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Assessment of Hanford Site Reduced Boundary Impacts

Limited Potential-to-Emit and Onsite Receptor Assessments

August 2015

SF Snyder

U.S. DEPARTMENT OF
ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Richland, Washington 99352

Summary

The U.S. Department of Energy's Richland Operations Office initiated this work to prospectively determine the potential impact of a proposed reduced Hanford Site controlled access boundary to the regulatory requirements of radiological air emission units at the Hanford Site 200 Areas. The reduced boundary would facilitate access to portions of the Hanford Site that are currently closed to the public. In addition, doses to several representative members of the public are presented.

Dose estimates for representative members of the public are based on average external exposure and inhalation dose estimates. Doses are presented for a Hanford Site tour participant, an intermittent hiker in the Wye Barricade region, and a hiker in a generalized portion of areas south and west of the Columbia River. The analyses do not include emission units in the 100 Areas, as it assumed those units will be closed prior to any activities that could involve public access in the vicinity. The 300 Area and 400 Area emission units are also excluded based on their potential-to-emit (PTE) receptor locations, which are remote from most of the River Corridor lands of interest.

The assessments to determine the impact to the PTE dose indicated in the Hanford Site FF-01 Air Operating Permit show that two of the evaluated stacks, located in the Hanford Site 200 West Area, have the potential to increase their PTE doses. However, neither increased PTE dose result would change stack classifications from a minor emission unit to a major emission unit.

Acknowledgements

The author is grateful for Hanford Site map graphics support provided by Christopher J Picken, Information Systems, Mission Support Alliance, LLC, Richland, WA.

Acronyms and Abbreviations

200E, 2E	Hanford Site 200 East Area
200W, 2W	Hanford Site 200 West Area
29r1	Reference to the document DOE/RL-2006-29, Revision 1 (Rhoads et al. 2010)
CAB	Controlled Area Boundary
CFR	Code of Federal Regulations
Ci	curie
DOE	U.S. Department of Energy
DOE-RL	U.S. DOE Richland Operations Office
EnergyNW	Energy Northwest Columbia Generating Station
ERDF	Environmental Restoration Disposal Facility
EPA	U.S. Environmental Protection Agency
GA	gross alpha
GB	gross beta
HRNM	Hanford Reach National Monument
LIGO	Laser Interferometer Gravitational-Wave Observatory
MEI	maximally exposed individual
mrem	millirem Effective Dose
PTE	potential-to-emit
RCILP	River Corridor Integrated Land Planning
TLD	thermoluminescent dosimeter
WAC	Washington Administrative Code
WDoH	Washington State Department of Health
WTP	Waste Treatment Plant

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1.0 Introduction

The U.S. Department of Energy's (DOE's) Richland Operations Office initiated this work to prospectively determine the potential impact of a reduced Hanford Site controlled access boundary to the regulatory requirements of several radiological air emission units in the Hanford Site 200 Areas. The proposed Hanford Site Controlled Area Boundary (CAB) considers a smaller controlled area than the currently proposed Potential Public Access Area (see Figure 1.1) and would facilitate daytime public access to portions of the Hanford Site for recreational activities (e.g., hiking, biking, birdwatching). Currently, much of the Hanford Site is restricted to DOE employee access. The primary concern of this particular task are the regulations in 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon at Department of Energy Facilities," and the permitting requirements of WAC 246-247, "Radiation Protection – Air Emissions."

Two assessments are presented. The first is an assessment of PTE (potential-to-emit) dose changes for some radioactive air minor emission units in the Hanford Site 200E and 200W Areas. The second is an assessment of doses to some short-term occupants of the Hanford Site areas between the Hanford Site boundary and CAB, for recreational activities or escorted tours. A third assessment for future Waste Treatment Plant (WTP) stacks is included in Appendix B. This WTP assessment was not included in the main text because the facility is currently in its design phase and facilities are under construction.

These assessments provide a portion of the information useful for determining whether recreational use of currently restricted areas on the Hanford Site might present financial costs for radioactive air emission units or an undue risk to public health in areas close to the proposed boundary.

The analyses do not include emission units in the 100 Areas as it assumed those units will be closed prior to any activities that could involve public access in the vicinity. The 300 Area emission units are also excluded based on their potential-to-emit (PTE) receptor locations, which are remote from most of the River Corridor lands of current interest (see Potential Public Access Area of Figure 1.1).

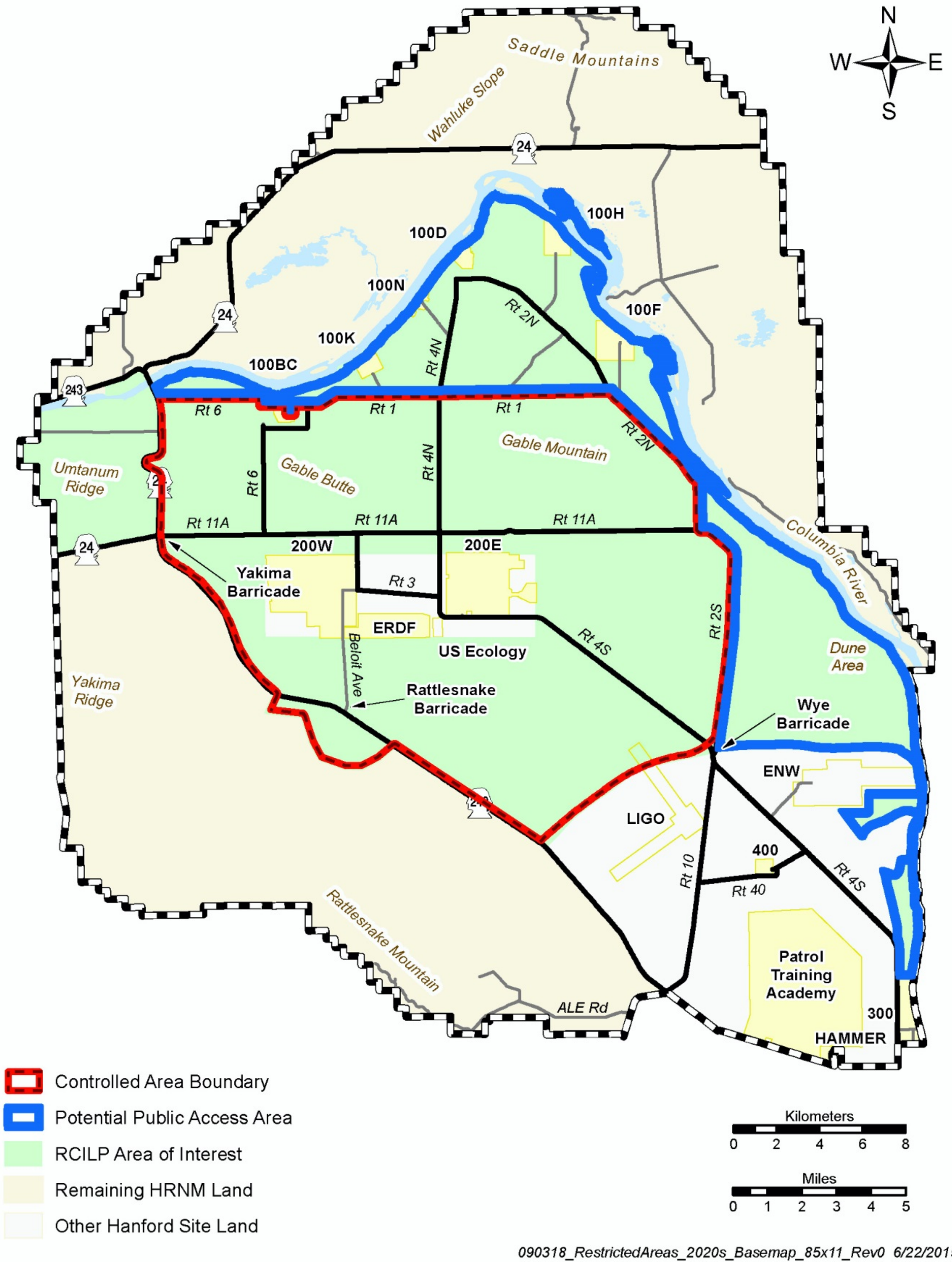

Figure 1.1. Hanford Site Reference Map with Proposed Controlled Area and Potential Public Access Area Boundaries

2.0 PTE Assessment of Minor Emission Units

Emission units (also referred to as “stacks”) are permitted by the Washington State Department of Health (WDoH) as major or minor emission units. Major emission units have a greater potential impact to receptors and, therefore, require more resources to manage. Minor emission units have a lesser impact to receptors and are operated to maintain minor emission unit status and ensure emissions remain below those of the major emission unit classification. Permit changes and additional resources would be required if a minor emission unit were determined to meet the criteria for a major emission unit. The Hanford Site Air Operating Permit includes the Hanford Site Radioactive Air Emissions License #FF-01 (FF-01).

This assessment evaluates existing minor emission units in the 200 East (200E) and 200 West (200W) Areas to determine whether they might be reclassified as major emission units if public access is allowed at some onsite locations in the year 2020.

The minor emission units to be evaluated for PTE dose changes are indicated in Table 2.1, Figure 2.1 for 200W stacks, and Figure 2.2 for 200E stacks. Table 2.1 also indicates the current PTE dose for emission units evaluated for PTE changes in this document. There are additional, existing minor emission units in the 200E and 200W Areas that are not evaluated because they are:

- soon scheduled for demolition (296-Z-15),
- soon scheduled for upgrade to major status (296-A-40, 296-P-23, 296-S-25),
- not expected to operate again (296-A-26),
- tank annuli exhausters with current PTEs of zero, or
- never expected to become major sources due to extremely low PTE doses.

In addition, Table 2.1 indicates the 2013 Hanford Site maximally exposed receptor dose based on actual 2013 radioactive emissions from the emission units, demonstrating a wide dose margin that can exist between the potential and actual emissions doses.

Table 2.1. Minor Emission Units Evaluated

Location	Stack	Physical Discharge Height (m)	Effective Discharge Height[(a)] (m)	2013 Flow Rate (m^3/sec)	Potential-to-Emit Dose[(a)] (mrem/yr)	2013 Emissions	2013 Hanford Site MEI Dose (mrem)
200W	291-S-1	61	> 40m	8.7	2.14E-3	GA, GB	9.5E-8
200W	296-T-7	8.5	52.2	0.05	7.50E-2	GA, GB, Cs-137	0.0E+0 (b)
200E	296-E-1	15.5	71.9	24.07	3.89E-2	GA,GB	1.4E-7
200E	296-A-21A	15.2	60.1	8.48	6.40E-2	GA, GB	3.4E-8
200E	296-A-22	19.4	34.7	0.23	1.00E-3	GA, GB	1.8E-9

Discharge height, flow rate, 2013 emissions and 2013 Hanford Site MEI dose from Rokkan et al. (2014).
GA = gross alpha, GB = gross beta, MEI = maximally exposed individual
(a) PTE doses from FF-01 (expiration 12/31/17) and effective discharge height calculated from FF-01 data.
(b) 2013 emissions levels were not above detection therefore, zero emissions in 2013.

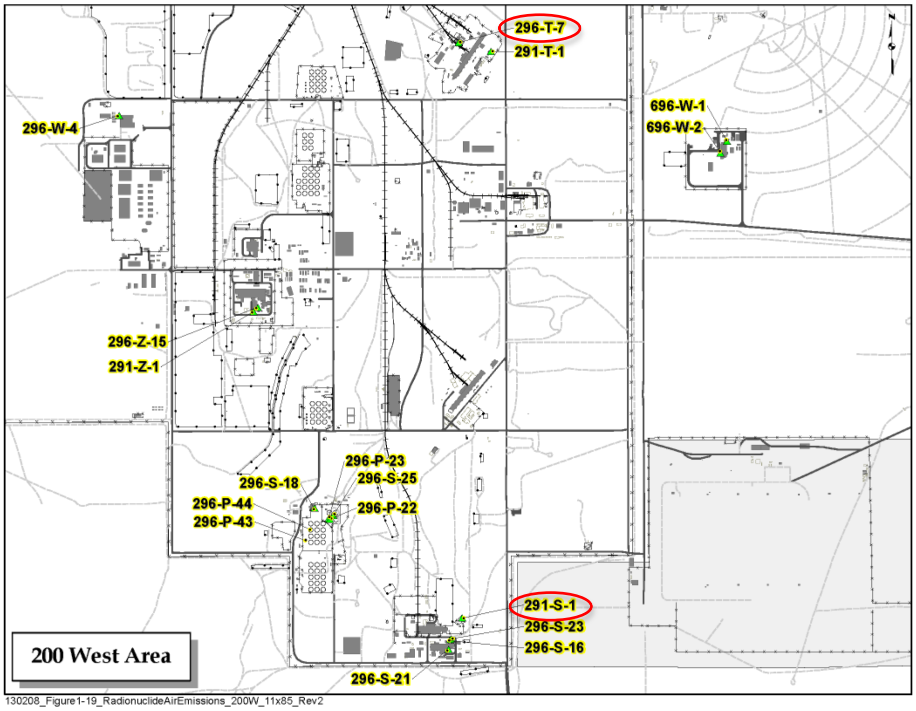

Figure 2.1. Hanford Site 200W Area Assessed Emission Units (circled)

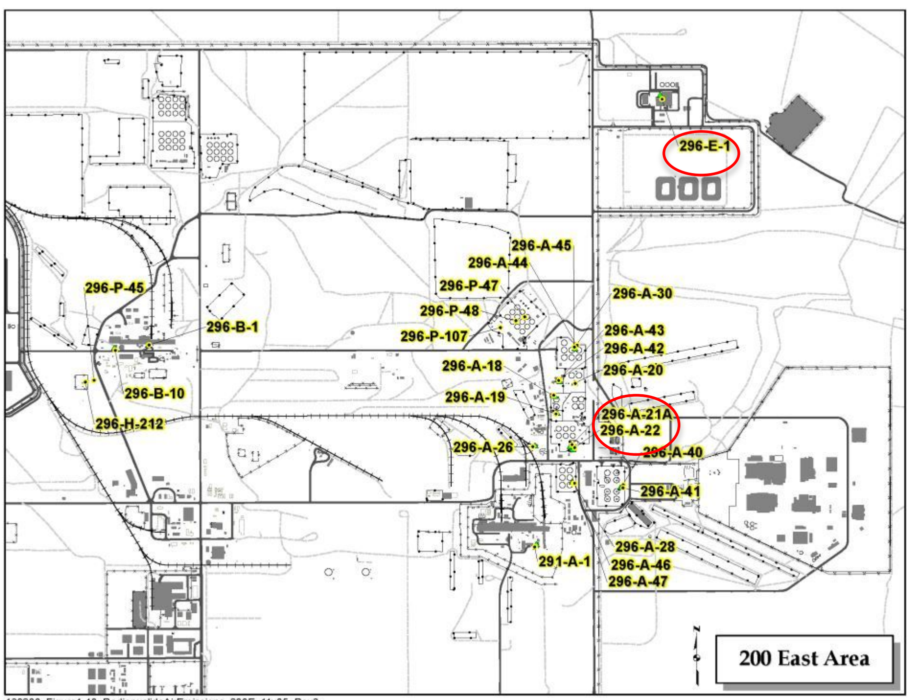

Figure 2.2. Hanford Site 200E Area Assessed Emission Units (circled)

Classification as a major or minor emission unit is determined by the dose resulting from unabated PTE estimates for an emission unit. A minor emission unit with a PTE dose less than or equal to 0.1 mrem/yr would change to a major emission unit for PTE doses above 0.1 mrem/yr. The PTE dose is reported in a Notice of Construction for an emission unit, which is submitted to the regulator (i.e., WDoH).

Guidance for the determination of a PTE dose is described in *Calculating Potential-to-Emit Radiological Releases and Doses* (Rhoads et al. 2010). Dose factors are provided in Rhoads et al. (2010) based on the current Hanford Site boundary and operations using CAP88-PC software (Rosnick 2007) and other approved software inputs (Rhoads et al. 2008). The dose factors are provided for the 200W offsite receptor (22,000 m SE) and onsite receptors at the Laser Interferometer Gravitational-Wave Observatory (LIGO); and the 200E offsite receptor (20,200 m ESE) and onsite receptor at Energy Northwest Columbia Generating Station (EnergyNW); see Figure 2.3. WDoH may approve alternative methods for PTE dose estimation. Dose factor information in Rhoads et al. (2010) is also based on whether the effective discharge height of the stack is above or below 40 m. All PTE doses in Table 2.1 were assumed to be calculated consistent with Rhoads et al. (2010). Information provided in Table 2.1 indicates that four of the five stacks under evaluation have effective discharge heights above 40 m. Only 296-A-22 in the 200E Area has an effective discharge height below 40 m. Table 2.2 indicates the area, receptor type, and discharge heights for the PTE dose values of each emission unit evaluated for potential PTE change.

The proposed CAB, which will accommodate daytime recreational use of additional onsite areas, indicates the need to review the existing PTE doses for any new locations that may be routinely occupied by a member of the public (i.e., the "abides or resides" criteria of WAC 246-247-30(15)). Intermittent occupancy (e.g., potential for persons to walk through or occasionally picnic at location) does not present a site at which a dose compliance point is determined (see discussion in Section 5 of Rhoads et al. 2008). Given the information for the Proposed Restricted Boundary of Figure 1.1, the only known new location for which the "abides or resides" criteria for a member of the public apply is the B Reactor area proposed for a museum (see Figure 2.3). The B Reactor receptor was evaluated at 7260 m NNW of 200W and 14,430 m NW of 200E. Therefore, this additional location was considered for assessing any increase to the existing PTE doses for the emission units evaluated.

Table 2.2. Summarized Basis for PTE Doses for Evaluated Emission Units

	200 West Area Emission Unit Assessed		**200 East Area Emission Unit Assessed**	
Effective Discharge Height	**2W Offsite Receptor (22,000 m SE)**	**2W Onsite Receptor (18,310 m ESE at LIGO)**	**2E Offsite Receptor (20,200 m ESE)**	**2E Onsite Receptor (16,630m ESE at EnergyNW)**
<40 m	n/a	n/a	n/a	296-A-22
≥40 m	291-S-1 296-T-7	n/a	296-E-1	296-A-21A

LIGO = Laser Interferometer Gravitational-Wave Observatory
EnergyNW = Energy NorthWest Columbia Generating Station

Figure 2.3. Locations of Offsite and Onsite PTE Receptors

2.1 Calculation of Reduced Boundary Receptor PTE Dose

All other factors being constant (e.g., release amounts, software, meteorology, intake rates, and exposure rates used in Rhoads et al. 2010), *offsite* receptor PTE doses will change in a manner directly proportional to radioactive material air concentration differences at each receptor location. The PTE doses for three of the five emission units were based on the dose to the offsite receptor.

For *onsite* receptors, however, the ingestion pathway component is based on ingestion of regional agricultural production rather than receptor-location agricultural production. Therefore, the onsite receptor dose changes proportionally to the air concentration differences only if the PTE dose is dominated by nuclide doses that are more significant for inhalation and external exposure dose pathways (such as the Pu-239 of Table 2.3). This significance is a function of both the nuclide-specific dose factor and the emission rate. As indicated in Table 2.3, nuclides such as Sr-90 have a greater PTE dose contribution from their offsite agricultural production, ingestion pathway doses. The inhalation and external dose component of Sr-90 for the onsite receptor is not as significant as the offsite agricultural intake dose component. Onsite receptor PTE doses are discussed in more detail in Section 2.1.3, for the evaluation of emission units based on onsite receptors.

Table 2.3. Example of 200E Effective Release Height ≥ 40 m Dose Factors

Nuclide	Offsite Receptor (mrem/Ci)	Onsite Receptor (mrem/Ci)	Dose Factor Higher for:
Sr-90+D	0.13	0.00938	Offsite receptor
Pu-239+D	2.64	3.27	Onsite receptor
Source: Table 4.7 of Rhoads et al. (2010)			

The PTE dose assessment considers air concentration differences at receptor locations. The CAP88-PC atmospheric dispersion model can be described with three general radionuclide categories: gases, iodines, and particulates. Gases include tritium and noble gases. Iodines are reactive nuclides that deposit out faster than gases or other non-iodine particulates. Particulates cover most elements and are represented by the long-lived Pu-239 for CAP88-PC modeling. Appendix A includes graphics that represent air concentration differences from emissions at 200W and 200E locations; short (<40m) and tall (≥40m) stacks; all receptors (onsite, offsite, and B Reactor); and the three general nuclide categories. This information is applied to specific stacks in the remainder of this section.

2.1.1 200 West PTE Dose Change Assessment

The offsite receptor resulted in the greater PTE dose for both 200W Area stacks (Table 2.2). To assess how the PTE might change with the addition of the B Reactor as a potential PTE receptor location, the ratio of the air concentrations at the B Reactor and the offsite receptor from Rhoads et al. (2010) (hereafter abbreviated “29r1” receptors in figures and tables reflecting the reference document number DOE/RL-2006-29, Revision 1) were determined for gases and particulates. Data for the third general nuclide category, iodines, was not determined because iodines were not a component of the PTE doses for the 200W stacks evaluated. CAP88-PC Version 3 (Rosnick 2013) was used as the appropriate atmospheric dispersion model for these calculations. While the B Reactor receptor is an *onsite* receptor, application of the higher offsite receptor ingestion pathway doses will provide a conservative (overestimating) result.

Table 2.4 and Figure 2.4 indicate the gases' air concentration ratios used for the 200W stack assessment, as well as the offsite air concentration ratios at the Controlled Area Boundary (CAB) locations.[1] Air concentrations are proportional to the CAP88-PC chi-over-Q (i.e., "X/Q") output values. Table 2.5 and Figure 2.5 indicate similar data points for particulates. Both the gas and particulate data indicate that the B Reactor receptor (7260 m NNW) would result in a greater PTE dose than the current offsite receptor (22,000 m NE).

Table 2.4. Offsite Receptor Air Concentration Ratios for Gases at 200W ≥40 m Release Height

Direction from Stack Toward:	H3 X/Q Ratio at CAB	H3 X/Q Ratio Offsite Receptor 29r1	H3 X/Q Ratio B Reactor
N	0.88	-	-
NNW	1.13	-	1.13
NW	1.11	-	-
WNW	1.13	-	-
W	1.69	-	-
WSW	1.37	-	-
SW	1.83	-	-
SSW	2.07	-	-
S	2.61	-	-
SSE	3.43	-	-
SE	2.85	1.00	-
ESE	2.58	-	-
E	1.00	-	-
ENE	0.67	-	-
NE	0.76	-	-
NNE	0.71	-	-

[1] CAB air concentration lines indicate CAB ratios for the Site Area (i.e., 200E or 200W) and emission height (i.e., <40 m or ≥40 m) indicated. They are generalized for a Site Area rather than a specific emission unit.

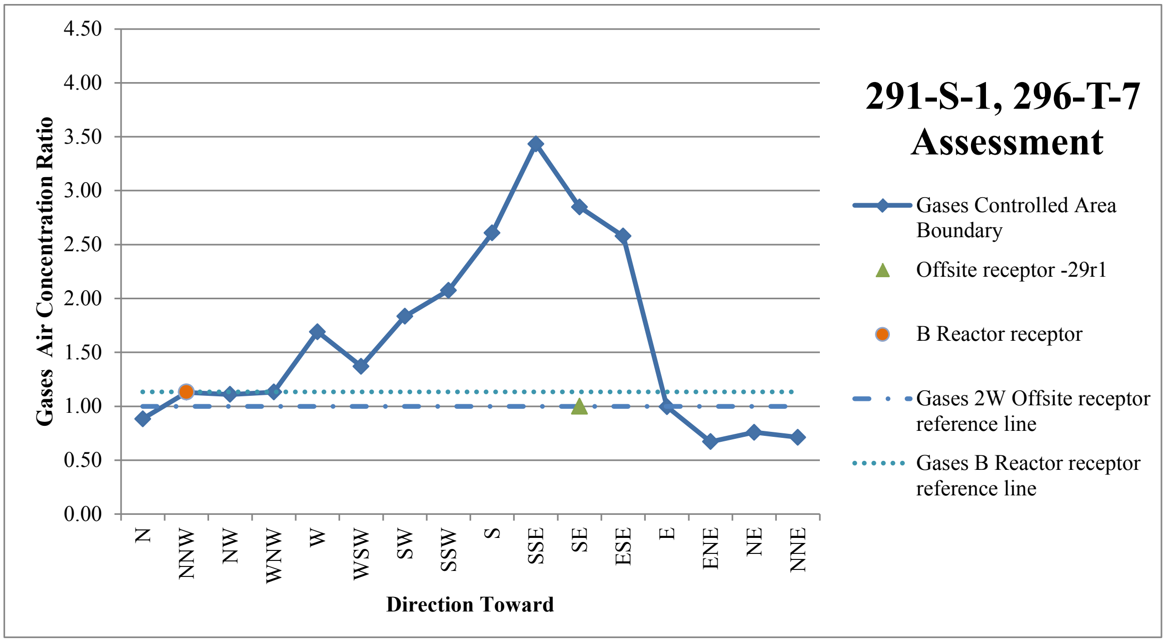

Figure 2.4. Graph of Table 2.4 Data (Gases 200W ≥40 m Release Height) and Receptor Locations

Table 2.5. Offsite Receptor Air Concentration Ratios for Particulates at 200W ≥40 m Release Height

Direction from Stack Toward:	Pu239 X/Q Ratio at CAB	Pu239 X/Q Ratio Offsite Receptor 29r1	Pu239 X/Q Ratio B Reactor
N	0.96	-	-
NNW	1.25	-	1.25
NW	1.22	-	-
WNW	1.26	-	-
W	1.95	-	-
WSW	1.58	-	-
SW	2.14	-	-
SSW	2.43	-	-
S	3.05	-	-
SSE	4.02	-	-
SE	3.23	1.00	-
ESE	2.87	-	-
E	1.05	-	-
ENE	0.71	-	-
NE	0.83	-	-
NNE	0.79	-	-

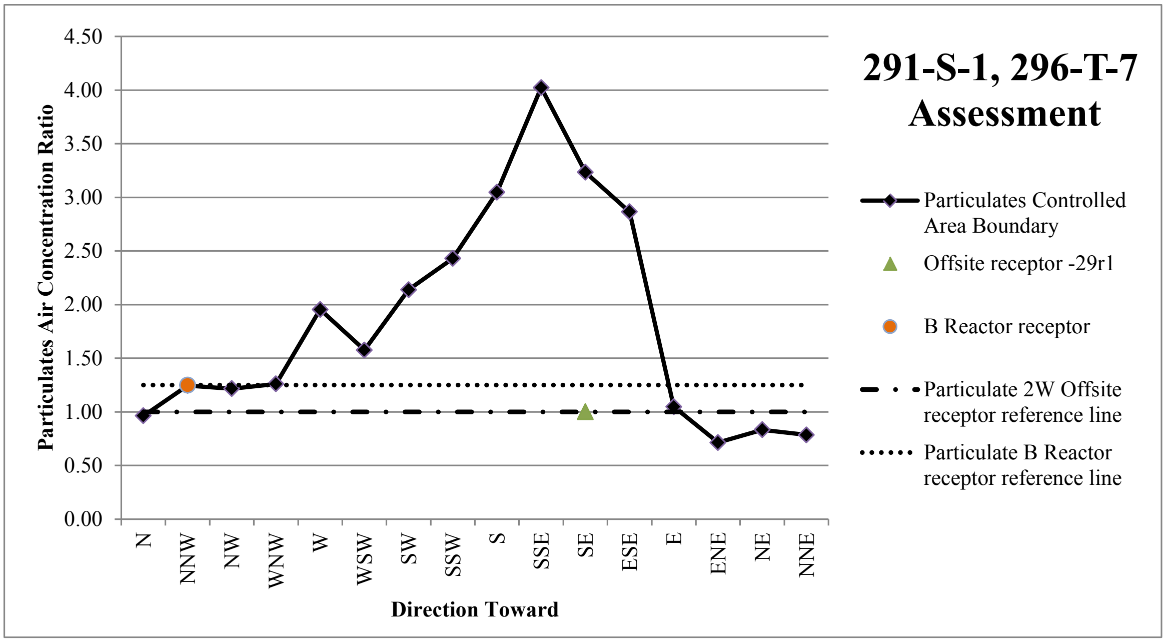

Figure 2.5. Graph of Table 2.5 Data (Particulates 200W ≥40 m Release Height) and Receptor Locations

The assessed changes to the PTE dose for the 200W Area stacks (291-S-1 and 296-T-7) for consideration of the new B Reactor PTE dose receptor location, conservatively based on agriculture grown in the immediate vicinity of the B Reactor, are indicated below.

200W stack 291-S-1	
Current PTE dose	2.14E-3 mrem
Current PTE based on general radionuclide category	Particulates only
Assessed change: (2.14E-3) x (1.25) =	**2.67E-3 mrem** at the B Reactor receptor location

200W stack 296-T-7	
Current PTE dose	7.50E-2 mrem
Current PTE based on general radionuclide category	Gases and particulates
Assessed change: (7.50E-2) x (1.25) =	**9.37E-2 mrem** at the B Reactor receptor location
Where the 1.25 factor is the maximum of the gas (1.13) and particulate (1.25) ratios	

Some locations in Figure 2.4 and Figure 2.5 indicate air concentrations even greater than those of the B Reactor receptor location. Clockwise, ESE through W air concentration ratios are greater than those determined for the 200W current PTE or B Reactor receptors and would indicate general directions where routinely occupied public facilities would not be ideal relative to 200W stack emissions of gases and particulates. This is not to say that public dose limits would be exceeded; it only indicates that doses may exceed the conservatively assessed PTE dose for these two stacks and new B Reactor PTE receptor location.

2.1.2 200 East 296-E-1 PTE Dose Change Assessment

The PTE dose receptors vary for the 200E Area stacks evaluated. Per Table 2.2, the offsite receptor resulted in the greater PTE dose for 296-E-1 and the onsite receptor resulted in the greater PTE dose for the other 200E stacks evaluated in Section 2.1.3 (296-A-22 and 296-A-21A).

As was done for the 200W stacks, to assess how the 296-E-1 PTE dose might change with the addition of the B Reactor (14,430 m NW for 200E) as a potential PTE receptor location, the ratio of the air concentrations at the B Reactor and the 29r1 offsite receptor from Rhoads et al. (2010) was determined for all general radionuclide categories: gases, iodines, and particulates. A portion of the CAB in the NW sector is at a closer distance than the B Reactor in the NW sector. As a result, the B Reactor is not indicated to be on the NW sector CAB for the 200E Area graphs.

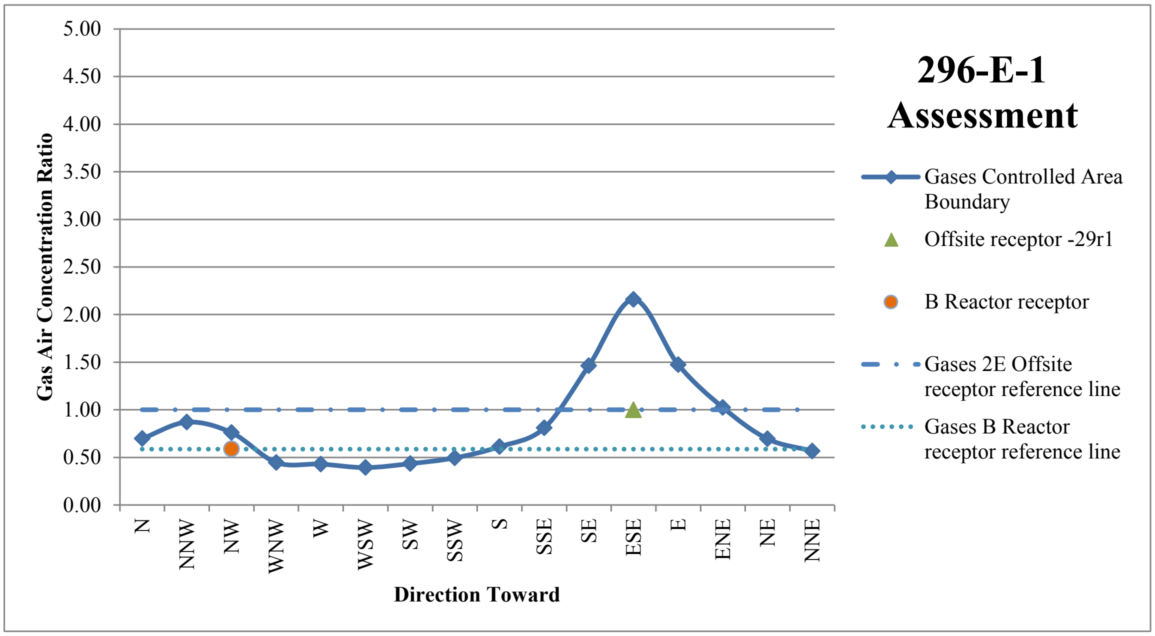

Figure 2.6. Offsite Receptor Ratios of Gases 200E ≥40 m Release Height and Receptor Locations

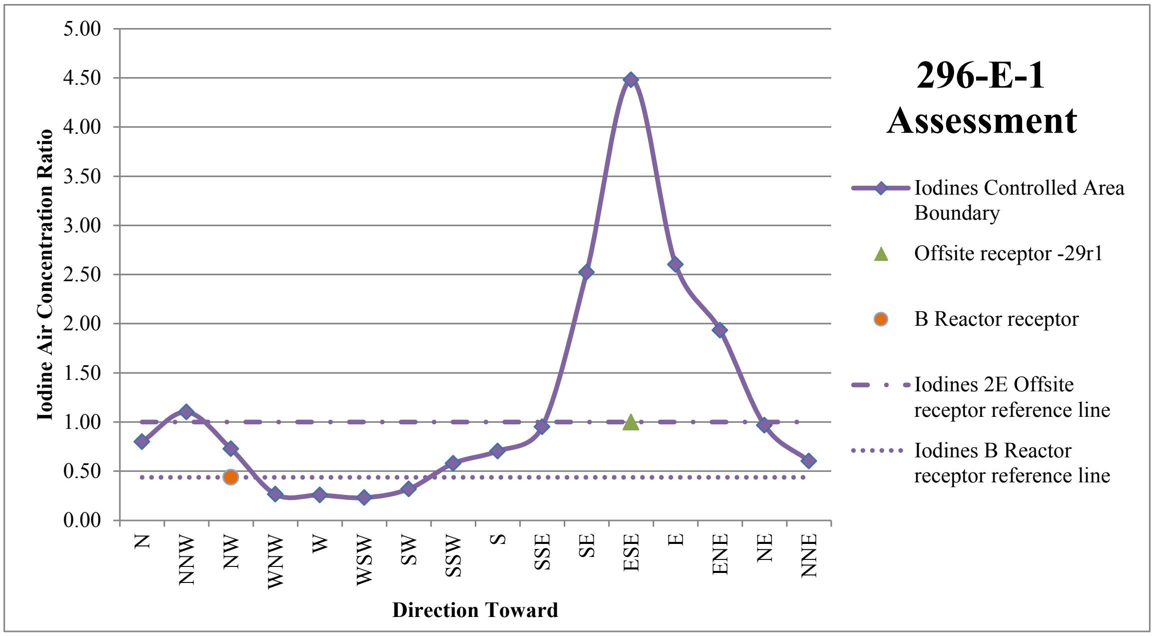

Figure 2.7. Offsite Receptor Ratios of Iodines 200E ≥40 m Release Height and Receptor Locations

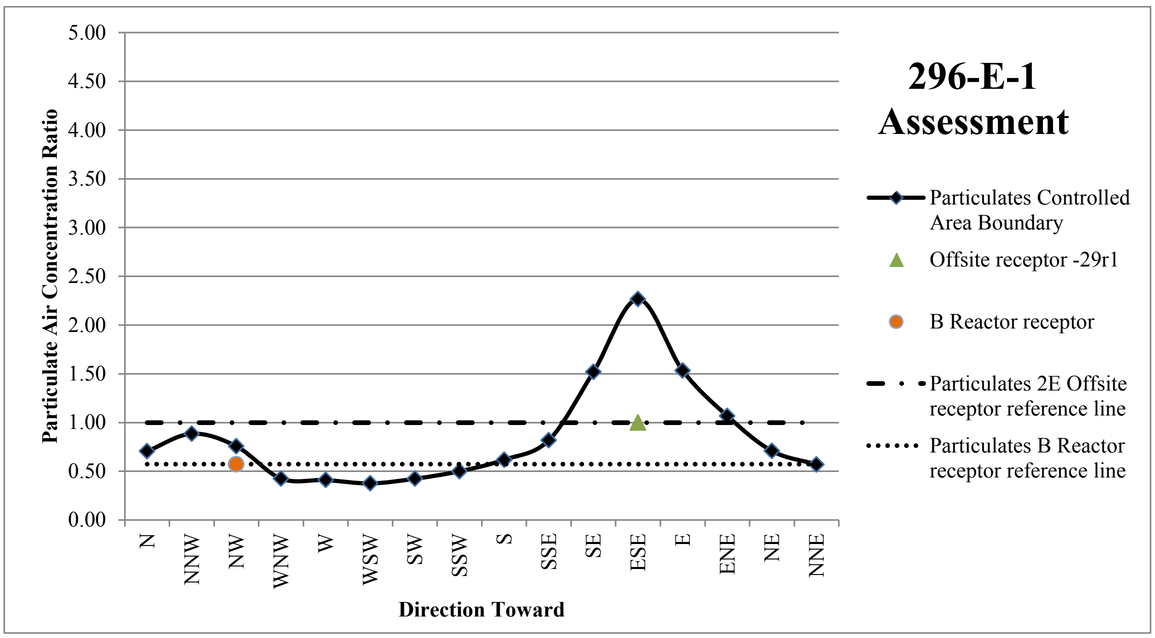

Figure 2.8. Offsite Receptor Ratios of Particulates 200E ≥40 m Release Height and Receptor Locations

Figure 2.6, Figure 2.7, and Figure 2.8 indicate that the B Reactor receptor would result in a lower PTE dose because air concentrations at that location would be lower than the current offsite receptor air concentration. Therefore, no matter the make-up of the current PTE dose for the 296-E-1 stack, the current PTE dose would not be expected to increase as a result of the CAB assessment.

Figure 2.6, Figure 2.7, and Figure 2.8 also indicate that E, ESE, and SE (as well as ENE for iodines and particulates) of the ≥40 m stacks in the 200E Area, air concentrations could be greater than those determined for the 200E current PTE offsite receptor. Directions in which air concentrations could be greater than those determined for the 200E current PTE *onsite* receptor are discussed in the next section. This indicates general directions where construction of a routinely occupied public facility close to the new reduced boundary would not be ideal relative to tall 200E stack emissions. This is not to say that public dose limits would be exceeded; it only indicates that doses would exceed the PTE for a "reside and abide" public occupant beyond the CAB in these directions.

2.1.3 200 East 296-A-21A and 296-A-22 PTE Change Assessment

The assessment of the 296-A-21A and 296-A-22 PTE doses differ from those evaluated previously because PTE doses are based on the onsite receptor location. The onsite receptor for the 200E Area is EnergyNW. For the current PTE doses for 296-A-21A and 296-A-22, results were driven by doses with greater inhalation and external dose pathways leading to the onsite receptor determination.

The following discussion explains why the ingestion component does not need to be reevaluated for these 200E Area emission units with a PTE dose based on the onsite receptor. The external exposure, inhalation, and ingestion components of the PTE doses for the offsite receptor ($PTE\ D_{off}$) and onsite receptor ($PTE\ D_{on}$) can be generalized with the following equations:

$$PTE\ D_{off} = A_{off/A/h} \cdot (Ext + Inh + Ing) \tag{2.1}$$

$$PTE\ D_{on} = [A_{on/A/h} \cdot (Ext + Inh)] + [A_{reg/A/h} \cdot Pop_{reg/200} \cdot (Ing)] \tag{2.2}$$

Where:

- $PTE\ D_{off}$ = PTE dose for offsite receptor
- $PTE\ D_{on}$ = PTE dose for onsite receptor
- $A_{off/A/h}$ = Air concentration at offsite receptor location specific to Hanford Area of emission unit location (A) and release height (h)
- Ext = External exposure pathway factors
- Inh = Inhalation pathway rates
- Ing = Ingestion pathway rates
- A_{on} = Air concentration at onsite receptor location specific to Hanford Area of emission unit location (A) and release height (h)
- $A_{reg/A/h}$ = Regional air concentration
- $Pop_{reg/200}$ = Regional population distribution around the 200 Areas

The candidate onsite receptor ingestion dose applied is the same for all <40 m stacks evaluated in the 200E Area (i.e., EnergyNW and B Reactor onsite receptor use the same ingestion dose values for a given emission unit). In the same manner, identical ingestion doses are applied to all ≥40 m stacks in the 200E Area. While the year 2000 census regional population values used in Rhoads et al. (2010) have been updated to consider the year 2010 census regional populations (Hamilton and Snyder 2011), the impact of this update is not evaluated further because any change would be uniformly applied to both the EnergyNW and B Reactor receptors.[2] Therefore, the PTE dose change can be based on air concentrations at the onsite receptor locations.

[2] The 2010 population will be used when the Rhoads et al. (2010) document is updated with the recently updated CAP88-PC Version 4 code.

2.1.3.1 Inhalation and External Exposure Dose Components

Onsite receptor PTE doses are based on air concentrations at the receptor location for inhalation and external exposure pathways for the 296-A-21A (≥40 m tall) stack and the 296-A-22 (<40 m stack). Information for each radionuclide category for both stacks is presented together. For gases, Figure 2.9 (≥40 m tall, 296-A-21A) and Figure 2.10 (<40 m stack, 296-A-22) indicate the potential change resulting from the additional consideration of the B Reactor potential PTE receptor. Figure 2.11 and Figure 2.12 indicate the respective results for iodines. Figure 2.13 and Figure 2.14 indicate the respective results for particulates. In all cases, the B Reactor receptor air concentration is less than that of the current PTE receptor, so no additional calculations need to be performed for these two stacks with respect to the location-specific component of the PTE dose (i.e., inhalation and external exposure component of the PTE dose). The existing PTE receptor for these stacks would not change.

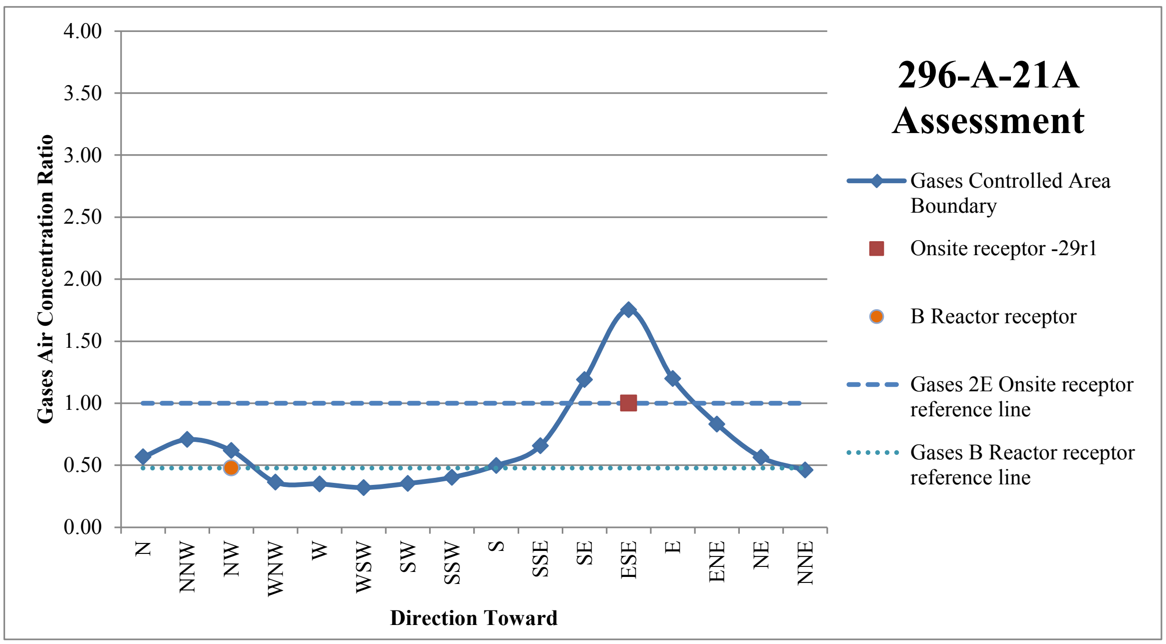

Figure 2.9. Onsite Receptor Ratios of Gases 200E ≥40 m Release Height and Receptor Locations

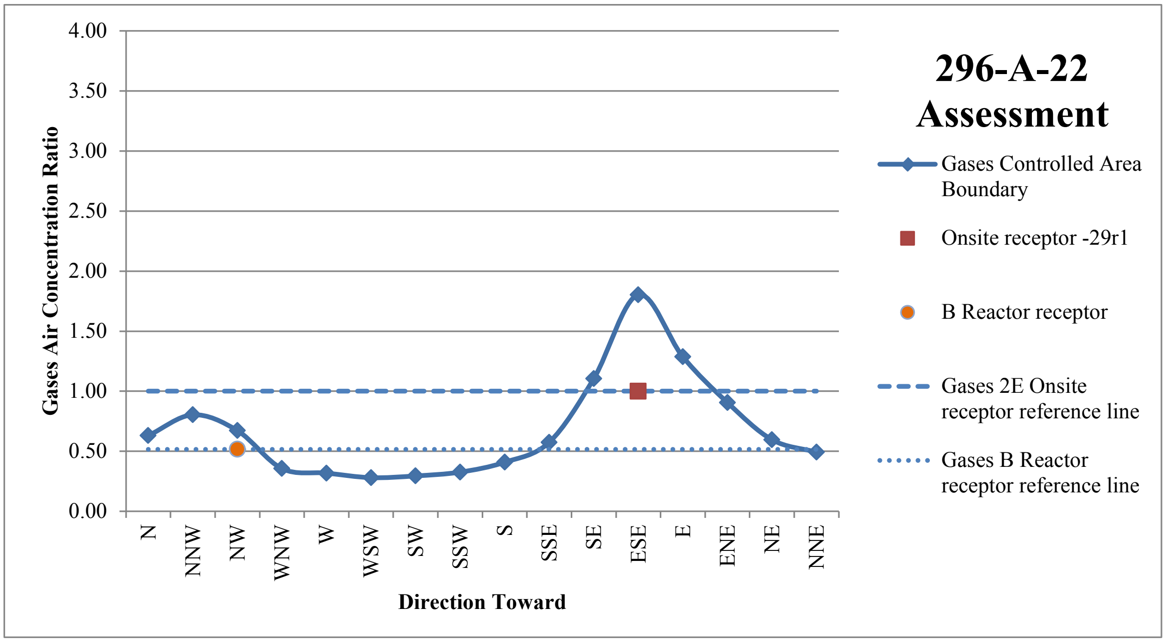

Figure 2.10. Onsite Receptor Ratios of Gases 200E <40 m Release Height and Receptor Locations

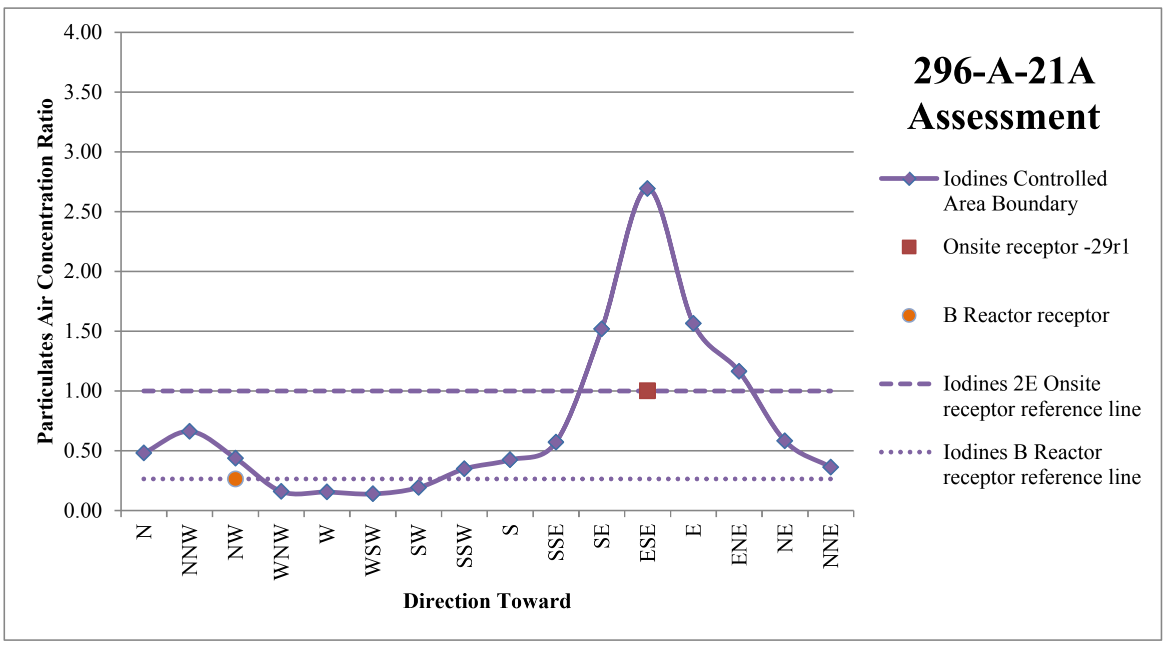

Figure 2.11. Onsite Receptor Ratios of Iodines 200E ≥40 m Release Height and Receptor Locations

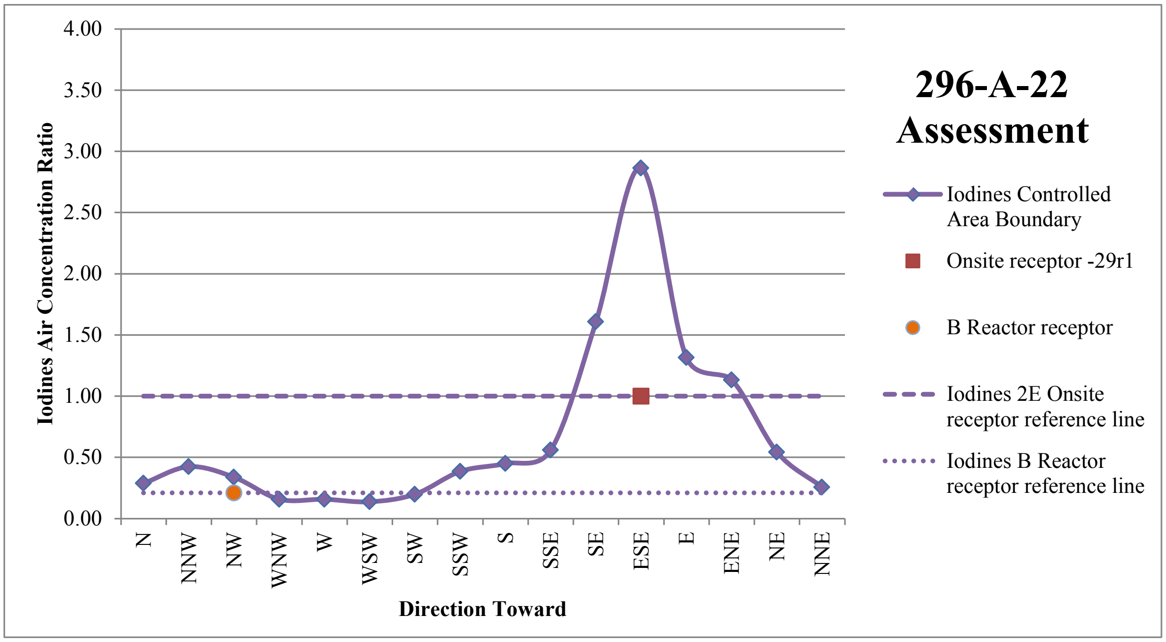

Figure 2.12. Onsite Receptor Ratios of Iodines 200E <40 m Release Height and Receptor Locations

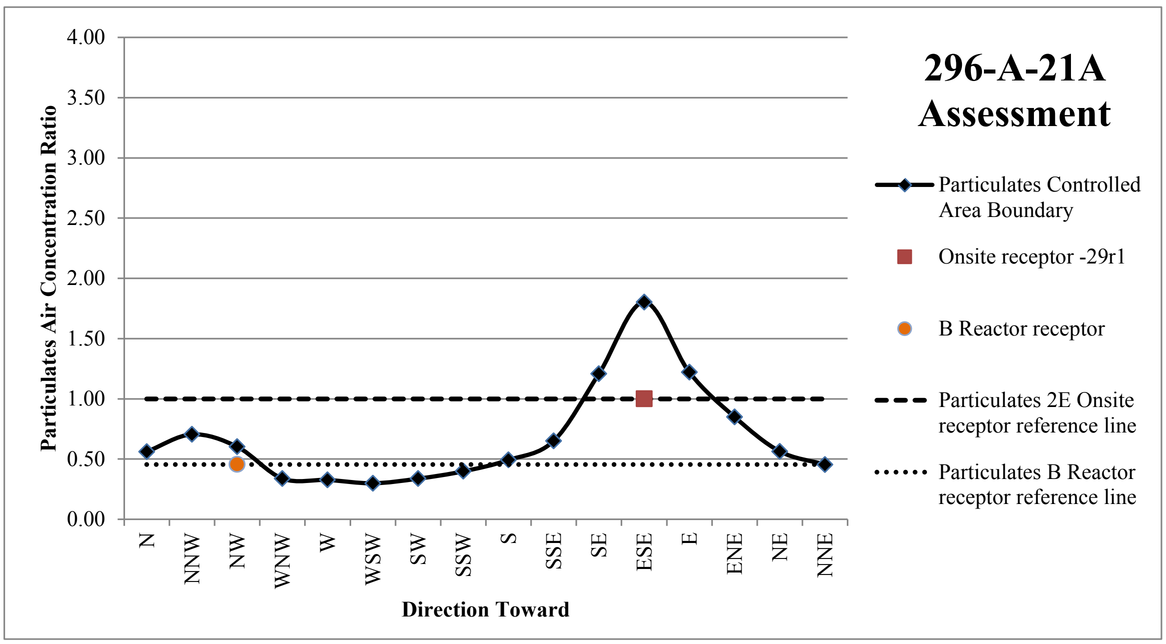

Figure 2.13. Onsite Receptor Ratios of Particulates 200E ≥40 m Release Height and Receptor Locations

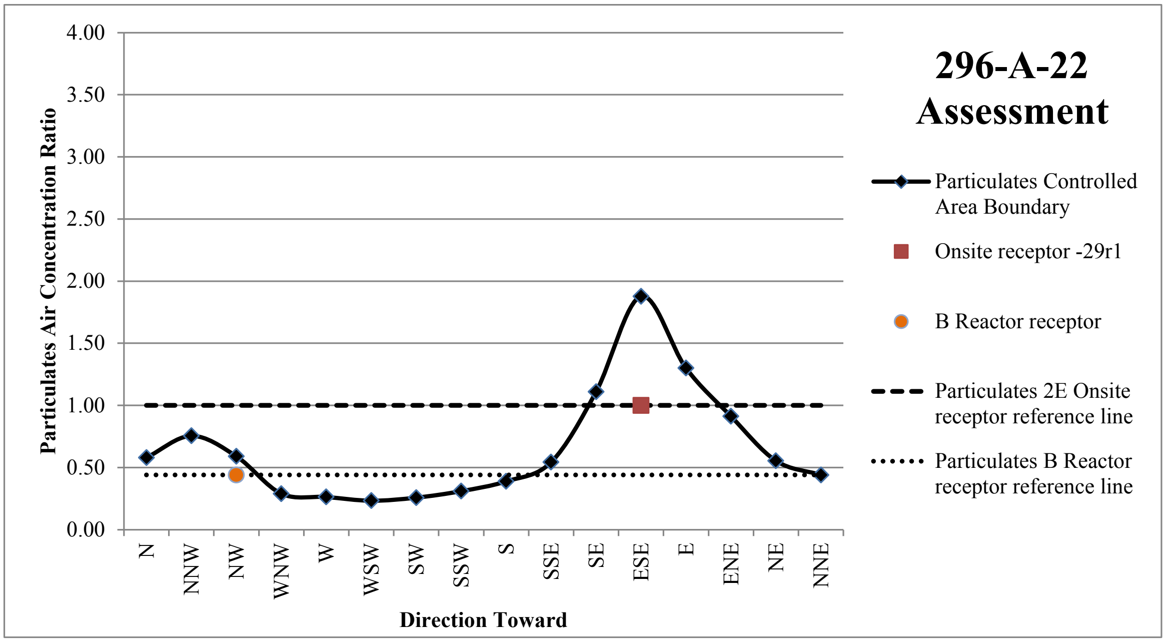

Figure 2.14. Onsite Receptor Ratios of Particulates 200E <40 m Release Height and Receptor Locations

The CAB air concentration ratios of the six figures above indicate elevated air concentrations in the E, ESE, and SE sectors (and ENE sector for iodines), relative to the 200E onsite PTE receptor location.

2.2 Conclusions of PTE Change Assessments

A Controlled Area Boundary of Figure 1.1 was evaluated to assess the impact to several minor emission units in the Hanford Site 200 Area. The concern was whether the current PTE doses for the evaluated stacks might change the emission unit classification from minor to major, as a result of the change in occupancy by a member of the public. The CAB change resulted in one new potential PTE receptor at the B Reactor. According to the modeling presented, two emission units would be expected to incur a PTE dose change as a result of the implementation of the CAB. These PTE doses at the B Reactor are overestimates but, even so, would not change stack classifications as minor emission units. This assessment indicates that all evaluated emission units would remain classified as minor emission units with PTE doses less than or equal to 0.1 mrem.

Table 2.6. Summary of PTE Dose Assessment

Area/Emission Unit	Current PTE Dose / Receptor	Controlled Area Boundary PTE Dose / Receptor
200W/ 291-S-1	2.14E-3 mrem/Offsite 22,000 m SE	2.67E-3 mrem/Onsite at B Reactor
200W/ 296-T-7	7.50E-2 mrem/Offsite 22,000 m SE	9.37E-2 mrem/Onsite at B Reactor
200E/ 296-E-1	3.89E-2 mrem/Offsite 20,200 m ESE	No change
200E/ 296-A-22	2.16E-5 mrem/Onsite at EnergyNW	No change
200E/ 296-A-21A	1.43E-3 mrem/Onsite at EnergyNW	No change

Additional information can be deduced from the air concentration evaluations. Figure 2.15 indicates approximate areas where the average gas- and particulate-air concentrations would be expected to exceed those at the 200 Area onsite receptor locations beyond the CAB. These would be locations where a person could be present for an intermittent, short-term exposure during recreational use of Hanford Site land. PTE doses are based on full-time occupancy at the receptor location, whether onsite or offsite. These regions of greater-than-onsite-receptor air concentrations are based on Section 2 figures and analysis that indicate beyond-CAB air concentration ratios are above 1.0 for particulates and gases. If new, routinely occupied facilities were constructed in the highlighted regions of Figure 2.15, PTEs for emission units in matched Hanford Site Areas would require review, especially if the PTE dose is based on the onsite receptor.

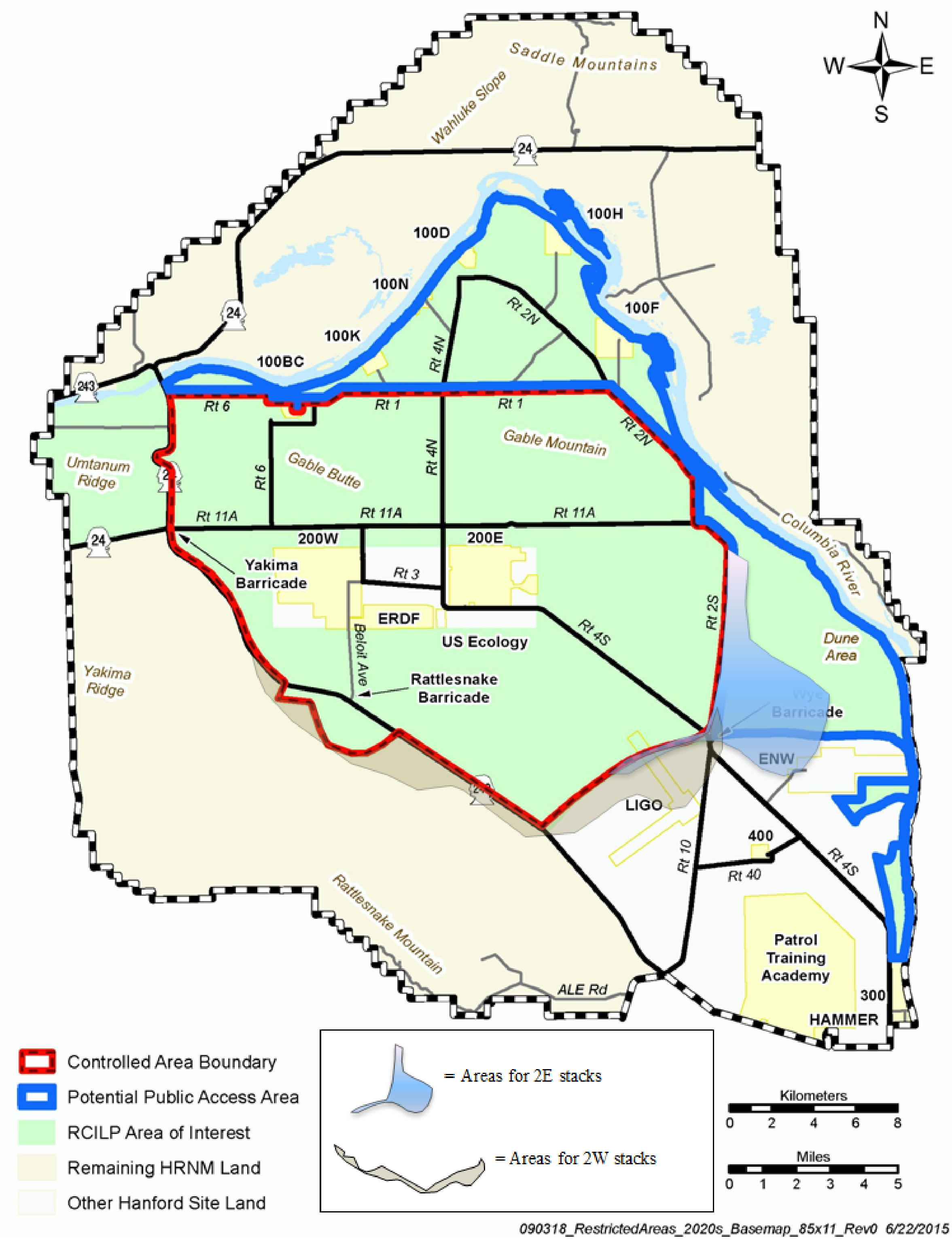

Figure 2.15. General Areas of Greater-than-or-Equal-to 200 Area PTE-based Air Concentrations for Gases and Particulates

3.0 Specific Receptor Dose Estimates

With implementation of the proposed reduced boundary of Figure 1.1, the doses to two receptors types who might visit the Hanford Site were determined. The receptors evaluated were for an Environmental Restoration Disposal Facility (ERDF) tour group participant and a recreational user of newly opened areas. Doses were estimated in a conservative (i.e., overestimating) manner that represents the values to most of the represented receptors. These receptors were assumed to traverse areas of the site with no intake of onsite foods (e.g., wild berries, rabbits, untreated water). Dose estimates are limited by sampling schedules. As an example, short-term receptor exposures (e.g., 2 hr hike) are based on data from longer-term averages (e.g., 2-week gross alpha samples). The longer sample collection frequency reduces short-term variations to some extent.

Dose limits applicable to each receptor include the following:

- **100 mrem/yr** – The applicable dose limit for a member of the public (WAC 246-221-060(1)(a)) for all pathways
- **10 mrem/yr** – The applicable dose limit, limited to radioactive air emissions (40 CFR Part 61, Subpart H, and WAC 173-480-040)

3.1 Dose to Tour Group Receptor in ERDF Vicinity

Hanford Site Tour Participant Scenario

A tourist is on a half-day tour of the U.S. DOE Hanford Site. To maximize exposure assumptions, the exposure is assumed to be at the ERDF, SE of the Hanford Site 200W Area for 4 hr. Actual exposure as the tour group travels around the Hanford Site, with most time spent at the B Reactor, would be less. Some pathway doses are double-accounted for conservatism (e.g., ambient air monitoring results would also capture stack emission particulates).

Pathways Evaluated

Pathway	Dose Basis	Over-estimating assumptions
External dose	ERDF TLD results used	Maximum results applied
Inhalation dose	Ambient air monitoring results (2008-2012 average, 200 East and 200 West)	Includes background and stack emissions
	2013 stack emissions from 200 East and 200 West; and 300 Area tritium	All emissions from each Area assumed to come from one stack
Ingestion dose	n/a	n/a
TLD = thermoluminescent dosimeter		

Results: Tour Participant

Pathway	mrem
External dose	0.072
Inhalation dose – ambient	0.0053
Inhalation dose – stack emissions	0.0000005
Ingestion dose	0
TOTAL	0.077

3.2 Dose to Recreational Receptor – Wye Barricade

Wye Barricade Scenario

Reflecting the results of the 200 Area PTE analysis in Section 2, a hiker or biker is assumed to spend time at the Wye Barricade area, where doses might exceed the PTE doses if a public receptor occupied the location all year long (see Figure 2.15). To conservatively account for ingestion doses, the individual is assumed to eat food grown at the Sagemoor Rd historical MEI location for the Hanford Site. This assumption also double-accounts for some inhalation dose. Several time frames are evaluated.

Pathways Evaluated

Pathway	Dose Basis	Overestimating Assumptions
External dose	Wye Barricade TLD results used	Average annual maximum results applied (DOE 2014, Mee 2014)
Inhalation dose	Ambient air monitoring results (2012, 2013 maximum, Wye Barricade)	Includes background and stack emissions
Inhalation and Ingestion dose	Sagemoor Rd receptor (2013)	Provides a result prorated for time of assumed exposure

Results: Wye Barricade Recreational

Pathway	1 hr/yr (mrem)	12 hr/yr (mrem)	2 hr/d for half a year (mrem)
External dose	0.0019	0.023	0.69
Inhalation dose	0.00007	0.00082	0.025
Inhalation and ingestion dose	0.000027	0.00033	0.010
TOTAL	0.002	0.024	0.7

3.3 Dose to Recreational Receptor – Non-specific Location

Non-specific Location Scenario

To generalize the recreational scenario to an undefined region outside of the reduced boundary fence, a hiker or biker is assumed to spend time at some undefined, newly accessible Hanford Site area. As with the Wye Barricade scenario, to conservatively account for ingestion doses, the individual is assumed to eat food grown at the Sagemoor Rd historical MEI location for the Hanford Site. This assumption also double-accounts for some inhalation dose. Several time frames are evaluated. Since this scenario represents a more generic location, a longer time frame was evaluated for routine visiting (12 hr/d for half a year) rather than the shorter time assumed for the more specific Wye Barricade location.

Pathways Evaluated

Pathway	Dose Basis	Overestimating assumptions
External dose	Average of 100 Area and generally, non-operational 200, 300, and 400 Area TLD results used	Average annual maximum results applied (DOE 2014, Mee 2014)
Inhalation dose	Ambient air monitoring results (2012, 2013 average, Wye Barricade)	Includes background and stack emissions
Inhalation and Ingestion dose	Sagemoor Rd receptor (2013)	Provides a result prorated for time of assumed exposure

Results: Generic Recreational

Pathway	1 hr/yr (mrem)	12 hr/yr (mrem)	12 hr/d for half a year mrem
External dose	0.0005	0.006	1.1
Inhalation dose	0.00006	0.00069	0.13
Inhalation and Ingestion dose	0.000027	0.00033	0.06
TOTAL	0.001	0.007	1.3

3.4 Receptor Dose Conclusions and Observations

Dose results were modeled in a manner that overestimates typical doses from average quarterly or annual results. For the representative exposure times assumed, all doses estimated were within public dose limits.

While generic and conservative, it may be noted that all dose estimates are driven by external dose pathway results. This may provide a simple method (TLD stations) of monitoring potential public exposures.

Hanford Site or EnergyNW TLD results are reported annually (DOE 2014, Mee 2014). Individual locations' results between the Hanford Site boundary and the reduced boundary were not fully reviewed for dose determinations. Multi-year trends should be reviewed for locations with annual averages greater than 100 mrem/yr, prior to any increased public access to ensure that there are no specific locations of concern with respect to the 100 mrem/yr public receptor limit. In a similar manner, ambient air monitoring results between the Hanford Site boundary and the reduced boundary were not specifically evaluated. Ambient air monitoring results less than the air concentration values in 40 CFR Part 61, Appendix E, Table 2 might provide some assurance that the locations may be compliant with 40 CFR Part 61, Subpart H. If either the TLD or ambient air results exceeded limits, the values could be used to determine limits on access hours.

4.0 References

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Appendix E to Part 61, "Compliance Procedures Methods for Determining Compliance with Subpart I." Title 40, *Code of Federal Regulations*, Part 61, as amended.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities." Title 40, *Code of Federal Regulations*, Part 61, as amended.

DOE. 2014. *Hanford Site Environmental Report for Calendar Year 2013*. RL/DOE-2013-47, Revision 0, U.S. Department of Energy, Richland Operations Office, Richland, WA.

Hamilton, EL, SF Snyder. 2011. *Hanford Site Regional Population – 2010 Census*. PNNL-20631, Pacific Northwest National Laboratory, Richland, WA.

Mee, D. 2014. *Columbia Generating Station, Radiological Environmental Monitoring Program, 2013 Annual Radiological Environmental Operating Report*. Energy Northwest, Columbia Generating Station, Richland, WA.

Rhoads, KR, LH Staven, SF Snyder, DJ Rokkan. 2008. *Methods for Calculating Doses to Demonstrate Compliance with Air Pathway Radiation Dose Standards at the Hanford Site*. DOE/RL-2007-53, Revision 0, U.S. Department of Energy, Richland Operations Office, Richland, WA.

Rhoads, KR, SF Snyder, RL Aaberg, DJ Rokkan. 2010. *Calculating Potential–to–Emit Radiological Releases and Doses.* DOE/RL–2006–29, Revision 1, U.S. Department of Energy, Richland Operations Office, Richland, WA.

Rokkan, DJ, SF Snyder, CJ Perkins. 2014. *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 2013*. DOE/RL-2014-14, U.S. Department of Energy, Richland Operations Office, Richland, WA.

Rosnick, R. 2007. *CAP88–PC Version 3.0 User Guide*. U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, D.C.

Rosnick, R. 2013. *CAP88–PC Version 3.0 User Guide*. U.S. Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, D.C. Last Accessed (1/8/15) at: http://www.epa.gov/radiation/assessment/CAP88/index.html#version3.

WAC 173-480-040, "Ambient Standard." Washington Administrative Code, Olympia, WA.

WAC 246-221-060, "Dose limits for individual members of the public." Washington Administrative Code, Olympia, WA.

WAC 246–247, "Radiation Protection – Air Emissions." Washington Administrative Code, Olympia, WA.

Appendix A

Air Concentration Ratio Graphics – All Receptors

The air concentration ratios for all three potential to emit (PTE) receptors are displayed on the following pages. The onsite receptor of Rhoads et al. 2010 has a greater air concentration for the gases, iodines, and particulates than that of the offsite receptor for the 200E and 200W locations; therefore, all air concentrations are presented as ratios to the onsite receptor. Data resulted from CAP88-PC version 3 output using unit releases of H-3 (vapor), I-129, and Pu-239 for gases, iodines, and particulates, respectively. Meteorology files were for 2004 through 2013.

Area/Effective Release Height	**Gases**	**Iodines**	**Particulates**
200W / < 40m	Figure A.1	Figure A.2	Figure A.3
200W / ≥ 40m	Figure A.4	Figure A.5	Figure A.6
200E / < 40m	Figure A.7	Figure A.8	Figure A.9
200E / ≥ 40m	Figure A.10	Figure A.11	Figure A.12

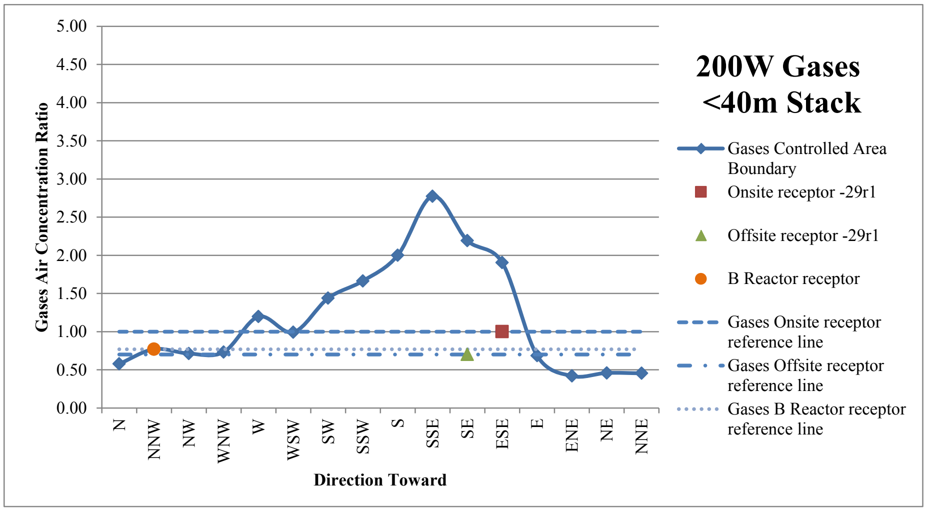

Figure A.1. Gases /200W / <40m Release Height Air Concentration Ratios

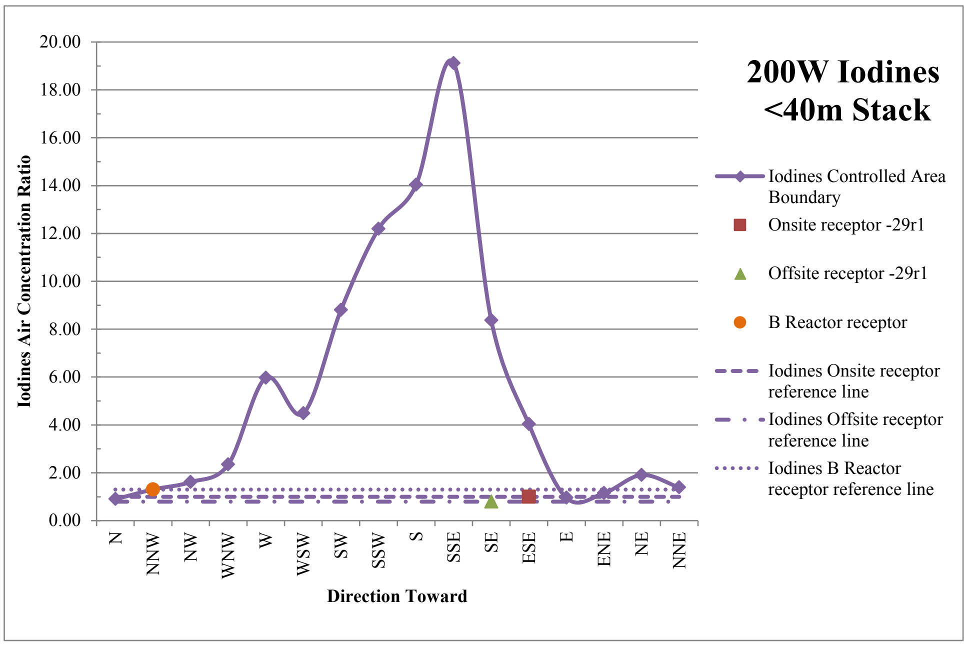

Figure A.2. Iodines /200W /<40m Release Height Air Concentration Ratios

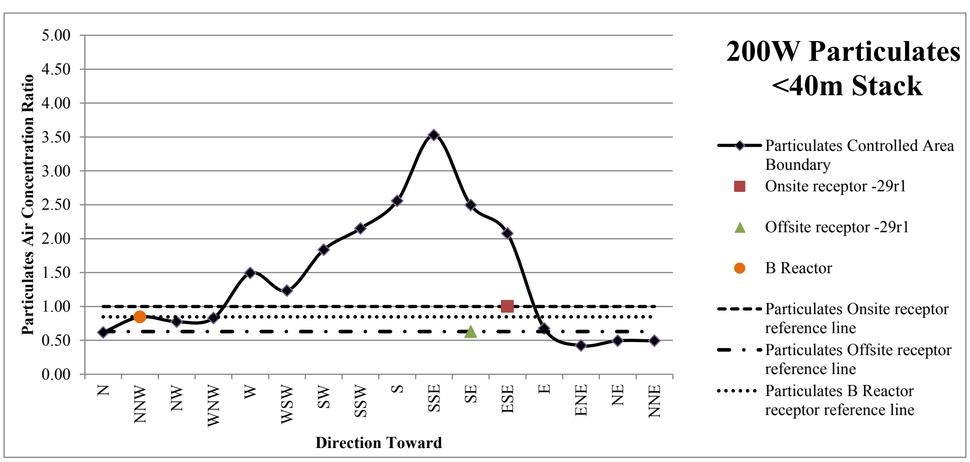

Figure A.3. Particulates /200W /<40m Release Height Air Concentration Ratios

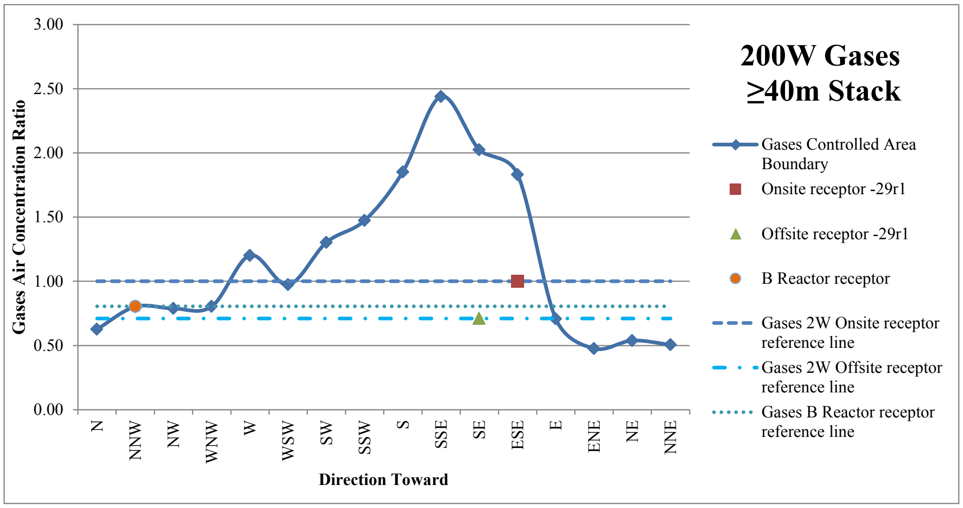

Figure A.4. Gases /200W / ≥40m Release Height Air Concentration Ratios

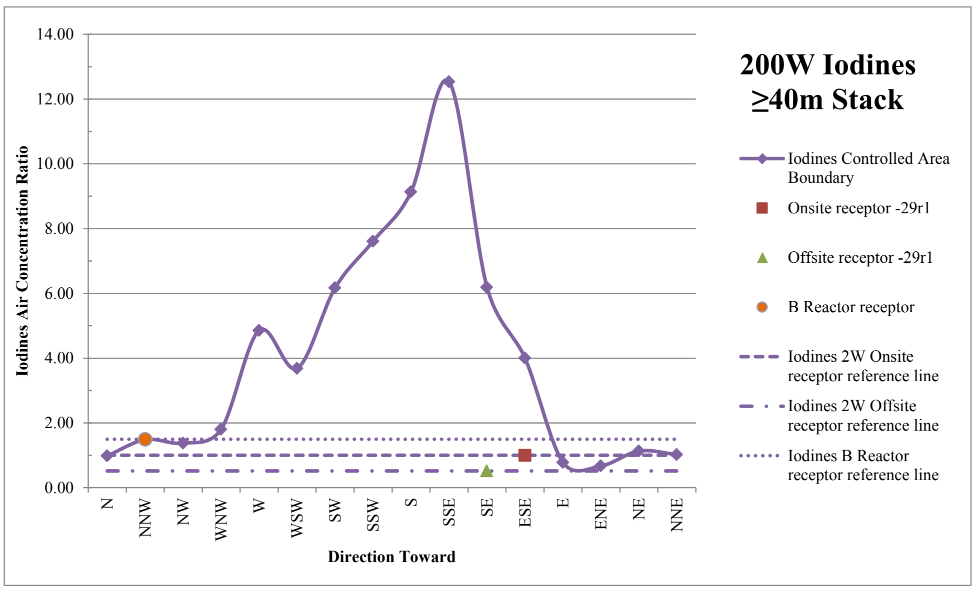

Figure A.5. Iodines /200W /≥40m Release Height Air Concentration Ratios

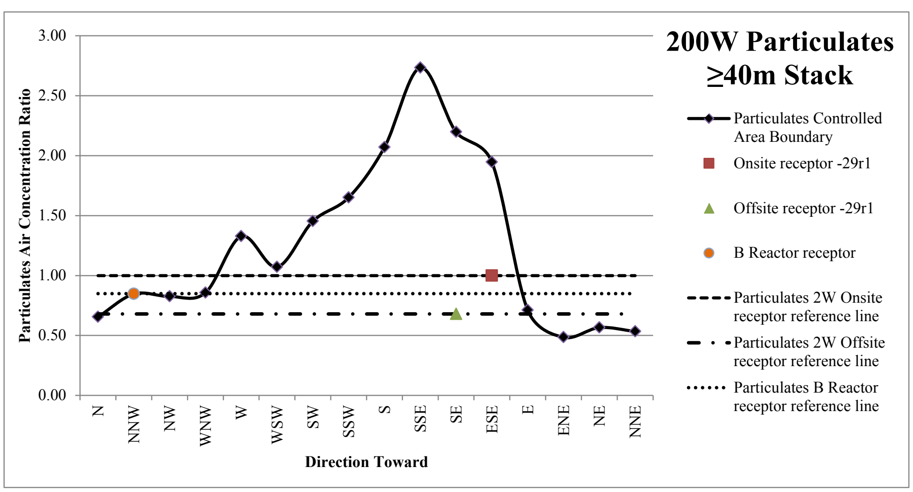

Figure A.6. Particulates /200W /≥40m Release Height Air Concentration Ratios

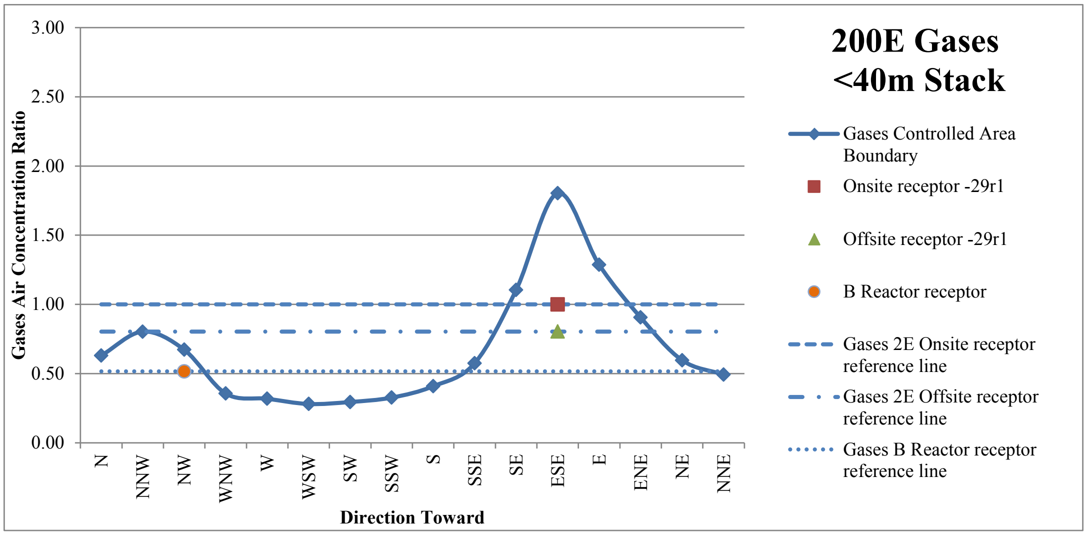

Figure A.7. Gases /200E / <40m Release Height Air Concentration Ratios

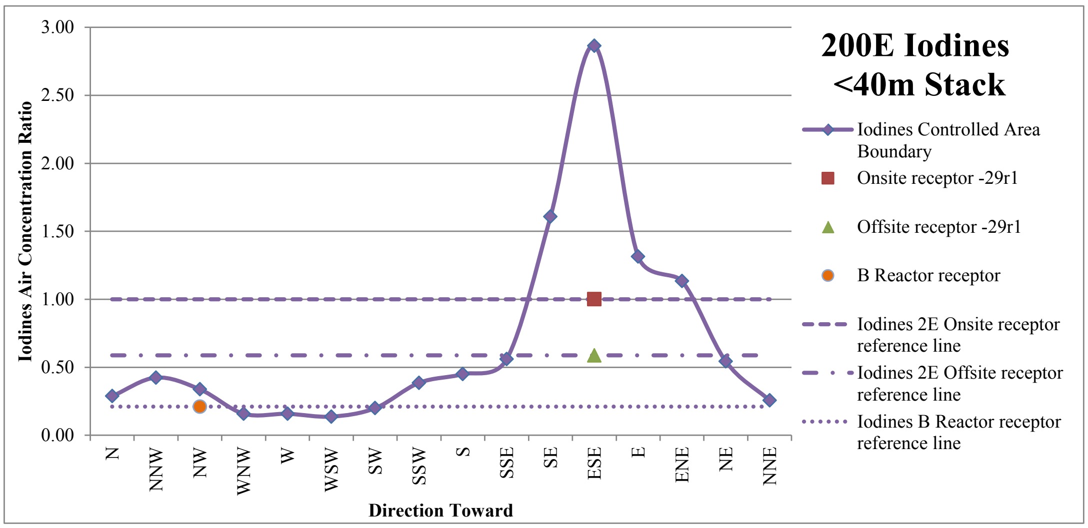

Figure A.8. Iodines /200E /<40m Release Height Air Concentration Ratios

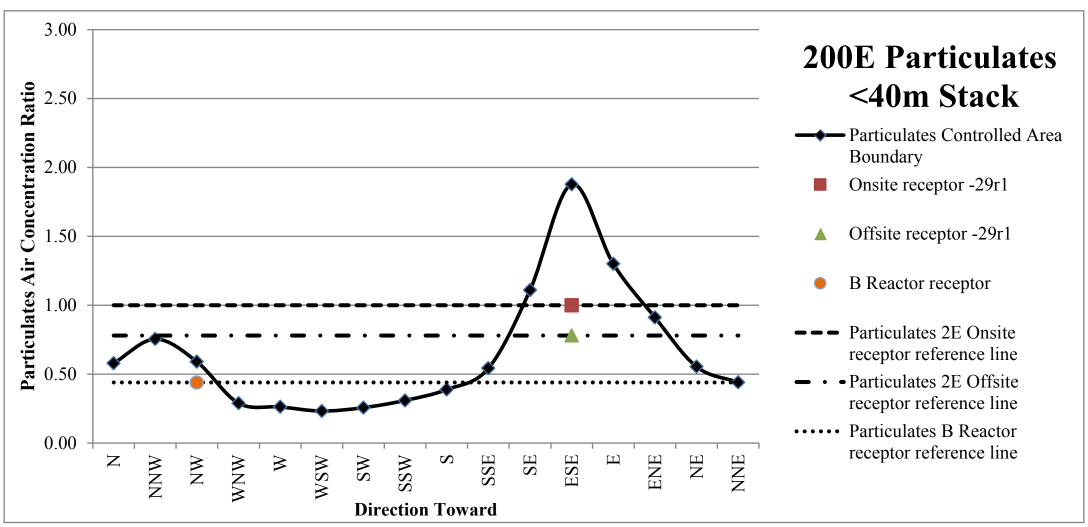

Figure A.9. Particulates /200E /<40m Release Height Air Concentration Ratios

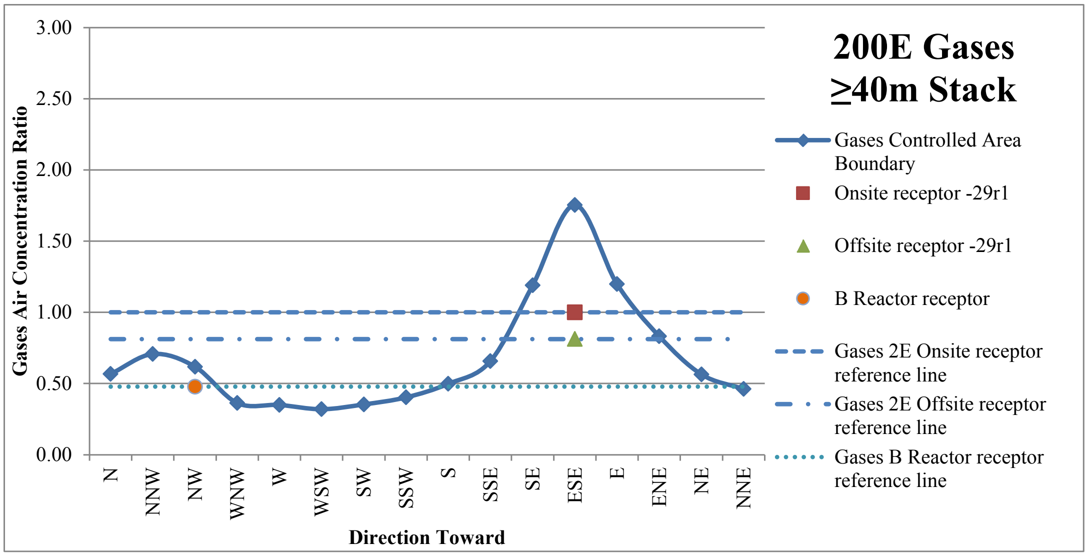

Figure A.10. Gases /200E / ≥40m Release Height Air Concentration Ratios

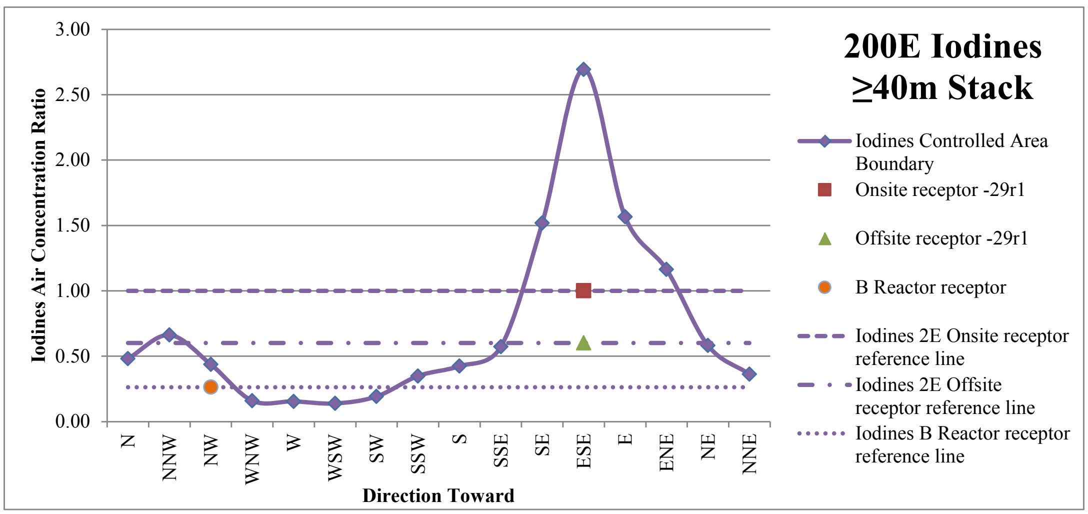

Figure A.11. Iodines /200E /≥40m Release Height Air Concentration Ratios

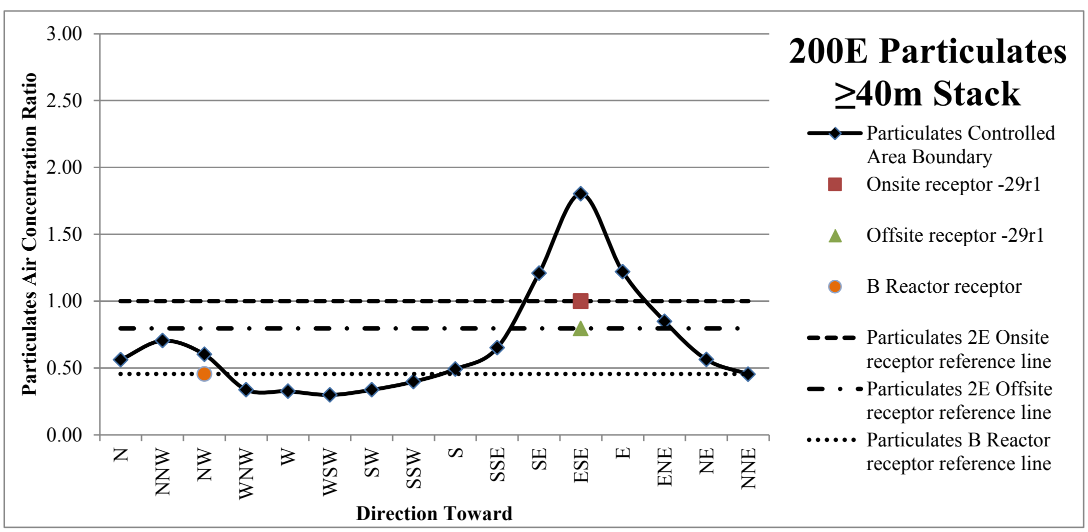

Figure A.12. Particulates /200E /≥40m Release Height Air Concentration Ratios

Appendix B

Review of WTP Minor Stacks

The Hanford Site Waste Treatment Plant (WTP) will begin operations at a future date in the 200E Area. Planning for future radioactive air emission units permitting has begun. This section reviews the potential impact to planned WTP emissions units that are just below the minor emission unit criteria as a result of the proposed fenceline change.

The potential-to-emit (PTE) doses from unabated emissions of WTP emission units reported in Section 15, Total Effective Dose Equivalent to the Maximally Exposed Individual, of BNI 2005 were reviewed and are summarized in Table B.1 in order of decreasing PTE dose. Stack PTE doses that are greater than 0.1 mrem/yr are considered major emission units. Stack PTE doses that are greater than 0.01 to 0.1 mrem/yr are classified as minor emission units. Stack IDs that are not highlighted in gray in Table B.1 have unabated doses that

- result in a major emission unit classification, or
- are several orders of magnitude less than the minor emission unit criteria.

The four highlighted stack IDs in Table B.1 were evaluated further to determine if current PTE doses might increase and warrant a change to a higher emission unit classification (minor or major) if the reduced boundary discussed in the main portion of this document were implemented. The first highlighted stack (HV-S4) is already planned to be classified as a major emission unit and will not be further evaluated. All evaluated stacks have PTE doses that are driven by only non-iodine particulates.

Effective release height and PTE receptor information are required to begin this evaluation. All emission units in the WTP reference have effective release heights greater than 40 m (see Table B.2, which reproduces Table 15-1 of BNI 2005) either as a result of the physical release height or when stack flow rates are considered with the physical release height. The reference document indicates that all PTE doses were limited by the offsite PTE receptor rather than the onsite PTE receptor. As such, the evaluation of potential PTE dose change resulting from the proposed reduced boundary follows that of a 200E stack with a height of ≥40 m and a PTE based on the offsite receptor, such as stack 296-E-1 of the main document (see main document, section 2.1.2).

To present more detail, nuclide-specific unabated doses and emissions rates for the evaluated WTP emission units are summarized in the Table B.3 through Table B.5. Stack 296-E-1 results (see main document's Figure 2.8 for particulates) indicate that the B Reactor offsite receptor, the only new PTE receptor resulting from the reduced Controlled Area Boundary, would not result in an increased PTE dose. A PTE receptor at B Reactor would incur a smaller dose because particulate air concentrations at the B Reactor location would be lower. Therefore, the conclusion is drawn that the PTE receptor for the planned WTP emissions units evaluated would also remain at the 200E offsite location (20,200 m ESE). Based on this evaluation, the current classification of major and minor emission units would remain unchanged from that based on the unabated emissions rates and the PTE doses reported in BNI 2005.

Table B.1. Unabated Dose and Significant Nuclide Contributors from WTP Emission Units

Reference Document Table No. – Source	Stack ID	Unabated Dose (mrem)	Significant Unabated Emissions Radionuclides[(a)]	Abated Dose (mrem)	Significant Abated Emissions Radionuclides[(a)]
15-6	HV-S3B	19,200	Am241, Cs137, Sr90, C14,Co60, Cm243, Cm244, Eu152, Eu154, Eu155, H3, I129, Np237, Pu238, Pu239, Pu240, Pu241, Sb125, Sm151, Tc99, Th232, U233, U234, U238, Y90, Ru106, Cs134, U232, Pa231, Ac227, Am243, Ra228, Cu242, Th229 (Cd113m and Se79 dose not included in assessment)	0.0248	C14 (also H3)
15-5	HV-S3A	19,200	Am241, Cs137, Sr90, C14,Co60, Cm243, Cm244, Eu152, Eu154, Eu155, I129, Np237, Pu238, Pu239, Pu240, Pu241, Sb125, Sm151, Tc99, U233, U234, U238, Y90, Ru106, Cs134, U232, Pa231, Ac227, Am243, Ra228, Cu242, Th229 (Cd113m and Se79 dose not included in assessment)	0.0248	C14 (also H3)
15-4	LV-S3	816	Am241,C14,Co60,Sr90, Cm243, Cm244, Cs137, Eu152, Eu154, Eu155, I129, Np237, Pu238, Pu239, Pu240, Pu241, Sb125, Sm151, Tc99, Th232, U233, U234, U238, Y90, Ru106, Cs134, U232, Pa231, Ac227, Th229 (Cd113m and Se79 dose not included in assessment)	0.293	C14, I129
15-16	HV-S2	31.8	Am241, Cs137, Sr90, ,Co60, Cm243, Cm244, Eu154, Pu238, Pu239, Pu241, Tc99, Y90, Pa231(Cd113m and Se79 dose not included in assessment)	1.59E-04	n/a
15-2	PT-S3	14.7	Am241, Cs137, Sr90; and Co60; Cm243, Cm244, Eu154, Pu238, Pu239,Pu241, Y90, Cs134, Pa231, Ac227 (Cd113m and Se79 dose not included in assessment)	1.31E-05	n/a

Reference Document Table No. – Source	Stack ID	Unabated Dose (mrem)	Significant Unabated Emissions Radionuclides[(a)]	Abated Dose (mrem)	Significant Abated Emissions Radionuclides[(a)]
15-3	PT-S4	6.9	Am241, Cs137, Sr90; Cm243, Cm244, Eu154 Pu239, Pa231(Cd113m and Se79 dose not included in assessment)	9.79E-06	n/a
15-10	PT-S2	2.17	Am241, Cs137, Sr90; Pu239, Cm243, Cm244 (Cd113m and Se79 dose not included in assessment)	1.09E-05	n/a
15-13	LV-S2	1.36	Am241, Sr90, Tc99 (Eu152, I129) (Cd113m and Se79 dose not included in assessment)	6.79E-06	n/a
15-20	LB-S2	0.889	Am241, Sr90, Eu154, Cs137 (Cd113m and Se79 dose not included in assessment)	4.45E-06	n/a
15-7	HV-S4	0.01	(Am241, Cs137, Sr90; ~equal split)	8.87E-08	n/a
15-15	**HV-S1**	2.00E-03	(* Gross alpha, gross beta)	1.00E-06	n/a
15-18	**LB-C2**	7.76E-04	(Sr90, Y90, Cs134)	3.88E-07	n/a
15-19	**LB-S1**	7.51E-04	(Sr90, Cs134)	3.75E-07	n/a
15-12	**LV-S1**	6.40E-05	(* Gross alpha, gross beta)	3.18E-08	n/a
15-17	**IHLW-S1**	4.10E-06	(* Gross alpha, gross beta)	2.06E-09	n/a
15-9	**PT-S1**	1.80E-06	(* Gross alpha, gross beta)	9.22E-10	n/a
15-14	**HV-C2**	6.00E-08	(* Gross alpha, gross beta)	3.01E-11	n/a
15-8	**PT-C2**	4.20E-08	(* Gross alpha, gross beta)	2.11E-11	n/a
15-11	**LV-C2**	2.50E-08	(* Gross alpha, gross beta)	2.50E-11	n/a

(a) *Significant* determined by nuclide-specific doses of ≥ 0.01 mrem, when total dose reaches this level. When total dose is ≤0.01 mrem predominant dose contributors indicated in parentheses.
(b) For calculations, gross alpha was assumed to be Am-241 and gross beta assumed to be Sr-90.
Bold Stack IDs are classified as minor emission units.
PT = Pretreatment Facility
LV = Low Activity Waste Facility
HV, IHLW = High-Level Waste Facility
LB = Analytical Laboratory

Table B.2. Stack Heights and Exit Flow Rates of WTP Stacks

Facility	Emission Unit	Stack Height (meters)	Stack Diameter (meters)	Stack Gas Exit Flowrate (ft^3/min)	Stack Gas Exit Velocity (meters/second)
Pretreatment	PT-C2	39.32	1.37	63,400	20
	PT-S1	60.96	1.57	72,500	18
	PT-S2	60.96	1.57	70,500	17
	PT-S3	60.96	0.61	4,000	7
	PT-S4	60.96	0.91	40,000	29
LAW	LV-C2	23.77	1.52	56,000	14
	LV-S1	60.96	1.22	40,000	16
	LV-S2	60.96	1.52	64,000	17
	LV-S3	60.96	0.46	7,150	20
HLW	HV-C2	18.28	1.12	40,000	18
	HV-S1	60.96	1.27	47,500	18
	IHLW-S1	60.96	0.61	10,500	17
	HV-S2	60.96	1.32	51,000	17
	HV-S3A	60.96	0.30	2,158	14
	HV-S3B	60.96	0.30	2,158	14
	HV-S4	60.96	0.51	2,090	5
LAB	LB-C2	36.00	1.22	42,000	17
	LB-S1	36.00	1.52	69,000	18
	LB-S2	36.00	0.71	14,500	17

Table 15-1 of BNI 2005

Table B.3. Emission Unit HV-S1 PTE Dose Contributors and Emission Rates

Nuclide	Reported Unabated Dose (mrem/yr)	Percentage of Total Unabated dose	Unabated Emission Rate (Ci/yr)
Gross alpha (assumed Am241)	8.94E-04	45%	1.52E-04
Gross beta (assumed Sr90)	1.11E-03	56%	4.45E-02
TOTAL PTE dose	**0.002**		

Reproduced from BNI 2005, Table 15-15.

Table B.4. Emission unit LB-C2 PTE Dose Contributors and Emission Rates

Nuclide	Reported Unabated Dose (mrem/yr)	Percentage of Total Unabated dose	Unabated Emission Rate (Ci/yr)
Sr90	4.36E-04	56%	5.53E-03
Y90	2.08E-05	3%	8.95E-02
Cs134	3.02E-04	39%	4.31E-03
Tc99	6.83E-06	1%	4.32E-04
TOTAL PTE dose	**7.76E-4**		

Reproduced from BNI 2005, Table 15-18.

Table B.5. Emission Unit LB-S1 PTE Dose Contributors and Emission Rates

Nuclide	Reported Unabated Dose (mrem/yr)	Percentage of Total Unabated dose	Unabated Emission Rate (Ci/yr)
Sr90	4.21E-04	56%	5.53E-03
Cs134	2.92E-04	39%	4.31E-03
Y90	2.00E-05	3%	8.95E-02
Tc99	6.61E-06	1%	4.32E-04
Np237	4.17E-06	1%	5.65E-07
TOTAL PTE dose	**7.51E-4**		

Reproduced from BNI 2005, Table 15-19.

Appendix B References

BNI. 2005. *Radioactive Air Emission Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant*. 24590-WTP-RPT-ENV-01-008, Rev 4, Bechtel National, Inc., Richland, WA.

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