

Annual Offsite Dose to Individuals from Gaseous Effluent Releases from the U.S. EPR for Bell Bend Nuclear Power Plant

**Table 5-7: Gaseous Pathway Doses at Nearest Milk Animal - Cow-Milk Ingestion Pathway**

| Location<br>[gaspar2 output file name] | Individual | Annual Dose (mrem/year) |          |          |          |          |          |          |          |
|--|------------|-------------------------|----------|----------|----------|----------|----------|----------|----------|
|  |            | Tot. Body               | GI-Tract | Bone     | Liver    | Kidney   | Thyroid  | Lung     | Skin     |
| SW 4.01 miles<br>[bb-hypo-1.out]       | Adult      | 3.72E-03                | 3.72E-03 | 1.74E-02 | 3.73E-03 | 3.73E-03 | 5.64E-03 | 3.72E-03 | 3.72E-03 |
|  | Teen       | 6.73E-03                | 6.73E-03 | 3.21E-02 | 6.74E-03 | 6.74E-03 | 9.78E-03 | 6.72E-03 | 6.72E-03 |
|  | Child      | 1.63E-02                | 1.63E-02 | 7.89E-02 | 1.63E-02 | 1.63E-02 | 2.23E-02 | 1.63E-02 | 1.63E-02 |
|  | Infant     | 3.37E-02                | 3.37E-02 | 1.54E-01 | 3.38E-02 | 3.38E-02 | 4.84E-02 | 3.37E-02 | 3.37E-02 |
| WSW 3.95 miles<br>[bb-hypo-1.out]      | Adult      | 7.52E-03                | 7.51E-03 | 3.51E-02 | 7.52E-03 | 7.52E-03 | 8.84E-03 | 7.51E-03 | 7.51E-03 |
|  | Teen       | 1.36E-02                | 1.36E-02 | 6.48E-02 | 1.36E-02 | 1.36E-02 | 1.57E-02 | 1.36E-02 | 1.36E-02 |
|  | Child      | 3.29E-02                | 3.29E-02 | 1.59E-01 | 3.29E-02 | 3.29E-02 | 3.71E-02 | 3.29E-02 | 3.29E-02 |
|  | Infant     | 6.81E-02                | 6.81E-02 | 3.12E-01 | 6.82E-02 | 6.82E-02 | 7.83E-02 | 6.81E-02 | 6.81E-02 |
| NW 4.21 miles<br>[bb-hypo-1.out]       | Adult      | 4.40E-03                | 4.39E-03 | 2.06E-02 | 4.41E-03 | 4.41E-03 | 7.16E-03 | 4.39E-03 | 4.39E-03 |
|  | Teen       | 7.96E-03                | 7.95E-03 | 3.79E-02 | 7.97E-03 | 7.98E-03 | 1.23E-02 | 7.95E-03 | 7.95E-03 |
|  | Child      | 1.92E-02                | 1.92E-02 | 9.32E-02 | 1.93E-02 | 1.93E-02 | 2.79E-02 | 1.92E-02 | 1.92E-02 |
|  | Infant     | 3.99E-02                | 3.98E-02 | 1.83E-01 | 3.99E-02 | 3.99E-02 | 6.10E-02 | 3.98E-02 | 3.98E-02 |
| S 3.02 miles<br>[bb-real-4.out]        | Adult      | 3.55E-03                | 3.54E-03 | 1.66E-02 | 3.56E-03 | 3.56E-03 | 7.12E-03 | 3.54E-03 | 3.54E-03 |
|  | Teen       | 6.42E-03                | 6.41E-03 | 3.06E-02 | 6.44E-03 | 6.44E-03 | 1.21E-02 | 6.41E-03 | 6.40E-03 |
|  | Child      | 1.55E-02                | 1.55E-02 | 7.52E-02 | 1.55E-02 | 1.56E-02 | 2.68E-02 | 1.55E-02 | 1.55E-02 |
|  | Infant     | 3.22E-02                | 3.21E-02 | 1.47E-01 | 3.22E-02 | 3.22E-02 | 5.95E-02 | 3.21E-02 | 3.21E-02 |
| SSW 0.74 miles<br>[bb-real-5.out]      | Adult      | 1.69E-02                | 1.68E-02 | 7.86E-02 | 1.69E-02 | 1.69E-02 | 4.73E-02 | 1.67E-02 | 1.67E-02 |
|  | Teen       | 3.04E-02                | 3.03E-02 | 1.45E-01 | 3.06E-02 | 3.06E-02 | 7.87E-02 | 3.03E-02 | 3.03E-02 |
|  | Child      | 7.35E-02                | 7.33E-02 | 3.56E-01 | 7.38E-02 | 7.38E-02 | 1.69E-01 | 7.33E-02 | 7.32E-02 |
|  | Infant     | 1.52E-01                | 1.52E-01 | 6.97E-01 | 1.53E-01 | 1.53E-01 | 3.86E-01 | 1.52E-01 | 1.52E-01 |
| W 4.03 miles<br>[bb-real-6.out]        | Adult      | 1.07E-02                | 1.07E-02 | 5.01E-02 | 1.08E-02 | 1.08E-02 | 2.42E-02 | 1.07E-02 | 1.07E-02 |
|  | Teen       | 1.94E-02                | 1.94E-02 | 9.24E-02 | 1.95E-02 | 1.95E-02 | 4.08E-02 | 1.93E-02 | 1.93E-02 |
|  | Child      | 4.68E-02                | 4.68E-02 | 2.27E-01 | 4.70E-02 | 4.70E-02 | 8.93E-02 | 4.67E-02 | 4.67E-02 |
|  | Infant     | 9.71E-02                | 9.69E-02 | 4.44E-01 | 9.74E-02 | 9.73E-02 | 2.00E-01 | 9.69E-02 | 9.69E-02 |

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**Table 5-7 (Continued)**

**Gaseous Pathway Doses at Nearest Milk Animal - Cow-Milk Ingestion Pathway**

| Location<br>[gaspar2 output file name]              | Individual | Annual Dose (mrem/year) |          |                 |          |          |          |          |          |
|---|------------|-------------------------|----------|-----------------|----------|----------|----------|----------|----------|
|   |            | Tot. Body               | GI-Tract | Bone            | Liver    | Kidney   | Thyroid  | Lung     | Skin     |
| WNW 4.02 miles<br>[bb-real-7.out]                   | Adult      | 5.56E-03                | 5.56E-03 | 2.60E-02        | 5.57E-03 | 5.57E-03 | 8.27E-03 | 5.55E-03 | 5.55E-03 |
|   | Teen       | 1.01E-02                | 1.01E-02 | 4.79E-02        | 1.01E-02 | 1.01E-02 | 1.44E-02 | 1.00E-02 | 1.00E-02 |
|   | Child      | 2.43E-02                | 2.43E-02 | 1.18E-01        | 2.43E-02 | 2.43E-02 | 3.28E-02 | 2.43E-02 | 2.43E-02 |
|   | Infant     | 5.04E-02                | 5.04E-02 | 2.31E-01        | 5.05E-02 | 5.05E-02 | 7.12E-02 | 5.04E-02 | 5.04E-02 |
| NNW 3.97 miles<br>[bb-real-8.out]                   | Adult      | 3.86E-03                | 3.86E-03 | 1.80E-02        | 3.87E-03 | 3.87E-03 | 6.59E-03 | 3.85E-03 | 3.85E-03 |
|   | Teen       | 6.98E-03                | 6.97E-03 | 3.33E-02        | 7.00E-03 | 7.00E-03 | 1.13E-02 | 6.97E-03 | 6.97E-03 |
|   | Child      | 1.69E-02                | 1.69E-02 | 8.18E-02        | 1.69E-02 | 1.69E-02 | 2.55E-02 | 1.69E-02 | 1.69E-02 |
|   | Infant     | 3.50E-02                | 3.49E-02 | 1.60E-01        | 3.51E-02 | 3.50E-02 | 5.59E-02 | 3.49E-02 | 3.49E-02 |
| <b>Worst-Case Location with Bounding Organ Dose</b> |            |                         |          |                 |          |          |          |          |          |
| SSW 0.74 miles<br>(1191 m)                          | Adult      | 1.69E-02                | 1.68E-02 | 7.86E-02        | 1.69E-02 | 1.69E-02 | 4.73E-02 | 1.67E-02 | 1.67E-02 |
|   | Teen       | 3.04E-02                | 3.03E-02 | 1.45E-01        | 3.06E-02 | 3.06E-02 | 7.87E-02 | 3.03E-02 | 3.03E-02 |
|   | Child      | 7.35E-02                | 7.33E-02 | 3.56E-01        | 7.38E-02 | 7.38E-02 | 1.69E-01 | 7.33E-02 | 7.32E-02 |
|   | Infant     | 1.52E-01                | 1.52E-01 | <b>6.97E-01</b> | 1.53E-01 | 1.53E-01 | 3.86E-01 | 1.52E-01 | 1.52E-01 |

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**Table 5-8: Summary of Gaseous Pathway Doses for the Maximally Exposed Individual**

| Critical Location<br>with Bounding Organ Dose                   | Individual | Annual Dose (mrem/year) |          |          |          |          |          |          |          |
|---|------------|-------------------------|----------|----------|----------|----------|----------|----------|----------|
|   |            | Tot. Body               | GI-Tract | Bone     | Liver    | Kidney   | Thyroid  | Lung     | Skin     |
| Plume Exposure Pathway  |            |                         |          |          |          |          |          |          |          |
| WSW 0.16 miles (251 m)<br>(from Table 5-2)                      | All        | 1.26E+00                | 1.26E+00 | 1.26E+00 | 1.26E+00 | 1.26E+00 | 1.26E+00 | 1.31E+00 | 3.93E+00 |
| Ground-Shine Exposure Pathway (at Worst-Case Nearest Residence) |            |                         |          |          |          |          |          |          |          |
| NNE 0.79 miles (1266 m)<br>(from Table 5-3)                     | All        | 5.28E-04                | 5.28E-04 | 5.28E-04 | 5.28E-04 | 5.28E-04 | 5.28E-04 | 5.28E-04 | 6.20E-04 |
| Inhalation Pathway (Nearest Residence)                          |            |                         |          |          |          |          |          |          |          |
| NNE 0.79 miles (1266 m)<br>(from Table 5-4)                     | Adult      | 5.83E-03                | 5.83E-03 | 1.06E-04 | 5.85E-03 | 5.87E-03 | 1.35E-02 | 5.90E-03 | 5.81E-03 |
|   | Teen       | 5.88E-03                | 5.89E-03 | 1.29E-04 | 5.91E-03 | 5.95E-03 | 1.57E-02 | 6.01E-03 | 5.86E-03 |
|   | Child      | 5.20E-03                | 5.19E-03 | 1.58E-04 | 5.23E-03 | 5.26E-03 | 1.70E-02 | 5.30E-03 | 5.18E-03 |
|   | Infant     | 2.99E-03                | 2.98E-03 | 8.25E-05 | 3.03E-03 | 3.03E-03 | 1.38E-02 | 3.07E-03 | 2.98E-03 |
| Meat Ingestion Pathway  |            |                         |          |          |          |          |          |          |          |
| WSW 0.33 miles (537 m)<br>(from Table 5-5)                      | Adult      | 7.30E-02                | 7.30E-02 | 3.53E-01 | 7.30E-02 | 7.30E-02 | 7.43E-02 | 7.29E-02 | 7.29E-02 |
|   | Teen       | 6.11E-02                | 6.11E-02 | 2.99E-01 | 6.11E-02 | 6.11E-02 | 6.21E-02 | 6.11E-02 | 6.11E-02 |
|   | Child      | 1.14E-01                | 1.14E-01 | 5.61E-01 | 1.14E-01 | 1.14E-01 | 1.15E-01 | 1.14E-01 | 1.14E-01 |
| Vegetable Ingestion Pathway (Nearest Garden)                    |            |                         |          |          |          |          |          |          |          |
| SSW 0.25 miles (408 m)<br>(from Table 5-6)                      | Adult      | 1.64E-01                | 1.64E-01 | 7.67E-01 | 1.64E-01 | 1.64E-01 | 2.90E-01 | 1.63E-01 | 1.63E-01 |
|   | Teen       | 2.66E-01                | 2.66E-01 | 1.27E+00 | 2.66E-01 | 2.66E-01 | 4.33E-01 | 2.65E-01 | 2.65E-01 |
|   | Child      | 6.32E-01                | 6.32E-01 | 3.08E+00 | 6.33E-01 | 6.33E-01 | 9.52E-01 | 6.31E-01 | 6.31E-01 |
| Cow-Milk Ingestion Pathway                                      |            |                         |          |          |          |          |          |          |          |
| SSW 0.74 miles (1191 m)<br>(from Table 5-7)                     | Adult      | 1.69E-02                | 1.68E-02 | 7.86E-02 | 1.69E-02 | 1.69E-02 | 4.73E-02 | 1.67E-02 | 1.67E-02 |
|   | Teen       | 3.04E-02                | 3.03E-02 | 1.45E-01 | 3.06E-02 | 3.06E-02 | 7.87E-02 | 3.03E-02 | 3.03E-02 |
|   | Child      | 7.35E-02                | 7.33E-02 | 3.56E-01 | 7.38E-02 | 7.38E-02 | 1.69E-01 | 7.33E-02 | 7.32E-02 |
|   | Infant     | 1.52E-01                | 1.52E-01 | 6.97E-01 | 1.53E-01 | 1.53E-01 | 3.86E-01 | 1.52E-01 | 1.52E-01 |



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Table 5-8 (Continued)

Summary of Gaseous Pathway Doses for the Maximally Exposed Individual

| Critical Location<br>with Bounding Organ Dose | Individual   | Annual Dose (mrem/year) |          |                               |          |          |          |          |          |  |
|---|--|-------------------------|----------|-------------------------------|----------|----------|----------|----------|----------|--|
|   |  | Tot. Body               | GI-Tract | Bone                          | Liver    | Kidney   | Thyroid  | Lung     | Skin     |  |
|   | Total Excluding Plume Dose - 10 CFR 50 Appendix I Compliance |                         |          |                               |          |          |          |          |          |  |
| Various (see above)                           | Adult  | 2.60E-01 <sup>(a)</sup> | 2.60E-01 | 1.20E+00                      | 2.60E-01 | 2.60E-01 | 4.26E-01 | 2.59E-01 | 2.59E-01 |  |
|   | Teen   | 3.64E-01                | 3.64E-01 | 1.71E+00                      | 3.64E-01 | 3.64E-01 | 5.90E-01 | 3.63E-01 | 3.63E-01 |  |
|   | Child  | 8.25E-01                | 8.25E-01 | <b>4.00E+00<sup>(b)</sup></b> | 8.27E-01 | 8.27E-01 | 1.25E+00 | 8.24E-01 | 8.24E-01 |  |
|   | Infant   | 1.56E-01                | 1.56E-01 | 6.98E-01                      | 1.57E-01 | 1.57E-01 | 4.00E-01 | 1.56E-01 | 1.56E-01 |  |

- (a) Total body adult dose: 5.28E-04 (ground shine) + 5.83E-03 (inhalation) + 7.30E-02 (meat) + 1.64E-01 (veggies) + 1.69E-02 (cow milk)  
= 2.60E-01 mrem/yr
- (b) Bounding dose (4 mrem/yr, child bone)





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### 5.3 Organ Dose to Hypothetical Maximally Exposed Individual (HMEI)

The organ dose to the HMEI is based on the critical receptor identified in Table 3-2 and described in Section 3.3. A summary of the results is presented in Table 5-9.

The following are noted:

- (a) The dose to the HMEI critical individual/organ is 6.0 mrem/yr (child bone), as compared to 4 mrem/yr for the MEI (from Table 5-8).
- (b) As noted in Section 3.3, the goat-milk ingestion pathway was selected for the HMEI in lieu of the cow-milk pathway (for the MEI) since it is more restrictive.
- (c) The entries in Table 5-9 are for the same physical location for all exposure pathways (namely WSW sector at 0.33 miles), except for the D/Q which is a bounding value applicable to the NE sector, at 0.5 mile. Scoping analysis showed that use of the actual D/Q value at the WSW sector (0.33 miles), which is lower than the bounding value used in the analysis by a factor of  $(1.246\text{E-}08/3.476\text{E-}09) = 3.6$ , has minimal impact on the critical individual/organ dose, reducing it from 6.00 to 5.95 mrem/yr. This is due to the dominance of C-14 in the overall dose and its uptake by vegetation as a result of photosynthesis, contributing 98.7% of the child bone dose (based on scoping analyses).

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**Table 5-9: Gaseous Pathway Doses for the Hypothetical Maximally Exposed Individual**

(From gaspar2 output file name bb-hypo-mei.out)

| Exposure Pathway                             | Individual | Annual Dose (mrem/year) |          |                         |          |          |          |          |          |
|--|------------|-------------------------|----------|-------------------------|----------|----------|----------|----------|----------|
|  |            | Tot. Body               | GI-Tract | Bone                    | Liver    | Kidney   | Thyroid  | Lung     | Skin     |
| Ground-Shine Exposure Pathway                | All        | 1.76E-03                | 1.76E-03 | 1.76E-03                | 1.76E-03 | 1.76E-03 | 1.76E-03 | 1.76E-03 | 2.06E-03 |
|  | Adult      | 7.22E-03                | 7.22E-03 | 1.27E-04                | 7.24E-03 | 7.27E-03 | 1.65E-02 | 7.30E-03 | 7.19E-03 |
| Inhalation Pathway (Nearest Residence)       | Teen       | 7.29E-03                | 7.29E-03 | 1.54E-04                | 7.32E-03 | 7.36E-03 | 1.92E-02 | 7.43E-03 | 7.26E-03 |
|  | Child      | 6.44E-03                | 6.43E-03 | 1.88E-04                | 6.47E-03 | 6.51E-03 | 2.07E-02 | 6.56E-03 | 6.41E-03 |
|  | Infant     | 3.71E-03                | 3.69E-03 | 9.87E-05                | 3.75E-03 | 3.75E-03 | 1.68E-02 | 3.79E-03 | 3.69E-03 |
| Meat Ingestion Pathway                       | Adult      | 7.30E-02                | 7.32E-02 | 3.54E-01                | 7.30E-02 | 7.30E-02 | 7.80E-02 | 7.29E-02 | 7.29E-02 |
|  | Teen       | 6.11E-02                | 6.12E-02 | 2.99E-01                | 6.11E-02 | 6.11E-02 | 6.47E-02 | 6.11E-02 | 6.11E-02 |
|  | Child      | 1.14E-01                | 1.14E-01 | 5.61E-01                | 1.14E-01 | 1.14E-01 | 1.19E-01 | 1.14E-01 | 1.14E-01 |
| Vegetable Ingestion Pathway (Nearest Garden) | Adult      | 1.95E-01                | 1.95E-01 | 9.17E-01                | 1.95E-01 | 1.95E-01 | 3.60E-01 | 1.94E-01 | 1.94E-01 |
|  | Teen       | 3.17E-01                | 3.17E-01 | 1.52E+00                | 3.17E-01 | 3.17E-01 | 5.36E-01 | 3.16E-01 | 3.16E-01 |
|  | Child      | 7.54E-01                | 7.53E-01 | 3.68E+00                | 7.55E-01 | 7.55E-01 | 1.17E+00 | 7.52E-01 | 7.52E-01 |
| Goat-Milk Ingestion Pathway                  | Adult      | 8.91E-02                | 8.82E-02 | 3.88E-01                | 8.97E-02 | 8.93E-02 | 2.58E-01 | 8.81E-02 | 8.80E-02 |
|  | Teen       | 1.58E-01                | 1.57E-01 | 7.16E-01                | 1.59E-01 | 1.59E-01 | 4.26E-01 | 1.57E-01 | 1.56E-01 |
|  | Child      | 3.74E-01                | 3.72E-01 | 1.76E+00                | 3.77E-01 | 3.76E-01 | 9.07E-01 | 3.72E-01 | 3.72E-01 |
| Total<br>10 CFR 50 Appendix I Compliance     | Infant     | 7.68E-01                | 7.65E-01 | 3.44E+00                | 7.76E-01 | 7.72E-01 | 2.07E+00 | 7.66E-01 | 7.65E-01 |
|  | Adult      | 3.66E-01                | 3.65E-01 | 1.66E+00                | 3.67E-01 | 3.66E-01 | 7.14E-01 | 3.64E-01 | 3.64E-01 |
|  | Teen       | 5.45E-01                | 5.44E-01 | 2.54E+00                | 5.46E-01 | 5.46E-01 | 1.05E+00 | 5.43E-01 | 5.42E-01 |
|  | Child      | 1.25E+00                | 1.25E+00 | 6.00E+00 <sup>(a)</sup> | 1.25E+00 | 1.25E+00 | 2.22E+00 | 1.25E+00 | 1.25E+00 |
|  | Infant     | 7.73E-01                | 7.70E-01 | 3.44E+00                | 7.82E-01 | 7.78E-01 | 2.09E+00 | 7.72E-01 | 7.71E-01 |

(a) Bounding dose (6 mrem/yr, child bone)



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## 6.0 RESULTS

The results from Section 5.0 are summarized in Table 6-1, along with the 10 CFR 50 acceptance criteria. It is seen that all doses are within the regulatory limits, and that the calculation objective has been achieved. The reported total body and skin doses are conservative since continuous exposure at the OCA boundary is not expected, nor realistic.

**Table 6-1: Gaseous Effluent Dose Summary**

| 10 CFR 50<br>Appendix I<br>Section | Type of Dose<br>[Location]  | Dose         |               | 10 CFR 50<br>Appendix I<br>Limit | Reference                     |
|------------------------------------|---|--------------|---------------|----------------------------------|-------------------------------|
| II.B.1                             | Noble-Gas Beta Air Dose (mrad/yr)<br>[OCA boundary]   | 4.5          |               | 20                               | Table 5-1                     |
|                                    | Noble-Gas Gamma Air Dose (mrad/yr)<br>[OCA boundary]  | 2.0          |               | 10                               |                               |
| II.B.2                             | Noble-Gas Total Body Dose (mrem/yr)<br>[OCA boundary]   | 1.3          |               | 5                                | Table 5-2                     |
|                                    | Noble-Gas Skin Dose (mrem/yr)<br>[OCA boundary]   | 3.9          |               | 15                               |                               |
| II.C                               | Radioiodine, Particulate, Tritium and C-14<br>Organ Dose (mrem/yr, child bone)<br>[Various locations] | 4.0<br>(MEI) | 6.0<br>(HMEI) | 15                               | Table 5-8<br>and<br>Table 5-9 |



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## 7.0 REFERENCES

1. AREVA Document Number 113-7004519-001, Design Change Request, "BBNPP Power Block Relocation." (for information only)
2. AREVA NP Document Number 38-7011432-002, "Response Revision 2 to AREVA BB RFI EPR-11-105 LOD – ER 2.2, 2.4, 2.5.3, 4.1, 4.2, and 4.3."
3. EPRI Technical Document 1021106, "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents," December 2010.
4. AREVA Document Number 32-9079121-003, "Calculation of the U.S. EPR Normal Operation Source Term (GALE) for Bell Bend."
5. AREVA Document Number 32-9062451-000, "Computer Code Documentation Package for GASPAR II."
6. US NRC NUREG/CR-4653, "GASPAR II - Technical Reference and User Guide," March 1987.
7. US NRC Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I," Rev. 1, October 1977.
8. AREVA Document Number 38-9042224-000, "Specific Activity Concentrations and Surface Contamination of Nuclides in Reactor Systems," Framatome ANP, September 2005.
9. "Carbon-14 Discharge at Three Light-Water Reactors," C. Kunz, Health Physics, Volume 49, Issue 1, July 1985, pp 25-35.
10. AREVA Document Number 38-7011395-000, "UniStar RFI #11-071 Response to AREVA BB-RFIEPR-11-106, FSAR 2.1.2 and ER 2.2, 4.4.1, 5.3.4 and 5.8.1 for BBNPP Cut and Fill" (August 2011)
11. "Environmental Distribution and Long-Term Dispersion of Reactor  $^{14}\text{CO}_2$  Around Two German Nuclear Power Plants," Levin, I. et al, Health Physics, Volume 54, Issue 2, February 1988, pp 149-156.
12. AREVA Document Number 126-9070087-008, "Environmental Report Section 2.7 Calculation for Bell Bend Nuclear Power Plant U.S. EPR"
13. AREVA NP Document 38-7007440-000, "Revised Response (Rev. 1) to AREVA RFI EPR-10-175 N," January 2011.
14. AREVA NP Document Number 126-9070954-004, "Agricultural Production and Radiological Exposure Pathway Data for Bell Bend Nuclear Power Plant 1"
15. AREVA NP Document 51-9133385-000, "Verification of Computer Code gaspar2 Version 1.0 on the HP UNIX 9000/800 Workstation Using the HP-UX B.11.11 Operating System."
16. AREVA NP Document 32-9086314-002, "Bell Bend US EPR Radiological Consequences of Design Basis Accidents for FSAR Chapter 15"



Annual Offsite Dose to Individuals from Gaseous Effluent Releases from the U.S. EPR for Bell Bend Nuclear Power Plant

### APPENDIX A: GASPAR2 INPUT PARAMETERS

| <b>Record Type</b> | <b>Record Description</b>                                      | <b>Value</b>         | <b>Reference</b> |
|--------------------|--|----------------------|------------------|
| 1                  | Case title   | See App. B           | NA               |
| 2                  | Type of calculation, 0 = population dose                       | 1                    | NA               |
|                    | # of source terms  | 1                    | NA               |
|                    | Print Control, 0= print cumulative dose for each term          | 1                    | NA               |
|                    | Block Data Change, if >0 then read changes                     | 0                    | NA               |
|                    | Print dose factor library, if > 0 print                        | 0                    | NA               |
|                    | PARTS calculation, if >0 then perform                          | 0                    | NA               |
|                    | Meteorological data entry, if 0 read with rest of data         | 0                    | NA               |
| 3                  | Distance to NE Corner of U.S. <sup>1</sup>                     | 590 miles            | NA               |
|                    | Fraction of the year leafy vegetables are grown                | 0.76                 | 126-9070954-003  |
|                    | Fraction of the year milk cows are on pasture                  | 0.58                 | 126-9070954-003  |
|                    | Fraction of the year MEI's vegetables are from own garden      | 0.58                 | 126-9070954-003  |
|                    | Fraction of the milk-cow feed is from pasture while on pasture | 1.0                  | 126-9070954-003  |
|                    | Average absolute humidity over growing season                  | 6.6 g/m <sup>3</sup> | 126-9070954-003  |
|                    | Average temperature over growing season <sup>2</sup>           | 63.2 F               | 126-9070954-003  |
|                    | Fraction of the year goats are on pasture                      | 0.58                 | 126-9070954-003  |
|                    | Fraction of the goat feed is from pasture while on pasture     | 1                    | 126-9070954-003  |
|                    | Fraction of the year beef cattle are on pasture                | 0.58                 | 126-9070954-003  |
|                    | Fraction of the beef cattle feed from pasture while on pasture | 1                    | 126-9070954-003  |
| 4                  | Population Data  | Not used             | NA               |
| 5                  | Milk Production Data   | Not used             | NA               |
| 6                  | Meat Production Data   | Not used             | NA               |
| 7                  | Vegetable Production Data                                      | Not used             | NA               |
| 8                  | Source term multiplier   | 1                    | NA               |
|                    | Source term  | See Table 3-1        | 32-9079121-002   |
| 9                  | Meteorological Data (Undecayed/Undepleted)                     | Not used             | NA               |
| 10                 | Meteorological Data (Decayed/Undepleted)                       | Not used             | NA               |
| 11                 | Meteorological Data (Decayed/Depleted)                         | Not used             | NA               |
| 12                 | Meteorological Data (Deposited)                                | Not used             | NA               |
| 13                 | Special Meteorological Data [Receptor Data]                    | See Table 3-2        | NA               |

(1) This is a dummy variable and is not used in this calculation.

This value is set to zero when an absolute humidity is input.





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---

## APPENDIX B: GASPAR2 INPUT FILES

### Input File Name: bb-hypo-1.inp

```

***** BB MEI Dose - Receptor Set 9 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3      1.8E+02
C 14     1.89E+1
AR41     3.4E+01
I 131    8.8E-03
I 133    3.2E-02
KR85M    1.5E+02
KR85     2.8E+03
KR87     5.6E+01
KR88     1.9E+02
XE131M   2.7E+03
XE133M   1.7E+02
XE133    7.3E+03
XE135M   1.5E+01
XE135    1.2E+03
XE138    1.2E+01
CR51     9.7E-05
MN54     5.7E-05
CO57     8.2E-06
CO58     4.8E-04
CO60     1.1E-04
FE59     2.8E-05
SR89     1.6E-04
SR90     6.3E-05
ZR95     1.0E-05
NB95     4.2E-05
RU103    1.7E-05
RU106    7.8E-07
SB125    6.1E-07
CS134    4.8E-05
CS136    3.3E-05
CS137    9.0E-05
BA140    4.2E-06
CE141    1.3E-05

1 COW-MILK      SW      6455 7.911E-08 7.911E-08 7.235E-08 1.694E-1011111111
1 COW-MILK      WSW     6357 1.599E-07 1.599E-07 1.487E-07 1.171E-1011111111
1 COW-MILK      NW      6766 9.349E-08 9.349E-08 7.212E-08 2.432E-1011111111
1 MEAT          N       804 1.330E-06 1.330E-06 1.303E-06 3.156E-0911111111
1 MEAT          NNE     824 1.483E-06 1.483E-06 1.442E-06 5.431E-0911111111

```



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---

**Input File Name: bb-hypo-2.inp**

```
***** BB MEI Dose - Receptor Set 10 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76    1.0    6.6    0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1      0      0      0
H 3      1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 MEAT      NE      994 9.226E-07 9.226E-07 8.704E-07 9.914E-09 11111111
1 MEAT      ENE     2208 1.600E-07 1.600E-07 1.479E-07 1.485E-09 11111111
1 MEAT      E      2154 6.205E-08 6.205E-08 5.565E-08 7.549E-10 11111111
1 MEAT      ESE     1786 6.758E-08 6.758E-08 6.084E-08 8.455E-10 11111111
1 MEAT      SE      938 1.900E-07 1.900E-07 1.727E-07 2.563E-09 11111111
```

**Input File Name: bb-hypo-3.inp**

```
***** BB MEI Dose - Receptor Set 11 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76    1.0    6.6    0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1      0      0      0
H 3      1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 MEAT      SSE     819 2.982E-07 2.982E-07 2.731E-07 3.888E-09 11111111
1 MEAT      S      799 2.632E-07 2.632E-07 2.416E-07 2.817E-09 11111111
1 MEAT      SSW     918 4.381E-07 4.381E-07 3.998E-07 3.506E-09 11111111
1 MEAT      SW      628 7.178E-07 7.178E-07 6.662E-07 3.223E-09 11111111
1 MEAT      WSW     537 1.755E-06 1.755E-06 1.639E-06 3.476E-09 11111111
```



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---

**Input File Name: bb-hypo-4.inp**

```

***** BB MEI Dose - Receptor Set 12 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 MEAT            W      534 3.431E-07 3.431E-07 3.216E-07 1.406E-09 11111111
1 MEAT            WNW    545 2.409E-07 2.409E-07 2.259E-07 1.533E-09 11111111
1 MEAT            NW     656 2.112E-07 2.112E-07 1.965E-07 1.742E-09 11111111
1 MEAT            NNW    806 6.270E-07 6.270E-07 6.120E-07 1.697E-09 11111111

```

**Input File Name: bb-mei-SB1.inp**

```

***** BB MEI Dose - Site Boundary Receptor Set 1 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 OCA            N      418 3.495E-06 3.495E-06 3.445E-06 6.796E-09 11111111
1 OCA            NNE    426 4.875E-06 4.875E-06 4.799E-06 1.210E-08 11111111
1 OCA            NE     507 1.835E-06 1.835E-06 1.744E-06 2.268E-08 11111111
1 OCA            ENE    519 8.727E-07 8.727E-07 8.194E-07 1.367E-08 11111111

```



Annual Offsite Dose to Individuals from Gaseous Effluent Releases from the U.S. EPR for Bell Bend Nuclear Power Plant

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**Input File Name: bb-mei-SB2.inp**

```

***** BB MEI Dose - Site Boundary Receptor Set 4 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 OCA                W      239 1.368E-06 1.368E-06 1.320E-06 3.402E-09 11111111
1 OCA                WNW    239 9.671E-07 9.671E-07 9.330E-07 3.872E-09 11111111
1 OCA                NW     244 1.229E-06 1.229E-06 1.191E-06 5.812E-09 11111111
1 OCA                NNW    359 2.456E-06 2.456E-06 2.424E-06 4.323E-09 11111111

```

**Input File Name: bb-mei-SB3.inp**

```

***** BB MEI Dose - Site Boundary Receptor Set 2 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 OCA                E      478 5.118E-07 5.118E-07 4.813E-07 7.162E-09 11111111
1 OCA                ESE    323 7.094E-07 7.094E-07 6.774E-07 8.245E-09 11111111
1 OCA                SE     270 1.283E-06 1.283E-06 1.232E-06 1.449E-08 11111111
1 OCA                SSE    263 1.785E-06 1.785E-06 1.716E-06 1.838E-08 11111111

```



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---

**Input File Name: bb-mei-SB4.inp**

```

***** BB MEI Dose - Site Boundary Receptor Set 3 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 OCA                S      263 1.557E-06 1.557E-06 1.497E-06 1.149E-08 11111111
1 OCA                SSW    268 3.072E-06 3.072E-06 2.953E-06 1.589E-08 11111111
1 OCA                SW     268 3.133E-06 3.133E-06 3.010E-06 9.454E-09 11111111
1 OCA                WSW    251 6.781E-06 6.781E-06 6.529E-06 9.765E-09 11111111

```

**Input File Name: bb-real-1.inp**

```

***** BB MEI Dose - Receptor Set 1 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL              N      1254 1.293E-06 1.293E-06 1.270E-06 2.294E-09 11111111
1 VEGET              N       833 1.289E-06 1.289E-06 1.262E-06 3.030E-09 11111111
1 INHAL              NNE    1266 1.417E-06 1.417E-06 1.382E-06 3.741E-09 11111111
1 VEGET              NNE    1395 1.232E-06 1.232E-06 1.197E-06 3.410E-09 11111111
1 INHAL              NE     1678 8.178E-07 8.178E-07 7.743E-07 5.401E-09 11111111

```





Annual Offsite Dose to Individuals from Gaseous Effluent Releases from the U.S. EPR for Bell Bend Nuclear Power Plant

---

**Input File Name: bb-real-2.inp**

```
***** BB MEI Dose - Receptor Set 2 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 VEGET          NE    2284 5.014E-07 5.014E-07 4.684E-07 3.279E-0911111111
1 INHAL          ENE    2892 1.148E-07 1.148E-07 1.052E-07 9.746E-1011111111
1 VEGET          ENE    2785 1.211E-07 1.211E-07 1.112E-07 1.036E-0911111111
1 INHAL          E     2248 5.937E-08 5.937E-08 5.322E-08 7.113E-1011111111
1 VEGET          E     2266 5.888E-08 5.888E-08 5.277E-08 7.034E-1011111111
```

**Input File Name: bb-real-3.inp**

```
***** BB MEI Dose - Receptor Set 3 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL          ESE    2281 5.279E-08 5.279E-08 4.743E-08 6.118E-1011111111
1 VEGET          ESE    1786 6.758E-08 6.758E-08 6.084E-08 8.455E-1011111111
1 INHAL          SE     1271 1.207E-07 1.207E-07 1.088E-07 1.609E-0911111111
1 VEGET          SE     1467 1.028E-07 1.028E-07 9.248E-08 1.364E-0911111111
```



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---

**Input File Name: bb-real-4.inp**

```
***** BB MEI Dose - Receptor Set 4 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1          0          0          0
H 3          1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL          SSE    1620 1.332E-07 1.332E-07 1.199E-07 1.674E-091111111
1 VEGET          SSE    1619 1.333E-07 1.333E-07 1.200E-07 1.676E-091111111
1 INHAL          S      1749 1.393E-07 1.393E-07 1.285E-07 1.223E-091111111
1 VEGET          S       811 2.582E-07 2.582E-07 2.369E-07 2.765E-091111111
1 COW-MILK       S     4855 7.536E-08 7.536E-08 6.918E-08 3.146E-101111111
```

**Input File Name: bb-real-5.inp**

```
***** BB MEI Dose - Receptor Set 5 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1          0          0          0
H 3          1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL          SSW    1675 2.520E-07 2.520E-07 2.318E-07 1.690E-091111111
1 VEGET          SSW     408 1.472E-06 1.472E-06 1.394E-06 9.504E-091111111
1 COW-MILK       SSW    1191 3.564E-07 3.564E-07 3.260E-07 2.686E-091111111
1 INHAL          SW     756 5.312E-07 5.312E-07 4.881E-07 2.547E-091111111
1 VEGET          SW     454 1.239E-06 1.239E-06 1.168E-06 4.892E-091111111
```



Annual Offsite Dose to Individuals from Gaseous Effluent Releases from the U.S. EPR for Bell Bend Nuclear Power Plant

---

**Input File Name: bb-real-6.inp**

```
***** BB MEI Dose - Receptor Set 6 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL          WSW    1019 5.792E-07 5.792E-07 5.219E-07 1.453E-0911111111
1 VEGET          WSW    596 1.460E-06 1.460E-06 1.357E-06 3.007E-0911111111
1 INHAL          W      596 2.862E-07 2.862E-07 2.670E-07 1.246E-0911111111
1 VEGET          W      819 1.758E-07 1.758E-07 1.617E-07 8.873E-1011111111
1 COW-MILK       W     6492 2.274E-07 2.274E-07 1.933E-07 1.188E-0911111111
```

**Input File Name: bb-real-7.inp**

```
***** BB MEI Dose - Receptor Set 7 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL          WNW     852 3.025E-07 3.025E-07 2.923E-07 1.084E-0911111111
1 VEGET          WNW    1424 1.423E-06 1.423E-06 1.410E-06 1.065E-0911111111
1 COW-MILK       WNW    6469 1.182E-07 1.182E-07 9.195E-08 2.390E-1011111111
1 INHAL          NW     748 2.134E-07 2.134E-07 2.003E-07 1.608E-0911111111
1 VEGET          NW     730 2.169E-07 2.169E-07 2.035E-07 1.650E-0911111111
```



Annual Offsite Dose to Individuals from Gaseous Effluent Releases from the U.S. EPR for Bell Bend Nuclear Power Plant

---

**Input File Name: bb-real-8.inp**

```
***** BB MEI Dose - Receptor Set 8 *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 INHAL            NNW    1291 3.641E-07 3.641E-07 3.540E-07 9.812E-101111111
1 VEGET            NNW    1338 3.986E-07 3.986E-07 3.888E-07 9.597E-101111111
1 COW-MILK         NNW    6388 8.201E-08 8.201E-08 6.389E-08 2.403E-101111111
```

**Input File Name: bb-hypo-mei.inp**

```
***** BB HMEI Dose *****
1 1 1 0 0 0 0
    590    0.583    0.583    0.76        1.0        6.6        0    0.583    1.0 0.583
1.0
***Source Term for BBNPP Unit 1 per 32-9079121-003
    1        0        0        0
H 3        1.8E+02
...
See bb-hypo-1.inp for complete list
...
CE141    1.3E-05

1 HYPO-MEI        WSW     537 1.755E-06 1.755E-06 1.639E-06 1.246E-081111111
```



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Power Plant

---

**APPENDIX C: GASPAR2 OUTPUT FILES**

All output files have been stored in ColdStor under:

\cold\A011PE2062\32-9077003-003\official\.

Refer to Table 4-1 in the main body for the list of files uploaded to ColdStor.