Draft

Advisory Board on Radiation and Worker Health
National Institute for Occupational Safety and Health

Review of NIOSH February 2020 Response to SC&A (September 2019) on Neutron Dose Assignment for K-25 and Portsmouth Gaseous Diffusion Plants

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Prepared by

Ron Buchanan, PhD, CHP

SC&A, Inc.
2200 Wilson Boulevard, Suite 300
Arlington, VA 22201-3324

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Abbreviations and Acronyms

ABRWH	Advisory Board on Radiation and Worker Health
GDP	gaseous diffusion plant
HPRS	health physics records system
ICRP	International Commission on Radiological Protection
K-25	Oak Ridge Gaseous Diffusion Plant
LOD	limit of detection
N:P	neutron-to-photon
n	neutron dose
n:p	neutron-to-photon
NIOSH	National Institute for Occupational Safety and Health
p	proton dose
QRA	quantile regression analyses
TBD	technical basis document
TLD	thermoluminescent dosimeter

1 Introduction and Background

The National Institute for Occupational Safety and Health (NIOSH) issued on May 6, 2019, the white paper, "Neutron Dose Assignment for K-25 and Portsmouth Gaseous Diffusion Plants" (NIOSH, 2019; hereafter the "white paper"). The purpose of the white paper was to determine a reasonable neutron-to-photon (N:P) ratio that can be used to assign dose for gaseous diffusion plant (GDP) energy employees during periods when neutron dose data were not reliable, not available, or not recorded. For the Oak Ridge Gaseous Diffusion Plant (K-25), this time period was prior to 1992. For Portsmouth, this time period was prior to 1995. SC&A was tasked on June 27, 2019, with reviewing the white paper. SC&A issued on September 16, 2019, the report, "SC&A's Review of NIOSH's White Paper, 'Neutron Dose Assignment for K-25 and Portsmouth Gaseous Diffusion Plants'" (SC&A, 2019; hereafter "SC&A's review"). NIOSH issued on February 6, 2020, the paper, "Responses to SC&A's Review of NIOSH's White Paper, 'Neutron Dose Assignment for K-25 and Portsmouth Gaseous Diffusion Plants' (Document No. SCA-TR-2019-SP002, Revision 0)" (NIOSH, 2020; hereafter the "response paper").

2 NIOSH's Response to SC&A's Review of the White Paper

NIOSH responded (NIOSH, 2020) to SC&A's review (SC&A, 2019) of the white paper (NIOSH, 2019) by addressing each of SC&A's three observations individually. The following sections summarize NIOSH's responses and SC&A's evaluation of those responses.

2.1 NIOSH's response to SC&A's observation 1: apparent inconsistency in use of limit of detection

2.1.1 SC&A (2019) observation 1

Observation 1 stated, in part (p. 7):

> The use of the neutron dosimetry data and photon dosimetry data that were *equal to* the LOD values needs to be clarified; i.e., were "equal to" values used in NIOSH's analysis, or only values that were greater than the LOD? A set method should have been consistently applied to the dosimetry data used from the three sites.

2.1.2 NIOSH (2020) response

> For both the Portsmouth and K-25 analyses, data *greater than or equal to* the limit of detection (LOD) were used; i.e., the approaches were consistent. The text from this White Paper will be revised when this verbiage is added to the Site Profile Technical Basis Documents (TBDs) to make these approaches clear. [p. 2]

2.1.3 SC&A evaluation of NIOSH response

SC&A concurs with NIOSH's resolution through page 9 of the white paper. However, refer to SC&A's additional discussion in observation 2 below concerning the use of dose values less than the LOD on pages 10–24 of the white paper.

2.2 NIOSH's response to SC&A's observation 2: use of Portsmouth dosimetry values near zero

2.2.1 SC&A (2019) observation 2

Observation 2 stated (pp. 7–8):

> As previously discussed in this review, dosimetry values equal to, or greater than, the LOD value were used to derive N:P ratios. However, when the white paper used the QRA [quantile regression analysis] method for the Portsmouth dosimetry data, as illustrated in figures 2 and 4 of the white paper, it appears from the plots (and from the number of data points (N), i.e., 3,727 on page 13 versus 161 on page 6) that recorded data with values as low as near zero might have been used. This is not consistent with the use of dosimetry that is equal to or greater than the LOD.

2.2.2 NIOSH (2020) response

> Uncensored neutron dose data and uncensored photon dose data were available for Portsmouth, so they were modeled as is. Modeling of complete data, when available, is always preferable to modeling censored data. [p. 2]

2.2.3 SC&A evaluation of NIOSH response

The 3,727 data points (for the period 1995–2001) used in the construction of figure 2 of the white paper consisted of neutron and photon dose values as low as 0.001 rem, which is less than the LOD value of 0.010 rem. These 3,727 data points were taken from the "Portsmouth HPRS (11-11-2014) uncensored external dosimetry" database (Portsmouth HPRS database), which NIOSH supplied to SC&A. The Portsmouth HPRS database is a subset of the complete database, "Unredacted Electronic Version of the Health Physics Records System," collected November 12, 2014 (SRBD Ref. ID 138026) (PGDP, n.d.). PGDP (n.d.) contains data for the period 1993–2011, with positive neutron data starting in 1995. The use of dose values less than the LOD is not apparent in the text of the white paper, where the wording suggests (e.g., p. 6) the use of only data greater than (or equal to, as later clarified by NIOSH in the response paper) the LOD value for Portsmouth. In contrast, it appears that only dose values great than or equal to the neutron and photon LOD values were used for the K-25 QRA plot (figure 1). It appears that some neutron data that were less than the LOD of 0.010 rem were used for the Y-12 (figure 3) QRA plot, while the photon doses were all greater than or equal to the LOD value.

There is an overarching program issue concerning the use of recorded values less than the detection limit. SC&A suggests deferring the use of recorded values less than the detection limit for the GDP neutron dose analysis to that overarching issue.

However, the use of doses less than the detection limit should be applied uniformly to the K-25, Y-12, and Portsmouth data in the GDP data analysis. The apparent lack of uniformity might have been the result of there not being any recorded values in the original records less than the LOD value for the K-25 neutron and photon data and the Y-12 photon data. However, it would have been helpful if this had been clarified in the text of the white paper.

2.3 NIOSH's response to SC&A's observation 3: use of the standard N:P ratios versus the quantile-regression and Monte Carlo approach

2.3.1 SC&A (2019) observation 3

Observation 3 stated (p. 8):

> SC&A concurs with the N:P ratios derived using standard analyses of the dosimetry data for Portsmouth, K-25, and Y-12. However, analyzing the QRA method recommended in the conclusions (page 16) of the white paper indicates that the resulting neutron doses assigned at the 50th percentile in IREP for dose reconstruction purposes would be approximately half of that assigned by the standard N:P averaged ratio method. The QRA method is not claimant favorable, nor consistent with neutron dose assignments at other U.S. Department of Energy sites.

2.3.2 NIOSH (2020) response

> Quantile regression analysis (QRA) is an established methodology available for use in the project (see ORAUT-RPRT-0087). QRA is the preferred methodology for assigning neutron dose based on photon measurements, and the example below demonstrates why one method is superior to another. [p. 3]

The response paper follows this statement with an example of using the N:P ratio versus quantile regression (NIOSH, 2020, pp. 3–4).

2.3.3 SC&A evaluation of NIOSH response

Again, this is an overarching issue concerning the use of recorded values less than the detection limit in conjunction with the QRA method. SC&A suggests deferring the use of recorded values less than the detection limit and the QRA method for the GDP neutron dose analysis to those overarching issues.

2.4 Calculating N:P values for Portsmouth

NIOSH provides an additional statement on page 2 of the response paper:

> While not part of this observation, NIOSH did try to replicate SC&A's calculated neutron-to-photon (N:P) value for Portsmouth (0.412) but was not able to exactly match this result. The difference between the NIOSH (0.369) and SC&A values (0.412) is likely due to the treatment of neutron data starting in 2010, when Portsmouth implemented the International Commission on Radiological Protection (ICRP) Publication 60 neutron weighting factors. The NIOSH value was calculated with a correction implemented to account for the weighting factor change. The approach used by SC&A would need to be seen directly to confirm the reason for this difference.

SC&A had used the appropriate ICRP neutron weighting factor beginning in 2010 for the Portsmouth data. Therefore, SC&A investigated NIOSH's N:P calculations for the white paper further and found that the following issues contributed to the difference in the derived Portsmouth N:P values (NIOSH's 0.369 versus SC&A's 0.412):

- NIOSH (2019, p. 6) used the "REMS Database Evaluation" database, dated January 28, 2015, in the derivation of N:P = 0.360 using neutron data equal to or greater than the LOD for the period 1999–2013. In this case, NIOSH derived an N:P value of 0.369 apparently using N:P = $n/(n + p)$, where n is the neutron dose and p is the photon dose. (NIOSH provided SC&A with a copy of the "REMS Database Evaluation" database, dated January 28, 2015.)

- NIOSH (2019) used the "Portsmouth HPRS (11-11-2014) uncensored external dosimetry" database for figure 2, using neutron data greater than zero for the period 1995–2001 (apparently taken from the original PGDP (n.d.), collected November 12, 2014).

- NIOSH (2019) used a combination of these databases in the construction of table 6. In other words, for table 6, column 3, NIOSH used the REMS database and for table 6, column 4, used the Portsmouth HPRS database.

- SC&A (2019) used the complete PGDP (n.d.) database collected November 12, 2014, that contains data for the period 1993–2011, with the first positive neutron dose recorded in 1995. SC&A used neutron data that were equal to or greater than the LOD of 0.010 rem, deriving an N:P value of 0.412 using N:P = n/p.

From SC&A's analysis of NIOSH's REMS database, it appears that in deriving the N:P ratio of 0.369 on page 6, and in table 6, column 3, NIOSH (2019) used N:P = $n/(n + p)$ instead of N:P = n/p. The N:P ratio calculations in the "REMS Database Evaluation" database dated January 28, 2015, tab "np ratios," column L, is the total of the neutron plus photon dose from tab "All employees," column O (which is the photon dose (column P) plus neutron dose (column R)). In addition, the total neutron plus photon dose used in the denominator consisted of:

- the original neutron dose before it was divided by the ICRP neutron weighting factor for the year 2010 and later
- the neutron dose value, not the photon LOD value of 0.010 rem, when the photon dose was less than the LOD value

Both of these incorrectly increased the denominator, resulting in a lowered N:P value and capping it at 1.0.

Therefore, the "Avg of individual n:p ratios" of 0.369 in column Q, row 2, (under tab "n:p ratios" in the "REMS Database Evaluation" database) was apparently derived from using N:P = $n/(n + p)$ instead of N:P = n/p. This would create a lower than normal value for N:P from the Portsmouth data. SC&A has reproduced an excerpt of this database's spreadsheet in table A-1 in attachment A of this evaluation, along with the correct photon doses (listed in column A of table A-1). The use of the correct photon dose values from column A of table A-1 results in an N:P value of 0.76 using the REMS database for the period 1999–2013. A check of several claims for Portsmouth on the NIOSH Division of Compensation Analysis and Support

Tracking System (NOCTS) shows that the original external photon dose and the external neutron dose were recorded in separate columns and not as a sum of the two.

Observation 4 (new): use of neutron plus photon for photon dose to calculate N:P
It appears that in deriving the N:P ratio of 0.369 on page 6, and in table 6, column 3, of the white paper, NIOSH (2019) used N:P = $n/(n + p)$ instead of N:P = n/p. This would create a lower than normal value for N:P from the Portsmouth data. If the QRA method is used for dose reconstruction as presented on pages 10–24 of the response paper (NIOSH, 2020), then the incorrect N:P value of 0.369 would not be used in dose reconstructions. However, either the correct N:P values should be derived and stated in the white paper, or NIOSH should clarify why the current value is correct.

3 Summary and Conclusions

This section summarizes SC&A's evaluation of the NIOSH response paper.

For observation 1: apparent inconsistence in use of LOD

- NIOSH (2020) responded that the text from the white paper will be revised when this verbiage is added to the site profile TBDs to make these approaches clear.

- SC&A concurs with this resolution through page 9 of the white paper. However, refer to SC&A's additional discussion under observation 2 below concerning the use of dose values less than the LOD in pages 10–24 of the white paper.

For observation 2: use of Portsmouth dosimetry values near zero

- NIOSH (2020) responded that uncensored neutron dose data and uncensored photon dose data were available for Portsmouth, so they were modeled as is. Modeling of complete data, when available, is always preferable to modeling censored data.

- SC&A finds that there is an overarching issue concerning the use of recorded values less than the detection limit. SC&A suggest deferring the use of recorded values less than the detection limit for the GDP neutron dose analysis to that overarching issue.

For observation 3: use of the standard N:P ratios versus the quantile-regression and Monte Carlo approach

- NIOSH's (2020) response was that QRA is an established methodology available for use in the project (refer to ORAUT-RPRT-0087). QRA is the preferred methodology for assigning neutron dose based on photon measurements, and the example below demonstrates why one method is superior to another.

- SC&A find that this is also an overarching issue concerning the use of recorded values less than the detection limit in conjunction with the QRA method. SC&A suggests deferring the use of recorded values less than the detection limit and the QRA method for the GDP neutron dose analysis to those overarching issues.

For observation 4 (new): calculating N:P values for Portsmouth

- NIOSH discussed the calculation of Portsmouth N:P ratios on page 2 of the response paper.

- SC&A reviewed NIOSH's discussion and found that it appears that in deriving the N:P ratio of 0.369 on page 6, and in table 6, column 3, of the white paper NIOSH (2019) used N:P = $n/(n + p)$ instead of N:P = n/p. This would create a lower than normal value for N:P from the Portsmouth data. If the QRA method is used for dose reconstruction as presented on pages 10–24 of the response paper, then the incorrect N:P value of 0.369 would not be used in dose reconstructions. However, either the correct N:P values should be derived and stated in the white paper, or NIOSH should clarify why the current value is correct.

SC&A concludes that the issue of using recorded dose values less than LOD and the use of the QRA method for deriving neutron dose for dose reconstruction are items that should be deferred to the resolution of these overarching issues. SC&A also finds that the data used for the calculation of the N:P value for Portsmouth on page 6 and table 6, column 3, of the white paper should be reevaluated or clarified by NIOSH.

4 References

International Commission on Radiological Protection (ICRP). (1991). 1990 recommendations of the International Commission on Radiological Protection (Publication 60). *Ann. ICRP, 21*(1-3).

National Institute for Occupational Safety and Health (NIOSH). (2018). *Applications of regression in external dose reconstruction* (ORAUT-RPRT-0087, rev. 00). SRDB Ref. ID 170100

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Portsmouth Gaseous Diffusion Plant (PGDP). (n.d.). *Unredacted electronic version of the Health Physics Records System* [Collected November 12, 2014]. SRDB Ref. ID 138026

SC&A, Inc. (2019). *SC&A's review of NIOSH's white paper, "Neutron dose assignment for K-25 and Portsmouth Gaseous Diffusion Plants"* (SCA-TR-2019-SP002, rev. 0). SRDB Ref. ID 178315

Attachment A: Example of n:p Calculations Used in White Paper

NIOSH's calculated n:p values using n:p = (adj. n)/(raw photon dose + raw neutron dose) under tab "np ratios" in the "REMS Database Evaluation" database, dated January 28, 2015 (columns L through Q), and in the white paper of May 6, 2019, page 6, and table 6, column 3. The DDE_PHOTONS in column A would have been the correct photon dose values to use to calculate n:p. The term "raw" refers to the original data not adjusted for zero photon doses or ICRP's weighting factor for 2010 and later neutron data. The term "Adj" refers to adjusting the neutron dose by the ICRP weighting factor. The "REMS Database Evaluation" database uses the notation "n:p" for neutron-to-photon. Dose values are in millirem.

Table A-1. Partial reproduction of the "REMS Database Evaluation" database with SC&A annotations

[Data base row]	**[Column] A**	**[Column] L**	**[Column] M**	**[Column] N**	**[Column] O**	**[Column] P**	**[Column] Q**
1	**DDE_ PHOTONS [Correct value]**	**photon [Actually raw photon + raw neutron]**	**[Raw] neutron**	**Adj neutron**	**np ratio [(adj. n) divided by (raw photon + raw neutron)]**	[blank cell]	**Avg of individual n:p ratios**
2	32	10	10 [a]	[blank cell]	1.000	[blank cell]	**0.369** [a]
3	26	24	10	[blank cell]	0.417	[blank cell]	Overall n:p ratio
4	21	22	12	[blank cell]	0.545	[blank cell]	[blank cell]
5	29	22	12	[blank cell]	0.545	[blank cell]	[blank cell]
6	18	31	13	[blank cell]	0.419	[blank cell]	**0.308** [a]
7	10	43	14	[blank cell]	0.326	[blank cell]	(total of neutron
8	10	38	17	[blank cell]	0.447	[blank cell]	dose divided by
9	14	44	18	[blank cell]	0.409	[blank cell]	total of photon
10	111	51	19	[blank cell]	0.373	[blank cell]	dose)
11	95	26	14	[blank cell]	0.538	[blank cell]	[blank cell]
12	60	14	14 [a]	[blank cell]	1.000	[blank cell]	[blank cell]
13	77	30	15	[blank cell]	0.500	[blank cell]	[blank cell]
14	51	28	17	[blank cell]	0.607	[blank cell]	[blank cell]
15	64	55	21	[blank cell]	0.382	[blank cell]	[blank cell]
16	59	66	27	[blank cell]	0.409	[blank cell]	[blank cell]
17	39	89	30	[blank cell]	0.337	[blank cell]	[blank cell]
18	34	96	32	[blank cell]	0.333	[blank cell]	[blank cell]
19	11	84	33	[blank cell]	0.393	[blank cell]	[blank cell]
20	15	112	35	[blank cell]	0.313	[blank cell]	[blank cell]
21	12	132	37	[blank cell]	0.280	[blank cell]	[blank cell]
22	86	97	37	[blank cell]	0.381	[blank cell]	[blank cell]
23	50	211	100	[blank cell]	0.474	[blank cell]	[blank cell]

[Data base row]	[Column] A	[Column] L	[Column] M	[Column] N	[Column] O	[Column] P	[Column] Q
1	**DDE_ PHOTONS [Correct value]**	**photon [Actually raw photon + raw neutron]**	**[Raw] neutron**	**Adj neutron**	**np ratio [(adj. n) divided by (raw photon + raw neutron)]**	[blank cell]	**Avg of individual n:p ratios**
24	77	63	12	[blank cell]	0.190	[blank cell]	[blank cell]
25	64	54	13	[blank cell]	0.241	[blank cell]	[blank cell]
26	47	63	16	[blank cell]	0.254	[blank cell]	[blank cell]
27	41	81	17	[blank cell]	0.210	[blank cell]	[blank cell]
28	51	95	18	[blank cell]	0.189	[blank cell]	[blank cell]
29	106	73	23	[blank cell]	0.315	[blank cell]	[blank cell]
30	57	166	80	[blank cell]	0.482	[blank cell]	[blank cell]
31	53	68	11	[blank cell]	0.162	[blank cell]	[blank cell]
32	69	155	49	[blank cell]	0.316	[blank cell]	[blank cell]
33	116	63	10	[blank cell]	0.159	[blank cell]	[blank cell]
34	116	11	11 [a]	[blank cell]	1.000	[blank cell]	[blank cell]
35	92	120	12	[blank cell]	0.100	[blank cell]	[blank cell]
36	107	76	25	[blank cell]	0.329	[blank cell]	[blank cell]
37	109	44	30	[blank cell]	0.682	[blank cell]	[blank cell]
38	79	132	39	[blank cell]	0.295	[blank cell]	[blank cell]
39	93	119	40	[blank cell]	0.336	[blank cell]	[blank cell]
40	14	165	58	[blank cell]	0.352	[blank cell]	[blank cell]
41	51	167	58	[blank cell]	0.347	[blank cell]	[blank cell]
42	108	161	69	[blank cell]	0.429	[blank cell]	[blank cell]
43	122	186	70	[blank cell]	0.376	[blank cell]	[blank cell]
44	151	188	72	[blank cell]	0.383	[blank cell]	[blank cell]
45	127	143	74	[blank cell]	0.517	[blank cell]	[blank cell]
46	68	63	10	[blank cell]	0.159	[blank cell]	[blank cell]
47	71	44	10	[blank cell]	0.227	[blank cell]	[blank cell]
48	41	42	11	[blank cell]	0.262	[blank cell]	[blank cell]
49	74	30	11	[blank cell]	0.367	[blank cell]	[blank cell]
50	79	28	13	[blank cell]	0.464	[blank cell]	[blank cell]
51	93	61	15	[blank cell]	0.246	[blank cell]	[blank cell]
52	68	31	18	[blank cell]	0.581	[blank cell]	[blank cell]
53	52	105	18	[blank cell]	0.171	[blank cell]	[blank cell]
54	63	88	20	[blank cell]	0.227	[blank cell]	[blank cell]
55	13	72	20	[blank cell]	0.278	[blank cell]	[blank cell]
56	87	83	20	[blank cell]	0.241	[blank cell]	[blank cell]
57	15	116	23	[blank cell]	0.198	[blank cell]	[blank cell]

[Data base row]	[Column] A	[Column] L	[Column] M	[Column] N	[Column] O	[Column] P	[Column] Q
1	**DDE_ PHOTONS [Correct value]**	**photon [Actually raw photon + raw neutron]**	**[Raw] neutron**	**Adj neutron**	**np ratio [(adj. n) divided by (raw photon + raw neutron)]**	[blank cell]	**Avg of individual n:p ratios**
58	31	105	26	[blank cell]	0.248	[blank cell]	[blank cell]
59	19	107	33	[blank cell]	0.308	[blank cell]	[blank cell]
60	53	78	37	[blank cell]	0.474	[blank cell]	[blank cell]
61	141	109	38	[blank cell]	0.349	[blank cell]	[blank cell]
62	110	111	43	[blank cell]	0.387	[blank cell]	[blank cell]
63	46	157	47	[blank cell]	0.299	[blank cell]	[blank cell]
64	34	190	49	[blank cell]	0.258	[blank cell]	[blank cell]
65	75	179	52	[blank cell]	0.291	[blank cell]	[blank cell]
66	78	209	58	[blank cell]	0.278	[blank cell]	[blank cell]
67	67	182	60	[blank cell]	0.330	[blank cell]	[blank cell]
68	95	59	12	[blank cell]	0.203	[blank cell]	[blank cell]
69	41	78	12	[blank cell]	0.154	[blank cell]	[blank cell]
70	64	59	13	[blank cell]	0.220	[blank cell]	[blank cell]
71	51	55	15	[blank cell]	0.273	[blank cell]	[blank cell]
72	46	93	25	[blank cell]	0.269	[blank cell]	[blank cell]
73	50	175	49	[blank cell]	0.280	[blank cell]	[blank cell]
74	126	100	50	[blank cell]	0.500	[blank cell]	[blank cell]
75	68	106	55	[blank cell]	0.519	[blank cell]	[blank cell]
76	40	101	55	[blank cell]	0.545	[blank cell]	[blank cell]
77	46	122	58	[blank cell]	0.475	[blank cell]	[blank cell]
78	47	101	60	[blank cell]	0.594	[blank cell]	[blank cell]
79	66	163	68	[blank cell]	0.417	[blank cell]	[blank cell]
80	105	142	75	[blank cell]	0.528	[blank cell]	[blank cell]
81	73	158	80	[blank cell]	0.506	[blank cell]	[blank cell]
82	73	157	82	[blank cell]	0.522	[blank cell]	[blank cell]
83	43	61	10	[blank cell]	0.164	[blank cell]	[blank cell]
84	90	51	16	[blank cell]	0.314	[blank cell]	[blank cell]
85	75	25	25 [a]	[blank cell]	1.000	[blank cell]	[blank cell]
86	65	74	45	[blank cell]	0.608	[blank cell]	[blank cell]
87	42	93	51	[blank cell]	0.548	[blank cell]	[blank cell]
88	29	124	59	[blank cell]	0.476	[blank cell]	[blank cell]
89	35	138	63	[blank cell]	0.457	[blank cell]	[blank cell]
90	51	155	65	[blank cell]	0.419	[blank cell]	[blank cell]
91	105	114	71	[blank cell]	0.623	[blank cell]	[blank cell]

[Data base row]	[Column] A	[Column] L	[Column] M	[Column] N	[Column] O	[Column] P	[Column] Q
1	**DDE_ PHOTONS [Correct value]**	**photon [Actually raw photon + raw neutron]**	**[Raw] neutron**	**Adj neutron**	**np ratio [(adj. n) divided by (raw photon + raw neutron)]**	[blank cell]	**Avg of individual n:p ratios**
92	35	146	73	[blank cell]	0.500	[blank cell]	[blank cell]
93	27	146	73	[blank cell]	0.500	[blank cell]	[blank cell]
94	42	185	80	[blank cell]	0.432	[blank cell]	[blank cell]
95	23	11	11 [a]	[blank cell]	1.000	[blank cell]	[blank cell]
96	58	33	20	[blank cell]	0.606	[blank cell]	[blank cell]
97	24	51	21	[blank cell]	0.412	[blank cell]	[blank cell]
98	21	21	21 [a]	[blank cell]	1.000	[blank cell]	[blank cell]
99	30	49	28	[blank cell]	0.571	[blank cell]	[blank cell]
100	13	53	29	[blank cell]	0.547	[blank cell]	[blank cell]
101	46	63	40	[blank cell]	0.635	[blank cell]	[blank cell]
102	76	98	40	[blank cell]	0.408	[blank cell]	[blank cell]
103	57	80	53	[blank cell]	0.663	[blank cell]	[blank cell]
104	50	95	53	[blank cell]	0.558	[blank cell]	[blank cell]
105	55	91	56	[blank cell]	0.615	[blank cell]	[blank cell]
106	52	179	74	[blank cell]	0.413	[blank cell]	[blank cell]
107	102	57	57 [a]	[blank cell]	1.000	[blank cell]	[blank cell]
108	75	121	66	[blank cell]	0.545	[blank cell]	[blank cell]
109	77	118	66	[blank cell]	0.559	[blank cell]	[blank cell]
110	78	120	70	[blank cell]	0.583	[blank cell]	[blank cell]
111	34	133	76	[blank cell]	0.571	[blank cell]	[blank cell]
112	33	158	82	[blank cell]	0.519	[blank cell]	[blank cell]
113	9	131	85	[blank cell]	0.649	—	[blank cell]
114	13	33	10	5	0.152	2010-13	[blank cell]
115	23	45	11	5.5	0.122	[blank cell]	[blank cell]
116	34	41	28	14	0.341	[blank cell]	[blank cell]
117	249	39	30	15	0.385	[blank cell]	[blank cell]
118	141	66	33	16.5	0.250	[blank cell]	[blank cell]
119	94	75	41	20.5	0.273	[blank cell]	[blank cell]
120	55	131	53	26.5	0.202	[blank cell]	[blank cell]
121	10	148	71	35.5	0.240	[blank cell]	[blank cell]
122	34	168	93	46.5	0.277	[blank cell]	[blank cell]
123	13	201	99	49.5	0.246	[blank cell]	[blank cell]
124	109	59	11	5.5	0.093	[blank cell]	[blank cell]
125	47	65	18	9	0.138	[blank cell]	[blank cell]

[Data base row]	[Column] A	[Column] L	[Column] M	[Column] N	[Column] O	[Column] P	[Column] Q
1	DDE_ PHOTONS [Correct value]	photon [Actually raw photon + raw neutron]	[Raw] neutron	Adj neutron	np ratio [(adj. n) divided by (raw photon + raw neutron)]	[blank cell]	Avg of individual n:p ratios
126	48	148	39	19.5	0.132	[blank cell]	[blank cell]
127	210	70	57	28.5	0.407	[blank cell]	[blank cell]
128	202	115	81	40.5	0.352	[blank cell]	[blank cell]
129	180	103	93	46.5	0.451	[blank cell]	[blank cell]
130	121	154	99	49.5	0.321	[blank cell]	[blank cell]
131	218	224	130	65	0.290	[blank cell]	[blank cell]
132	121	284	143	71.5	0.252	[blank cell]	[blank cell]
133	139	429	180	90	0.210	[blank cell]	[blank cell]
134	109	93	10	5	0.054	[blank cell]	[blank cell]
135	147	13	13 [a]	6.5	0.500	[blank cell]	[blank cell]
136	33	50	20	10	0.200	[blank cell]	[blank cell]
137	128	83	21	10.5	0.127	[blank cell]	[blank cell]
138	62	152	24	12	0.079	[blank cell]	[blank cell]
139	30	28	28 [a]	14	0.500	[blank cell]	[blank cell]
140	83	62	29	14.5	0.234	[blank cell]	[blank cell]
141	258	40	40 [a]	20	0.500	[blank cell]	[blank cell]
142	259	197	50	25	0.127	[blank cell]	[blank cell]
143	313	160	51	25.5	0.159	[blank cell]	[blank cell]
144	221	203	64	32	0.158	[blank cell]	[blank cell]
145	319	205	84	42	0.205	[blank cell]	[blank cell]
146	222	325	107	53.5	0.165	[blank cell]	[blank cell]
147	167	231	110	55	0.238	[blank cell]	[blank cell]
148	186	314	112	56	0.178	[blank cell]	[blank cell]
149	206	292	112	56	0.192	[blank cell]	[blank cell]
150	53	329	119	59.5	0.181	[blank cell]	[blank cell]
151	110	50	11	5.5	0.110	[blank cell]	[blank cell]
152	39	126	16	8	0.063	[blank cell]	[blank cell]
153	10	98	45	22.5	0.230	[blank cell]	[blank cell]
154	10	264	58	29	0.110	[blank cell]	[blank cell]
155	10	248	62	31	0.125	[blank cell]	[blank cell]
156	10	264	97	48.5	0.184	[blank cell]	[blank cell]
157	10	330	108	54	0.164	[blank cell]	[blank cell]
158	10	431	112	56	0.130	[blank cell]	[blank cell]
159	10	356	135	67.5	0.190	[blank cell]	[blank cell]

[Data base row]	[Column] A	[Column] L	[Column] M	[Column] N	[Column] O	[Column] P	[Column] Q
1	**DDE_ PHOTONS [Correct value]**	**photon [Actually raw photon + raw neutron]**	**[Raw] neutron**	**Adj neutron**	**np ratio [(adj. n) divided by (raw photon + raw neutron)]**	[blank cell]	**Avg of individual n:p ratios**
160	10	463	150	75	0.162	[blank cell]	[blank cell]
161	10	409	151	75.5	0.185	[blank cell]	[blank cell]
162	10	410	151	75.5	0.184	[blank cell]	[blank cell]
[NA]	**[0.76 [b]]**	[NA]	[NA]	[NA]	**[0.369 [c]]**	[NA]	[NA]

[[a] The accompanying photon dose was to be adjusted from zero to 0.010 rem but instead the photon dose was set to the neutron dose value.]
[[b] Average of n:p values using column A values for the photon dose in the equation n:p = n/p.]
[[c] Average of n:p values using column O values for the (n +p) dose in the equation n:p = n/(n + p).]