19E+03	8.19E+05	9.75E-06		
21	2.96E-08	8.11E+03	8.11E+05	2.40E-02	*SAMDA Total REM/yr	
	Total STC Freq.			**Total REM/yr**		**Percent Diff**
	1.31E-06			5.19E-01	5.05E-01	3%

* Value from APR1400-K-PNR-013902-P, Table 2a

Table 9
RAI-SA2 Sensitivity Case
Offsite Exposure By Source Term Category At-Power Internal Flooding

STC	STC Frequency (per year)	Conditional Person-Sv Offsite Sensitivity SECPOP (2010)	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite		
1	6.21E-09	6.52E+04	6.52E+06	4.05E-02		
2	0.00E+00	3.08E+02	3.08E+04	0.00E+00		
3	0.00E+00	9.66E+04	9.66E+06	0.00E+00		
4	0.00E+00	8.20E+04	8.20E+06	0.00E+00		
5	7.40E-10	3.61E+03	3.61E+05	2.67E-04		
6	6.08E-09	1.84E+04	1.84E+06	1.12E-02		
7	9.38E-10	4.61E+04	4.61E+06	4.32E-03		
8	1.03E-09	5.96E+04	5.96E+06	6.14E-03		
9	4.24E-08	1.75E+01	1.75E+03	7.42E-05		
10	3.28E-07	4.22E+01	4.22E+03	1.38E-03		
11	5.33E-09	1.92E+02	1.92E+04	1.02E-04		
13	7.82E-10	3.41E+04	3.41E+06	2.67E-03		
14	1.60E-11	1.80E+03	1.80E+05	2.88E-06		
16	3.78E-12	5.17E+03	5.17E+05	1.95E-06		
17	1.43E-08	1.22E+02	1.22E+04	1.74E-04		
18	1.56E-10	2.91E+03	2.91E+05	4.54E-05		
19	2.76E-09	4.46E+03	4.46E+05	1.23E-03		
20	6.19E-12	8.19E+03	8.19E+05	5.07E-06		
21	1.57E-08	8.11E+03	8.11E+05	1.27E-02	***SAMDA**	
	Total STC Freq.			**Total REM/yr**	**Total REM/yr**	**Percent Diff**
	4.24E-07			8.08E-02	7.89E-02	2%

* Value from APR1400-K-PNR-013902-P, Table 2b

Table 10
RAI-SA2 Sensitivity Case
Offsite Exposure By Source Term Category At-Power Internal Fire

STC	STC Frequency (per year)	Conditional Person-Sv Offsite Sensitivity SECPOP (2010)	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite		
1	8.31E-08	6.52E+04	6.52E+06	5.42E-01		
2	0.00E+00	3.08E+02	3.08E+04	0.00E+00		
3	0.00E+00	9.66E+04	9.66E+06	0.00E+00		
4	0.00E+00	8.20E+04	8.20E+06	0.00E+00		
5	2.38E-08	3.61E+03	3.61E+05	8.59E-03		
6	2.60E-08	1.84E+04	1.84E+06	4.78E-02		
7	4.36E-09	4.61E+04	4.61E+06	2.01E-02		
8	6.16E-09	5.96E+04	5.96E+06	3.67E-02		
9	2.83E-07	1.75E+01	1.75E+03	4.95E-04		
10	9.62E-07	4.22E+01	4.22E+03	4.06E-03		
11	5.56E-07	1.92E+02	1.92E+04	1.07E-02		
13	3.71E-09	3.41E+04	3.41E+06	1.27E-02		
14	2.39E-09	1.80E+03	1.80E+05	4.30E-04		
16	5.71E-10	5.17E+03	5.17E+05	2.95E-04		
17	3.99E-08	1.22E+02	1.22E+04	4.87E-04		
18	2.34E-08	2.91E+03	2.91E+05	6.81E-03		
19	6.51E-09	4.46E+03	4.46E+05	2.90E-03		
20	9.34E-10	8.19E+03	8.19E+05	7.65E-04		
21	4.38E-08	8.11E+03	8.11E+05	3.55E-02	*SAMDA	
	Total STC Freq.			**Total REM/yr**	**Total REM/yr**	**Percent Diff**
	2.07E-06			7.30E-01	7.11E-01	3%

* Value from APR1400-K-PNR-013902-P, Table 2c

Table 11
RAI-SA2 Sensitivity Case
Offsite Exposure By Source Term Category LPSD Internal Events

STC	STC Frequency (per year)	Conditional Person-Sv Offsite Sensitivity SECPOP (2010)	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite		
1	1.46E-08	6.52E+04	6.52E+06	9.52E-02		
2	6.62E-09	3.08E+02	3.08E+04	2.04E-04		
3	2.79E-08	9.66E+04	9.66E+06	2.70E-01		
4	1.78E-11	8.20E+04	8.20E+06	1.46E-04		
5	6.75E-10	3.61E+03	3.61E+05	2.44E-04		
6	1.06E-08	1.84E+04	1.84E+06	1.95E-02		
7	3.13E-09	4.61E+04	4.61E+06	1.44E-02		
8	3.61E-08	5.96E+04	5.96E+06	2.15E-01		
9	1.01E-07	1.75E+01	1.75E+03	1.77E-04		
10	2.55E-06	4.22E+01	4.22E+03	1.08E-02		
11	1.02E-07	1.92E+02	1.92E+04	1.96E-03		
13	4.94E-10	3.41E+04	3.41E+06	1.68E-03		
14	1.18E-11	1.80E+03	1.80E+05	2.12E-06		
16	2.00E-12	5.17E+03	5.17E+05	1.03E-06		
17	7.41E-09	1.22E+02	1.22E+04	9.04E-05		
18	1.15E-10	2.91E+03	2.91E+05	3.35E-05		
19	1.10E-09	4.46E+03	4.46E+05	4.91E-04		
20	4.08E-08	8.19E+03	8.19E+05	3.34E-02		
21	8.13E-09	8.11E+03	8.11E+05	6.59E-03	***SAMDA**	
	Total STC Freq.			**Total REM/yr**	**Total REM/yr**	**Percent Diff**
	2.91E-06			6.70E-01	6.57E-01	2%

* Value from APR1400-K-PNR-013902-P, Table 2d

Table 12
RAI-SA2 Sensitivity Case
Offsite Exposure By Source Term Category LPSD Internal Flooding

STC	STC Frequency (per year)	Conditional Person-Sv Offsite Sensitivity SECPOP (2010)	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite		
1	0.00E+00	6.52E+04	6.52E+06	0.00E+00		
2	0.00E+00	3.08E+02	3.08E+04	0.00E+00		
3	0.00E+00	9.66E+04	9.66E+06	0.00E+00		
4	0.00E+00	8.20E+04	8.20E+06	0.00E+00		
5	0.00E+00	3.61E+03	3.61E+05	0.00E+00		
6	1.84E-08	1.84E+04	1.84E+06	3.39E-02		
7	0.00E+00	4.61E+04	4.61E+06	0.00E+00		
8	0.00E+00	5.96E+04	5.96E+06	0.00E+00		
9	0.00E+00	1.75E+01	1.75E+03	0.00E+00		
10	0.00E+00	4.22E+01	4.22E+03	0.00E+00		
11	0.00E+00	1.92E+02	1.92E+04	0.00E+00		
13	0.00E+00	3.41E+04	3.41E+06	0.00E+00		
14	0.00E+00	1.80E+03	1.80E+05	0.00E+00		
16	0.00E+00	5.17E+03	5.17E+05	0.00E+00		
17	0.00E+00	1.22E+02	1.22E+04	0.00E+00		
18	0.00E+00	2.91E+03	2.91E+05	0.00E+00		
19	0.00E+00	4.46E+03	4.46E+05	0.00E+00		
20	0.00E+00	8.19E+03	8.19E+05	0.00E+00		
21	0.00E+00	8.11E+03	8.11E+05	0.00E+00	*SAMDA	
	Total STC Freq.			**Total REM/yr**	**Total REM/yr**	**Percent Diff**
	1.84E-08			3.39E-02	3.29E-02	3%

* Value from APR1400-K-PNR-013902-P, Table 2e

Table 13
RAI-SA2 Sensitivity Case
Offsite Exposure By Source Term Category LPSD Internal Fire

STC	STC Frequency (per year)	Conditional Person-Sv Offsite Sensitivity SECPOP (2010)	Conditional Person-REM Offsite	Expected Person-REM/yr Offsite		
1	7.52E-09	6.52E+04	6.52E+06	4.90E-02		
2	3.40E-09	3.08E+02	3.08E+04	1.05E-04		
3	2.50E-08	9.66E+04	9.66E+06	2.42E-01		
4	9.16E-12	8.20E+04	8.20E+06	7.51E-05		
5	3.47E-10	3.61E+03	3.61E+05	1.25E-04		
6	1.31E-08	1.84E+04	1.84E+06	2.41E-02		
7	1.61E-09	4.61E+04	4.61E+06	7.42E-03		
8	6.86E-08	5.96E+04	5.96E+06	4.09E-01		
9	5.18E-08	1.75E+01	1.75E+03	9.07E-05		
10	1.46E-06	4.22E+01	4.22E+03	6.16E-03		
11	6.19E-08	1.92E+02	1.92E+04	1.19E-03		
13	2.54E-10	3.41E+04	3.41E+06	8.66E-04		
14	6.04E-12	1.80E+03	1.80E+05	1.09E-06		
16	1.03E-12	5.17E+03	5.17E+05	5.33E-07		
17	3.81E-09	1.22E+02	1.22E+04	4.65E-05		
18	5.91E-11	2.91E+03	2.91E+05	1.72E-05		
19	5.66E-10	4.46E+03	4.46E+05	2.52E-04		
20	3.52E-08	8.19E+03	8.19E+05	2.88E-02		
21	4.18E-09	8.11E+03	8.11E+05	3.39E-03	***SAMDA**	
	Total STC Freq.			**Total REM/yr**	**Total REM/yr**	**Percent Diff**
	1.74E-06			7.72E-01	7.50E-01	3%

* Value from APR1400-K-PNR-013902-P, Table 2f

Table 14
RAI-SA2 Sensitivity Case
Offsite Property Damage Costs By Source Term Category for At-Power Internal Events

STC	STC Frequency (per year)	Conditional Property Costs ($) Sensitivity SECPOP (2010)	Expected Property Costs ($)		
1	5.33E-08	1.91E+10	1.02E+03		
2	2.41E-08	5.00E+07	1.21E+00		
3	5.31E-11	2.85E+10	1.51E+00		
4	6.49E-11	2.15E+10	1.40E+00		
5	2.46E-09	3.94E+08	9.69E-01		
6	1.23E-09	4.13E+09	5.08E+00		
7	1.14E-08	1.03E+10	1.17E+02		
8	1.30E-08	1.60E+10	2.08E+02		
9	3.67E-07	3.18E+07	1.17E+01		
10	7.64E-07	3.02E+07	2.31E+01		
11	1.33E-08	4.26E+07	5.67E-01		
13	1.80E-09	5.80E+09	1.04E+01		
14	4.28E-11	5.77E+07	2.47E-03		
16	7.30E-12	3.41E+08	2.49E-03		
17	2.70E-08	3.35E+07	9.05E-01		
18	4.19E-10	1.02E+08	4.27E-02		
19	4.01E-09	3.15E+08	1.26E+00		
20	1.19E-11	6.65E+08	7.91E-03		
21	2.96E-08	8.57E+08	2.54E+01		
			Total $	***SAMDA Total $**	**Percent Diff**
			1427	1391	3%

* Value from APR1400-K-PNR-013902-P, Table 3a

Table 15
RAI-SA2 Sensitivity Case
Offsite Property Damage Costs By Source Term Category for
At-Power Internal Flooding

STC	STC Frequency (per year)	Conditional Property Costs ($) Sensitivity SECPOP (2010)	Expected Property Costs ($)		
1	6.21E-09	1.91E+10	1.19E+02		
2	0	5.00E+07	0.00E+00		
3	0	2.85E+10	0.00E+00		
4	0	2.15E+10	0.00E+00		
5	7.40E-10	3.94E+08	2.92E-01		
6	6.08E-09	4.13E+09	2.51E+01		
7	9.38E-10	1.03E+10	9.66E+00		
8	1.03E-09	1.60E+10	1.65E+01		
9	4.24E-08	3.18E+07	1.35E+00		
10	3.28E-07	3.02E+07	9.91E+00		
11	5.33E-09	4.26E+07	2.27E-01		
13	7.82E-10	5.80E+09	4.54E+00		
14	1.60E-11	5.77E+07	9.23E-04		
16	3.78E-12	3.41E+08	1.29E-03		
17	1.43E-08	3.35E+07	4.79E-01		
18	1.56E-10	1.02E+08	1.59E-02		
19	2.76E-09	3.15E+08	8.69E-01		
20	6.19E-12	6.65E+08	4.12E-03		
21	1.57E-08	8.57E+08	1.35E+01		
			Total $	***SAMDA Total $**	**Percent Diff**
			201	196	3%

* Value from APR1400-K-PNR-013902-P, Table 3b

Table 16
RAI-SA2 Sensitivity Case
Offsite Property Damage Costs By Source Term Category for At-Power Internal Fire

STC	STC Frequency (per year)	Conditional Property Costs ($) Sensitivity SECPOP (2010)	Expected Property Costs ($)		
1	8.31E-08	1.91E+10	1.59E+03		
2	0.00E+00	5.00E+07	0.00E+00		
3	0.00E+00	2.85E+10	0.00E+00		
4	0.00E+00	2.15E+10	0.00E+00		
5	2.38E-08	3.94E+08	9.38E+00		
6	2.60E-08	4.13E+09	1.07E+02		
7	4.36E-09	1.03E+10	4.49E+01		
8	6.16E-09	1.60E+10	9.86E+01		
9	2.83E-07	3.18E+07	9.00E+00		
10	9.62E-07	3.02E+07	2.91E+01		
11	5.56E-07	4.26E+07	2.37E+01		
13	3.71E-09	5.80E+09	2.15E+01		
14	2.39E-09	5.77E+07	1.38E-01		
16	5.71E-10	3.41E+08	1.95E-01		
17	3.99E-08	3.35E+07	1.34E+00		
18	2.34E-08	1.02E+08	2.39E+00		
19	6.51E-09	3.15E+08	2.05E+00		
20	9.34E-10	6.65E+08	6.21E-01		
21	4.38E-08	8.57E+08	3.75E+01		
			Total $	***SAMDA Total $**	**Percent Diff**
			1975	1926	3%

*Value from APR1400-K-PNR-013902-P, Table 3c

Table 17
RAI-SA2 Sensitivity Case
Offsite Property Damage Costs By Source Term Category for
LPSD Internal Events

STC	STC Frequency (per year)	Conditional Property Costs ($) Sensitivity SECPOP (2010)	Expected Property Costs ($)		
1	1.46E-08	1.91E+10	2.79E+02		
2	6.62E-09	5.00E+07	3.31E-01		
3	2.79E-08	2.85E+10	7.95E+02		
4	1.78E-11	2.15E+10	3.83E-01		
5	6.75E-10	3.94E+08	2.66E-01		
6	1.06E-08	4.13E+09	4.38E+01		
7	3.13E-09	1.03E+10	3.22E+01		
8	3.61E-08	1.60E+10	5.78E+02		
9	1.01E-07	3.18E+07	3.21E+00		
10	2.55E-06	3.02E+07	7.70E+01		
11	1.02E-07	4.26E+07	4.35E+00		
13	4.94E-10	5.80E+09	2.87E+00		
14	1.18E-11	5.77E+07	6.81E-04		
16	2.00E-12	3.41E+08	6.82E-04		
17	7.41E-09	3.35E+07	2.48E-01		
18	1.15E-10	1.02E+08	1.17E-02		
19	1.10E-09	3.15E+08	3.47E-01		
20	4.08E-08	6.65E+08	2.71E+01		
21	8.13E-09	8.57E+08	6.97E+00		
			Total $	***SAMDA Total $**	**Percent Diff**
			1851	1804	3%

* Value from APR1400-K-PNR-013902-P, Table 3d

Table 18
RAI-SA2 Sensitivity Case
Offsite Property Damage Costs By Source Term Category for
LPSD Internal Flooding

STC	STC Frequency (per year)	Conditional Property Costs ($) Sensitivity SECPOP (2010)	Expected Property Costs ($)		
1	0.00E+00	1.91E+10	0.00E+00		
2	0.00E+00	5.00E+07	0.00E+00		
3	0.00E+00	2.85E+10	0.00E+00		
4	0.00E+00	2.15E+10	0.00E+00		
5	0.00E+00	3.94E+08	0.00E+00		
6	1.84E-08	4.13E+09	7.60E+01		
7	0.00E+00	1.03E+10	0.00E+00		
8	0.00E+00	1.60E+10	0.00E+00		
9	0.00E+00	3.18E+07	0.00E+00		
10	0.00E+00	3.02E+07	0.00E+00		
11	0.00E+00	4.26E+07	0.00E+00		
13	0.00E+00	5.80E+09	0.00E+00		
14	0.00E+00	5.77E+07	0.00E+00		
16	0.00E+00	3.41E+08	0.00E+00		
17	0.00E+00	3.35E+07	0.00E+00		
18	0.00E+00	1.02E+08	0.00E+00		
19	0.00E+00	3.15E+08	0.00E+00		
20	0.00E+00	6.65E+08	0.00E+00		
21	0.00E+00	8.57E+08	0.00E+00		
			Total $	***SAMDA Total $**	**Percent Diff**
			76	74	3%

* Value from APR1400-K-PNR-013902-P, Table 3e

Table 19
RAI-SA2 Sensitivity Case
Offsite Property Damage Costs By Source Term Category for
LPSD Internal Fire

STC	STC Frequency (per year)	Conditional Property Costs ($) Sensitivity SECPOP (2010)	Expected Property Costs ($)		
1	7.52E-09	1.91E+10	1.44E+02		
2	3.40E-09	5.00E+07	1.70E-01		
3	2.50E-08	2.85E+10	7.13E+02		
4	9.16E-12	2.15E+10	1.97E-01		
5	3.47E-10	3.94E+08	1.37E-01		
6	1.31E-08	4.13E+09	5.41E+01		
7	1.61E-09	1.03E+10	1.66E+01		
8	6.86E-08	1.60E+10	1.10E+03		
9	5.18E-08	3.18E+07	1.65E+00		
10	1.46E-06	3.02E+07	4.41E+01		
11	6.19E-08	4.26E+07	2.64E+00		
13	2.54E-10	5.80E+09	1.47E+00		
14	6.04E-12	5.77E+07	3.49E-04		
16	1.03E-12	3.41E+08	3.51E-04		
17	3.81E-09	3.35E+07	1.28E-01		
18	5.91E-11	1.02E+08	6.03E-03		
19	5.66E-10	3.15E+08	1.78E-01		
20	3.52E-08	6.65E+08	2.34E+01		
21	4.18E-09	8.57E+08	3.58E+00		
			Total $	***SAMDA Total $**	**Percent Diff**
			2102	2049	3%

* Value from APR1400-K-PNR-013902-P, Table 3f

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**ER 1-8428**
SRP Section:	**Environmental Report**
Application Section:	**APR1400 Environmental Report**
Date of RAI Issue:	**03/22/2016**

Question No. EIS ACC/SA-8

10 CFR 51.55(a) requires each applicant for a standard design certification under subpart B of 10 CFR Part 52 (i.e., 10 CFR 52.47(b)(2)) to submit with its application a separate document entitled, "Applicant's Environmental Report—Standard Design Certification." The environmental report must address the costs and benefits of severe accident mitigation design alternatives, and the bases for not incorporating severe accident mitigation design alternatives in the design to be certified.

The environmental standard review plan (ESRP) Section 7.2, Severe Accidents, of NUREG 1555 directs the staff to evaluate and independently confirm severe accident risks and analyses presented in an Environmental Report (ER) (i.e., the APR1400 ER, “Applicant’s Environmental Report – Standard Design Certification,” found under ML15006A038 and the proprietary technical report, “Severe Accident Mitigation Design Alternatives (SAMDAs) for the APR1400,’ under ML15012A105) of accidents involving radioactive material that can be postulated for the plant under review. The scope of this review should include probability-weighted consequence (i.e., risks) analysis for severe accidents, including dose and socioeconomic risk impacts based on plant specific data in sufficient detail to appropriately evaluate the risks for severe accidents.

The staff requires the following additional information in order to complete its review of the environmental impacts of severe accidents and to ensure appropriate documentation of the applicant’s assessment in the APR1400 Environmental Report.

Provide a discussion in ER Section 3, Base Risk, on the dominant severe accident sequences for large release evaluated from the Level 2 PRA and how they were determined. This characterizes the risk profile of the plant and should include a list showing leading contributors to large release frequency (e.g., from dominant severe accident sequences from the PRA).

The response to this RAI also may need to be reflected in or based on information contained in the DCD’s FSAR Chapter 19.

The NRC staff request that any revisions to the ER or supporting technical reports be provided as a markup as part of the response to this RAI.

This RAI is related to the Environmental Audit Information Needs ER-TI-7 (ML15198A023).

Response

Section 3 of the ER will be updated to include the information shown in the Attachment.

Impact on DCD

No changes to the DCD are needed.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

The ER will be updated as stated above.

power events and low-power shutdown events are presented in Tables 1a and 1b, respectively.

Representative releases were determined for each STC. The SAMDA Technical Report (Reference 4) analyzes representative sequences from each STC and develops timing and release characteristic information for representative fission product groups. This information was used to approximate the radiological release plumes used in the Level 3 PRA.

Offsite consequences were calculated from the Level 3 PRA. For each STC, the Level 3 PRA provided values for the conditional offsite dose and conditional offsite property damage that would result if a fission product release with the plume characteristics used to represent the STC occurred. The total expected dose consequence was obtained by multiplying the conditional offsite dose by the expected frequency for each STC and then summing the expected doses for all STCs.

The conditional dose and expected dose for each STC along with the total expected dose are shown in Tables 2a through 2f. Similarly, the total expected property damage was obtained by multiplying the conditional property damage value by the expected frequency for each STC and then summing the expected property damage values for all STCs. The conditional property costs and expected property costs for each STC along with the total expected property costs are shown in Tables 3a through 3f.

A subset of the STCs is considered to result in "large" releases. DCD Section 19.1.4.2.1.3 presents the definition of a "large" release and Table 19.1-29 delineates the STCs that are considered "large" release. All fission product releases are included in the SAMDA analysis regardless of whether the release is large or not. Therefore, the definition of "large" is not germane to this analysis. Details of how accident sequences are binned into each STC are provided in that section of the DCD as well as the criteria used to select the accident sequence used to represent each STC. The dominant sequence for each STC are presented in Table 7 of Reference 4.

Table 6f (2 of 2)

Item No.	Event Name	Probability	Fussell-Vesely Importance	Description	Disposition
16	BF_F000-AC_F137-A20A	8.60E-03	3.23E-03	BARRIER FAILURE BETWEEN F000-AC AND F137-A20A	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
17	BF_F137-A09D_F157-A17C	8.60E-03	3.06E-03	BARRIER FAILURE BETWEEN F137-A09D AND F157-A17C	Given the low importance of this event, very little benefit would be obtained from efforts to reduce the importance further. Therefore, no SAMA items are added.
18	%F078-A03D	3.13E-04	2.98E-03	FIRE IN CLASS 1E LOADCENTER 01D RM	Fire frequency for compartment – no impact on SAMDA analysis.
19	%F055-A14C	5.66E-05	2.80E-03	FIRE IN PIPE CHASE & VALVE RM	Fire frequency for compartment – no impact on SAMDA analysis.
20	%F157-ATOC	5.54E-05	2.76E-03	FIRE IN TSC EQUIP. REPAIR & MAINT ROOM	Fire frequency for compartment – no impact on SAMDA analysis.
21	%F157-A16C	5.52E-05	2.73E-03	FIRE IN GENERAL ACCESS AREA	Fire frequency for compartment – no impact on SAMDA analysis.
22	SEQ-AS-P04B-02	1.00E+00	2.50E-03	AS POS 4B SEQUENCE 02 IDENTIFIER	Sequence identifier – no impact on SAMDA analysis.
23	%F137-A11D	2.33E-04	2.20E-03	FIRE IN ELECTRICAL PENETRATION RM (D)	Fire frequency for compartment – no impact on SAMDA analysis.
24	SEQ-AS-P10-02	1.00E+00	2.10E-03	AS POS 10 SEQUENCE 02 IDENTIFIER	Sequence identifier – no impact on SAMDA analysis.
25	SEQ-AS-P05-02	1.00E+00	2.06E-03	AS POS 5 SEQUENCE 02 IDENTIFIER	Sequence identifier – no impact on SAMDA analysis.
26	%F157-A19D	2.03E-04	2.05E-03	FIRE IN I & C EQUIP. RM	Fire frequency for compartment – no impact on SAMDA analysis.
27	%F137-AEPB	1.96E-04	1.90E-03	FIRE IN ELECTRICAL PENETRATION ROOM (B)	Fire frequency for compartment – no impact on SAMDA analysis.
28	%F137-A15B	2.01E-04	1.90E-03	FIRE IN 480V CLASS 1E MCC 04B RM	Fire frequency for compartment – no impact on SAMDA analysis.

Add a new page to insert Table 7 shown on next page.

Table 7 Dominant sequences for each STCs

STC	Frequency for Internal Events (/ry)	Percent (%)	Dominant Sequences		
			CET sequence (Fraction)	PDS	ET sequence (Fraction)
1	5.33E-08	4.1	Sequence 2 of CET 2 (75.2% of STC 1)	PDS 2	Sequence 54 of LSSB-D (65.7% of PDS 2)
2	2.41E-08	1.8	Sequence 1 of CET 1 (100.0% of STC 2)	PDS 1	Sequence 9 of SGTR (65.3% of PDS 1)
3	5.31E-11	0.0	Sequence 2 of CET 3 (100.0% of STC 3)	PDS 3	Sequence 1 of ISLOCA (100.0% of PDS 3)
4	6.49E-11	0.0	Sequence 1 of CET 3 (100.0% of STC 4)	PDS 3	Sequence 1 of ISLOCA (100.0% of PDS 3)
5	2.46E-09	0.2	Sequence 1 of CET 5 (100.0% of STC 5)	PDS 5	Sequence 30 of LOOP (86.9% of PDS 5)
6	1.23E-09	0.1	Sequence 2 of CET 6 (100.0% of STC 6)	PDS 6	Sequence 33 of PLOCCW (33.6% of PDS 6)
7	1.14E-08	0.9	Sequence 1 of CET 7 (88.6% of STC 7)	PDS 7	Sequence 2 of MLOCA (52.1% of PDS 7)
8	1.30E-08	1.0	Sequence 2 of CET 7 (84.3% of STC 8)	PDS 7	Sequence 2 of MLOCA (52.1% of PDS 7)
9	3.67E-07	28.0	Sequence 3 of CET 7 (51.6% of STC 9)	PDS 7	Sequence 2 of MLOCA (52.1% of PDS 7)
			Sequence 4 of CET 8 (39.8% of STC 9)	PDS 8	Sequence 14 of LOOP (41.8% of PDS 7)
10	7.64E-07	58.2	Sequence 34 of CET 14 (23.4% of STC 10)	PDS 14	Sequence 17 of PLOCCW (26.9% of PDS 14)
			Sequence 38 of CET 14 (23.1% of STC 10)		
11	1.33E-08	1.0	Sequence 41 of CET 33 (34.5% of STC 11)	PDS 33	Sequence 19 of PLOCCW (30.0% of PDS 33)
12	-	-	-	-	-
13	1.79E-09	0.1	Sequence 5 of CET 14 (22.3% of STC 13)	PDS 14	Sequence 17 of PLOCCW (26.9% of PDS 14)
			Sequence 7 of CET 14 (22.3% of STC 13)		
14	4.28E-11	0.0	Sequence 39 of CET 33 (51.8% of STC 14)	PDS 33	Sequence 19 of PLOCCW (30.0% of PDS 33)
15	-	-	-	-	-
16	7.30E-12	0.0	Sequence 29 of CET 33 (72.6% of STC 16)	PDS 33	Sequence 19 of PLOCCW (30.0% of PDS 33)
17	2.70E-08	2.1	Sequence 25 of CET 14 (35.4% of STC 17)	PDS 14	Sequence 17 of PLOCCW (26.9% of 14)
			Sequence 27 of CET 14 (35.4% of STC 17)		
18	4.19E-10	0.0	Sequence 40 of CET 33 (51.8% of STC 18)	PDS 33	Sequence 19 of PLOCCW (30.0% of PDS 33)
19	4.01E-09	0.3	Sequence 33 of CET 14 (48.1% of STC 19)	PDS 14	Sequence 17 of PLOCCW (26.9% of PDS 14)
			Sequence 36 of CET 14 (48.1% of STC 19)		
20	1.19E-11	0.0	Sequence 30 of CET 33 (72.6% of STC 18)	PDS 33	Sequence 19 of PLOCCW (30.0% of PDS 33)
21	2.96E-08	2.3	Sequence 26 of CET 14 (35.4% of STC 21)	PDS 14	Sequence 17 of PLOCCW (26.9% of PDS 14)
			Sequence 28 of CET 14 (35.4% of STC 21)		
Sum	**1.31E-06**	**100.0**			

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**ER 1-8428**
SRP Section:	**Environmental Report**
Application Section:	**APR1400 Environmental Report**
Date of RAI Issue:	**03/22/2016**

Question No. EIS ACC/SA-11

10 CFR 51.55(a) requires each applicant for a standard design certification under subpart B of 10 CFR Part 52 (i.e., 10 CFR 52.47(b)(2)) to submit with its application a separate document entitled, "Applicant's Environmental Report—Standard Design Certification." The environmental report must address the costs and benefits of severe accident mitigation design alternatives, and the bases for not incorporating severe accident mitigation design alternatives in the design to be certified.

The environmental standard review plan (ESRP) Section 7.2, Severe Accidents, of NUREG 1555 directs the staff to evaluate and independently confirm severe accident risks and analyses presented in an Environmental Report (ER) (i.e., the APR1400 ER, “Applicant’s Environmental Report – Standard Design Certification,” found under ML15006A038 and the proprietary technical report, “Severe Accident Mitigation Design Alternatives (SAMDAs) for the APR1400,’under ML15012A105) of accidents involving radioactive material that can be postulated for the plant under review. The scope of this review should include probability-weighted consequence (i.e., risks) analysis for severe accidents, including dose and socioeconomic risk impacts based on plant specific data in sufficient detail to appropriately evaluate the risks for severe accidents.

The staff requires the following additional information in order to complete its review of the environmental impacts of severe accidents and to ensure appropriate documentation of the applicant’s assessment in the APR1400 Environmental Report.

Provide the basis for the statement on page A19 of APR1400-E-P-NR-14006-P, Severe Accident Mitigation Design Alternatives (SAMDAs) for the APR1400, Revision 0, that states that “Economic costs are the recommended MACCS values as given for the NUREG-1150 study as updated using recent Consumer Price Indexes from the Bureau of Labor” versus using current local or regional values for the Surry site (i.e., the location of the APR1400 severe accident analysis). Additionally, investigate why the dose increased from Case 1 (Base) to Case 5 (Decontamination Cost Sensitivity) when only cost numbers were increased (Section 5.9 of

APR1400-E-P-NR-14006-P). Properly document the results in the ER and APR1400-E-P-NR-14006-P with a discussion of any changes.

The NRC staff request that any revisions to the ER or supporting technical reports be provided as a markup as part of the response to this RAI.

This RAI is related to the Environmental Audit Information Needs ER-TI-15 (ML15198A023).

Response

Section 5.3 of APR1400-E-P-NR-14006-P was updated to provide the basis for the use of NUREG-1150 “example usage” values for base Economic Cost parameters used in the WinMACCS analysis (see Attachment (1/4)). These parameter base values were used because the APR1400 Level 3 analysis is based on the Surry site model documented in NUREG-1150 as a representative site. These values are then scaled via consumer price index (CPI) to today’s dollars.

Sensitivity Case 5 was created to analyze the impact of an increase in the cost of farm decontamination (CDFRM) and nonfarm decontamination (CDNFRM) cost parameters. The results show that changes in these decontamination cost parameters not only affect the economic costs due to a severe accident, but also the amount of population dose received. The effect on cost as well as dose is because the decontamination costs affect the habitability decision making performed by the WinMACCS software for the land area: is the land immediately inhabitable, will the land be habitable after decontamination, or will the land be habitable after a both decontamination and interdiction. These evaluations of habitability are integral in determining the amount of population dose and economic costs attributed to decontamination, interdiction, and condemnation of property calculated by the software. Therefore, this sensitivity also shows that changes in decontamination cost parameters can also impact calculated population dose in addition to economic costs. (Reference MACCS Manual - SAND97-0594, May 1998)

Section 10 of APR1400-E-P-NR-14006-P has been updated to add detail to the results of Case 5 and the impact of decontamination costs on population dose (see Attachment (2/4)), and typos have been corrected (SCT-1 to STC-1) in the Section 9 tables for consistency (see Attachment (3/4) and (4/4)).

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

The SAMDA technical report, APR1400-E-P-NR-14006-NP, will be revised as discussed above. There is no impact on the Environmental Reports.

5.2. EARLY User Input File: "AEARLY.INP"

The AEARLY.INP file provides the main input for the EARLY calculation phase of WinMACCS.

The EARLY module models the time period immediately following a radioactive release. This transient period is commonly referred to as the emergency phase. It may extend up to 1 week after the arrival of the first plume at any downwind spatial interval. The subsequent intermediate and long-term periods are treated by CHRONC. In the EARLY module, the user may specify emergency response scenarios that include evacuation, sheltering, and dose-dependent relocation. The EARLY module has the capability for combining results from up to three different emergency response scenarios. This is accomplished by appending change records to the EARLY input file. The first emergency-response scenario is defined in the main body of the EARLY input file. Up to two additional emergency-response scenarios can be defined through change record sets positioned at the end of the file.

The emergency evacuation model was modeled as a single evacuation zone extending out 10 miles from the plant. The average evacuation speed is estimated (Reference 6, Table 4.2-1) to be approximately 1.8 m/s (4 mph). For the purpose of this analysis, an average evacuation speed of 1.8 m/s is used with a 7,200 sec delay between the alarm and start of evacuation, with no sheltering for the base case.

A sensitivity case for the important evacuation parameters was run and is described in the Detailed Calculations and Results sections below.

To demonstrate the possible significance of these assumptions, a sensitivity WinMACCS run (Case 4) was made with the alarm times and the delay times arbitrarily reduced by 0.5 hr (1,800 sec). The results, which are reported in the Summary of Results section, demonstrate that the WinMACCS consequences are not significantly sensitive to the timings used.

5.3. CHRONC User Input File: "ACHRONC.INP"

This file provides the main input for the CHRONC calculation phase of WinMACCS. It calculates the long-term dose impact on the population.

The CHRONC module simulates the events that occur following the emergency-phase time period modeled by EARLY. CHRONC calculates the total accumulated dose received by a population after the emergency phase or starting on about the 8th day, up to 50 years of time. Various long-term protective actions may be taken during this period to limit radiation doses to acceptable levels. CHRONC calculates the individual health effects that result from both (1) direct exposure to contaminated ground and inhalation of resuspended materials as well as (2) indirect health effects caused by the consumption of contaminated food and water by individuals who could reside both on and off the computational grid. CHRONC also calculates the economic costs of the long-term protective actions as well as the cost of the emergency response actions that were modeled in the EARLY module.

Insert "A"

~~Economic costs are the recommended MACCS values as given for the NUREG-1150 study (Reference 9) updated using recent Consumer Price Indexes from the Bureau of Labor (Reference 10).~~ Reference 9 uses economic values that are based on 1986 Consumer Price Index. From Reference 10, values for the CPI of 108.9 for 1986 and 127.9 for 1990 were obtained. Therefore, the unit costs from Reference 9 were multiplied by a factor of 1.17 (=127.9/108.9) to represent revised SPS region values.

Additionally, from Reference 10, a CPI value of 218.6 for 2011 was obtained. Sensitivity unit costs from Reference 9 were multiplied by a factor of 2.01 (=218.6/108.9) to represent current APR1400 (Surry) region values (Case 5).

A

Economic costs are based on the original “example usage” values for the MACCS parameters as given for the NUREG-1150 study (Reference 9). The “example usage” values were selected as the base value for this analysis because the APR1400-DC is based on the Surry plant site data documented in Reference 9. The “example usage” values are updated using recent Consumer Price Indexes from the Bureau of Labor (Reference 10) to account for cost increases that have occurred since the original values were developed.

10. CONCLUSION

The greatest overall sensitivity was observed for the economic data due to a 50 percent reduction in the timing parameters OALARM, PLDUR, and PDELAY for CASE3.

The sensitivity was observed for the economic data due to a decrease to 90 percent evacuation of the population in CASE2 for STCs 9 and 10. However, these STCs are associated with no containment failure scenarios.

STC specific

Also some ~~STC specific~~ sensitivity was noted for CASE5, which used a higher factor (2.01) for the parameters CDFRM and CDNFRM. The sensitivity on the factor of 1.17 vs 2.01 on farm and non-farm decontamination parameters CDFRM and CDNFRM resulted in differences of no more than 10 percent for half of the STCs.

The sensitivity for the parameter DLTSHL, delay time to take shelter (7,200 vs. 5,400 sec) was shown to be insignificant for CASE4.

This result shows that changes in these decontamination cost parameters not only affect the economic costs due to a severe accident, but also the amount of population dose received. The effect on cost as well as dose is because the decontamination costs affect the habitability decision making performed by the WinMACCS software for the land area: is the land immediately inhabitable, will the land be habitable after decontamination, or will the land be habitable after a both decontamination and interdiction. These evaluations of habitability are integral in determining the amount of population dose and economic costs attributed to decontamination, interdiction, and condemnation of property calculated by the software. Therefore, this sensitivity also case shows that changes in decontamination cost parameters can also impact calculated population dose in addition to economic cost.

Table 9-1 Summary of Results for Population Dose

TS

Table 9-2 Summary of Results for Offsite Economic Costs

TS

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**ER 1-8428**
SRP Section:	**Environmental Report**
Application Section:	**APR1400 Environmental Report**
Date of RAI Issue:	**03/22/2016**

Question No. EIS ACC/SA-15

10 CFR 51.55(a) requires each applicant for a standard design certification under subpart B of 10 CFR Part 52 (i.e., 10 CFR 52.47(b)(2)) to submit with its application a separate document entitled, "Applicant's Environmental Report—Standard Design Certification." The environmental report must address the costs and benefits of severe accident mitigation design alternatives, and the bases for not incorporating severe accident mitigation design alternatives in the design to be certified.

The environmental standard review plan (ESRP) Section 7.2, Severe Accidents, of NUREG 1555 directs the staff to evaluate and independently confirm severe accident risks and analyses presented in an Environmental Report (ER) (i.e., the APR1400 ER, “Applicant’s Environmental Report – Standard Design Certification,” found under ML15006A038 and the proprietary technical report, “Severe Accident Mitigation Design Alternatives (SAMDAs) for the APR1400,’under ML15012A105) of accidents involving radioactive material that can be postulated for the plant under review. The scope of this review should include probability-weighted consequence (i.e., risks) analysis for severe accidents, including dose and socioeconomic risk impacts based on plant specific data in sufficient detail to appropriately evaluate the risks for severe accidents.

The staff requires the following additional information in order to complete its review of the environmental impacts of severe accidents and to ensure appropriate documentation of the applicant’s assessment in the APR1400 Environmental Report.

Provide a revised base case analysis by adding modeling of a non-evacuating cohort with appropriate justification and supporting references. As stated in Section 4.6.3, Cohort Modeling, of NUREG/CR-7009, MACCS Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses (SOARCA) Project, “…only two cohorts were used in Sample Problem A with percentages of 95 percent for the general public and 5 percent for the non-evacuating public. The percentages were adjusted to 99.5% and 0.5%, respectively, in the final NUREG-1150 report. In SOARCA the population fractions were developed based on the

actual site population data [shown in Table 4-21]." Note that the evacuation cohort population fraction in the final NUREG-1150 (Cohort 2) and in SOARCA (Cohort 6) were set to 0.005, or 0.5 percent. The staff does not consider that assuming 100 percent evacuation (i.e., not having an evacuation cohort specified in the MACCS calculations) is reasonable to apply for the base case analysis.

The NRC staff request that any revisions to the ER or supporting technical reports be provided as a markup as part of the response to this RAI.

Response

The APR1400 Level 3 analysis base case has been revised to use the updated evacuation percentage of 99.5% and non-evacuation percentage of 0.05%, consistent with percentages documented in the final version of NUREG-1150. WinMACCS parameter WTFRAC for emergency cohort 1 was set to 0.995 (99.5%) and parameter WTFRAC for emergency cohort 2 was set to 0.005 (0.5%). Table A-1 of this RAI documents the 99.5% evacuation results in comparison to the originally documented results assuming a 100% evacuation percentage.

Table A-1 of this RAI shows that two Population Dose values increased slightly and sixteen Offisite Economic Cost values decreased for the release categories identified.

Upon reanalysis of the base case, the APR1400 Level 3 analysis document (APR1400-K-P-NR-013902-P R1) and APR1400 SAMDA analysis document (APR1400-K-P-NR-013901-P R1) were updated to reflect these changes by both updating the document text and calculated values displayed throughout the documents.

The APR1400 Level 3 analysis document (APR1400-K-P-NR-013902-P R1) was updated in the following sections:

- Section 5.2 EARLY User Input File – a paragraph was added discussing the change of the population evacuation percentage to 99.5%.
- Section 7 Detailed Calculations – the first paragraph was updated to reflect the change of the population evacuation percentage to 99.5%.
- Section 8 Computer Input and Output – the population evacuation percentage was updated to 99.5%
- Section 8 Computer Input and Output – type for Case 2 corrected to 90%
- Section 9 Summary of Results – tables for Population Dose and Offisite Economic Cost were updated to reflect the change in population evacuation percentage to 99.5%.
- Section 11 References – Reference added for NUREG-1150 Volume 1
- Attachment III WinMACCS Input File Listings for Base Case – EARLY.INP was updated to reflect the change in population evacuation percentage to 99.5%.

With the change in the base case population evacuation percentage to 99.5%, sensitivity cases 3, 4, and 5 would need to be revised in the final documentation. This update was not

performed in this RAI response and impact of this change on the original sensitivity case results would negligible.

The APR1400 SAMDA analysis document (APR1400-K-P-NR-013901-P R1) was extensively updated to reflect the change in population evacuation percentage to 99.5% on population dose and offsite economic costs. The following sections were updated:

- Section 4.1 Averted Public Exposure (APE)
- Section 4.2 Averted Offsite Property Damage Costs (AOC)
- Section 4.6 Total Unmitigated Baseline Risk
- Section 7 SAMDA Benefit Evaluation (Subsection 7.1 through 7.22)
- Section 10.1 Averted Public Exposure (APE)
- Section 10.2 Averted Offsite Property Damage Costs (AOC)
- Section 10.6 Total Unmitigated Baseline Risk
- Tables 2a through 2f (Offsite Exposure)
- Tables 3a through 3f (Offsite Property Damage Costs)
- Table 4 Initial List of Candidate Improvements for APR1400 SAMDA

Section 4.6 shows that the NPV for the change in population evacuation percentage decreased from $1,026,517 to $1,022,835. APE is shown as increasing slightly (from $76,794 to $76,826) and AOC decreased slightly ($104,687 to $100,973). It is shown that the impact of the change in evacuation percentage does not change the overall conclusion made in the SAMDA analysis.

Secondarily, a sensitivity was performed to expand the cohort modeling as specified in NUREG/CR-7009, MACCS Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses (SOARCA) Project. Table A-2 of this RAI shows that using the six cohort evacuation model from the SOARCA that only slight variations in population dose verses the two cohort model for 99.5% population evacuation. The offsite economic costs show no change between the six cohort model from the SOARCA and the two cohort model.

Impact on DCD

DCD Section 19.2.6.5 will be updated as shown in Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Table A-1

Comparison of 100% Evacuation versus 99.5% Evacuation

	Population Dose, Sieverts	
CET End Point (Release Mode)	Old CASE 1 BASE 100% Evac	New CASE 1 BASE 99.5% Evac
SCT-1	6.34E+04	6.34E+04
STC-2	3.03E+02	**3.04E+02**
STC-3	9.42E+04	9.42E+04
STC-4	8.00E+04	8.00E+04
STC-5	3.52E+03	3.52E+03
STC-6	1.79E+04	1.79E+04
STC-7	4.48E+04	4.48E+04
STC-8	5.77E+04	**5.78E+04**
STC-9	1.73E+01	1.73E+01
STC-10	4.17E+01	4.17E+01
STC-11	1.94E+02	1.94E+02
STC-13	3.31E+04	3.31E+04
STC-14	1.76E+03	1.76E+03
STC-16	5.01E+03	5.01E+03
STC-17	1.20E+02	1.20E+02
STC-18	2.84E+03	2.84E+03
STC-19	5.82E+03	5.82E+03
STC-20	7.94E+03	7.94E+03
STC-21	7.85E+03	7.85E+03

	Offsite Economic Cost, $	
CET End Point (Release Mode)	Old CASE 1 BASE 100% Evac	New CASE 1 BASE 99.5% Evac
SCT-1	1.86E+10	1.86E+10
STC-2	5.00E+07	**2.47E+07**
STC-3	2.77E+10	2.77E+10
STC-4	2.09E+10	2.09E+10
STC-5	3.91E+08	**3.75E+08**
STC-6	4.02E+09	**4.00E+09**
STC-7	1.00E+10	**9.99E+09**
STC-8	1.56E+10	**1.55E+10**
STC-9	3.17E+07	**2.93E+04**
STC-10	3.01E+07	**9.07E+04**
STC-11	4.24E+07	**3.74E+05**
STC-13	5.67E+09	**5.64E+09**
STC-14	5.86E+07	**1.86E+07**
STC-16	3.43E+08	**3.14E+08**
STC-17	3.34E+07	**5.08E+05**
STC-18	1.05E+08	**6.54E+07**
STC-19	3.60E+08	**3.28E+08**
STC-20	6.68E+08	**6.42E+08**
STC-21	8.42E+08	**8.16E+08**

*Highlighted entries show differences between 100% and 99.5% evacuation percentages.

Table A-2

Comparison of 100% Evacuation versus 99.5% Evacuation and SOARCA (6 Cohorts)

	Population Dose, Sieverts		
CET End Point (Release Mode)	Old Case 1 BASE 100% Evac	New Case 1 RAI-SA-15 99.5/0.5_2	Base Case 6 Cohorts 99.5 to 0.5 SOARCA
SCT-1	6.34E+04	6.34E+04	6.28E+04
STC-2	3.03E+02	3.04E+02	3.02E+02
STC-3	9.42E+04	9.42E+04	9.43E+04
STC-4	8.00E+04	8.00E+04	8.02E+04
STC-5	3.52E+03	3.52E+03	3.53E+03
STC-6	1.79E+04	1.79E+04	1.79E+04
STC-7	4.48E+04	4.48E+04	4.44E+04
STC-8	5.77E+04	5.78E+04	5.73E+04
STC-9	1.73E+01	1.73E+01	1.73E+01
STC-10	4.17E+01	4.17E+01	4.15E+01
STC-11	1.94E+02	1.94E+02	1.91E+02
STC-13	3.31E+04	3.31E+04	3.28E+04
STC-14	1.76E+03	1.76E+03	1.75E+03
STC-16	5.01E+03	5.01E+03	4.98E+03
STC-17	1.20E+02	1.20E+02	1.19E+02
STC-18	2.84E+03	2.84E+03	2.83E+03
STC-19	5.82E+03	5.82E+03	5.80E+03
STC-20	7.94E+03	7.94E+03	7.92E+03
STC-21	7.85E+03	7.85E+03	7.79E+03

	Offsite Economic Cost, $		
CET End Point (Release Mode)	Case 1 BASE 100% Evac	Case 1 RAI-SA-15 99.5/0.5_2	Base Case 6 Cohorts 99.5 to 0.5 SOARCA
SCT-1	1.86E+10	1.86E+10	1.86E+10
STC-2	5.00E+07	2.47E+07	2.47E+07
STC-3	2.77E+10	2.77E+10	2.77E+10
STC-4	2.09E+10	2.09E+10	2.09E+10
STC-5	3.91E+08	3.75E+08	3.75E+08
STC-6	4.02E+09	4.00E+09	4.00E+09
STC-7	1.00E+10	9.99E+09	9.99E+09
STC-8	1.56E+10	1.55E+10	1.55E+10
STC-9	3.17E+07	2.93E+04	2.93E+04
STC-10	3.01E+07	9.07E+04	9.07E+04
STC-11	4.24E+07	3.74E+05	3.74E+05
STC-13	5.67E+09	5.64E+09	5.64E+09
STC-14	5.86E+07	1.86E+07	1.86E+07
STC-16	3.43E+08	3.14E+08	3.14E+08
STC-17	3.34E+07	5.08E+05	5.08E+05
STC-18	1.05E+08	6.54E+07	6.54E+07
STC-19	3.60E+08	3.28E+08	3.28E+08
STC-20	6.68E+08	6.42E+08	6.42E+08
STC-21	8.42E+08	8.16E+08	8.16E+08

The important basic events (i.e., FV > 0.5%) from the at-power and LPSD PRA importance analyses have been reviewed, and the basic events included in the top 100 cutsets have been also reviewed. The cost benefits of the basic events associated with 93 SSCs have been reviewed. The total maximum benefit calculated for improving the SSCs associated with the reviewed basic events would be small and much lower than the cost of any plant design change to improve performance of the SSCs.

19.2.6.5 Cost Impacts of Candidate Design Improvements

The unmitigated risk monetary value is calculated using the methodology given in NEI 05-01 for the performance of cost-benefit analyses. The value of unmitigated risk can be used to represent the maximum benefit that could be achieved if all risk was eliminated for at-power events. The methodology of the Producer Price Index (Reference 40) determines the present worth net value of public risk according to the following formula:

NPV = (APE + AOC + AOE + AOSC) – COE

Where:

NPV = present value of current risk ($),

APE = present value of averted public exposure ($),

AOC= present value of averted offsite property damage costs ($),

AOE= present value of averted occupational exposure ($),

AOSC= present value of averted onsite costs ($)

COE = cost of any enhancement implemented to reduce risk ($).

76,826 100,973 1,022,835

NPV = (~~$76,794~~ + $ ~~104,687~~ + $ 4,216 + $ 840,820) – $0 = $~~1,026,517~~

76,826 100,973 1,022,835

This value can be viewed as the maximum risk benefit attainable if all core damage scenarios from internal events are eliminated over the 60-years plant life. The detailed calculation is provided in Section 4 of Reference 38.

The conversion factor used for assigning a monetary value to on-site and off-site exposures was $2,000/person-rem averted, which is consistent with the NRC's regulatory analysis

guidelines presented in NEI 05-01. The occupational exposure associated with severe accidents was assumed at 23,300 person-rem/accident. This value includes a short-term component of 3,300 person-rem/accident and a long-term component of 20,000 person-rem/accident. These estimates are consistent with the "best estimate" values presented in Subsection 5.7.3 of NUREG/BR-0184 (Reference 41). In calculating base risk, the accident-related onsite exposures were calculated using the best estimate exposure components applied over the on-site cleanup period. For onsite cleanup, the accident-related on-site exposures were calculated over a 10-year cleanup period. Costs associated with immediate dose, long-term dose and total dose are calculated for at-power internal events, internal flooding events, and internal fire events, along with LPSD internal events, internal flooding events, and internal fire events.

The parameters that influence the cost-benefit analyses of the SAMDA evaluations were examined to determine if a change in value for one of the parameters would change the conclusions of the evaluation. Equations for each of the four types of averted costs each contain a term for the real discount rate and evaluation period. Therefore, a change in either of those terms would have a direct impact on the averted costs calculated.

NEI 05-01 recommends using a 7% discount rate for cost-benefit analyses and suggests that a 3% discount rate should be used for sensitivity analyses on the maximum benefit and the unscreened SAMDAs to indicate the sensitivity of the results to the choice of discount rate. The NPV for a 3% discount rate is calculated to be ~~$1,152,850~~ 1,145,569 (Reference 42).Using maximum benefit calculated for the 3% discount rate above, the SAMDA items were reviewed and screened again. No changes to the screening results were identified using the higher maximum benefit value.

19.2.6.6 Cost-Benefit Comparison

As discussed above, all design changes to reduce risk would provide small or negligible benefit and the cost of any associated design change would greatly exceed any potential benefit. Therefore, no specific cost-benefit comparisons are necessary.