



OFFICE OF RIVER PROTECTION

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Richland, Washington 99352

AUG 01 2016

16-ECD-0032

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Ms. Smith:

NONRADIOACTIVE AIR EMISSIONS NOTICE OF CONSTRUCTION PERMIT APPLICATION FOR THE WASTE TREATMENT AND IMMOBILIZATION PLANT EFFLUENT MANAGEMENT FACILITY

Reference: Ecology letter from C. Hanlon-Meyer to R. Skinnerland, Ecology, "Second Tier Petition by the U.S. Department of Energy," dated January 21, 2016.

The U.S. Department of Energy, Office of River Protection submits for your review and approval 24590-WTP-RPT-ENV-15-007, Rev. 0, *Nonradioactive Air Emissions Notice of Construction Permit Application for the WTP Effluent Management Facility*, (Attachment 1). Also provided for transmittal to the Washington State Department of Ecology (Ecology) are a completed Ecology form, ECY 070-410, *Notice of Construction Application*, (Attachment 2), an electronic compact disk containing 24590-WTP-RPT-ENV-15-007, *Air Model Run for Nonrad NOC Permit*, (Attachment 3), the Waste Treatment and Immobilization Plant (WTP) Project Report, 24590-WTP-RPT-ENV-15-005, Rev. 0, *Best Available Control Technology Analysis for Toxic Air Pollutants for the WTP Effluent Management Facility*, (Attachment 4), and the WTP Project Calculation, 24590-BOF-M4C-DEP-00001, *DFLAW Effluent Management Facility Air Emissions Estimate*, (Attachment 5).

The Application proposes the construction of the Effluent Management Facility (EMF) in support of the direct feed of low-activity waste configuration at WTP. To support approval to construct the EMF, a separate radioactive air emissions permit application will be submitted to the Washington State Department of Health. All other WTP emission units remain unchanged.

Toxic Air Pollutant emissions from the EMF were assessed using the Environmental Protection Agency-approved AERMOD air dispersion model. Results of the assessment show that only dimethyl mercury exceeded its corresponding acceptable source impact level. It is proposed that the Washington River Protection Solutions LLC document, RPP-ENV-59016, Rev. 01, *Second Tier Review Petition for Hanford Tank Farm and Waste Treatment Plan Dimethyl Emissions* (Petition), which was reviewed and approved by Ecology (Reference), be used to satisfy WAC 173-460-090, *Second Tier Review*, requirements for dimethyl mercury. All other toxic air pollutant emissions are less than the corresponding WAC 173-460-150 acceptable source impact levels.

Ms. Alexandra K. Smith
16-ECD-0032

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AUG 01 2016

If you have any questions, please contact Dennis W. Bowser, Environmental Compliance Division, (509) 373-2566.



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Attachment 1
16-ECD-032
(38 Pages Excluding Cover Sheet)

24590-WTP-RPT-ENV-15-007, Rev. 0, *Nonradioactive Air Emissions
Notice of Construction Permit Application for the WTP Effluent
Management Facility*



Nonradioactive Air Emissions Notice of Construction Permit Application for the WTP Effluent Management Facility

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History Sheet

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Acronyms

ASIL	acceptable source impact level
BACT	best available control technology
BARCT	best available radioactive control technology
BOF	Balance of Facilities
DEM	Digital Elevation Model
DEP	Direct Feed LAW Effluent Management Facility Process System
DOE	US Department of Energy
DVP	Direct Feed LAW Effluent Management Facility Vessel Vent Process System
Ecology	Washington State Department of Ecology
EMF	Effluent Management Facility
EPA	US Environmental Protection Agency
HEPA	high-efficiency particulate air (filter)
HLW	High-Level Waste (Facility)
Lab	Analytical Laboratory
LAW	Low-Activity Waste (Facility)
LAWPS	Low-Activity Waste Pretreatment System
NOC	notice of construction
NSR	new source review
PSD	Prevention of Significant Deterioration
PT	Pretreatment (Facility)
RLD	radioactive liquid waste disposal system
SQER	small quantity emissions rate
TAP	toxic air pollutants
T-BACT	best available control technology for toxic air pollutants
WDOH	Washington State Department of Health
WTP	Hanford Tank Waste Treatment and Immobilization Plant

1 Introduction

2 This nonradioactive air emissions notice of construction (NOC) permit application is provided to obtain
3 the Washington State Department of Ecology's (Ecology) approval of planned changes associated with
4 the Hanford Tank Waste Treatment and Immobilization Plant (WTP) that require construction of a new
5 emission unit.

6
7 The application proposes to construct the new Effluent Management Facility (EMF) at WTP in support of
8 directly feeding low-activity waste into the Low-Activity Waste (LAW) Facility—the configuration of
9 which is referred to as Direct Feed LAW. The EMF is necessary to support the Direct Feed LAW
10 configuration at WTP. The Direct Feed LAW configuration allows Hanford Site waste treatment at WTP
11 to commence near-term while design and technical decisions associated with the High-Level
12 Waste (HLW) and Pretreatment (PT) facilities are resolved. The EMF will have one new emission unit
13 with the potential to emit both radioactive and nonradioactive air emissions. All other WTP emissions
14 units remain unchanged and continue under construction as permitted under DE02NWP-002, Rev 2 (CCN
15 258062).

16
17 The application is prepared consistent with the requirements in WAC 173-400, *General Regulations for*
18 *Air Pollution Sources*, and WAC 173-460, *Controls of New Sources of Toxic Air Pollutants*. This
19 application describes the necessary role of the EMF in the Direct Feed LAW configuration of WTP. As a
20 new source of emissions at WTP, this application is focused on the new EMF emission unit. Existing
21 emission units permitted under DE02NWP-002, Rev 2 (CCN 258062), will be referred to as appropriate,
22 but this application is focused on the EMF emission unit. Complete descriptions of existing WTP
23 emission units are described in the Ecology-approved 24590-WTP-RPT-ENV-01-009, Rev 1,
24 *Nonradioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste*
25 *Treatment and Immobilization Plant*, and 24590-WTP-RPT-ENV-12-002, Rev 1, *Nonradioactive Air*
26 *Emissions Notice of Construction Permit Application Supplement to DE02NWP-002*.

27
28 Emissions of criteria air pollutants and toxic air pollutants (TAP) for this activity were estimated based on
29 the Direct Feed LAW bounding feed vector provided by the Tank Operations Contractor in *Feed Vector*
30 *Development in Support of WTP Environmental Risk Assessment Activities* (WRPS 2016). Estimated
31 potential TAPs emissions showed that several TAPs exceed de minimis value in WAC 173-460-150,
32 *Controls of New Sources of Toxic Air Pollutants: Table of ASIL, SQER, and De Minimis Emissions*
33 *Values*. Because several of these TAPs also exceed small quantity emission rates (SQER), air dispersion
34 modeling using the US Environment Protection Agency's (EPA) approved AERMOD was used to assess
35 ambient air impacts to corresponding acceptable source impact levels (ASIL). Results of the modeling
36 analysis determined that only dimethyl mercury exceeded its corresponding ASIL. To address the WAC
37 173-460-090, *Controls of New Sources of Toxic Air Pollutants: Second Tier Review*, requirements for
38 dimethyl mercury, review of the Ecology-approved RPP-ENV-59016, Rev 1, *Second Tier Review Petition*
39 *for Hanford Tank Farms and Waste Treatment Plant Dimethyl Mercury Emissions* (herein referred to as
40 the Second-Tier Review Petition) (WRPS 2015) shows that potential dimethyl mercury emissions from
41 EMF are bounded by the emission rate used in the petition.

42
43 To fulfill the WAC 173-460-040(3)(a), *Controls of New Sources of Toxic Air Pollutants: New Source*
44 *Review*, best available control technology for toxic air pollutants (tBACT) requirement, report
45 24590-WTP-RPT-ENV-15-005, *Best Available Control Technology Analysis for Toxic Air Pollutants for*
46 *the WTP Effluent Management Facility*, was prepared to accompany this application to Ecology. The
47 technologies selected for abatement of particulate and aerosols were determined to be high-efficiency

1 particulate air (HEPA) filters. Technologies considered for the abatement of gaseous and vapor-bound
2 TAPs exceeding de minimis levels and the dimethyl mercury ASIL were eliminated due to technical
3 infeasibilities or because the costs exceeded the amounts Ecology considers to be economically
4 justifiable.

5
6 Since the existing WTP Project is also permitted under Prevention of Significant Deterioration (PSD)
7 permit PSD-02-01 (Ecology 2013b)—because the original project’s total NO_x and PM₁₀ emissions
8 exceeded corresponding significance levels—the new EMF emission source was assessed for
9 applicability under the PSD. The maximum potential emissions of all criteria pollutants resulting from
10 the proposed EMF emission unit are estimated to be below WAC 173-400-110(5), *General Regulations*
11 *for Air Pollution Sources: New Source Review (NSR) for Sources and Portable Sources*, Table 5 criteria
12 pollutant exemption levels. Specifically, potential emissions of NO_x are estimated at 0.0 tons per year
13 and potential emissions of particulate matter are estimated at 0.0 tons per year. Since emissions of all
14 criteria pollutants are less than emission unit exemption levels, new source review under PSD is not
15 required for the EMF.

16 **2 Scope**

17 This application is focused on the new EMF emission unit. Unmodified WTP emission units that
18 continue under construction will be highlighted where appropriate, but emissions estimates and best
19 available control technology (BACT) and toxics-BACT (T-BACT) conclusions remain as identified in the
20 existing report 24590-WTP-RPT-ENV-01-009, Rev. 2, *Nonradioactive Air Emissions Notice of*
21 *Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant*, and
22 24590-WTP-RPT-ENV-12-002, Rev. 1, *Nonradioactive Air Emissions Notice of Construction Permit*
23 *Application Supplement to DE02NWP-002*, and associated air permit approval DE02NWP-002, Rev 2
24 (CCN 258062).

25
26 To support Ecology’s review of the EMF emission unit, this application is prepared consistent with
27 Ecology’s form ECY 070-410, *Notice of Construction Application Form* (Ecology 2013a), and includes
28 the following:

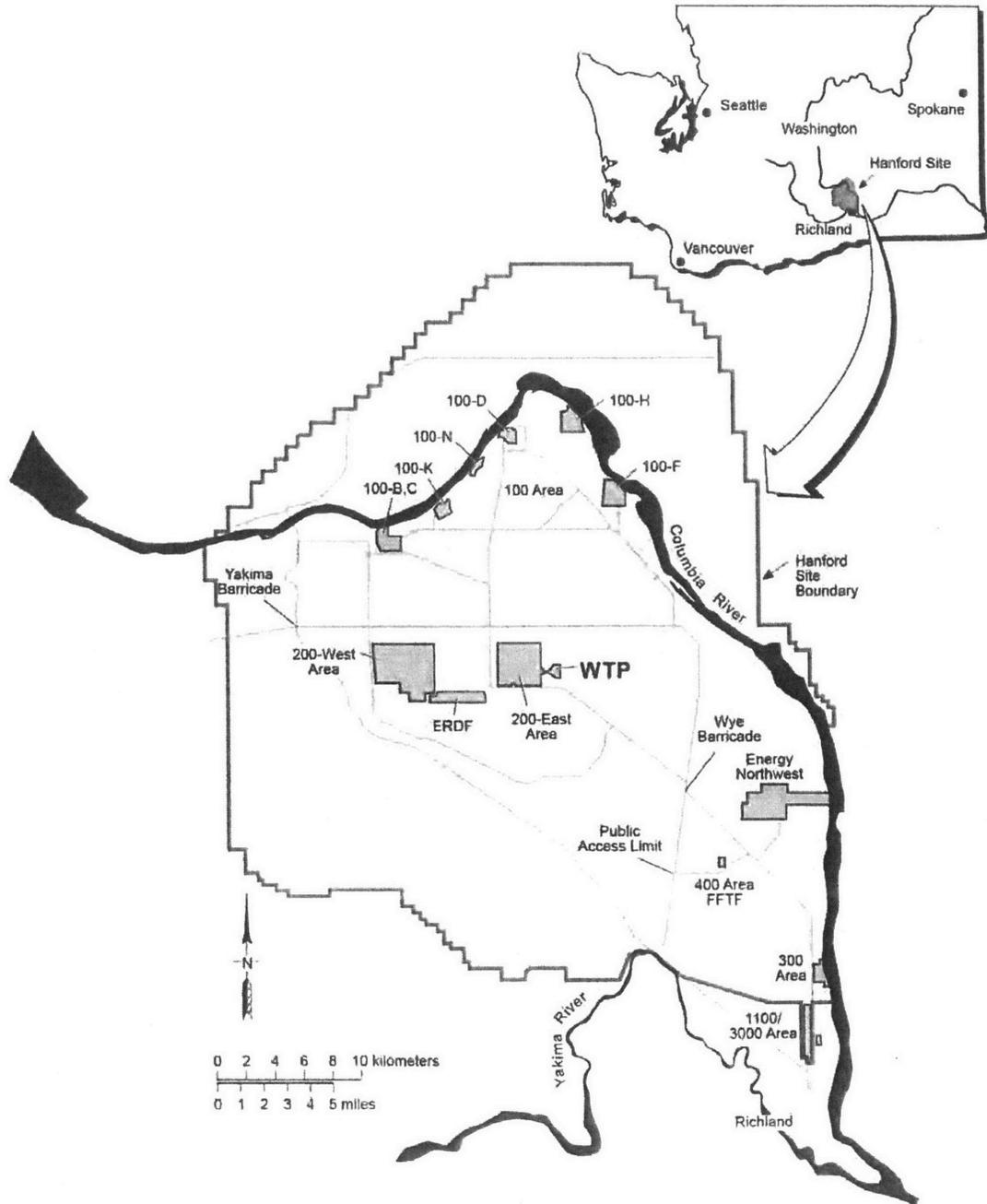
- 29
- 30 • Review of applicable regulatory requirements
- 31 • State Environmental Policy Act
- 32 • Project description
- 33 • Emissions estimations
- 34 • Ambient air impact analysis
- 35 • BACT/T-BACT

36 **3 Facility Location**

37 The EMF is located on the WTP site on the eastern part of the 200-East Area on the US Department of
38 Energy (DOE) Hanford Site (refer to Figure 3-1 and Figure 3-2). The WTP site is northwest of Richland,
39 Washington; on the 7.5-minute quadrangle topographic map of Gable Butte, it is in Section 3, T12N,
40 R26E, Willamette Meridian. The latitude and longitude coordinates corresponding to the general WTP
41 site are approximately N 46°33’4”, W 119°30’9”.

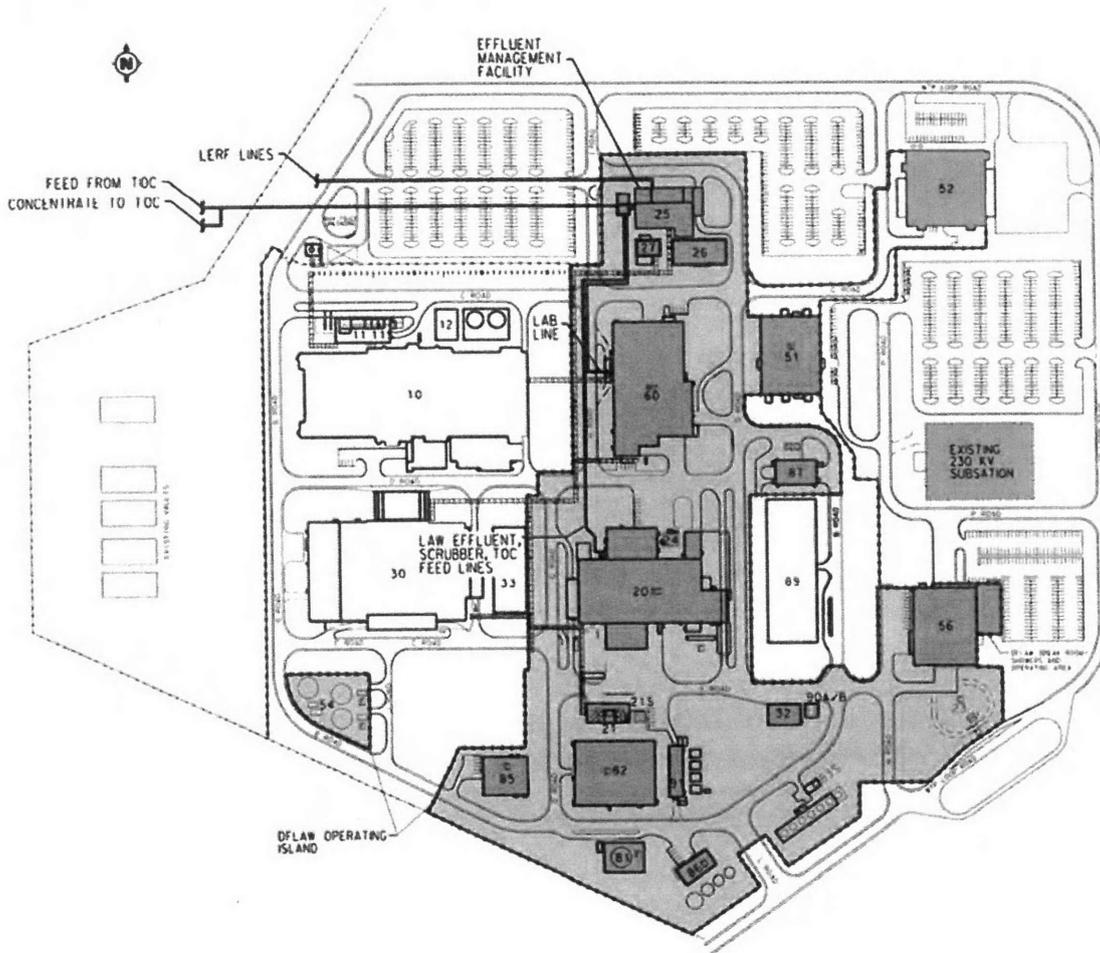
1 The address for the WTP site is as follows:
2
3 US Department of Energy, Office of River Protection
4 Hanford Site
5 200-East Area, Waste Treatment Plant
6 Richland, WA 99352
7

8 **Figure 3-1 Location of the WTP on the Hanford Site**



9
10

1 **Figure 3-2 Location of EMF within the WTP**



2

3 **4 Responsible Manager**

4 Mr. KW Smith, Manager
5 US Department of Energy, Office of River Protection
6 P.O. Box 450, MSIN H6-60
7 Richland, WA 99352
8 (509) 372-2315

9 **5 Review of Applicable Regulatory Requirements**

10 In Washington State, Ecology is responsible for establishing and maintaining the air quality standards to
11 protect the public health (RCW 70.94.011). Facilities with new sources of criteria and TAP emissions are
12 required to comply with the new source review requirements in WAC 173-400, "General Regulations for
13 Air Pollution Sources," and WAC 173-460, "Controls of New Sources of Toxic Air Pollutants."
14

1 Estimated potential TAP emissions showed that several TAPs exceed WAC 173-460-150 de minimis
2 levels. As a result, the new EMF emission unit requires submittal of this NOC permit application, per
3 WAC 173-460-040.

4
5 The EMF includes two reagent storage vessels located on the north side of the EMF LAW effluent
6 process building (building 25). The vessels are located outdoors and contain sodium nitrite and sodium
7 hydroxide. Each vessel ventilates to the atmosphere via a conservation pressure relief closure device.
8 Since sodium hydroxide is considered a TAP, the vessel was considered for new source review
9 applicability. Review of WAC 173-400-110(4) concludes that these tanks fall under the WAC 173-400-
10 110(4)(b)(viii) emission unit exemption since they are equipped with a closure device and store aqueous
11 solutions of inorganic salts and bases.

12 13 **5.1 Other Clean Air Act Regulations**

14 **5.1.1 Prevention of Significant Deterioration Review**

15 The existing WTP Project is permitted under PSD-02-01 (Ecology 2013b) because estimated emissions of
16 NO_x and PM₁₀ exceeded corresponding significance levels. To assess the proposed EMF emission unit
17 for actions under PSD, a review of potential criteria pollutant emissions was performed. Results of the
18 review conclude that potential emissions of all criteria pollutants from the EMF are less than WAC 173-
19 400-110(5) new source review (NSR) exemption levels (Table 8-1). Specifically, potential emissions of
20 NO_x and particulate matter are each estimated at 0.0 tons per year. Since potential emissions of PSD
21 pollutants are less than NSR exemption levels, permitting actions under PSD is not required. This
22 conclusion was confirmed by Ecology Headquarters PSD Lead, Marc Crooks, on March 7, 2016 (refer to
23 CCN 285554, *Ecology Confirmation the EMF Not Subject to PSD Permitting*).

24 25 **5.1.2 Review for WAC 246-247, Radiation Protection—Air Emissions**

26 The Washington State Department of Health (WDOH) oversees permitting of radioactive air emissions
27 sources under regulations in WAC 246-247, *Radiation Protection—Air Emissions*. Because the new
28 EMF emission unit has the potential to emit radioactive air emissions, a separate permit application
29 24590-WTP-RPT-ENV-15-008, *Radioactive Air Emissions Notice of Construction Permit Application for*
30 *the WTP Effluent Management Facility*, will be submitted to the WDOH in parallel with this application
31 to obtain the WDOH's approval to construct the new EMF and associated radioactive air emission unit.
32 The radioactive NOC is prepared consistent with the application requirements listed in
33 WAC 246-247-110, *Radiation Protection—Air Emissions: Appendix A—Application Information*
34 *Requirements*.

35 36 **5.1.3 Review for WAC 173-401, Operating Permit Regulation**

37 The WAC 173-401, *Operating Permit Regulation*, specifies the permitting requirements for major
38 sources, including the Hanford Site. The current DE02NWP-002 (CCN 258062) is included in Hanford
39 Site Air Operating Permit 00-05-006 (Ecology 2013c). In parallel with the submittal of this application,
40 an administrative amendment request will be included in the submission to Ecology, requesting the
41 incorporation of the revised DE02NWP-002 into Air Operating Permit 00-05-006.

42 43 **5.1.4 New Source Performance Standards**

44 The Clean Air Act of 1970 requires certain categories of emissions sources to meet the New Source
45 Performance Standards established under 40 CFR 60, *Standards of Performance for New Stationary*

1 Sources. Review of 40 CFR 60 confirms that there are no New Source Performance Standards applicable
2 to the EMF emission unit.

3 4 **5.1.5 National Emissions Standards for Hazardous Air Pollutants**

5 The Clean Air Act of 1970 requires certain categories of emissions sources to meet standards established
6 under 40 CFR 63, *National Emission Standards for Hazardous Air Pollutants for Source Categories*.
7 Review of 40 CFR 63 confirms that there are no National Emissions Standards for Hazardous Air
8 Pollutants applicable to the EMF emission unit.

9 **6 State Environmental Policy Act**

10 This Project fulfills the requirements of WAC 197-11, *SEPA Rules*, and RCW 43.21C.030(2)(c),
11 *Guidelines for State Agencies: Local Governments—Statements—Reports—Advice—Information*, per
12 RCW 43.21C.150, *State Environmental Policy: RCW 43.21C.030(2)(c) Inapplicable When Statement*
13 *Previously Prepared Pursuant to National Environmental Policy Act*, which states the following:

14
15 The requirements of RCW 43.21C.030(2)(c) pertaining to the preparation of a detailed
16 statement by branches of government shall not apply when an adequate detailed
17 statement has been previously prepared pursuant to the national environmental policy act
18 of 1969, in which event said prepared statement may be utilized in lieu of a separately
19 prepared statement under RCW 43.21C.030(2)(c).

20
21 Document DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement*
22 *for the Hanford Site, Richland, Washington (TC & WM EIS)* (DOE 2012), meets the agencies' review
23 needs for the current proposal. The lead reviewing agency is the DOE Office of River Protection. The
24 point of contact is Mary Beth Burandt, Document Manager.

25 **7 Project Description**

26 **7.1 WTP Baseline Process Overview**

27 The WTP is being constructed to store and treat mixed radioactive and dangerous Hanford tank waste
28 from the Hanford Site tank system. In the baseline configuration, the WTP consists of three main process
29 facilities: the PT, LAW, and HLW facilities—supported by an Analytical Laboratory (Lab). In the
30 baseline configuration, tank waste will be received into the PT Facility, where it will be separated into
31 low-activity waste and high-level waste feed, then immobilized in a glass matrix and poured into steel
32 containers. Support systems and utilities required for the WTP will be provided by the Balance of
33 Facilities (BOF). The BOF includes steam plant boilers, Type I diesel generator, turbine generators,
34 diesel engine driven fire water pumps, and glass former storage facility. Construction of these facilities
35 commenced in CY 2002 and has been ongoing.

36
37 Detailed process descriptions of each existing WTP emissions unit are provided in the previously
38 submitted *Nonradioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank*
39 *Waste Treatment and Immobilization Plant*, 24590-WTP-RPT-ENV-01-009, Rev 1 and *Nonradioactive*
40 *Air Emissions Notice of Construction Permit Application Supplement to DE02NWP-002*, 24590-WTP-
41 RPT-ENV-12-002, Rev 1.

1 **7.2 WTP Direct Feed LAW Process Overview**

2 To facilitate the processing of tank waste into glass at the earliest possible date, an interim Direct Feed
3 LAW configuration is being implemented. The Direct Feed LAW configuration does not require changes
4 to existing WTP emission units, but it will require the construction of the EMF to manage LAW Facility
5 effluents that were to be sent to the PT Facility in the baseline configuration. It is planned that the WTP
6 will operate in the Direct Feed LAW configuration until the PT and HLW facilities are operational. After
7 which time, operation of those facilities will be pursued.

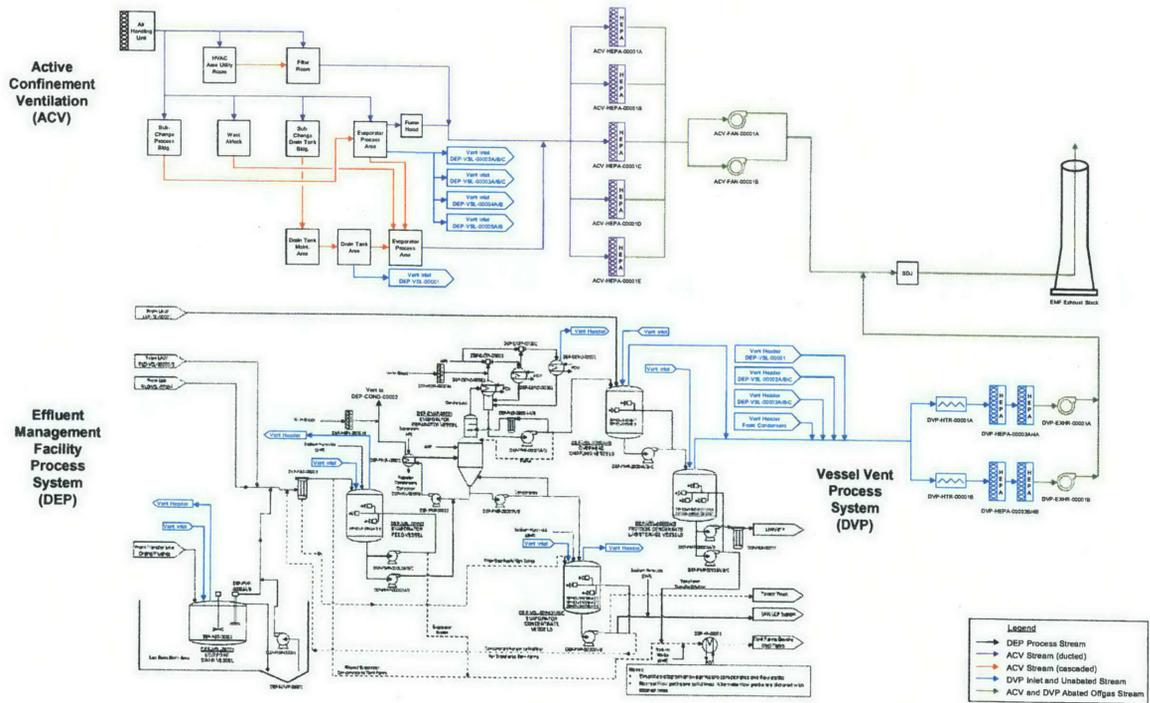
8
9 Since the WTP PT Facility will not be available, Hanford Site tank waste will be received into the new
10 Low-Activity Waste Pretreatment System (LAWPS), which will function to produce the WTP LAW
11 Facility feed. Pretreatment of tank waste to remove cesium and solids will be performed by LAWPS,
12 which assumes the tank waste pretreatment function while technical decisions associated with the WTP
13 PT Facility are being resolved. Note that the LAWPS and its associated emission source(s) will be
14 designed and permitted by a separate Hanford Site contractor; therefore, it is outside the scope of this
15 application. In the Direct Feed LAW configuration, the WTP LAW Facility, Lab, and BOF (including
16 EMF) will operate while the WTP PT and HLW facilities continue under construction to support the
17 future baseline WTP configuration.

18
19 The EMF's purpose is to support processing of secondary liquid waste streams generated during
20 low-activity waste melter offgas control system operation. The EMF will also process small amounts of
21 effluent from the Lab radioactive liquid waste disposal system (RLD) vessels, as well as the waste transfer
22 line flushing effluent. In the baseline WTP configuration, these waste streams are processed in the WTP
23 PT Facility.

24
25 In the Direct Feed LAW configuration, the EMF will collect and treat the liquid effluents in an
26 evaporator. The evaporator overheads (process condensate) will be piped to the 200-Area Liquid Effluent
27 Retention Facility / Effluent Treatment Facility for further processing. The residual EMF evaporator
28 bottoms (process concentrate) is returned to the LAW Facility for vitrification. The concentrate may also
29 be returned to Tank Farms, the LAWPS, or disposed at an alternate location via tanker truck. Figure 7-1
30 provides the process schematic of the EMF.

31
32 Support systems and utilities required for Direct Feed LAW to operate will continue to be provided by the
33 existing BOF.

Figure 7-1 Process Schematic of the Effluent Management Facility



1 **7.3 Effluent Management Facility**

2 The EMF will be comprised of four buildings. The LAW effluent process building (building 25) will
3 house the Direct Feed LAW Effluent Management Facility Process System (DEP) evaporator, related
4 process equipment, the Direct Feed LAW Effluent Management Facility Vessel Vent Process System
5 (DVP) system HEPA preheater, and HEPA filters and fans, as well as collect and process the liquid
6 effluent. The LAW effluent drain tank building (also part of building 25) will house the low-point drain
7 vessel. The LAW effluent utility building (building 26) will house the active confinement ventilation
8 system (ACV) HEPA filters and fans, various utility pumps and holding vessels, and associated electrical
9 equipment. The LAW effluent electrical building (building 27) will house most of the EMF electrical
10 equipment and control network.

11
12 **7.3.1 EMF Evaporator and Process Vessel Vent System**

13 Liquid effluents from the LAW Facility and Lab vessels will be transferred through the EMF evaporator
14 feed vessel to the DEP system evaporator located in the LAW effluent process building (building 25).
15 Liquid effluents from transfer line flush water from the EMF low-point drain vessel will also be
16 transferred through the evaporator feed vessel. These liquid effluent streams pass through a prefilter prior
17 to entering the feed vessel. The evaporator feed vessel will be purged with air drawn through the vessel
18 head space and will be vented to the vessel vent header. This vessel will have the capability to receive
19 sodium hydroxide for pH adjustment, and demineralized water for flushing. Effluent will be continuously
20 pumped from the feed vessel to the evaporator to maintain a constant liquid level in the evaporator.

21
22 The DEP system evaporator separator will receive feed from the evaporator feed vessel that has passed
23 through the evaporator reboiler. The evaporator will be operated under vacuum to lower the boiling point
24 of the concentrate. The overhead vapors, mainly water, will pass through an impingement plate and
25 demister pads to remove entrained liquid, with the overhead vapor continuing on to the primary
26 condenser. The majority of the bottom liquid will be recycled through the reboiler, with a small amount
27 sent to the evaporator concentrate vessels.

28
29 Overhead vapor from the evaporator and steam from the steam-jet air ejectors will be condensed and
30 collected in the overhead sampling vessels. Spent caustic scrubber solution from the LAW Facility offgas
31 caustic scrubber will also be collected in the overhead sampling vessels. The EMF overhead sampling
32 vessel effluent is transferred to the 200 Area Liquid Effluent Retention Facility / Effluent Treatment
33 Facility.

34
35 Concentrate (bottoms) will be pumped from the evaporator to the evaporator concentrate vessels and
36 recirculated through the evaporator reboiler to maintain a constant solution density in the evaporator and
37 to prevent buildup of settled solids in the waste. The concentrate may be recycled back to the LAW
38 concentrate receipt process system for vitrification, returned to the Tank Farms double-shell tanks system,
39 or returned to the LAWPS. An additional option of offloading to a tanker truck may be available.

40
41 The DEP system process vessels and evaporator offgas are ventilated to the DVP system HEPA filters, as
42 discussed in Section 10.

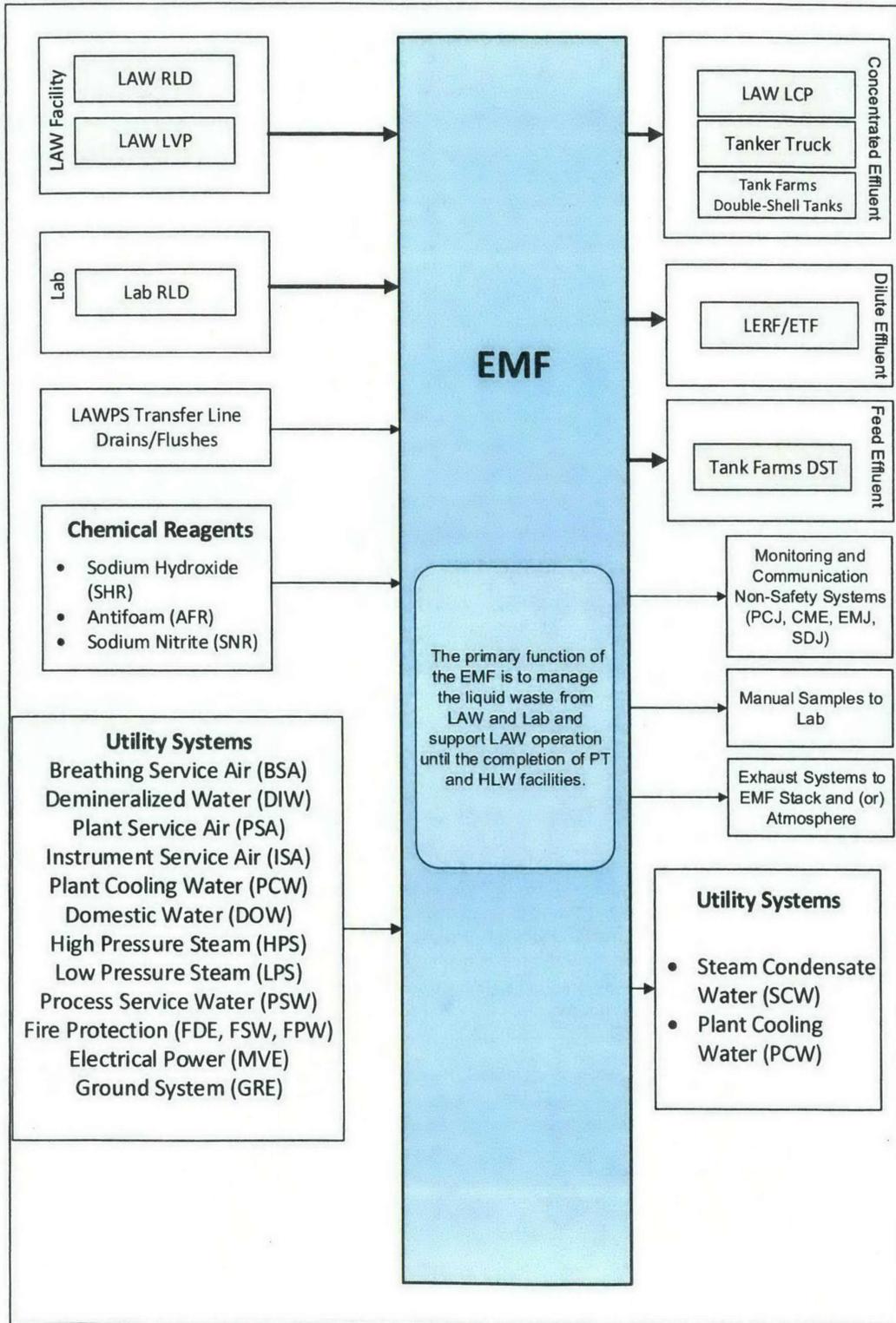
43
44 **7.3.2 Effluent Management Facility Ventilation System**

45 The EMF ventilation system is referred to as the Active Confinement Ventilation (ACV) system. This
46 system operates on a once-through ventilation strategy whereby air is cascaded from areas of lower
47 radiological contamination potential to areas of higher contamination potential before being exhausted

1 from the facility emission unit. The ACV system has supply and exhaust components. The supply
2 component of the ACV system follows the design of contamination area C2 ventilation supply systems
3 used in other WTP facilities, and the exhaust component of the ACV system generally follows the design
4 of contamination area C3 ventilation exhaust systems used in other WTP facilities. All outside air is
5 conditioned in the ACV system air handling units before being delivered to the EMF building areas,
6 except for the electrical building (building 27), which has its own HVAC system. The air is then treated
7 through HEPA filtration for radiological control and exhausted through exhaust fans, then combined with
8 the HEPA filtered air from the DVP vessel vent process system stream, and finally discharged to the
9 atmosphere via the EMF stack (Figure 7-1). Figure 7-2 represents an overall view of the Direct Feed
10 LAW functions relative to new and existing facilities, interfaces with existing systems, and new or
11 modified systems.

12
13 Insignificant amounts of TAPs are expected to be present in the EMF ACV systems.

1 **Figure 7-2 Effluent Management Facility Context Diagram**



2
 3 Note: LAW RLD = submerged bed scrubber / wet electrostatic precipitator effluent
 4 LAW LVP = caustic scrubber effluent

1 **8 Emission Estimates**

2 The unabated (potential) and abated emission rates for criteria pollutants and TAP emissions from the
 3 EMF evaporator process vessels and DEP system evaporator are based on 24590-BOF-M4C-DEP-00001,
 4 *DFLAW Effluent Management Facility Air Emissions Estimate*. Complete descriptions of the emissions
 5 estimate methodology and bounding assumptions are included in the above calculation. The following
 6 descriptions are intended to summarize the emissions estimates.

7
 8 **8.1 Potential Criteria Pollutant Emissions**

9 As described in 24590-BOF-M4C-DEP-00001, Section 6.1.31, the EMF will not generate criteria
 10 pollutant gases because the DEP system does not contain the necessary thermal or kinetic conditions to
 11 produce measurable amounts of inorganic constituents of potential concern. As a result, there is no
 12 potential source for CO/CO₂, NO/NO₂, and SO₂ generation in the EMF. Carbonate, nitrite/nitrate, and
 13 sulfuric salts may be present, but they are nonvolatile and will remain as entrained liquids/solids in the
 14 EMF liquid effluents. Particulates, volatile organics, and lead are estimated to be emitted at insignificant
 15 rates below WAC 173-400-110(5) criteria pollutant emission unit exemption levels. Table 8-1 provides a
 16 summary of the EMF potential criteria pollutant emissions.

17

Table 8-1 EMF Annual Potential Criteria Pollutant Emission Estimates

Criteria Pollutant	Potential Emissions (Tons per Year)	WAC 173-400-110(5) Exemption Level (Tons per Year)
CO	0.00	5.0
NO_x	0.00	2.0
SO₂	0.00	2.0
PM₁₀	0.00	0.75
PM_{2.5}	0.00	0.5
Total PM	0.03	1.25
VOC	0.08	2.0
Pb	0.000	0.005

18 **9 Toxic Air Pollutant Emissions and Ambient Air Impact**
 19 **Analysis**

20 **9.1 Emissions Estimate**

21 As previously described, the EMF emissions are based on 24590-BOF-M4C-DEP-00001, *DFLAW*
 22 *Effluent Management Facility Air Emissions Estimate*. The TAP emissions were calculated using several
 23 conservative assumptions to bound potential emissions. For particulate TAP emissions, the emissions
 24 estimate assumes the waste feed to EMF has the same composition as the waste feed to the LAW Facility.
 25 Vapor emissions are estimated using waste feed compositions diluted by transfer line flush water. The
 26 feed vector used for the waste composition was the Direct Feed LAW bounding feed vector provided in

1 *Feed Vector Development in Support of WTP Environmental Risk Assessment Activities* (WRPS 2016).
2 The EMF emissions estimate combines the following offgas streams:

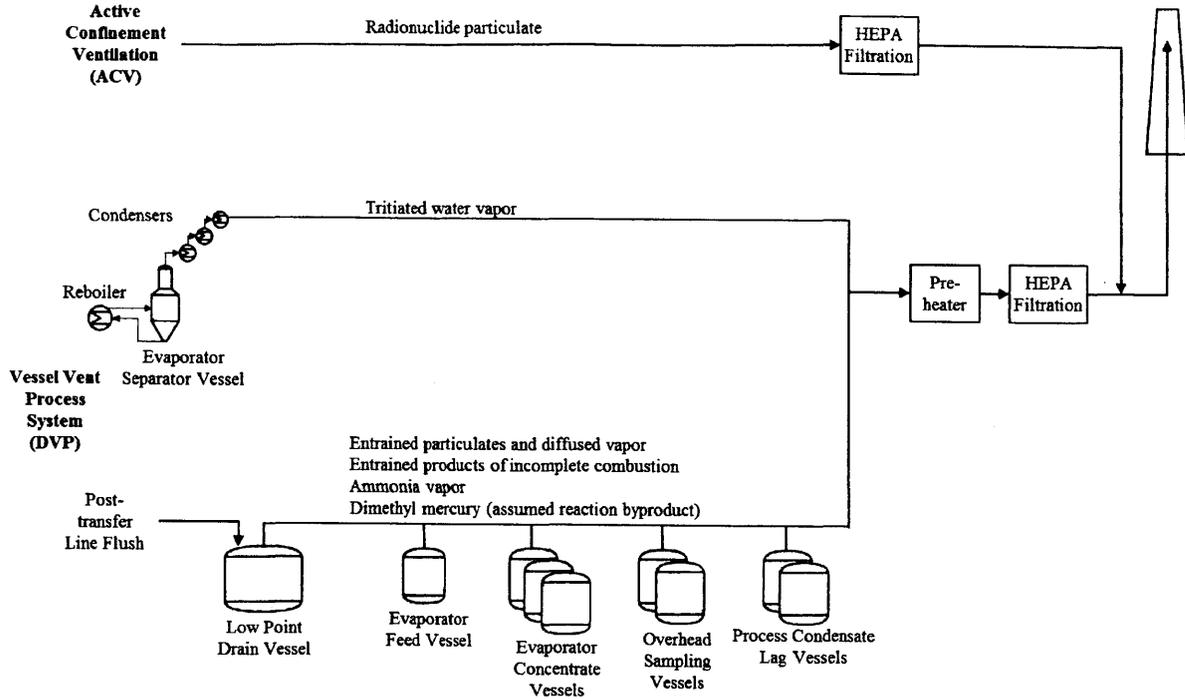
- 3 • ACV system
- 4 • Direct Feed LAW Effluent Management Facility Vessel Vent Process System (DVP) which consists
5 of:
 - 6 - DEP system evaporator/condenser exhaust
 - 7 - DEP system vessel ventilation

8
9 As described in Section 7.3.2, the ACV system is considered an insignificant source of TAP emissions
10 and any potential emissions are bound by the conservative assumptions integrated into the DVP emission
11 source.

12
13 The DVP system is composed of two main parts, the DEP system evaporator/condenser exhaust and the
14 DEP system vessel ventilation, which contribute the bulk of potential emissions. Particulate-bound
15 constituents are assumed to enter the ventilation stream through entrainment (Section 6.2.3 of 24590-
16 BOF-M4C-DEP-00001), while vapor phase constituents are assumed to diffuse into the ventilation stream
17 in their entirety (Section 6.2.16 of 24590-BOF-M4C-DEP-00001). The DVP emissions also include the
18 contribution of products of incomplete combustion from the LAW Facility offgas effluents, along with
19 ammonia used in the LAW Facility selective catalytic reducer, which is assumed to be captured by the
20 LAW offgas caustic scrubber effluent (Section 5.3.1.3.2 of 24590-BOF-M4C-DEP-00001). The
21 emissions estimate also assumes the presence of dimethyl mercury (Section 5.3.1.3.3 of 24590-BOF-
22 M4C-DEP-00001). Although dimethyl mercury is not quantified in the feed vector, it is assumed to be
23 present in the EMF as a reaction product in the DEP vessels that completely diffuses into the ventilation
24 stream.

25
26 Constituents for which there were no feed or products of incomplete combustion data were assumed to be
27 emitted at the average emissions rates of quantified feed constituents and products of incomplete
28 combustion, respectively (Section 5.2.4.2.2 of 24590-BOF-M4C-DEP-00001). Figure 9-1 illustrates the
29 various exhaust streams quantified in the emissions estimate.

1 **Figure 9-1 Illustration of EMF Emission Sources**



2
3

4 **9.2 Toxic Air Pollutant Emissions Screening and Air Impact Assessment**

5 Estimated emissions of more than 400 organic and inorganic compounds from the EMF emission source
 6 are documented in 24590-BOF-M4C-DEP-00001, Tables 8-4 through 8-6. Screening analysis
 7 determined that 173 of these compounds are identified in WAC 173-460-150 as TAPs (Appendix A).
 8 From that screening, 165 of the 173 have estimated potential emissions above 0.0 grams per second.
 9 These 165 TAPs were further screened to determine if their potential emissions exceeded their
 10 corresponding de minimis levels (Table A-1). Results of that screening (Table 9-1) showed that potential
 11 emission rates of 24 TAPs exceeded their corresponding de minimis threshold.

12 Since screening also confirmed that potential emissions of several TAPs exceeded their corresponding
 13 SQER, air dispersion modeling using the EPA's approved AERMOD model was performed to assess
 14 ambient air impacts to corresponding ASILs. The AERMOD results confirmed that only dimethyl
 15 mercury exceeded its corresponding ASIL. All other TAP emissions are less than their corresponding
 16 ASILs (Table 9-1).

17

18 **9.2.1 Tier II Health Impact Assessment for Dimethyl Mercury**

19 It is proposed that RPP-ENV-59016, *Second Tier Review Petition for Hanford Tank Farm and Waste*
 20 *Treatment Plant Dimethyl Mercury Emissions* (Petition) (WRPS 2015), which was previously reviewed
 21 and approved by Ecology on January 21, 2016 (CCN 290160), be used to satisfy WAC 173-460-090,
 22 "Second Tier Review," requirements for dimethyl mercury for this notice of construction application.
 23 RPP-ENV-59016 is a bounding dimethyl mercury health impact assessment that effectively covers the
 24 emissions from the activities proposed in this application. The locations of the emission points for
 25 modeling were chosen to be representative of the locations of the individual emission points of dimethyl

1 mercury associated with the retrieval, transfer, and treatment of tank waste at the Hanford Tank Farms
2 and the WTP.

3
4 The Petition utilized a conservative assumption to bound dimethyl mercury emissions from the WTP and
5 the EMF. The Petition assumed that existing WTP emission unit elemental mercury emissions were
6 assumed to be dimethyl mercury. For the new EMF, the Petition assumed that dimethyl mercury
7 emissions were emitted at the same rate as the PT Facility, plus an additional factor of 100 was applied.
8 The resulting bounding dimethyl mercury emission rate for the EMF in the Petition equated to
9 $5.0E-05$ gram per second.

10
11 In comparison to the Petition, the EMF emission units estimated potential dimethyl mercury emission rate
12 identified in 24590-BOF-M4C-DEP-00001 *DFLAW Effluent Management Facility Air Emissions*
13 *Estimate*, is $5.29E-07$ gram per second (Table 8-6 in 24590-BOF-M4C-DEP-00001). Comparing this
14 rate to the $5.0E-05$ gram per second rate in the Hanford Site Petition shows that the EMF's estimated
15 dimethyl mercury emissions in this NOC Application are bounded by the Petition.

Table 9-1 Toxic Air Pollutant Emissions From EMF in Excess of De Minimis Emission Values

Pollutant	CAS	ASIL Averaging Period	Unabated Emission Rate (lb/averaging period)	De Minimis Level (lb/averaging period)	Abated Emission Rate (lb/averaging period)	SQER (lb/averaging period)	EMF Ambient Air Impact from AEMROD ($\mu\text{g}/\text{m}^3$)	ASIL ($\mu\text{g}/\text{m}^3$)	Percent of ASIL ¹
Organics									
N-Nitrosomethylethylamine	10595-95-6	Annual	1.17E+00	1.53E-03	1.17E+00	3.05E-02	4.60E-07	1.59E-04	0.29%
Bis(2-ethylhexyl)phthalate	117-81-7	Annual	1.17E+00	4.00E-01	1.17E+00	8.00E+00	4.60E-07	4.17E-02	0.00%
Aroclors (Total PCB)	1336-36-3	Annual	1.80E+00	1.68E-02	1.80E+00	3.36E-01	7.07E-07	1.75E-03	0.04%
Dibenzo[a,i]pyrene	189-55-9	Annual	1.17E+00	8.72E-04	1.17E+00	1.74E-02	4.60E-07	9.09E-05	0.51%
Dibenzo[a,h]pyrene	189-64-0	Annual	1.17E+00	8.72E-04	1.17E+00	1.74E-02	4.60E-07	9.09E-05	0.51%
Dibenzo[a,l]pyrene	191-30-0	Annual	1.17E+00	8.72E-04	1.17E+00	1.74E-02	4.60E-07	9.09E-05	0.51%
Dibenzo[a,e]pyrene	192-65-4	Annual	1.17E+00	8.72E-03	1.17E+00	1.74E-01	4.60E-07	9.09E-04	0.05%
Indeno(1,2,3-cd)pyrene	193-39-5	Annual	1.17E+00	8.72E-02	1.17E+00	1.74E+00	4.60E-07	9.09E-03	0.01%
Dibenz[a,j]acridine	224-42-0	Annual	1.17E+00	8.72E-02	1.17E+00	1.74E+00	4.60E-07	9.09E-03	0.01%
Dibenz[a,h]acridine	226-36-8	Annual	1.17E+00	8.72E-02	1.17E+00	1.74E+00	4.60E-07	9.09E-03	0.01%
5-Methylchrysene	3697-24-3	Annual	1.17E+00	8.72E-03	1.17E+00	1.74E-01	4.60E-07	9.09E-04	0.05%
3-Methylcholanthrene	56-49-5	Annual	1.17E+00	1.53E-03	1.17E+00	3.05E-02	4.60E-07	1.59E-04	0.29%
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	Annual	1.70E-06	5.05E-07	8.49E-12	1.01E-05	3.33E-18	5.26E-08	0.00%
5-Nitroacenaphthene	602-87-9	Annual	1.17E+00	2.59E-01	1.17E+00	5.18E+00	4.60E-07	2.70E-02	0.00%
Acetamide	60-35-5	Annual	1.17E+00	4.80E-01	1.17E+00	9.59E+00	4.60E-07	5.00E-02	0.00%
N-Nitroso-di-n-propylamine	621-64-7	Annual	3.40E-02	4.80E-03	3.40E-02	9.59E-02	1.33E-08	5.00E-04	0.00%
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	Annual	2.84E-06	2.52E-06	1.42E-11	5.05E-05	5.57E-18	2.63E-07	0.00%

Table 9-1 Toxic Air Pollutant Emissions From EMF in Excess of De Minimis Emission Values

Pollutant	CAS	ASIL Averaging Period	Unabated Emission Rate (lb/averaging period)	De Minimis Level (lb/averaging period)	Abated Emission Rate (lb/averaging period)	SQER (lb/averaging period)	EMF Ambient Air Impact from AEMROD ($\mu\text{g}/\text{m}^3$)	ASIL ($\mu\text{g}/\text{m}^3$)	Percent of ASIL ¹
4,4-DDE	72-55-9	Annual	1.17E+00	9.88E-02	1.17E+00	1.98E+00	4.60E-07	1.03E-02	0.00%
Bromodichloromethane	75-27-4	Annual	1.17E+00	2.59E-01	1.17E+00	5.18E+00	4.60E-07	2.70E-02	0.00%
Naphthalene	91-20-3	Annual	3.68E+00	2.82E-01	3.68E+00	5.64E+00	1.44E-06	2.94E-02	0.00%
Inorganics									
Chromium VI	18540-29-9	Annual	1.00E+00	6.40E-05	5.00E-06	1.28E-03	1.96E-12	6.67E-06	0.00%
Dimethyl Mercury ²	593-74-8	24-hr	1.01E-04	1.00E-99	1.01E-04	1.00E-99	4.37E-07	1.00E-99	>100%
Cadmium	7440-43-9	Annual	2.82E-02	2.28E-03	1.41E-07	4.57E-02	5.53E-14	2.38E-04	0.00%
Ammonia	7664-41-7	24-hr	1.92E+01	4.65E-01	1.92E+01	9.31E+00	8.32E-02	7.08E+01	0.12%

¹ Value rounded. Actual percent of ASIL, when shown at 0.00%, is less than 0.005%.

² Per Section 9.2.1, it is proposed that the Second-Tier Review Petition, which was previously reviewed and approved by Ecology on January 21, 2016, be used to satisfy WAC 173-460-090 requirements for dimethyl mercury for this application. The Second-Tier Review Petition is a bounding dimethyl mercury health impact assessment that covers the emissions from the activities proposed in this application.

1 **9.3 Air Dispersion Modeling**

2 Annual, 24-hour, and 1-hour ground-level TAP concentrations, expressed as micrograms per cubic meter,
3 were determined using EPA’s approved air dispersion model AERMOD version 15181 and preprocessors
4 AERMET version 15181, AERMAP version 11103, and BPIP-Prime version 04274 (EPA 2015). The
5 modeling analysis used BEE-Line Software’s BEEST version 11.03 to assess the EMF emission unit’s
6 impacts to ASILs (Providence/Oris 2015). The BEEST program is a Windows-based user interface to the
7 EPA-approved AERMOD.

8
9 AERMOD utilizes individual emission point release characteristics, source emission rates, surface and
10 upper air meteorological data, terrain data, and receptor data to determine maximum annual, 24-hour, and
11 1-hour concentrations affecting offsite receptors. Details of the modeling analysis are provided below
12 and included in 24590-RMCD-04990, *Air Model Run for Nonrad NOC Permit 24590-WTP-RPT-ENV-*
13 *15-007.*

14
15 **Release Characteristics**

16
17 Stack characteristics were modeled as a point source with release parameters corresponding to design
18 specifications. A summary of the release parameters for the modeled source is provided in Table 9-2.
19

Table 9-2 WTP Stack Release Parameters

Stack Parameter	EMF		
Stack height	150 ft		
Stack temperature	95 °F		
Exit diameter	3.1 ft		
Exit velocity	52.1 ft/sec		
Exit flowrate	24,000 acfm		
EMF building dimensions (L×W×H)	Building 25	Building 26	Building 27
	Tier 1: 48×34×37 ft Tier 2: 20×18×23 ft	35×23×14 ft	18×12×20 ft

20
21 The basis for the stack parameters included the following:

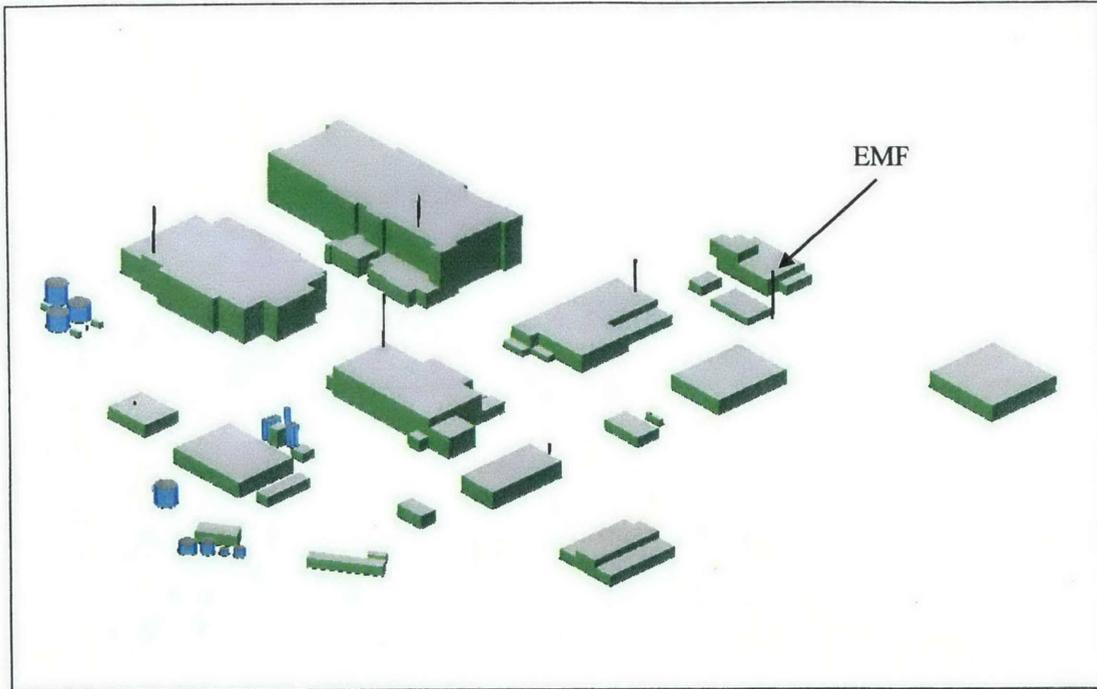
- 22
23 • 24590-BOF-M8C-C3V-00002, *EMF Stack Height Evaluation Calculation*
24 • 24590-WTP-BODCN-ENG-15-0016, *Updates to Incorporate DFLAW Content*
25 • 24590-BOF-M4C-DEP-00001, *DFLAW Effluent Management Facility Air Emissions Estimate*
26 • 24590-BOF-P1-25-00001, *Balance of Facilities LAW Effluent Process Bldg & LAW Effluent Drain*
27 *Tank Bldg General Arrangement Plan at Elev 0 Ft - 0 In*
28 • 24590-BOF-P1-26-00002, *Balance of Facilities LAW Effluent Utility Bldg & LAW Effluent Electrical*
29 *Bldg General Arrangement Sections A and B*

30

1 **Building Downwash**
2

3 The building profile input program (BPIP-Prime) was used to determine dominant structures for building
4 downwash calculations made in AERMOD for point sources. Direction-specific building heights and
5 widths of the dominant downwash structures were included in the AERMOD input file directly from the
6 BPIP-Prime results.
7

8 **Figure 9-2 BPIP-Prime Map of WTP Structures**



9
10
11 **AERMET Meteorological Data**
12

13 The AERMET preprocessing program was run with a sequential hourly meteorological data set. Five
14 consecutive years of meteorological data (CY 2001 through CY 2005) were modelled to select the year
15 that produced the highest ambient air impacts. Results conclude that CY 2004 meteorological data
16 produced the highest ambient air impacts and was therefore selected to assess EMF TAPs emissions
17 against acceptable source impact levels.

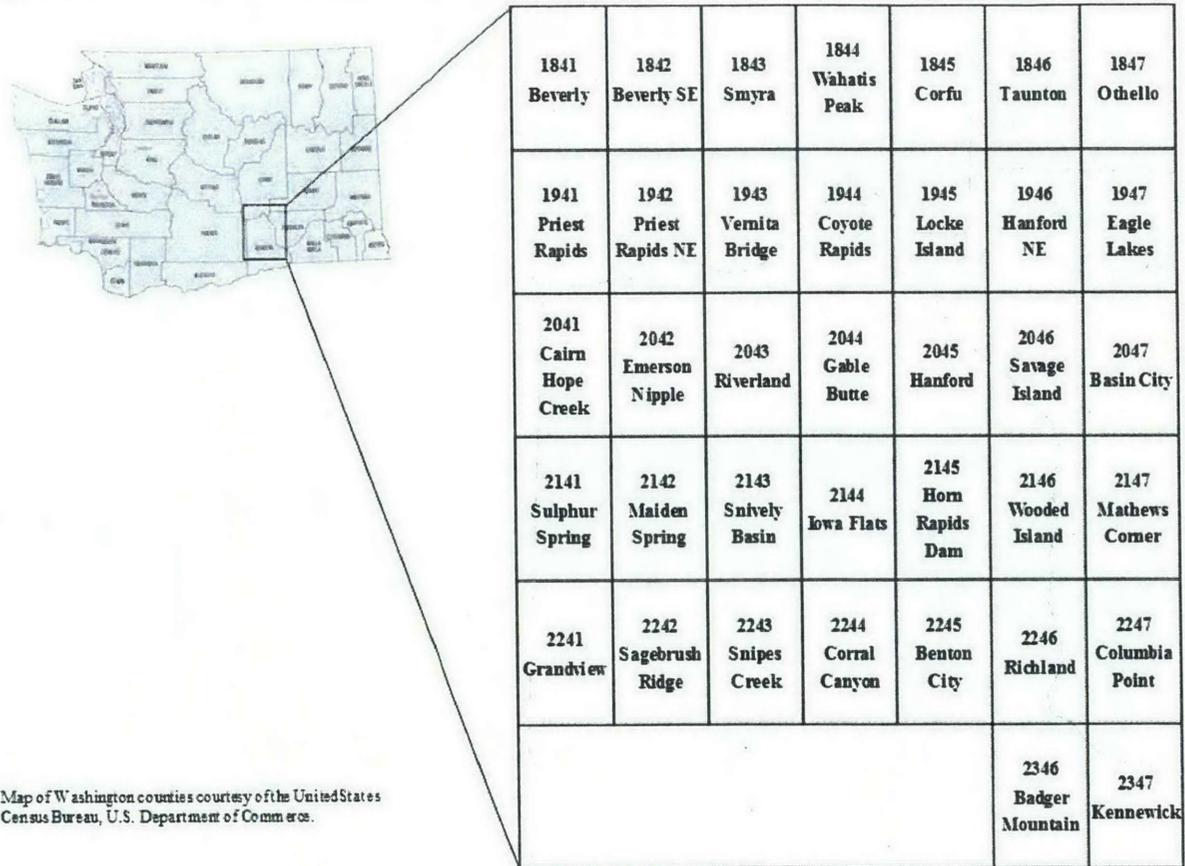
18
19 Surface air data (e.g., wind direction, wind speed, temperature, and precipitation) have been obtained
20 from station 21 of the Hanford Meteorological Monitoring Network, which is located in the 200-East
21 Area within 1 mi of WTP. The surface data is read into the model in CD-144 format.

22
23 Upper air data used to calculate mixing heights was obtained from the National Weather Service station
24 number 04106 in Spokane, Washington, which is representative of upper air east of the Cascade
25 Mountains. The upper air data is read into the model in FSL format.
26

1 **AERMAP**

2
 3 The AERMAP preprocessor required input of 10-Meter Digital Elevation Model (DEM) files, which were
 4 loaded from the Geomorphological Research Group¹ website at [http://rocky.ess.washington.edu](http://rocky.ess.washington.edu/data/raster/tenmeter/byquad/wallawalla/index.html)
 5 /data/raster/tenmeter/byquad/wallawalla/index.html (accessed February, 2006). The website contains free
 6 10-meter DEM files for download into AERMAP. Review of the Washington State 10-meter DEMs plot
 7 shows that the Walla Walla quadrangle contained the necessary DEM files for the Hanford Site boundary.
 8 Figure 9-3 lists the DEM file numbers used in the modeling analysis.

9
 10 **Figure 9-3 Map and Listing of DEM Files**



11
 12
 13 **Modeled Receptors**

14
 15 The modeling analysis used discrete receptor locations to identify the maximum impact for pollutant
 16 emissions. Because past modeling efforts showed prevailing winds to the east, a receptor grid with
 17 500-meter spacing was extended 10 km around the eastern property boundary to be sure that the
 18 maximum impacts were identified. In addition, the Energy Northwest Columbia Generating Station was
 19 also considered since there is onsite public access. A receptor location near the city of West Richland

¹ Geomorphological Research Group operates under the Quaternary Research Center & Department of Earth and
 Space Sciences, Box 351310, University of Washington, Seattle, WA 98195-1310.

1 was also considered. A total of 1811 receptor locations were modeled to determine the highest
2 ground-level concentration at an offsite receptor.

3
4 The model was run for the EMF stack using a unitized emission rate of 1 g/sec which yielded unitized
5 results of 8.78767, 0.82655, and 0.02725 $\mu\text{g}\cdot\text{s}/\text{g}\cdot\text{m}^3$ for the 1-hr, 24-hr, and annual ambient air impacts,
6 respectively. Results of the analysis showed that the maximum average impact sites are all located along
7 the Hanford Site boundary to the east and east-northeast of the WTP site.

8
9 The resulting concentrations from the AERMOD model were multiplied by the EMF TAP emission rates.
10 The resulting value was then compared to corresponding ASIL identified in WAC 173-460-150. Results
11 showed that all TAP emissions, except dimethyl mercury, are below corresponding ASILs (Table 9-1).

12 **10 Best Available Control Technology for Emissions of Toxic** 13 **Air Pollutants**

14 **10.1 Selected T-BACT for the Effluent Management Facility**

15 Pursuant to WAC 173-460-060(2), *Controls of New Sources of Toxic Air Pollutants: Control Technology*
16 *Requirements*, a T-BACT analysis is required for TAP emissions in excess of de minimis levels.
17 Estimated emissions from Section 9 show that several TAPs exceed de minimis levels (Table 9-1).

18
19 *A Best Available Control Technology Analysis for Toxic Air Pollutants for the WTP Effluent Management*
20 *Facility*, 24590-WTP-RPT-ENV-15-005 was prepared using the "top-down" approach established for
21 T-BACT. The approach consists of the following steps:

- 22
- 23 1. Identify all control technologies for an emissions source
- 24 2. Eliminate technically infeasible options
- 25 3. Rank remaining control technologies by control effectiveness
- 26 4. Evaluate most effective control(s) and document results
- 27 5. Select T-BACT.

28
29 The first step taken was to determine the quantity of TAP emissions from the EMF. As described in
30 Section 8, the DVP was defined and evaluated as the unabated emission source from the EMF. The DVP
31 system is comprised of two main parts: (1) the DEP system evaporator/condenser exhaust and (2) the
32 DEP system vessel ventilation—which contributes the bulk of potential emissions. As previously
33 described in Section 7.3.2, the ACV system also ventilates to the EMF emission unit; however, it is
34 considered an insignificant source of TAP emissions, and any potential emissions are bound by the
35 conservative assumptions integrated into the DVP emission source. As a result, the ACV system is not
36 considered in the T-BACT evaluation.

37
38 As described in Section 5.1.2, to address potential radioactive emissions from the EMF, a best available
39 radioactive control technology (BARCT) analysis was performed in parallel with the T-BACT analysis
40 and is documented in 24590-WTP-RPT-ENV-15-004, *Best Available Radionuclide Control Technology,*
41 *Analysis Addendum for the WTP Effluent Management Facility*. The BARCT selected HEPA filtration
42 for the control of radionuclide emissions from the EMF emission sources. The BARCT analysis will
43 accompany the radioactive air emissions NOC permit application submittal to WDOH (24590-WTP-RPT-

1 ENV-15-008, *Radioactive Air Emissions Notice of Construction Permit Application for the WTP Effluent*
 2 *Management Facility*), previously described in Section 5.1.2.

3
 4 The EMF T-BACT includes a detailed evaluation of available emission control technologies for the TAPs
 5 exceeding de minimis levels. After an effectiveness analysis, the cost per ton of pollutants removed was
 6 considered. For control of particulate and aerosol emissions, HEPA filtration was selected. The
 7 dual-stage HEPA filters on the DVP system will provide a combined particulate removal efficiency
 8 greater than 99.9995% (removal efficiency of 99.95% for single-stage filtration and 99.9995% for dual-
 9 stage filtration).

10
 11 The T-BACT also considered control technologies available for the removal of inorganic gases, including
 12 dimethyl mercury and volatile organic compounds. Toxic inorganic gases and volatile organic
 13 compounds were estimated to be emitted from the EMF in low quantities (Table 9-1). It was determined
 14 that in order to remove these pollutants, the cost per ton to remove the pollutants would exceed the cost
 15 ceiling effectiveness threshold established by Ecology in previously approved permitting efforts on the
 16 Hanford Site (WRPS 2010). Therefore, due to the extremely low emissions rates and prohibitive cost per
 17 ton to remove these pollutants, no T-BACT is proposed for removal of toxic organic gases or volatile
 18 organic compound emissions from EMF.

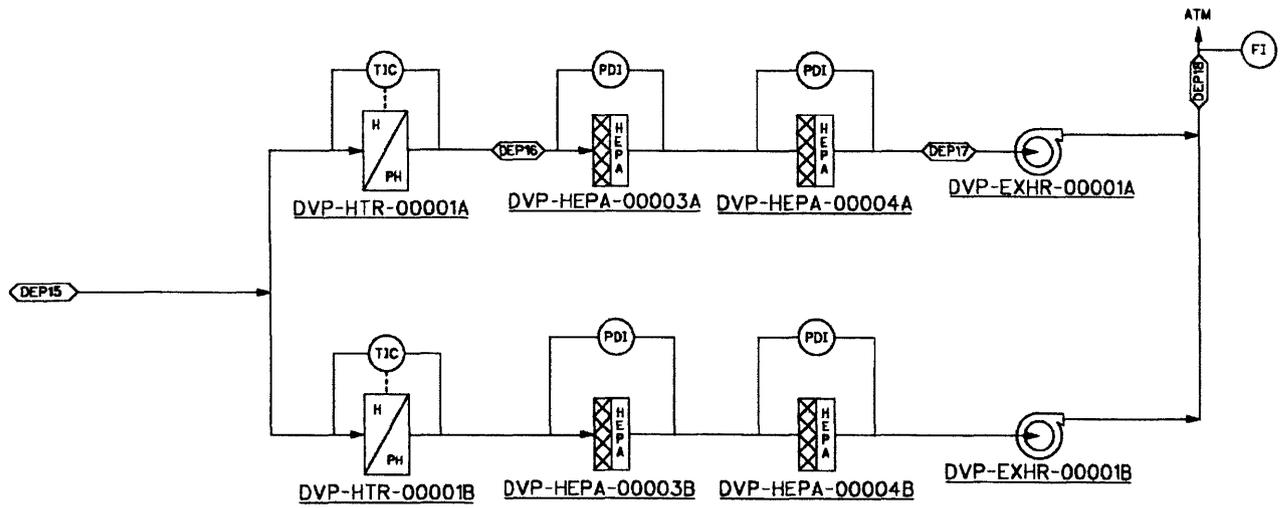
19
 20 The selected T-BACT for the EMF emissions is identified in Table 10-1 and illustrated in Figure 10-1.

21
 22 **Table 10-1 Proposed T-BACT for New EMF Emission Unit**

Facility	Emission Source	Flue Name	Proposed T-BACT Controls		
			Inorganic Gases (Ammonia and Dimethyl Mercury)	Particulates and Aerosols	Volatile Organics
EMF	DVP vessel vent and process system	EMF stack	N/A	HEPA (dual)	N/A
	ACV system ¹		N/A	HEPA	N/A

¹ The ACV system is considered a de minimis source of TAP emissions. A separate BARCT analysis selected HEPA filtration for control of particulate and aerosol radionuclide emissions.

Figure 10-1 Evaporator Process Vessel Vent (DVP) Controls



11 References

11.1 Project Documents

24590-BOF-M4C-DEP-00001, Rev A, *DFLAW Effluent Management Facility Air Emissions Estimate*.

24590-BOF-M8C-C3V-00002, Rev A, *EMF Stack Height Evaluation Calculation*.

0-BOF-P1-25-00001, *Balance of Facilities LAW Effluent Process Bldg & LAW Effluent Drain Tank Bldg General Arrangement Plan at Elev 0 Ft - 0 In*.

24590-BOF-P1-26-00002, Rev 0, *Balance of Facilities LAW Effluent Utility Bldg & LAW Effluent Electrical Bldg General Arrangement Sections A and B*.

24590-RMCD-04990, *Air Model Run for Nonrad NOC Permit 24590-WTP-RPT-ENV-15-007*.

24590-WTP-BODCN-ENG-15-0016, *Updates to Incorporate DFLAW Content*.

24590-WTP-RPT-ENV-01-009, Rev 1, *Nonradioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant*.

24590-WTP-RPT-ENV-12-002, Rev 1, *Nonradioactive Air Emissions Notice of Construction Permit Application Supplement to DE02NWP-002*.

24590-WTP-RPT-ENV-15-004, *Best Available Radionuclide Control Technology Analysis Addendum for the WTP Effluent Management Facility*.

24590-WTP-RPT-ENV-15-005, *Best Available Control Technology Analysis for Toxic Air Pollutants for the WTP Effluent Management Facility*.

24590-WTP-RPT-ENV-15-008, *Radioactive Air Emissions Notice of Construction Permit Application for the WTP Effluent Management Facility*.

CCN 258062, letter, J. Hedges (Ecology) to K. Smith (DOE-ORP), *Notice of Construction Approval Order for Diesel Turbines and Fire Pumps at the Waste Treatment Plant*. April 24, 2013.

CCN 285554, email, R Haggard (BNI) to WTP PDC, *Ecology Confirmation that EMF Not Subject to PSD Permitting*. March 14, 2016.

CCN 290160, letter, C. Hanlon-Meyer (Ecology) to R. Skinnerland (DOE-ORP), *Second Tier Petition by the U.S. Department of Energy*. January 21, 2016.

11.2 Codes and Standards

40 CFR 60. *Standards of Performance for New Stationary Sources*. Code of Federal Regulations.

40 CFR 63. *National Emission Standards for Hazardous Air Pollutants for Source Categories*. Code of Federal Regulations.

- 1 RCW 43.21C. *State Environmental Policy*. Revised Code of Washington, Olympia, WA.
- 2 RCW 43.21C.150. *State Environmental Policy: RCW 43.21C.030(2)(c) Inapplicable When Statement*
3 *Previously Prepared Pursuant to National Environmental Policy Act*. Revised Code of Washington,
4 Olympia, WA.
- 5 RCW 43.21C.030(2)(c). *State Environmental Policy: Guidelines for State Agencies, Local*
6 *Governments—Statements—Reports—Advice—Information*. Revised Code of Washington,
7 Olympia, WA.
- 8 RCW 70.94.011. *Washington Clean Air Act: Declaration of Public Policies and Purpose*. Revised Code
9 of Washington, Olympia, WA.
- 10 WAC 173-400. *General Regulations for Air Pollution Sources*. Washington Administrative Code,
11 Olympia, WA.
- 12 WAC 173-400-110, *General Regulations for Air Pollution Sources: Dangerous Waste Regulation-New*
13 *Source Review (NSR) for Sources and Portable Sources*. Washington Administrative Code,
14 Olympia, WA.
- 15 WAC 173-401. *Operating Permit Regulation*. Washington Administrative Code, Olympia, WA.
- 16 WAC 173-460. *Controls for New Sources of Toxic Air Pollutants*. Washington Administrative Code,
17 Olympia, WA.
- 18 WAC 173-460-040. *Controls for New Sources of Toxic Air Pollutants: New Source Review*. Washington
19 Administrative Code, Olympia, WA.
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Appendix A

Emissions Estimates Summary Supporting EMF Nonradioactive Air Emissions NOC Permit Application

Table A-1 Toxic Air Pollutant Emissions from EMF

CAS #	Constituents of Potential Concern	Unabated Emissions ^a (g/sec)	Abated Emissions ^a (g/sec)	Averaging Period	Unabated Emissions (lb/ averaging period)	Above De Minimis?	Abated Emissions (lb/ averaging period)	Above SQR?	Ambient Air Impact 1-hr. Conc. ^b (µg/m ³)	Ambient Air Impact 24-hr. Conc. ^b (µg/m ³)	Ambient Air Impact Annual Conc. ^b (µg/m ³)	ASIL (µg/m ³)	Above ASIL?
100-41-4	Ethylbenzene	3.34E-10	3.34E-10	year	2.32E-05	No	2.32E-05	No	2.93E-09	2.76E-10	9.10E-12	4.00E-01	No
100-42-5	Styrene	5.91E-10	1.60E-10	24-hr	1.13E-07	No	3.05E-08	No	1.41E-09	1.32E-10	4.36E-12	9.00E+02	No
100-44-7	Benzyl chloride	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	2.04E-02	No
101-77-9	4,4-Methylenedianiline	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	2.17E-03	No
103-33-3	Azobenzene	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	3.23E-02	No
10595-95-6	N-Nitrosomethylethylamine	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	1.59E-04	No
106-44-5	p-Cresol (4-methyl phenol)	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	6.00E+02	No
106-46-7	1,4-Dichlorobenzene	1.02E-07	1.01E-07	year	7.08E-03	No	7.05E-03	No	8.91E-07	8.38E-08	2.76E-09	9.09E-02	No
106-88-7	1,2-Epoxybutane	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	2.00E+01	No
106-89-8	Epichlorohydrin (1-chloro-2,3 epoxypropane)	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	4.35E-02	No
106-93-4	Ethylene dibromide	1.60E-10	1.60E-10	year	1.11E-05	No	1.11E-05	No	1.41E-09	1.32E-10	4.36E-12	1.41E-02	No
106-99-0	1,3-Butadiene	5.37E-09	5.37E-09	year	3.73E-04	No	3.73E-04	No	4.72E-08	4.44E-09	1.46E-10	5.88E-03	No
107-02-8	Acrolein	8.68E-09	8.68E-09	24-hr	1.65E-06	No	1.65E-06	No	7.63E-08	7.17E-09	2.36E-10	6.00E-02	No
107-05-1	3-Chloropropene	5.91E-10	5.91E-10	year	4.11E-05	No	4.11E-05	No	5.19E-09	4.88E-10	1.61E-11	1.67E-01	No
107-06-2	1,2-Dichloroethane	6.18E-10	1.87E-10	year	4.30E-05	No	1.30E-05	No	1.64E-09	1.55E-10	5.10E-12	3.85E-02	No
107-13-1	Acrylonitrile	6.34E-09	5.91E-09	year	4.41E-04	No	4.11E-04	No	5.19E-08	4.88E-09	1.61E-10	3.45E-03	No
107-21-1	Ethylene glycol (1,2-ethanediol)	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	4.00E+02	No
107-98-2	Propylene glycol monomethyl ether	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	7.00E+03	No
108-05-4	vinyl acetate	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	2.00E+02	No
108-10-1	Hexone	2.09E-09	2.09E-09	24-hr	3.97E-07	No	3.97E-07	No	1.83E-08	1.72E-09	5.68E-11	3.00E+03	No
108-39-4	m-Cresol	4.29E-05	4.29E-05	24-hr	8.18E-03	No	8.18E-03	No	3.77E-04	3.55E-05	1.17E-06	6.00E+02	No
108-88-3	Toluene	1.26E-09	8.34E-10	24-hr	2.41E-07	No	1.59E-07	No	7.33E-09	6.89E-10	2.27E-11	5.00E+03	No
108-90-7	Chlorobenzene	6.23E-10	1.93E-10	24-hr	1.19E-07	No	3.67E-08	No	1.69E-09	1.59E-10	5.25E-12	1.00E+03	No
108-95-2	Phenol	1.34E-07	1.34E-07	24-hr	2.56E-05	No	2.55E-05	No	1.18E-06	1.11E-07	3.65E-09	2.00E+02	No
109-86-4	2-Methoxyethanol	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	6.00E+01	No
110-54-3	Hexane	3.12E-08	3.12E-08	24-hr	5.93E-06	No	5.93E-06	No	2.74E-07	2.57E-08	8.49E-10	7.00E+02	No
110-80-5	2-Ethoxyethanol	1.13E-04	1.13E-04	24-hr	2.15E-02	No	2.15E-02	No	9.93E-04	9.34E-05	3.08E-06	7.00E+01	No
110-82-7	Cyclohexane	5.91E-10	5.91E-10	24-hr	1.12E-07	No	1.12E-07	No	5.19E-09	4.88E-10	1.61E-11	6.00E+03	No
111-15-9	Ethylene glycol monoethyl ether acetate	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	3.00E+02	No
111-44-4	Bis(2-chloroethyl)ether	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.41E-03	No
111-76-2	2-Butoxyethanol	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	1.30E+04	No
1120-71-4	1,3-Propane sultone	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.45E-03	No
117-81-7	Bis(2-ethylhexyl)phthalate	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	4.17E-02	No

Table A-1 Toxic Air Pollutant Emissions from EMF

CAS #	Constituents of Potential Concern	Unabated Emissions ^a (g/sec)	Abated Emissions ^a (g/sec)	Averaging Period	Unabated Emissions (lb/averaging period)	Above De Minimis?	Abated Emissions (lb/averaging period)	Above SQR?	Ambient Air Impact 1-hr. Conc. ^b (µg/m ³)	Ambient Air Impact 24-hr. Conc. ^b (µg/m ³)	Ambient Air Impact Annual Conc. ^b (µg/m ³)	ASIL (µg/m ³)	Above ASIL?
118-74-1	Hexachlorobenzene	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.96E-03	No
121-14-2	2,4-Dinitrotoluene	2.29E-08	2.27E-08	year	1.59E-03	No	1.58E-03	No	2.00E-07	1.88E-08	6.20E-10	1.12E-02	No
122-66-7	1,2-Diphenylhydrazine	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	4.00E-03	No
123-91-1	1,4-Dioxane	5.91E-09	5.91E-09	year	4.11E-04	No	4.11E-04	No	5.19E-08	4.88E-09	1.61E-10	1.30E-01	No
124-48-1	Chlorodibromomethane	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	3.70E-02	No
127-18-4	Tetrachloroethene	1.95E-10	1.95E-10	year	1.35E-05	No	1.35E-05	No	1.71E-09	1.61E-10	5.30E-12	1.69E-01	No
133-06-2	Captan	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.52E+00	No
1336-36-3	Aroclors (Total PCB)	2.59E-05	2.59E-05	year	1.80E+00	Yes	1.80E+00	Yes	2.28E-04	2.14E-05	7.07E-07	1.75E-03	No
156-60-5	1,2-trans-Dichloroethene	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	8.07E+02	No
1634-04-4	tert-Butyl methyl ether	1.69E-05	1.69E-05	year	1.17E+00	No	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	3.85E+00	No
1746-01-6	2,3,7,8-Tetrachlorodibenzo(p)dioxin (TCDD)	5.65E-17	2.82E-22	year	3.93E-12	No	1.96E-17	No	2.48E-21	2.33E-22	7.70E-24	2.63E-08	No
189-55-9	Dibenzo[a,i]pyrene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	9.09E-05	No
189-64-0	Dibenzo[a,h]pyrene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	9.09E-05	No
191-30-0	Dibenzo[a,l]pyrene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	9.09E-05	No
192-65-4	Dibenzo[a,e]pyrene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	9.09E-04	No
193-39-5	Indeno[1,2,3-cd]pyrene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	9.09E-03	No
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin	4.44E-16	2.22E-21	year	3.08E-11	No	1.54E-16	No	1.95E-20	1.83E-21	6.04E-23	2.63E-07	No
205-82-3	Benzo[j]fluoranthene	1.00E-09	5.00E-15	year	6.95E-05	No	3.48E-10	No	4.39E-14	4.13E-15	1.36E-16	9.09E-03	No
205-99-2	Benzo(b)fluoranthene	8.29E-11	4.15E-16	year	5.77E-06	No	2.88E-11	No	3.64E-15	3.43E-16	1.13E-17	9.09E-03	No
207-08-9	Benzo(k)fluoranthene	1.80E-09	9.02E-15	year	1.25E-04	No	6.27E-10	No	7.93E-14	7.46E-15	2.46E-16	9.09E-03	No
218-01-9	Chrysene	6.78E-10	3.39E-15	year	4.71E-05	No	2.36E-10	No	2.98E-14	2.80E-15	9.24E-17	9.09E-02	No
224-42-0	Dibenz[a,j]acridine	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	9.09E-03	No
226-36-8	Dibenz[a,h]acridine	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	9.09E-03	No
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl (PCB 118)	7.13E-14	3.56E-19	year	4.96E-09	No	2.48E-14	No	3.13E-18	2.95E-19	9.71E-21	2.63E-04	No
319-84-6	alpha-BHC	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.30E-03	No
319-85-7	beta-BHC	2.44E-12	1.22E-17	year	1.70E-07	No	8.48E-13	No	1.07E-16	1.01E-17	3.32E-19	2.33E-03	No
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	5.98E-15	2.99E-20	year	4.16E-10	No	2.08E-15	No	2.63E-19	2.47E-20	8.15E-22	2.63E-04	No
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)	3.04E-15	1.52E-20	year	2.12E-10	No	1.06E-15	No	1.34E-19	1.26E-20	4.15E-22	2.63E-04	No
3268-87-9	Octachlorodibenzo(p)dioxin	8.00E-11	4.00E-16	year	5.56E-06	No	2.78E-11	No	3.52E-15	3.31E-16	1.09E-17	2.63E-04	No
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	4.06E-17	2.03E-22	year	2.82E-12	No	1.41E-17	No	1.78E-21	1.68E-22	5.53E-24	2.63E-04	No
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin	7.83E-12	3.91E-17	year	5.44E-07	No	2.72E-12	No	3.44E-16	3.23E-17	1.07E-18	2.63E-06	No
3697-24-3	5-Methylchrysene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	9.09E-04	No
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	1.94E-15	9.68E-21	year	1.35E-10	No	6.73E-16	No	8.51E-20	8.00E-21	2.64E-22	5.26E-05	No

Table A-1 Toxic Air Pollutant Emissions from EMF

CAS #	Constituents of Potential Concern	Unabated Emissions* (g/sec)	Abated Emissions* (g/sec)	Averaging Period	Unabated Emissions (lb/ averaging period)	Above De Minimis?	Abated Emissions (lb/ averaging period)	Above SQER?	Ambient Air Impact 1-hr. Conc. ^b (µg/m ³)	Ambient Air Impact 24-hr. Conc. ^b (µg/m ³)	Ambient Air Impact Annual Conc. ^b (µg/m ³)	ASIL (µg/m ³)	Above ASIL?
39001-02-0	Octachlorodibenzofuran	3.41E-11	1.70E-16	year	2.37E-06	No	1.19E-11	No	1.50E-15	1.41E-16	4.65E-18	2.63E-04	No
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin	1.91E-16	9.55E-22	year	1.33E-11	No	6.64E-17	No	8.39E-21	7.89E-22	2.60E-23	2.63E-07	No
39635-31-9	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	5.96E-16	2.98E-21	year	4.15E-11	No	2.07E-16	No	2.62E-20	2.46E-21	8.13E-23	2.63E-04	No
40321-76-4	1,2,3,7,8-Pentachlorodibenzo(p)dioxin	1.25E-16	6.23E-22	year	8.67E-12	No	4.33E-17	No	5.48E-21	5.15E-22	1.70E-23	2.63E-08	No
50-00-0	Formaldehyde	1.69E-05	1.69E-05	year	1.17E+00	No	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	1.67E-01	No
50-32-8	Benzo(a)pyrene	6.81E-09	6.77E-09	year	4.74E-04	No	4.71E-04	No	5.95E-08	5.60E-09	1.85E-10	9.09E-04	No
510-15-6	Chlorobenzilate	3.29E-10	1.65E-15	year	2.29E-05	No	1.14E-10	No	1.45E-14	1.36E-15	4.49E-17	3.23E-02	No
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	2.67E-11	1.34E-16	year	1.86E-06	No	9.29E-12	No	1.17E-15	1.10E-16	3.64E-18	2.63E-07	No
51-79-6	Ethyl carbamate (urethane)	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	3.45E-03	No
52663-72-6	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	1.03E-15	5.13E-21	year	7.14E-11	No	3.57E-16	No	4.51E-20	4.24E-21	1.40E-22	2.63E-04	No
532-27-4	2-Chloroacetophenone	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	3.00E-02	No
53-70-3	Dibenz[a,h]anthracene	3.82E-09	1.45E-09	year	2.66E-04	No	1.01E-04	No	1.28E-08	1.20E-09	3.96E-11	8.33E-04	No
540-73-8	1,2-Dimethylhydrazine	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	6.25E-06	No
542-75-6	1,3-Dichloropropene	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	6.25E-06	No
542-88-1	Bis(chloromethyl)ether	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	7.69E-05	No
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	1.53E-16	7.63E-22	year	1.06E-11	No	5.30E-17	No	6.70E-21	6.30E-22	2.08E-23	2.63E-06	No
56-23-5	Carbon tetrachloride	7.36E-10	3.05E-10	year	5.12E-05	No	2.12E-05	No	2.68E-09	2.52E-10	8.32E-12	2.38E-02	No
56-49-5	3-Methylcholanthrene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	Yes	1.48E-04	1.39E-05	4.60E-07	1.59E-04	No
56-55-3	Benzo(a)anthracene	1.29E-09	6.45E-15	year	8.97E-05	No	4.48E-10	No	5.67E-14	5.33E-15	1.76E-16	9.09E-03	No
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	2.44E-11	1.22E-16	year	1.70E-06	Yes	8.49E-12	No	1.07E-15	1.01E-16	3.33E-18	5.26E-08	No
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	6.67E-11	3.33E-16	year	4.63E-06	No	2.32E-11	No	2.93E-15	2.75E-16	9.08E-18	5.26E-07	No
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	1.02E-11	5.09E-17	year	7.07E-07	No	3.54E-12	No	4.47E-16	4.20E-17	1.39E-18	2.63E-07	No
57465-28-8	3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	1.35E-16	6.73E-22	year	9.36E-12	No	4.68E-17	No	5.92E-21	5.57E-22	1.83E-23	2.63E-07	No
57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo(p)dioxin	4.20E-16	2.10E-21	year	2.92E-11	No	1.46E-16	No	1.84E-20	1.73E-21	5.72E-23	2.63E-07	No
57-74-9	Chlordane	1.71E-11	8.54E-17	year	1.19E-06	No	5.93E-12	No	7.50E-16	7.06E-17	2.33E-18	2.94E-03	No
584-84-9	2,4-Toluene diisocyanate	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	7.00E-02	No
58-89-9	gamma-BHC (Lindane)	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	3.23E-03	No
593-60-2	Bromoethene (Vinyl bromide)	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	3.00E+00	No
59-89-2	Morpholine, 4-Nitroso-	1.21E-08	1.21E-08	year	8.43E-04	No	8.43E-04	No	1.07E-07	1.00E-08	3.30E-10	5.26E-04	No
60-11-7	Dimethyl aminoazobenzene	1.12E-09	5.61E-15	year	7.80E-05	No	3.90E-10	No	4.93E-14	4.64E-15	1.53E-16	7.69E+04	No
602-87-9	5-Nitroacenaphthene	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	2.70E-02	No
60-35-5	Acetamide	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	5.00E-02	No
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	1.43E-16	7.14E-22	year	9.93E-12	No	4.97E-17	No	6.28E-21	5.90E-22	1.95E-23	2.63E-07	No

Table A-1 Toxic Air Pollutant Emissions from EMF

CAS #	Constituents of Potential Concern	Unabated Emissions ^a (g/sec)	Abated Emissions ^a (g/sec)	Averaging Period	Unabated Emissions (lb/ averaging period)	Above De Minimis?	Abated Emissions (lb/ averaging period)	Above SQER?	Ambient Air Impact 1-hr. Conc. ^b (µg/m ³)	Ambient Air Impact 24-hr. Conc. ^b (µg/m ³)	Ambient Air Impact Annual Conc. ^b (µg/m ³)	ASIL (µg/m ³)	Above ASIL?
621-64-7	N-Nitroso-di-n-propylamine	4.89E-07	4.89E-07	year	3.40E-02	Yes	3.40E-02	No	4.30E-06	4.04E-07	1.33E-08	5.00E-04	No
624-83-9	Methyl isocyanate	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	1.00E+00	No
62-53-3	Aniline	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	6.25E-01	No
62-75-9	N-Nitrosodimethylamine	2.10E-09	2.10E-09	year	1.46E-04	No	1.46E-04	No	1.84E-08	1.73E-09	5.71E-11	2.17E-04	No
630-20-6	1,1,1,2-Tetrachloroethane	1.69E-05	1.69E-05	year	1.17E+00	No	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	1.35E-01	No
65510-44-3	2,3,4,4',5-Pentachlorobiphenyl (PCB 123)	9.52E-17	4.76E-22	year	6.62E-12	No	3.31E-17	No	4.18E-21	3.93E-22	1.30E-23	2.63E-04	No
67-56-1	Methyl alcohol	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	4.00E+03	No
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.12E-16	1.06E-21	year	1.47E-11	No	7.37E-17	No	9.32E-21	8.76E-22	2.89E-23	2.63E-06	No
67-63-0	Isopropyl alcohol	1.65E-08	1.65E-08	1-hr	1.31E-07	No	1.31E-07	No	1.45E-07	1.36E-08	4.49E-10	3.20E+03	No
67-66-3	Chloroform	6.31E-10	2.00E-10	year	4.39E-05	No	1.39E-05	No	1.76E-09	1.65E-10	5.45E-12	4.35E-02	No
67-72-1	Hexachloroethane	2.36E-06	2.36E-06	year	1.64E-01	No	1.64E-01	No	2.07E-05	1.95E-06	6.43E-08	9.09E-02	No
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	6.16E-16	3.08E-21	year	4.28E-11	No	2.14E-16	No	2.71E-20	2.55E-21	8.39E-23	5.26E-05	No
70362-50-4	3,4,4',5-Tetrachlorobiphenyl (PCB 81)	7.25E-17	3.62E-22	year	5.04E-12	No	2.52E-17	No	3.18E-21	3.00E-22	9.88E-24	2.63E-04	No
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	4.09E-11	2.04E-16	year	2.84E-06	Yes	1.42E-11	No	1.80E-15	1.69E-16	5.57E-18	2.63E-07	No
71-43-2	Benzene	9.36E-10	5.05E-10	year	6.51E-05	No	3.51E-05	No	4.44E-09	4.17E-10	1.38E-11	3.45E-02	No
71-55-6	1,1,1-Trichloroethane	1.98E-10	1.98E-10	24-hr	3.77E-08	No	3.77E-08	No	1.74E-09	1.63E-10	5.39E-12	1.00E+03	No
72-55-9	4,4-DDE	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	1.03E-02	No
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	3.48E-13	1.74E-18	year	2.42E-08	No	1.21E-13	No	1.53E-17	1.44E-18	4.74E-20	2.63E-07	No
74472-37-0	2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	1.22E-16	6.12E-22	year	8.51E-12	No	4.25E-17	No	5.38E-21	5.06E-22	1.67E-23	5.26E-05	No
74-83-9	Bromomethane	8.30E-10	3.99E-10	24-hr	1.58E-07	No	7.60E-08	No	3.51E-09	3.30E-10	1.09E-11	5.00E+00	No
74-87-3	Chloromethane	1.23E-09	7.95E-10	24-hr	2.34E-07	No	1.51E-07	No	6.99E-09	6.57E-10	2.17E-11	9.00E+01	No
75-00-3	Chloroethane	3.99E-10	3.99E-10	24-hr	7.60E-08	No	7.60E-08	No	3.51E-09	3.30E-10	1.09E-11	3.00E+04	No
75-01-4	Vinyl chloride	4.05E-10	4.05E-10	year	2.82E-05	No	2.82E-05	No	3.56E-09	3.35E-10	1.10E-11	1.28E-02	No
75-05-8	Acetonitrile	1.46E-07	1.46E-07	year	1.01E-02	No	1.01E-02	No	1.28E-06	1.20E-07	3.97E-09	6.00E+01	No
75-07-0	Acetaldehyde	1.69E-05	1.69E-05	year	1.17E+00	No	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	3.70E-01	No
75-09-2	Methylenechloride	1.19E-07	1.18E-07	year	8.26E-03	No	8.23E-03	No	1.04E-06	9.78E-08	3.23E-09	1.00E+00	No
75-21-8	Ethylene oxide (Oxirane)	3.44E-08	3.44E-08	year	2.39E-03	No	2.39E-03	No	3.02E-07	2.84E-08	9.38E-10	1.14E-02	No
75-25-2	Bromoform	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	9.09E-01	No
75-27-4	Bromodichloromethane	1.69E-05	1.69E-05	year	1.17E+00	Yes	1.17E+00	No	1.48E-04	1.39E-05	4.60E-07	2.70E-02	No
75-34-3	1,1-Dichloroethane	1.60E-10	1.60E-10	year	1.11E-05	No	1.11E-05	No	1.41E-09	1.32E-10	4.36E-12	6.25E-01	No
75-35-4	1,1-Dichloroethene	2.52E-10	2.52E-10	24-hr	4.79E-08	No	4.79E-08	No	2.21E-09	2.08E-10	6.86E-12	2.00E+02	No
75-44-5	Phosgene (hydrogen phosphide)	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	3.00E-01	No
75-45-6	Chlorodifluoromethane	5.91E-10	5.91E-10	24-hr	1.12E-07	No	1.12E-07	No	5.19E-09	4.88E-10	1.61E-11	5.00E+04	No

Table A-1 Toxic Air Pollutant Emissions from EMF

CAS #	Constituents of Potential Concern	Unabated Emissions ^a (g/sec)	Abated Emissions ^a (g/sec)	Averaging Period	Unabated Emissions (lb/averaging period)	Above De Minimis?	Abated Emissions (lb/averaging period)	Above SQER?	Ambient Air Impact 1-hr. Conc. ^b (µg/m ³)	Ambient Air Impact 24-hr. Conc. ^b (µg/m ³)	Ambient Air Impact Annual Conc. ^b (µg/m ³)	ASIL (µg/m ³)	Above ASIL?
76-44-8	Heptachlor	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	7.69E-05	No
77-47-4	Hexachlorocyclopentadiene	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	2.00E-01	No
78-87-5	1,2-Dichloropropane	1.60E-10	1.60E-10	year	1.11E-05	No	1.11E-05	No	1.41E-09	1.32E-10	4.36E-12	1.00E-01	No
78-93-3	2-Butanone	6.44E-08	6.40E-08	24-hr	1.23E-05	No	1.22E-05	No	5.62E-07	5.29E-08	1.74E-09	5.00E+03	No
79-00-5	1,1,2-Trichloroethane	1.87E-10	1.87E-10	year	1.30E-05	No	1.30E-05	No	1.65E-09	1.55E-10	5.11E-12	6.25E-02	No
79-01-6	Trichloroethene	6.44E-10	2.13E-10	year	4.48E-05	No	1.48E-05	No	1.87E-09	1.76E-10	5.80E-12	5.00E-01	No
79-10-7	2-Propenoic acid	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	1.00E+00	No
79-34-5	1,1,2,2-Tetrachloroethane	1.88E-10	1.88E-10	year	1.30E-05	No	1.30E-05	No	1.65E-09	1.55E-10	5.11E-12	1.72E-02	No
79-46-9	2-Nitropropane	3.95E-08	3.95E-08	24-hr	7.52E-06	No	7.52E-06	No	3.47E-07	3.26E-08	1.08E-09	2.00E+01	No
80-62-6	Methyl methacrylate	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	7.00E-02	No
822-06-0	Hexamethylene-1,5-diisocyanate	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	7.00E-02	No
85-44-9	Phthalic anhydride (1,2-benzenedicarboxylic anhydride)	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	2.00E+01	No
87-68-3	Hexachlorobutadiene	1.01E-07	1.01E-07	year	7.05E-03	No	7.05E-03	No	8.91E-07	8.38E-08	2.76E-09	4.55E-02	No
87-86-5	Pentachlorophenol	9.76E-08	9.76E-08	year	6.78E-03	No	6.78E-03	No	8.57E-07	8.06E-08	2.66E-09	2.17E-01	No
88-06-2	2,4,6-Trichlorophenol	1.68E-06	1.68E-06	year	1.17E-01	No	1.17E-01	No	1.48E-05	1.39E-06	4.58E-08	5.00E-02	No
90-04-0	o-Anisidine	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	2.50E-02	No
91-20-3	Naphthalene	5.29E-05	5.29E-05	year	3.68E+00	Yes	3.68E+00	No	4.65E-04	4.37E-05	1.44E-06	2.94E-02	No
91-94-1	3,3'-Dichlorobenzidine	1.26E-09	6.29E-15	year	8.75E-05	No	4.37E-10	No	5.53E-14	5.20E-15	1.71E-16	2.94E-03	No
924-16-3	N-Nitroso-di-n-Buetylamine	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	3.23E-04	No
94-59-7	Safrole (5-(2-Propenyl)-1,3-benzodioxole)	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.59E-02	No
95-48-7	2-Methylphenol	5.96E-05	5.96E-05	24-hr	1.14E-02	No	1.14E-02	No	5.24E-04	4.93E-05	1.62E-06	6.00E+02	No
95-53-4	o-Toluidine	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	1.96E-02	No
96-12-8	1,2-Dibromo-3-chloropropane	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	5.26E-04	No
96-18-4	1,2,3-Trichloropropane	4.31E-10	2.15E-15	24-hr	8.21E-08	No	4.10E-13	No	1.89E-14	1.78E-15	5.87E-17	1.84E+00	No
96-45-7	Ethylene thiourea	4.31E-10	2.15E-15	year	3.00E-05	No	1.50E-10	No	1.89E-14	1.78E-15	5.87E-17	7.69E-02	No
98-82-8	Isopropylbenzene	1.69E-05	1.69E-05	24-hr	3.21E-03	No	3.21E-03	No	1.48E-04	1.39E-05	4.60E-07	4.00E+02	No
10028-15-6	Ozone	0.00E+00	0.00E+00	1-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	1.80E+02	No
10102-44-0	Nitrogen dioxide	0.00E+00	0.00E+00	1-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	4.70E+02	No
18540-29-9	Chromium VI	1.44E-05	7.20E-11	year	1.00E+00	Yes	5.00E-06	No	6.32E-10	5.95E-11	1.96E-12	6.67E-06	No
593-74-8	Dimethyl Mercury	5.29E-07	5.29E-07	24-hr	1.01E-04	Yes	1.01E-04	Yes	4.64E-06	4.37E-07	1.44E-08	1.00E-99	Yes
630-08-0	Carbon monoxide	0.00E+00	0.00E+00	1-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	2.30E+04	No
7439-97-6	Mercury	1.48E-07	7.38E-13	24-hr	2.81E-05	No	1.41E-10	No	6.49E-12	6.10E-13	2.01E-14	9.00E-02	No

Table A-1 Toxic Air Pollutant Emissions from EMF

CAS #	Constituents of Potential Concern	Unabated Emissions ^a (g/sec)	Abated Emissions ^a (g/sec)	Averaging Period	Unabated Emissions (lb/ averaging period)	Above De Minimis?	Abated Emissions (lb/ averaging period)	Above SQR?	Ambient Air Impact 1-hr. Conc. ^b (µg/m ³)	Ambient Air Impact 24-hr. Conc. ^b (µg/m ³)	Ambient Air Impact Annual Conc. ^b (µg/m ³)	ASIL (µg/m ³)	Above ASIL?
7440-43-9	Cadmium	4.06E-07	2.03E-12	year	2.82E-02	Yes	1.41E-07	No	1.78E-11	1.68E-12	5.53E-14	2.38E-04	No
7440-48-4	Cobalt	8.02E-08	4.01E-13	24-hr	1.53E-05	No	7.64E-11	No	3.52E-12	3.31E-13	1.09E-14	1.00E-01	No
7440-62-2	Vanadium	1.33E-07	6.63E-13	24-hr	2.53E-05	No	1.26E-10	No	5.83E-12	5.48E-13	1.81E-14	2.00E-01	No
7647-01-0	Hydrogen chloride	0.00E+00	0.00E+00	24-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	9.00E+00	No
7664-39-3	Hydrogen Fluoride	0.00E+00	0.00E+00	24-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	1.40E+01	No
7664-41-7	Ammonia	1.01E-01	1.01E-01	24-hr	1.92E+01	Yes	1.92E+01	Yes	8.84E-01	8.32E-02	2.74E-03	7.08E+01	No
7723-14-0	Phosphorus	0.00E+00	0.00E+00	24-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	2.00E+01	No
7782-41-4	Fluorine gas	0.00E+00	0.00E+00	24-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	1.58E+01	No
7782-50-5	Chlorine	0.00E+00	0.00E+00	24-hr	0.00E+00	No	0.00E+00	No	0.00E+00	0.00E+00	0.00E+00	2.00E-01	No

^a Blue font indicates constituents with assumed emission rates (refer to Section 9.1).

^b The ambient air impact was determined by multiplying the abated emissions by the air modeling results for the 1-hr, 24-hr, and annual averaging periods (8.78767, 0.82655, and 0.02725 µg-s/g-m³, respectively). Bold font indicates the appropriate Ambient Air Impact for comparison with the ASIL.

^c It is proposed that the Second-Tier Review Petition, which was previously reviewed and approved by Ecology on January 21, 2016, be used to satisfy WAC 173-460-090 requirements for dimethyl mercury for this application. The Second-Tier Review Petition is a bounding dimethyl mercury health impact assessment that covers the emissions from the activities proposed in this application (Section 9.2.1).

Attachment 2
16-ECD-0032
(7 Pages Excluding Cover Sheet)

ECY 070-410,
Notice of Construction Application



Notice of Construction Application

This application applies statewide for facilities under the Department of Ecology's jurisdiction. Submit this form for review of your project to construct a new or modified source of air emissions. Please refer to Ecology Forms ECY 070-410a-g, "Instructions for NOC Application," for general information about completing the application.

Ecology offers up to two hours of free pre-application assistance. We encourage you to schedule a pre-application meeting with the contact person specified for the location of your proposal, below. If you use up your two hours of free pre-application assistance, we will continue to assist you after you submit Part 1 of the application and the application fee. You may schedule a meeting with us at any point in the process.

Upon completion of the application, please enclose a check for the initial fee and mail to:

**Department of Ecology
Cashiering Unit
P.O. Box 47611
Olympia, WA 98504-7611**

For Fiscal Office Use Only:
001-NSR-216-0299-000404

Check the box for the location of your proposal. For assistance, call the contact listed below:		
	Ecology Permitting Office	Contact
<input type="checkbox"/>	Chelan, Douglas, Kittitas, Klickitat, or Okanogan County Ecology Central Regional Office – Air Quality Program	Lynnette Haller (509) 457-7126 lynnette.haller@ecy.wa.gov
<input type="checkbox"/>	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla or Whitman County Ecology Eastern Regional Office – Air Quality Program	Greg Flibbert (509) 329-3452 gregory.flibbert@ecy.wa.gov
<input type="checkbox"/>	San Juan County Ecology Northwest Regional Office – Air Quality Program	David Adler (425) 649-7082 david.adler@ecy.wa.gov
<input type="checkbox"/>	For actions taken at Kraft and Sulfite Paper Mills and Aluminum Smelters Ecology Industrial Section – Waste 2 Resources Program Permit manager: _____	Garin Schrieve (360) 407-6916 garin.schrieve@ecy.wa.gov
<input checked="" type="checkbox"/>	For actions taken on the US Department of Energy Hanford Reservation Ecology Nuclear Waste Program	Philip Gent (509) 372-7983 philip.gent@ecy.wa.gov



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Check the box below for the fee that applies to your application.

New project or equipment:

<input checked="" type="checkbox"/>	\$1,500: Basic project initial fee covers up to 16 hours of review.
<input type="checkbox"/>	\$10,000: Complex project initial fee covers up to 106 hours of review.

Change to an existing permit or equipment:

<input type="checkbox"/>	\$200: Administrative or simple change initial fee covers up to 3 hours of review Ecology may determine your change is complex during completeness review of your application. If your project is complex, you must pay the additional \$675 before we will continue working on your application.
<input type="checkbox"/>	\$875: Complex change initial fee covers up to 10 hours of review
<input type="checkbox"/>	\$350 flat fee: Replace or alter control technology equipment under WAC 173-400-114 Ecology will contact you if we determine your change belongs in another fee category. You must pay the fee associated with that category before we will continue working on your application.

Read each statement, then check the box next to it to acknowledge that you agree.

<input checked="" type="checkbox"/>	The initial fee you submitted may not cover the cost of processing your application. Ecology will track the number of hours spent on your project. If the number of hours Ecology spends exceeds the hours included in your initial fee, Ecology will bill you \$95 per hour for the extra time.
<input checked="" type="checkbox"/>	You must include all information requested by this application. Ecology may not process your application if it does not include all the information requested.
<input checked="" type="checkbox"/>	Submittal of this application allows Ecology staff to visit and inspect your facility.



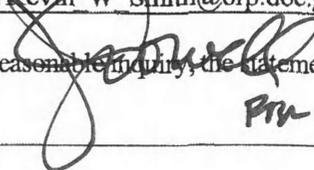
Notice of Construction Application

Part 1: General Information

I. Project, Facility, and Company Information

1. Project Name Hanford Tank Waste Treatment and Immobilization Plant	
2. Facility Name Department of Energy, Office of River Protection	
3. Facility Street Address 2440 Stevens Center Place, H660, Richland, WA 99354	
4. Facility Legal Description Treatment and storage of radioactive and dangerous mixed waste from Hanford Site Double Shell Tank system	
5. Company Legal Name (if different from Facility Name) Department of Energy, Office of River Protection	
6. Company Mailing Address (street, city, state, zip) PO Box 450, MSIN H6-60, Richland, WA 99352	

II. Contact Information and Certification

1. Facility Contact Name (who will be onsite) Dennis Bowser	
2. Facility Contact Mailing Address (if different than Company Mailing Address)	
3. Facility Contact Phone Number 509-373-2566	4. Facility Contact E-mail Dennis W Bowser@rl.gov
5. Billing Contact Name (who should receive billing information) Dennis Bowser	
6. Billing Contact Mailing Address (if different than Company Mailing Address)	
7. Billing Contact Phone Number 509-373-2566	8. Billing Contact E-mail Dennis W Bowser@rl.gov
9. Consultant Name (optional – if 3 rd party hired to complete application elements) NA	
10. Consultant Organization/Company NA	
11. Consultant Mailing Address (street, city, state, zip) NA	
12. Consultant Phone Number NA	13. Consultant E-mail NA
14. Responsible Official Name and Title (who is responsible for project policy or decision-making) Kevin Smith	
16. Responsible Official Phone 509-372-2315	17. Responsible Official E-mail Kevin W Smith@orp.doe.gov
18. Responsible Official Certification and Signature I certify, based on information and belief formed after reasonable inquiry, the statements and information in this application are true, accurate and complete. <div style="text-align: right;"> KSM</div>	



Notice of Construction Application

1. Facility Contact Name (who will be onsite) Dennis Bowser	
2. Facility Contact Mailing Address (if different than Company Mailing Address)	
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9. Consultant Name (optional – if 3 rd party hired to complete application elements) NA	
10. Consultant Organization/Company NA	
11. Consultant Mailing Address (street, city, state, zip) NA	
12. Consultant Phone Number NA	13. Consultant E-mail NA
Signature _____ Date _____	

Part 2: Technical Information

The Technical Information may be sent with this application form to the Cashiering Unit, or may be sent directly to the Ecology regional office with jurisdiction along with a copy of this application form.

For all sections, check the box next to each item as you complete it.

III. Project Description

Please attach the following to your application.

- Written narrative describing your proposed project.
- Projected construction start and completion dates.
- Operating schedule and production rates.
- List of all major process equipment with manufacturer and maximum rated capacity.
- Process flow diagram with all emission points identified.
- Plan view site map.

- Manufacturer specification sheets for major process equipment components.
- Manufacturer specification sheets for pollution control equipment.
- Fuel specifications, including type, consumption (per hour & per year) and percent sulfur.



DEPARTMENT OF
ECOLOGY
State of Washington

Notice of Construction Application

IV. State Environmental Policy Act (SEPA) Compliance

Check the appropriate box below.

SEPA review is complete:

Include a copy of the final SEPA checklist and SEPA determination (e.g., DNS, MDNS, EIS) with your application.

SEPA review has not been conducted:

If review will be conducted by another agency, list the agency. You must provide a copy of the final SEPA checklist and SEPA determination before Ecology will issue your permit.

Agency Reviewing SEPA:

If the review will be conducted by Ecology, fill out a SEPA checklist and submit it with your application. You can find a SEPA checklist online at www.ecy.wa.gov/programs/sea/sepa/docs/echecklist.doc



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V. Emissions Estimations of Criteria Pollutants

Does your project generate criteria air pollutant emissions? Yes No

If yes, please provide the following information regarding your criteria emissions in your application.

- The names of the criteria air pollutants emitted (i.e., NO_x, SO₂, CO, PM_{2.5}, PM₁₀, TSP, VOC, and Pb)
- Potential emissions of criteria air pollutants in tons per hour, tons per day, and tons per year (include calculations)
- If there will be any fugitive criteria pollutant emissions, clearly identify the pollutant and quantity

VI. Emissions Estimations of Toxic Air Pollutants

Does your project generate toxic air pollutant emissions? Yes No

If yes, please provide the following information regarding your toxic air pollutant emissions in your application.

- The names of the toxic air pollutants emitted (specified in WAC 173-460-150¹)
- Potential emissions of toxic air pollutants in pounds per hour, pounds per day, and pounds per year (include calculations)
- If there will be any fugitive toxic air pollutant emissions, clearly identify the pollutant and quantity

VII. Emission Standard Compliance

Provide a list of all applicable new source performance standards, national emission standards for hazardous air pollutants, national emission standards for hazardous air pollutants for source categories, and emission standards adopted under Chapter 70.94 RCW.

Does your project comply with all applicable standards identified? Yes No

VIII. Best Available Control Technology

Provide a complete evaluation of Best Available Control Technology (BACT) for your proposal.

IX. Ambient Air Impacts Analyses

Please provide the following:

- Ambient air impacts analyses for Criteria Air Pollutants (including fugitive emissions)
- Ambient air impacts analyses for Toxic Air Pollutants (including fugitive emissions)

¹ <http://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150>



Notice of Construction Application

Discharge point data for each point included in air impacts analyses (include only if modeling is required)

- Exhaust height
- Exhaust inside dimensions (ex. diameter or length and width)
- Exhaust gas velocity or volumetric flow rate
- Exhaust gas exit temperature
- The volumetric flow rate
- Description of the discharges (i.e., vertically or horizontally) and whether there are any obstructions (ex., raincap)
- Identification of the emission unit(s) discharging from the point
- The distance from the stack to the nearest property line
- Emission unit building height, width, and length
- Height of tallest building on-site or in the vicinity and the nearest distance of that building to the exhaust
- Whether the facility is in an urban or rural location

Does your project cause or contribute to a violation of any ambient air quality standard or acceptable source impact level? Yes No

Attachment 3
16-ECD-0032
Compact Disk

24590-WTP-RPT-ENV-15-007,
Air Model Run for Nonrad NOC Permit

Attachment 4
16-ECD-0032
(74 Pages Excluding Cover Sheet)

24590-WTP-RPT-ENV-15-005, Rev. 0,
*Best Available Control Technology Analysis for
Toxic Air Pollutants for the WTP Effluent Management Facility*



Best Available Control Technology Analysis for Toxic Air Pollutants for the WTP Effluent Management Facility

Document title:

Document number: 24590-WTP-RPT-ENV-15-005, Rev 0

Contract number: DE-AC27-01RV14136

Department: Process Engineering

Author(s): Daniel Choroser *Daniel Choroser*

Checked by: William Hix *William Hix*

Issue status: Approved

Approved by: Robert Hanson

Approver's position: Process EGS

Approver's signature: *Robert Hanson* 6/22/2016
Signature Date

River Protection Project
Waste Treatment Plant
2435 Stevens Center Place
Richland, WA 99354
United States of America
Tel: 509 371 2000

History Sheet

Rev	Reason for revision	Revised by
0	Initial release, issued to support notice of construction permit application for the Effluent Management Facility	Daniel Choroser

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Acronyms

ACV	Active Confinement Ventilation System
BACT	best available control technology
BARCT	best available radionuclide control technology
COPC	constituent of potential concern
DEP	Direct Feed LAW Effluent Management Facility Process System
DFLAW	Direct Feed Low-Activity Waste
DOE	US Department of Energy
DST	double-shell tank
DVP	Direct Feed LAW Effluent Management Facility Vessel Vent Process System
Ecology	Washington State Department of Ecology
EMF	Effluent Management Facility
EPA	US Environmental Protection Agency
ESP	electrostatic precipitator
HEME	high-efficiency mist eliminator
HEMF	high-efficiency metal fiber (filter)
HEPA	high-efficiency particulate air (filter)
HLW	High-Level Waste (Facility)
HSS	hydrosonic scrubber
Lab	Analytical Laboratory
LAER	lowest achievable emissions rate
LAW	Low-Activity Waste (Facility)
LVP	LAW secondary offgas/vessel vent process system
PM	particulate matter
PT	Pretreatment (Facility)
RACT	reasonably achievable control technology
SBS	submerged bed scrubber
SVOC	semivolatile organic compound
TAP	toxic air pollutant
T-BACT	best available control technology for toxic air pollutants
TLP	treated LAW evaporation process system
TPY	US tons per year

ULPA	ultra-low penetration air (filter)
VOC	volatile organic compound
WAC	Washington Administrative Code
WESP	wet electrostatic precipitator
WTP	Hanford Tank Waste Treatment and Immobilization Plant

Executive Summary

This best available control technology for toxic air pollutants (T-BACT) demonstration report documents the five-step process performed for recommending emission control technologies for the mitigation of emissions of toxic material from the new emission unit at the Hanford Tank Waste Treatment and Immobilization Plant (WTP) Effluent Management Facility (EMF). The EMF is being constructed to support the processing and recycling of effluents during Direct Feed Low-Activity Waste (DFLAW) operations. Performance of the five basic steps of the US Environmental Protection Agency's and the Washington State Department of Ecology's "top-down" T-BACT process are described in the following paragraphs.

The first step was to determine the magnitude of toxic air emissions from the EMF. The unabated offgas stream constituents used in the T-BACT analysis are based on calculation 24590-BOF-M4C-DEP-00001, *DFLAW Effluent Management Facility Air Emissions Estimate*, which provides estimated emission rates for 408 organic, inorganic, and radionuclide constituents of potential concern from the EMF. The offgas stream from EMF process was defined and evaluated as unabated emission sources from the EMF. Table ES-1 summarizes the emission unit addressed in this report. A summary table of predicted unabated emissions of toxic particulates and aerosols, toxic inorganic gases, volatile organic compounds (VOC), and semivolatile organic compounds (SVOC) is provided in Table 3-2. Across the board, the unabated EMF offgas toxics emissions are minimal compared to offgas streams from the Low-Activity Waste (LAW), High-Level Waste (HLW), and Pretreatment (PT) facilities. This statement applies to each of the three types of toxics emissions addressed in this report: (1) toxic particulates and aerosols, (2) toxic inorganic gases, and (3) VOC/SVOCs.

Table ES-1 Summary of the Effluent Management Facility Emission Unit

Facility	Emission Unit (point source)	Stream Number	Description
EMF	EM-1	DEP15	Process vessel ventilation and DEP evaporator extraction exhaust

DEP = Direct Feed LAW Effluent Management Facility Process System

The second step was to identify all potentially applicable control technologies. A search for commercially available toxic air emission control technologies was performed. References are provided in Section 8. The available control technologies applicable to toxic particulates and aerosols are described in Section 4 and include separators, electrostatic precipitators, filters, mist eliminators, and scrubbers. Toxic inorganic gases are discussed in Section 5, and VOC/SVOCs are discussed in Section 6. For each control technology, the average removal efficiency for applicable constituents was determined from referenced sources.

The third step was to eliminate technically infeasible options. Screening criteria were applied to eliminate any control technology that was not available (i.e., cannot be obtained commercially) or not applicable (i.e., unable to be reasonably installed and operated for control of the EMF emissions). The screening process was used to develop a short list of control technologies for further T-BACT analysis.

The fourth step was to rank the remaining control technologies in order of effectiveness for the pollutant under review.

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Best Available Control Technology
Analysis for Toxic Air Pollutants for the WTP Effluent
Management Facility

The fifth step was to evaluate the environmental, energy, and economic impacts. In this analysis, the control technology with the highest control efficiency was evaluated first. If this technology was found to have no adverse energy, environmental, or economic impacts, it was then proposed as T-BACT and no further analysis was necessary. If the top technology was shown to have unacceptable impacts, the next most effective control technology in the list was then similarly evaluated until a technology was determined to be appropriate for being proposed as T-BACT.

Calculation 24590-BOF-M4C-DEP-00001 identified three groups of toxic air emissions from the EMF. These three groups were (1) toxic particulates and aerosols, (2) toxic inorganic gases, and (3) VOC/SVOCs. The proposed T-BACT for toxic particulate and aerosol emissions is the use of dual-stage high-efficiency particulate air (HEPA) filters, with a predicted removal efficiency of 99.9995%. The environmental, energy, and economic analyses for HEPA filtration resulted in no unacceptable impacts. The cost of HEPA filtration for control of toxic particulates and aerosols is offset by the required treatment of radionuclide particulates with the same HEPA filters.

Toxic inorganic gases and VOC/SVOCs were predicted to be emitted from the EMF in extremely low amounts. It was determined that in order to remove these pollutants with best available technologies, the cost per ton to remove these pollutants would exceed the ceiling cost-effectiveness threshold previously set by the Washington State Department of Ecology and the US Environmental Protection Agency. Therefore, due to the extremely low emissions rates and prohibitive cost per ton to remove these pollutants, no T-BACT is proposed for removal of toxic inorganic gases or VOC/SVOC emissions from the EMF.

1 Introduction

This best available control technology for toxic air pollutants (T-BACT) demonstration report details the process used to select the emission control technologies for the mitigation of toxic air pollutant (TAP) emissions from the Hanford Tank Waste Treatment and Immobilization Plant (WTP) Effluent Management Facility (EMF). The WTP is located at the US Department of Energy (DOE) Hanford Site near Richland, Washington.

Note: This T-BACT report is specific to the EMF; it is an addendum to the existing T-BACT analysis for the other WTP facilities (24590-WTP-RPT-ENV-01-005, *Best Available Control Technology Analysis for Toxic Air Pollutants for the WTP*). The conclusions reached in the existing T-BACT analysis for the other WTP facilities remain unchanged.

The following subsections provide a brief description of the purpose of the EMF, its proposed location, and the expected operating lifetime of the facility. In addition, the introduction includes the objectives, the purpose, and a summary of the analysis procedure used for preparing the T-BACT report, using the procedures in the US Environmental Protection Agency's (EPA) TD8831N481990, *EPA New Source Review Workshop Manual, Prevention of Significant Deterioration and Nonattainment Area Permitting* (EPA 1990).

1.1 Purpose

This document provides information on TAP emissions, the proposed control technologies, why certain technologies were proposed, or why they were not feasible for mitigation of toxic emissions from the EMF. The information presented demonstrates that the emission control equipment proposed for the EMF complies with Washington State regulations concerning T-BACT, as defined in Washington Administrative Code (WAC) 173-460, *Control for New Sources of Toxic Air Pollutants*. Information in this document will be used to support the notice of construction permit application for the EMF at WTP.

The EMF will handle waste streams that contain radioactive and toxic constituents of potential concern (COPC). To address the radioactive constituents, a best available radioactive control technology (BARCT) analysis was performed in parallel with the T-BACT analysis and is documented in a separate report (24590-WTP-RPT-ENV-15-004, *Best Available Radionuclide Control Technology Analysis Addendum for the WTP Effluent Management Facility*).

1.2 Facility Function

The purpose of the WTP is to convert high-level radioactive mixed liquid waste to a solid vitrified form (borosilicate glass) for final disposal. Underground storage tanks located at the Hanford Site are single- and double-shelled tanks (DST) managed by the DOE Office of River Protection. The tank contents will be transferred to the WTP. The WTP will have a nominal lifetime of approximately 40 years, and is designed to produce a maximum of 30 metric tons of immobilized low-activity waste and 7.5 metric tons of immobilized high-level waste per day (refer to DOE Contract DE-AC27-01RV14136 [WTP Contract] [DOE 2000], Section C).

To facilitate the processing of tank waste into glass at the earliest possible date, the EMF is being constructed to support the operation scenario of directly feeding to the Low-Activity Waste (LAW)

Facility (referred to as the “Direct Feed LAW” operating scenario). In this scenario, the LAW Facility and Analytical Laboratory (Lab) will be commissioned to operate while the Pretreatment (PT) and High-Level Waste (HLW) facilities are completed. The purpose of the EMF is to process secondary waste streams associated with the LAW melter offgas (i.e., submerged bed scrubber [SBS] condensate, wet electrostatic precipitator [WESP] drains, and caustic scrubber effluent) and line flushes/drains during Direct Feed LAW operation. An evaporator is used to concentrate the secondary waste streams from the LAW melter offgas and recycle back to the LAW Facility to incorporate into the glass. The EMF will have a nominal lifetime of approximately 40 years, and is designed to work in concert with the LAW Facility and Lab.

1.3 Facility Location

The WTP is located near the center of the DOE Hanford Site, which covers approximately 560 square miles of semi-arid land in southeastern Washington State. The site is located northwest of Richland, Washington. The WTP is being built at the eastern end of the 200 East Area of the Hanford Site, near the former Grout Treatment Facility, 241-AP Tank Farms Complex, and Plutonium/Uranium Extraction Plant (PUREX). The EMF (buildings 25, 26, and 27) is to be added within the WTP site. Figure 1-1 shows the WTP location within the Hanford Site, and Figure 1-2 shows the EMF location within the WTP site.

1.4 Methodology

The five basic steps of EPA’s and the Washington State Department of Ecology’s (Ecology) “top-down” T-BACT process for evaluation of air toxics emission control technologies are presented in the following subsections, along with a brief description of each step. A flowchart showing the T-BACT process methodology used during the development of this report is provided in Figure 1-3.

1.4.1 Step 1, Define Facility Process Variables

The first step in the top-down T-BACT analysis is to describe the facility’s physical and chemical processes, including estimated emissions of each organic and inorganic COPC. The unabated offgas stream constituents used in this T-BACT analysis are based on calculation 24590-BOF-M4C-DEP-00001, *DFLAW Effluent Management Facility Air Emissions Estimate*, which provides estimated emission rates for 408 organic, inorganic, and radionuclide COPCs from the EMF. Appendix A includes the emissions estimates for constituents applicable to this T-BACT demonstration.

1.4.2 Step 2, Identify Available Control Technologies

The second step in the top-down T-BACT analysis is to identify commercially available toxic air emission control options. This step involves a search for available technologies that can reduce the emission levels for the toxic contaminants of concern selected in step 1. Technologies required under previously completed lowest achievable emission rate (LAER) determinations are available for T-BACT purposes and are also included as control alternatives. They usually represent the “top” alternative because they represent the highest emission reduction.

The informational sources used to identify control technologies include the following:

- The US Environmental Protection Agency’s (EPA) reasonably available control technology (RACT) / best available control technology (BACT) / LAER Clearinghouse reviews
- Previous T-BACT demonstrations

- Regulatory authorities
- Federal, state, and local new source review permits
- Control technology vendors
- Literature searches
- Internet searches
- Similar commercial and government applications

1.4.3 Step 3, Determine Technical Feasibility

The third step of the top-down T-BACT methodology is to determine the technical feasibility of the control technologies. This process eliminates options that are technically infeasible. The determination of feasibility is based on evaluating vendor specifications and commercial or government application experience data for available control technologies identified in step 2. Control options determined to be technically infeasible will be eliminated from further consideration in the T-BACT analysis.

1.4.4 Step 4, Rank Feasible Technologies by Removal Efficiency

In the fourth step, the remaining control alternatives that were not eliminated are ranked in order of effectiveness for the pollutant under review, either gases or particulate matter (PM) and aerosols. The most effective control technology is ranked at the top.

1.4.5 Step 5, Evaluate the Environmental, Energy, and Economic Impacts

The fifth step, evaluating the most effective controls, begins with the most effective control option. The option is analyzed with respect to the following three factors (at minimum):

- Energy impacts
- Environmental impacts (includes significant or unusual impacts on other media, water, or solid waste)
- Economic impacts (cost and operational effectiveness)

For this analysis, the energy benefits or penalties are determined based on the energy cost per ton of pollutant removed. Determination of adverse environmental impact is based on waste generation (e.g., hazardous waste), water pollution, emission of unregulated pollutants, and health and safety impact to workers and the general public. Economic impacts are based on average and incremental cost effectiveness, expressed as cost per ton of pollutant removed. Other factors can include adverse or beneficial impacts on other process operations, including other control technologies.

In this analysis, the control technology with the highest control efficiency is evaluated first. If this technology is found to have acceptable energy, environmental, or economic impacts, it is then proposed as T-BACT and no further analysis is necessary. If the top technology is shown to be inappropriate, based on energy, environmental, or economic impacts, the applicant must fully document the justification for this conclusion. Then the next most effective control technology in the list becomes the new candidate and is similarly evaluated. This process continues until the technology under consideration cannot be eliminated due to energy, environmental, or economic impacts, which would demonstrate the technology to be appropriate as T-BACT.

Figure 1-1 Hanford Tank Waste Treatment and Immobilization Plant Location at the Hanford Site

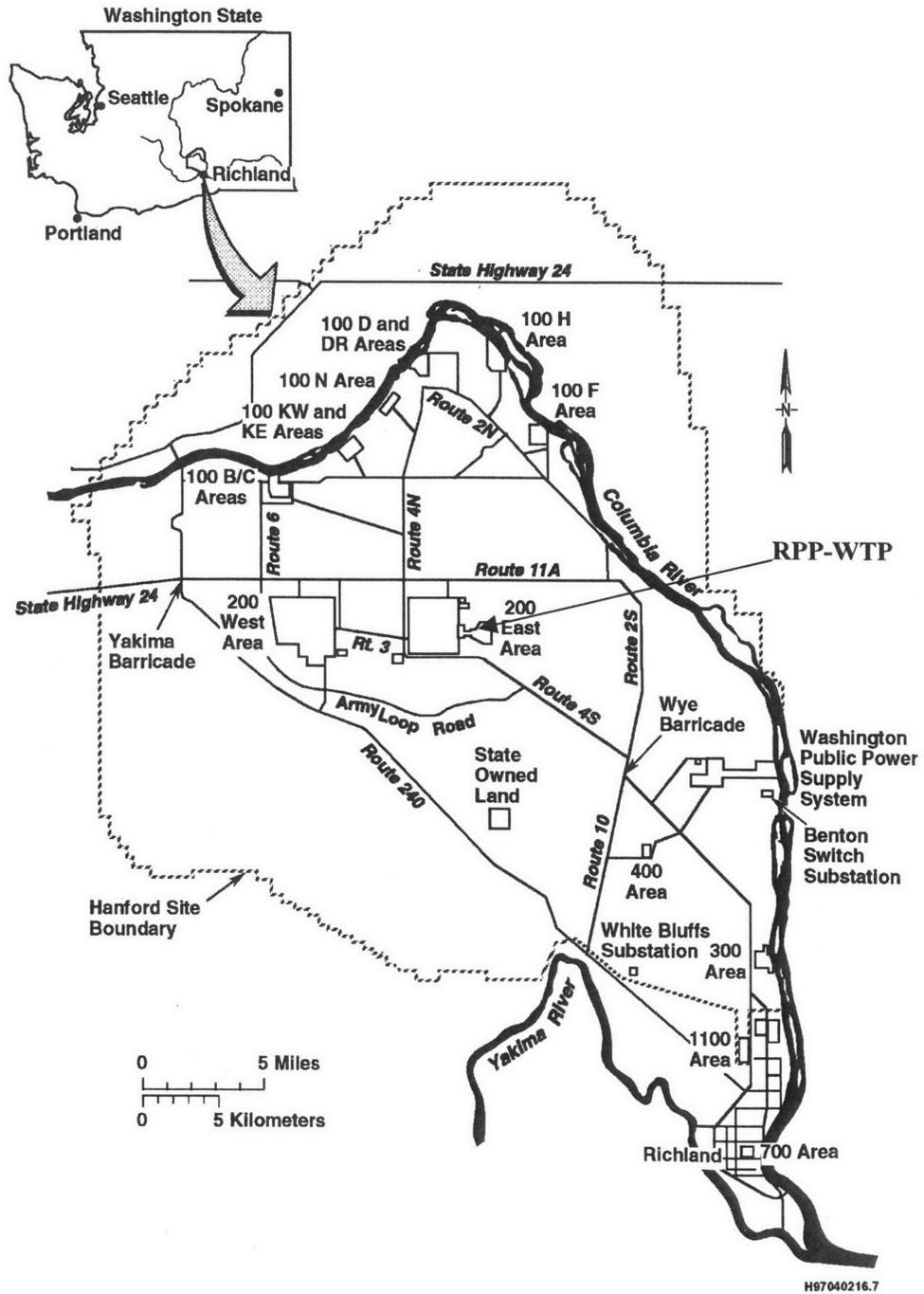
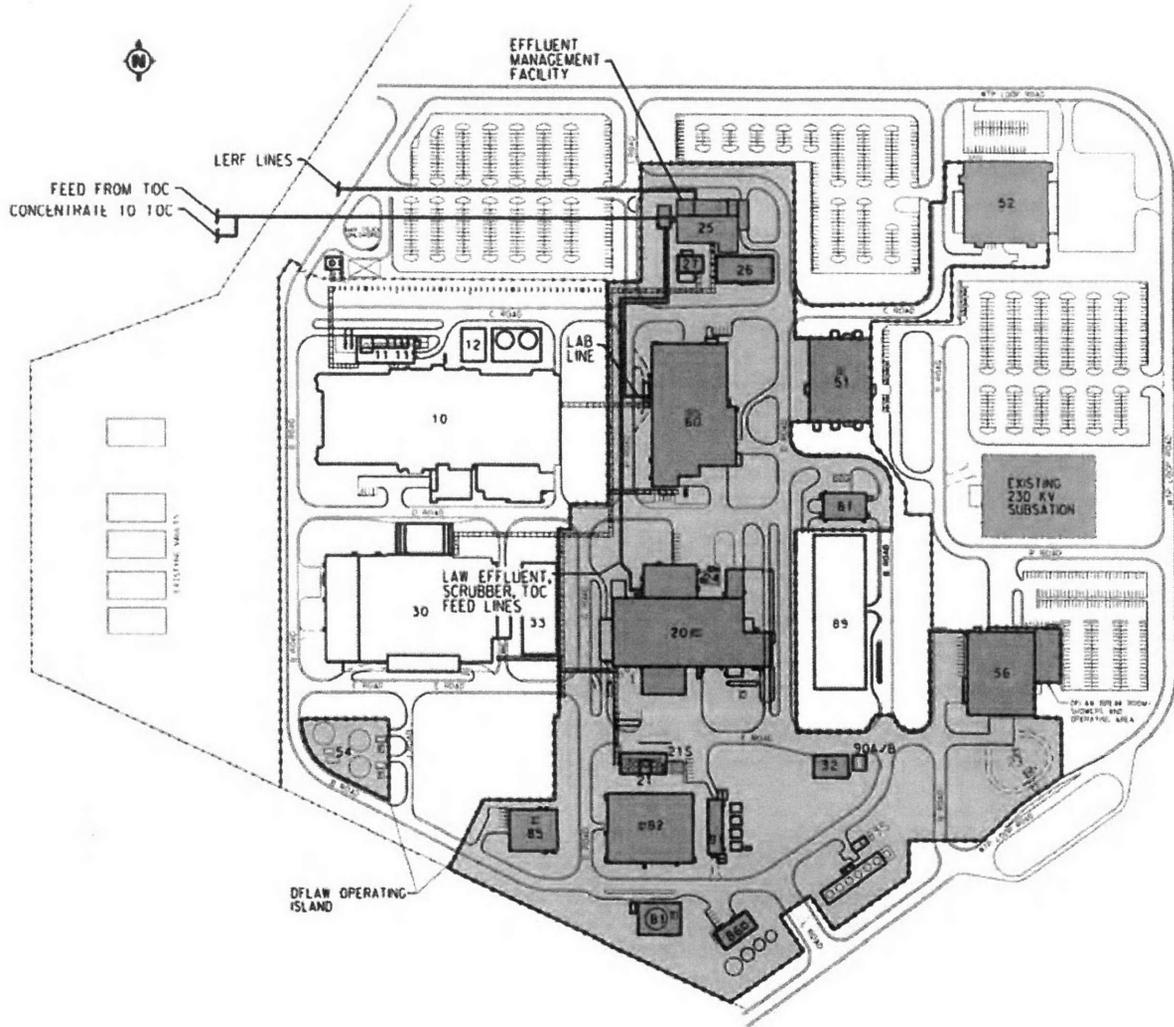
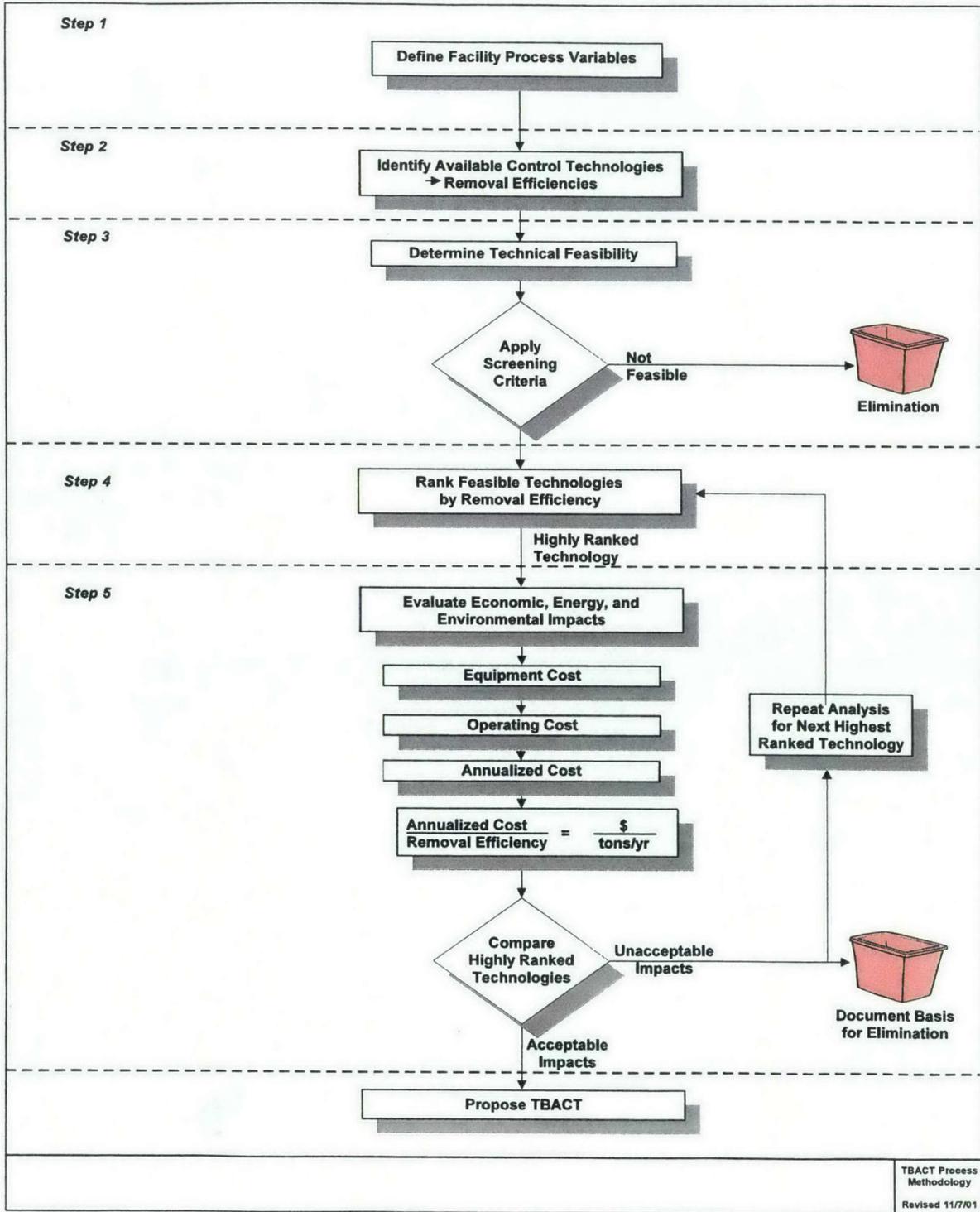


Figure 1-2 Effluent Management Facility Location at the Hanford Tank Waste Treatment and Immobilization Plant Site



(Source: 24590-LAW-PDACP-NS-15-0002, DF LAW Update for LAW and Addition of the Effluent Management Facility and Transfer Lines)

Figure 1-3 Best Available Control Technology for Toxic Air Pollutants Process Methodology



2 Regulatory Requirements and Guidance

This section reviews the regulatory requirements and guidance pertaining to toxic air emissions that may apply to the EMF at WTP.

In Washington State, Ecology is responsible for establishing air quality standards to protect the public health and the environment, according to RCW 70.94, *Washington Clean Air Act*. In addition, Ecology has the authority to regulate toxic air emissions in Washington State through the promulgation of WAC 173-460.

The TAP new source review requirements supplement the new source review requirements codified at WAC 173-400-110, *General Regulations for Air Pollution Sources – New Source Review (NSR) for Sources and Portable Sources*. Ecology requires new sources that emit TAPs to apply for a notice of construction approval (WAC 173-460-040). Ecology also requires that T-BACT be used whenever a source of TAP emissions is established (WAC 173-460-040(3)(a)). Because the EMF is a new source of TAP emissions, a T-BACT demonstration is required. This analysis is intended to satisfy the requirement to propose T-BACT for EMF emission sources that may emit TAPs.

3 Process Description

3.1 Effluent Management Facility Process Overview

Offgas generated by the LAW vitrification processes will be treated in independent offgas treatment systems (refer to 24590-WTP-RPT-ENV-01-005). The function of the EMF is to treat radioactive, dangerous liquid effluent derived from secondary waste streams resulting from treatment of the LAW melter offgas streams. These secondary waste streams include SBS condensate, caustic scrubber effluent, WESP drains, flushing/drainage of transfer lines to and from Tank Farms, and decontamination of miscellaneous equipment involved with operations related to the direct transfer of Hanford tank waste to the LAW Facility. In addition, liquid wastes will be generated by the Lab in order to support Direct Feed LAW operations. Compatible Lab wastes may be transferred to the EMF until the High-Level Waste Facility or the PT Facility begins hot commissioning.

The effluents from LAW and Lab operations will be collected in the EMF. The EMF will blend together the effluent streams, with the exception of the caustic scrubber effluent from the LAW secondary offgas/vessel vent process system (LVP). The EMF will concentrate the blended effluent in an evaporator to reduce the total volume to be returned to either the LAW Facility or Tank Farms. Due to the fact that caustic scrubber effluent will, by design, contain virtually no radionuclides or toxics, this stream will be combined with the evaporator condensate and sent to the 200 Area Liquid Effluent Retention Facility / Effluent Treatment Facility.

The Direct Feed LAW Effluent Management Facility Process System (DEP) concentrates the liquid effluent from LAW and Lab via evaporation. Some salt species are volatile in the LAW melter and are not fully captured in the glass. Recycling those volatile salt species captured by the SBS or WESP will cause buildup in the recycle loop until steady-state conditions are achieved. Note that this approach is consistent with the baseline design which recycled LAW effluents to the treated LAW evaporation process system (TLP) evaporator in the PT Facility. The DEP evaporator condensate and LVP caustic scrubber effluent are blended and transferred to the Liquid Effluent Retention Facility / Effluent Treatment Facility after qualification.

The EMF process consists of two interfacing systems: the DEP system and the Direct Feed LAW Effluent Management Facility Vessel Vent Process System (DVP). The DEP system consists of the main processing equipment in the EMF, including the liquid storage vessels, the DEP evaporator unit, and related transfer pumps. The DVP system comprises the ventilation system that evacuates the headspaces from within the DEP process vessels and also vents minute quantities of noncondensables from the DEP evaporator aftercondenser vent. These emissions combine into a single process stream, numbered DEP15, before being treated. Stream DEP18 represents the treated process vessel ventilation and evaporator noncondensables (treated DEP15), which is subsequently exhausted to the EMF stack. Refer to Figure 3-1 for a simplified flow diagram of the EMF process.

3.2 Effluent Management Facility Ventilation Overview

The ventilation system that serves the EMF is referred to as the Active Confinement Ventilation System (ACV). The ACV system uses the cascade principle with the direction of airflow from areas of low or no contamination to areas of higher potential contamination. Conditioned air supplied to the EMF cascades through the area of potential contamination and exits via the ACV exhaust system's filtered

exhaust. The vessels, piping, and vessel ventilation act as the primary confinement, while the ACV system provides secondary confinement for the EMF. No TAPs are expected to be in the ACV system.

3.3 Effluent Management Facility Emission Unit

The EMF has a single emission unit: EM-1. Emission unit EM-1 is the combination of the ACV exhaust and the DVP system exhaust. The ACV system does not emit toxic particulates, aerosols, gases, or volatile organic compounds (VOC) / semivolatile organic compounds (SVOC); therefore, the system is not addressed in this T-BACT demonstration. Only toxic emission contributions originating from the DVP system exhaust are assessed in this T-BACT demonstration. Figure 3-2 depicts the emission unit addressed in this T-BACT demonstration.

3.4 Effluent Management Facility Emissions Estimate Results and Stream Descriptions

Table 3-2 provides a summary of the estimated total unabated toxic emissions from the EMF. More detailed information on emission estimates can be found in Appendix A, Table A-1 and Table A-2 or calculation 24590-BOF-M4C-DEP-00001.

Stream DEP15 is the stream containing unabated airborne effluents from the DVP system exhaust. This stream has a relatively low volumetric and mass flow. This stream will contain, in relatively minute amounts, PM and aerosols, inorganic gases, and VOC/SVOCs. Figure 3-2 provides a graphic representation of emission stream from the EMF and associated EMF emission units. Figure 3-1 shows the overall EMF process and associated emission sources. The stream numbers provided in the figures are consistent with the process streams numbers presented in calculation 24590-BOF-M4C-DEP-00001. Table 3-1 provides the crosswalk between the stream number, emission source, and the emission unit.

Table 3-1 Emission Units and Associated Stream Number

Facility	Emissions Unit	Stream Number	Description
EMF	EM-1	DEP15	DVP system exhaust - EMF vessel ventilation and evaporator extraction exhaust (unabated)

Table 3-2 Estimated Total Unabated Emissions

Unabated Offgas Stream		Total Particulates/Aerosols (Inorganic + Organic)	Inorganic Gases	Organic Gases (VOCs & SVOCs)
DEP15	g/sec	3.43×10^{-3}	1.01×10^{-1}	2.33×10^{-3}
	lb/yr	238	7022	162

Figure 3-1 Process Schematic of the Effluent Management Facility

Note: Streams labeled "vent header" combine in a single header that feeds to the proposed T-BACT before release.

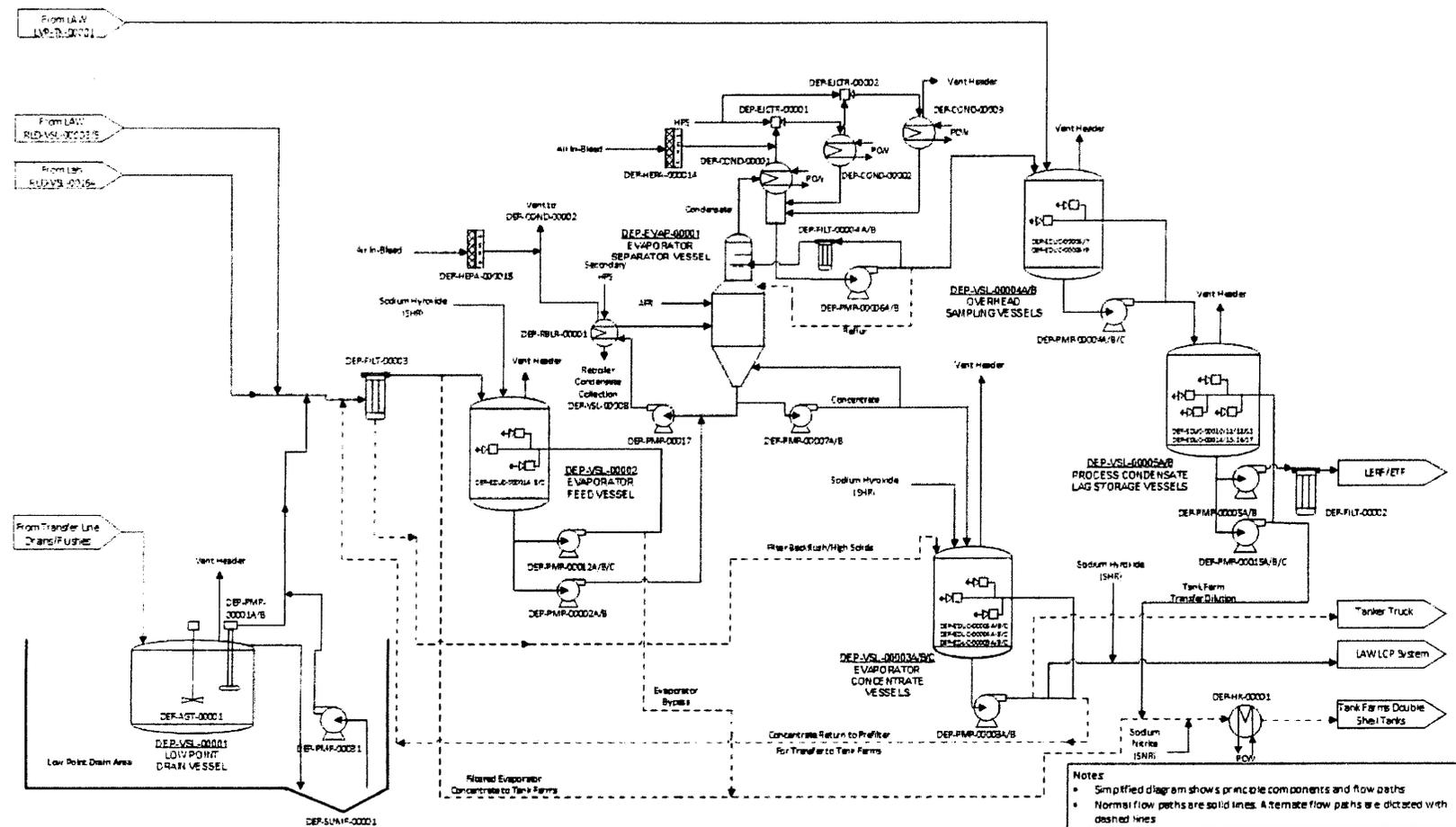
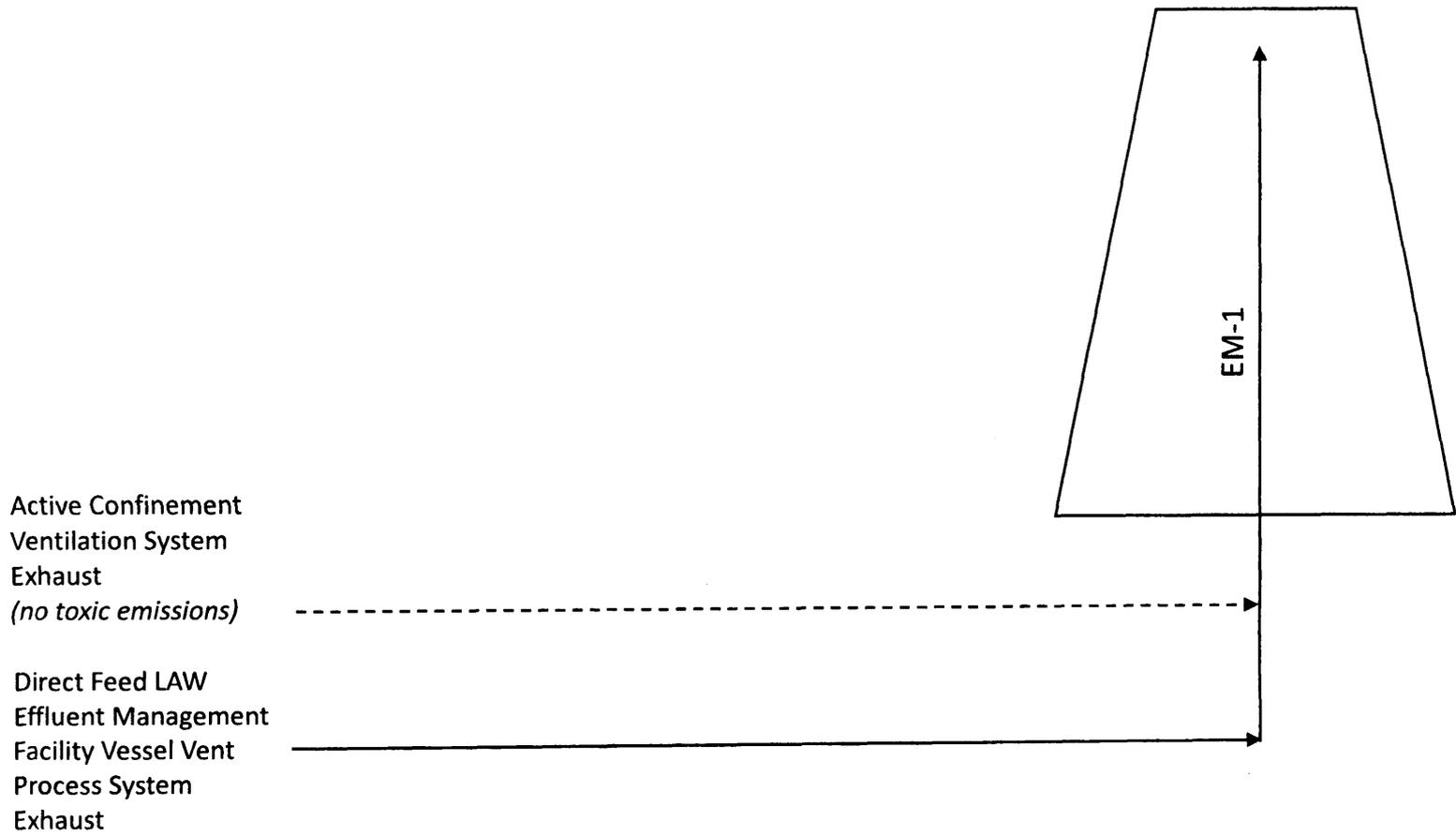


Figure 3-2 Effluent Management Facility Emissions Unit for T-BACT Analysis



4 Particulate Material and Aerosols

4.1 Particulate and Aerosol Emissions from the Effluent Management Facility

The first step of the T-BACT process is to define the facility process variables. The unabated offgas stream constituents used in the T-BACT analysis are based on values from calculation 24590-BOF-M4C-DEP-00001. Appendix A provides the emissions estimates of all unabated offgas stream COPCs used in this T-BACT analysis. The EMF emissions estimate has identified PM and aerosols of both inorganic (primarily metallic) and organic types, summarized below in Table 4-1.

Table 4-1 Summary of Organic and Inorganic Particulate and Aerosol Emissions

Emissions Type	Unabated Emissions Rate	
	g/sec	lb/yr
Total Inorganic Particulates and Aerosols	3.43×10^{-3}	238
Total Organic Particulates and Aerosols	1.32×10^{-7}	9.18×10^{-3}
Total Particulates and Aerosols	3.43×10^{-3}	238

4.2 Identification of Control Technologies

Information regarding available control technologies for particulates and aerosols is provided in this section. Information was obtained from the following sources:

- EPA RACT/BACT/LAER Clearinghouse reviews
- Previous T-BACT demonstrations
- Regulatory authorities
- Literature searches
- Information from technology vendors
- Research and development reports
- Similar commercial and government applications (West Valley Demonstration Project, Savannah River Defense Waste Processing Facility, and Oak Ridge Toxic Substances Control Act Incinerator)

Available control options are those air pollution control technologies which have a practical potential for application to the process emissions and which are available from a vendor. Control technologies include not only equipment to remove or treat releases, they also include measures to prevent or reduce emissions. This section discusses the literature search that was performed and provides a description of each technology available for the control of particulates and aerosols.

4.2.1 RACT/BACT/LAER Clearinghouse Review and Literature Search

Section 8 contains a list of references, including those from a RACT/BACT/LAER Clearinghouse review and literature search performed for technologies pertaining to the control of particulate and aerosol emissions. Information was also gathered from Internet searches of DOE and EPA websites. Resources used from these databases include publications from DOE national laboratories and EPA programs, and proceedings of DOE nuclear air cleaning conferences. Existing references from previous Hanford

T-BACT analyses were also used. Additional information was obtained from publicly available documents from existing nuclear facilities in the United States and other countries.

4.2.2 Descriptions of the Control Technologies for Particulates and Aerosols

The following subsections describe the major types of equipment for control of particulate and aerosol emissions. The control technologies are categorized as separators, electrostatic precipitators (ESP), filters, mist eliminators, and scrubbers.

4.2.2.1 Separators

Cyclones and Multicyclones

Cyclones use inertia to remove particles from the gas stream. The cyclone imparts centrifugal force on the gas stream, usually within a conical-shaped chamber. Cyclones operate by creating a double vortex inside the cyclone body. The incoming gas is forced into a circular motion down the cyclone near the inner surface of the cyclone tube. At the bottom of the cyclone, the gas turns and spirals up through the center of the tube and out of the top of the cyclone. Particles in the gas stream are forced toward the cyclone walls by the centrifugal force of the spinning gas but are opposed by the fluid drag force of the gas traveling through and out of the cyclone. For large particles, inertial momentum overcomes the fluid drag force so that the particles reach the cyclone walls and are collected. For small particles, the fluid drag force overwhelms the inertial momentum and causes these particles to leave the cyclone with the exiting gas. Gravity also causes the larger particles that reach the cyclone walls to travel down into a bottom hopper. Although they rely on the same separation mechanism as momentum separators, cyclones are more effective because they have a more complex gas flow pattern. Refer to Figure 4-1 for an illustration of a cyclone.

Cyclones are generally classified into four types, which depend on how the gas stream is introduced into the device and how the collected dust is discharged. The four types include (1) tangential inlet with axial discharge, (2) axial inlet with axial discharge, (3) tangential inlet with peripheral discharge, and (4) axial inlet with peripheral discharge. The first two types are the most common.

Pressure drop is an important parameter because it relates directly to operating costs and control efficiency. Higher control efficiencies for a given cyclone can be obtained by higher inlet velocities, but this also increases the pressure drop. In general, 60 ft/sec is considered the best operating velocity. Common ranges of pressure drops for cyclones are 0.07 to 0.14 psi for low-efficiency units (high throughput), 0.14 to 0.2 psi for medium-efficiency units (conventional), and 0.3 to 0.36 psi for high-efficiency units.

When high-efficiency (which requires small cyclone diameter) and large throughput are both desired, a number of cyclones can be operated in parallel. In a multiple tube cyclone, the housing contains a large number of tubes that have a common gas inlet and outlet in the chamber. The gas enters the tubes through axial inlet vanes, which impart a circular motion.

Cyclones are used to control particulates—primarily particulates greater than 10 μm in aerodynamic diameter. However, there are high-efficiency cyclones designed to be effective for particulates less than or equal to 10 μm and less than or equal to 2.5 μm in aerodynamic diameter (PM_{10} and $\text{PM}_{2.5}$). Although cyclones may be used to collect particles larger than 200 μm , gravity settling chambers or simple momentum separators are usually satisfactory and less subject to abrasion.

The collection efficiency of cyclones varies as a function of particle size and cyclone design. Cyclone efficiency generally increases with particle size and (or) density, inlet duct velocity, cyclone body length, number of gas revolutions in the cyclone, ratio of cyclone body diameter to gas exit diameter, dust loading, and smoothness of the cyclone inner wall. Cyclone efficiency will decrease with increases in gas viscosity, body diameter, gas exit diameter, gas inlet duct area, and gas density. A common factor contributing to decreased control efficiencies in cyclones is air leakage into the dust outlet.

Control efficiency ranges for single cyclones are often based on three classifications of cyclone: (1) conventional, (2) high-efficiency, and (3) high-throughput. The control efficiency range for conventional single cyclones is estimated to be 30 to 90% for PM₁₀ and 0 to 40% for PM_{2.5}.

High-efficiency single cyclones are designed to achieve higher control of smaller particles than conventional cyclones. High-efficiency single cyclones can remove 5 µm particles at up to 90% efficiency, with higher efficiencies achievable for larger particles. The control efficiency ranges for high-efficiency single cyclones are 60 to 95% for PM₁₀ and 20 to 70% for PM_{2.5}. High-efficiency cyclones come with higher pressure drops, which require higher energy costs to move the waste gas through the cyclone. Cyclone design is generally driven by a specified pressure-drop limitation, rather than by meeting a specified control efficiency.

High-throughput cyclones are only guaranteed to remove particles greater than 20 µm, although collection of smaller particles does occur to some extent. The control efficiency ranges for high-throughput cyclones are 10 to 40% for PM₁₀ and 0 to 10% for PM_{2.5}. Multicyclones are reported to achieve from 80 to 95% collection efficiency for 5 µm particles.

Typical gas flow rates for a single cyclone unit are 18 to 420 scf/sec. Flows at the high end of this range and higher (up to approximately 1800 scf/sec) use multiple cyclones in parallel. There are single cyclone units employed for specialized applications which have flow rates of up to approximately 1060 scf/sec and as low as 0.02 scf/sec. Inlet gas temperatures are only limited by the materials of construction of the cyclone, and cyclones have been operated at temperatures as high as 1000°F. Waste gas pollutant loadings typically range from 1×10^{-4} to 0.01 lb/scf. For specialized applications, loadings can be as high as 1 lb/scf and as low as 6×10^{-5} lb/scf. Cyclones perform more efficiently with higher pollutant loadings, provided that the device does not become choked. Higher pollutant loadings are generally associated with higher flow designs.

A multiple cyclone separator consists of a number of small-diameter cyclones operating in parallel to each other and having a common gas inlet and outlet. The flow pattern differs from that of a conventional cyclone; the gas enters at the top of the collecting tube and has a swirling action imparted to it by a stationary vane positioned in its path. The diameters of the collecting tubes are typically 9 to 12 in. Removal efficiencies range from 80 to 95% for 5 µm particles. These cyclones are useful for high gas flows, have simple designs, and low initial costs. High-humidity gases can cause condensation and agglomeration/plugging. (Refer to EPA-452/F-03-005, *Air Pollution Control Technology Fact Sheet – Cyclones* [EPA 2003a].)

4.2.2.2 Electrostatic Precipitators

Electrostatic precipitators (ESPs) are particulate control devices that use electrical forces to move particles entrained within an exhaust stream onto collection surfaces. The entrained particles are given an electrical charge when they pass through a corona, a region where gaseous ions flow. Electrodes in the

center of the flow lane are maintained at a high voltage and generate the electrical field that forces the particles to the collector walls. The separated particles are then removed for treatment or disposal.

Dry Electrostatic Precipitator

In a wire-pipe ESP, also called a tubular ESP, the exhaust gas flows vertically through conductive tubes, generally with many tubes operating in parallel. The tubes may be formed as a circular, square, or hexagonal honeycomb. Square and hexagonal pipes can be packed closer together than cylindrical pipes, reducing wasted space. Pipes are generally 3 to 12 in. in diameter and 3 to 12 ft in length. The high voltage electrodes are long wires or rigid "masts" suspended from a frame in the upper part of the ESP that run through the axis of each tube. Both an upper and lower frame support rigid electrodes. In modern designs, sharp points are added to the electrodes to provide additional ionization sites either at the entrance to a tube or along the entire length in the form of stars.

In the wire-plate ESP, the exhaust gas flows horizontally and parallel to vertical plates of sheet metal. Plate spacing is typically between 9 to 18 in. The high-voltage electrodes are weighted, long wires that hang between the plates. Some later designs use rigid electrodes (hollow pipes approximately 1 to 1.6 in. in diameter) in place of wire. Within each flow path, gas flow must pass each wire in sequence as it flows through the unit. The flow areas between the plates are called ducts. Duct heights are typically 20 to 45 ft.

In dry ESPs, the collectors are knocked, or "rapped," by various mechanical means to dislodge the particulates, which slide downward into a hopper where they are collected. Some newer dry wire-pipe ESPs are cleaned acoustically with sonic horns. The horns, typically cast-metal horn bells, are usually powered by compressed air, and a vibrating metal plate that periodically interrupts the airflow introduces acoustic vibration. As with a rapping system, the collected particulates slide downward into the hopper. The hopper is evacuated periodically as it becomes full. Dust is removed through a valve into a dust-handling system, such as a pneumatic conveyor, and is then disposed of in an appropriate manner.

Typical new equipment design efficiencies are between 99 and 99.9% for PM₁₀ and PM_{2.5}. Older existing equipment has a range of actual operating efficiencies of 90 to 99.9%. Although several factors determine ESP collection efficiency, ESP size is most important. Size determines treatment time; the longer a particle spends in the ESP, the greater its chance of being collected. Maximizing electric field strength will maximize ESP collection efficiency. Collection efficiency is also affected by dust resistivity, gas temperature, chemical composition (of the dust and the gas), and particle size distribution. Typical gas flow rates for dry wire-pipe ESPs are 17 to 1700 scf/sec. Dry wire-pipe ESPs can operate at very high temperatures, up to 1300°F (705°C). Operating gas temperature and chemical composition of the dust are key factors influencing dust resistivity and must be carefully considered in the design of an ESP. Typical inlet concentrations to a wire-pipe ESP are 6×10^{-5} to 6×10^{-4} lb/scf. It is common to pretreat a waste stream, usually with a wet spray or scrubber, to bring the stream temperature and pollutant loading into a manageable range. Highly toxic flows with concentrations well below 6×10^{-5} lb/scf are sometimes controlled with ESPs.

In general, dry ESPs operate most efficiently with dust resistivities between 2×10^3 and 8×10^9 ohm-in. In general, the most difficult particles to collect are those with aerodynamic diameters between 0.1 and 1.0 μm . Particles between 0.2 and 0.4 μm usually show the most penetration. This is most likely a result of the transition region between field and diffusion charging.

When much of the pollutant loading consists of relatively large particles, mechanical collectors such as cyclones or spray coolers may be used to reduce the load on the ESP, especially at high inlet

concentrations. Gas conditioning equipment to improve ESP performance by changing dust resistivity is occasionally used as part of the original design, but more frequently it is used to upgrade existing ESPs. The equipment injects an agent into the gas stream ahead of the ESP. Usually, the agent mixes with the particles and alters their resistivity to promote higher migration velocity, and thus higher collection efficiency. (Refer to EPA-452/F-03-027, *Air Pollution Control Technology Fact Sheet – Dry Electrostatic Precipitator (ESP) – Wire-Pipe Type* [EPA 2003b]; and EPA-452/F-03-028, *Air Pollution Control Technology Fact Sheet – Dry Electrostatic Precipitator (ESP) – Wire-Plate Type* [EPA 2003c].)

Wet Electrostatic Precipitator

Wet electrostatic precipitators (WESPs) function similarly to dry ESPs, with the exception that WESPs use a continuous or intermittent washwater stream to remove the collected particles, rather than a mechanical or acoustic agitation system. This washwater particle removal system does not re-entrain particles, as the mechanical or acoustic agitation systems tend to do in the dry ESPs. WESPs are very effective at removing aerosols and particles with very high resistivities. As with dry ESPs, typical new equipment design efficiencies for WESPs are between 99 and 99.9% for PM₁₀ and PM_{2.5}. Typical gas flow rates for wire-pipe WESPs are 17 to 1700 scf/sec. Typical gas flow rates for wire-plate WESPs are 1700 to 8300 scf/sec. Most small plate-type WESPs (1700 to 3500 scf/sec) use flat plates instead of wires for the high-voltage electrodes. Both wire-pipe and wire-plate WESPs are limited to operating at temperatures lower than approximately 170 to 190°F (75 to 90°C). Typical inlet concentrations to a wire-pipe WESP are 6×10^{-5} to 6×10^{-4} lb/scf. Typical inlet concentrations to a wire-plate WESP are 1×10^{-4} to 7×10^{-3} lb/scf. It is common to pretreat a waste stream, usually with a wet spray or scrubber, to bring the stream temperature and pollutant loading into a manageable range. Highly toxic flows with concentrations well below 6×10^{-5} lb/scf are also sometimes controlled with ESPs. Dust resistivity is not a factor for WESPs because of the high humidity atmosphere, which lowers the resistivity of most materials. Particle size is much less of a factor for WESPs compared to dry ESPs. Due to the lack of resistivity concerns and the reduced re-entrainment, WESPs can efficiently collect much smaller particles. When the pollutant loading is exceptionally high or consists of relatively large particles (larger than 2 μm), venturi scrubbers or spray chambers may be used to reduce the load on the WESP. Much larger particles (larger than 10 μm) are controlled with mechanical collectors such as cyclones. Gas conditioning equipment to reduce both inlet concentration and gas temperature is occasionally used as part of the original design of a WESP. (Refer to EPA-452/F-03-029, *Air Pollution Control Technology Fact Sheet – Wet Electrostatic Precipitator (ESP) – Wire-Pipe Type* [EPA 2003d]; and EPA-452/F-03-030, *Air Pollution Control Technology Fact Sheet – Wet Electrostatic Precipitator (ESP) – Wire-Plate Type* [EPA 2003e].)

4.2.2.3 Filters

Baghouse (Fabric) Filters

In a fabric filter, a particulate loaded gas stream is passed through a tightly woven or felted fabric, causing PM in the flue gas to be collected on the fabric by sieving and other mechanisms. Fabric filters may be in the form of sheets, cartridges, or bags, with a number of the individual fabric filter units housed together in a group. Bags are the most common type of fabric filter. Bags may be 20 ft to 30 ft long and 5 inches to 12 inches in diameter. See Figure 4-2 for an illustration of bag house filters.

Baghouse filters are separated into two groups, standard and custom, which are further separated into low, medium, and high capacity. Standard baghouse filters are factory-built, off-the-shelf units. They may handle up to 1800 scf/sec. Custom baghouse filters are designed for specific applications and are built to

the specifications prescribed by the customer. These units are generally much larger than standard units (i.e., from 1800 to more than 18,000 scf/sec).

Gas temperatures up to about 500°F (260°C), with surges to about 550°F (290°C), typically can be accommodated with the appropriate fabric material. Some fabrics (e.g., polyolefins, nylons, acrylics, and polyesters) are useful only at relatively low temperatures of 200 to 300°F (95 to 150°C). For high-temperature flue gas streams, more thermally stable fabrics (e.g., fiberglass, Teflon, or Nomex) must be used. Spray coolers or dilution air can be used to lower the temperature of the pollutant stream. This prevents the temperature limits of the fabric from being exceeded. Lowering the temperature, however, increases the humidity of the pollutant stream. Therefore, the minimum temperature of the pollutant stream must remain above the dewpoint of any condensable in the stream. The baghouse and associated ductwork should be insulated and possibly heated if condensation may occur.

Typical inlet concentrations to baghouses are 6×10^{-5} to 1×10^{-3} lb/scf; but in extreme cases, inlet conditions may vary between 6×10^{-6} to more than 1×10^{-2} lb/scf. Moisture and corrosives content are the major gas stream characteristics requiring design consideration. Standard fabric filters can be used in pressure and vacuum service, but only within the range of about ± 25 in. of water column. Well-designed and operated baghouses have been shown to be capable of reducing overall particulate emissions to less than 3×10^{-6} lb/scf, and in a number of cases, to as low as 1×10^{-7} to 7×10^{-7} lb/scf. Typical new equipment design efficiencies are between 99 and 99.9%. (Refer to EPA-452/F-03-024, *Air Pollution Control Technology Fact Sheet – Fabric Filter – Mechanical Shaker Cleaned Type* [EPA 2003f]).

Prefilters (Roughing Filters)

Prefilters can be classified as either low-efficiency (Group I), moderate-efficiency (Group II), or high-efficiency (Group III) filters. Group I panel filters are shallow, tray-like assemblies of coarse fibers or crimped metal mesh enclosed in a steel or cardboard casing and have a 10 to 35% efficiency. Group II and III filters are extended media, dry-type units. The medium is pleated or formed as bags to increase the surface area. Group II filters are effective in removing $5+ \mu\text{m}$ particles, while Group III filters can filter even smaller particles. Filter media can be chosen to minimize damage from corrosion. Prefilters have a high dust-loading capacity, but they can create relatively high pressure drops and the spent filters must be handled as solid waste. Group II filters are rated for 20 to 80% removal efficiency, and Group III filters are rated for 85 to 95% removal efficiency. (Refer to DOE-HDBK-1169-2003, *Nuclear Air Cleaning Handbook*, 4th Edition [DOE 2003], Section 3.4; and 24590-WTP-M6-50-00002, *P&ID Symbols and Legend Sheet 2 of 8*).

High-Efficiency Metal Fiber Filters

High-efficiency metal fiber (HEMF) filters are composed of stainless steel fibers sintered together into a mat, giving the filter a high loading capacity, high strength, and a low pressure drop. Removal efficiencies of up to 99.97% can be achieved for particles greater than $0.3 \mu\text{m}$. HEMF filters can tolerate high temperatures and wet conditions, though their removal efficiency can be quite low when wet. In addition, free liquids with dissolved acid gases negatively affect the metal-type filters. The filters can be welded into steel housings or frames, eliminating the need for gaskets and adhesives. Although only recently used in low flow rate streams in the nuclear industry, HEMF filters have been commercially available for about 14 years. These filters can be cleaned in place or removed and cleaned. The duration between cleanings depends on the particle loading and the number of filters used. Figure 4-3 provides an illustration of a HEMF filter. (Refer to CCN 020413, *HEMF Filter Evaluation*; and NUREG/CP-0130, CONF-9020823,

Vol. 2, *Proceedings of the 22nd DOE/NRC Nuclear Air Cleaning Conference: Sessions 9-16*, Session 10, Filters and Filter Performance [DOE 1993].)

High-Efficiency Particulate Air and Ultra-Low Penetration Air Filters

High-efficiency particulate air (HEPA) and ultra-low penetration air (ULPA) filters consist of fine fibers or a series of pleated or folded strips. Materials vary, but generally these are made of synthetic fibrous materials. The principle of this type of filtration is not to restrict the passage of particulates by the gap between fibers, but to alter the airflow streamlines. The airflow will slip around the fiber, but any higher-density aerosols or PM will not change direction as rapidly, and as a result of their inertia (velocity), will tend to impact the fiber. Once attached, most particulates will not be re-entrained in the air stream. Figure 4-4 provides an illustration of a HEPA filter.

HEPA and ULPA filters are classified by their minimum collection efficiency. Many international standards and classes currently exist for high-efficiency filters. In general, HEPA and ULPA filters are defined as having the following minimum efficiency ratings for a single stage:

HEPA	99.97% efficiency (based on in-place testing) for the removal of 0.3 μm diameter or larger particulates
ULPA	99.9995% efficiency for the removal of 0.12 μm diameter or larger particulates.

Dual stage HEPA filters provide 99.9995% collection efficiency. The first HEPA filter is credited for a decontamination factor of 2000, and the second a decontamination factor of 100. Dual-stage HEPA filters, as opposed to single-stage HEPA, are to be considered as one of the control technologies for this T-BACT analysis. Dual-stage HEPA filters are used ubiquitously throughout the WTP for control of airborne particulate and aerosol emissions. (Refer to 24590-WTP-RPT-ENV-01-005.)

Some extended media filters are capable of much higher efficiencies. Commercially available filters can control particulates with 0.01 μm diameter at efficiencies of 99.99+% and particulates with 0.1 μm diameter at efficiencies of 99.9999+%. Several factors determine HEPA and ULPA filter collection efficiency. These include gas filtration velocity, particle characteristics, and filter media characteristics. In general, the collection efficiency increases with increasing velocity and particle size. In addition, the collection efficiency increases as the dust cake thickness and density increases on the filter.

HEPA and ULPA filters are currently limited to low capacity airflow applications. Standard filter packs are factory-built, off-the-shelf units. They may handle from less than 4 up to 35 standard cubic ft per second. HEPA filtration systems designed for nuclear applications require higher capacities. For these applications, filter banks, or modules are ducted together in parallel to increase airflow capacity. Commercially available modular systems can accommodate airflow rates up to 670 scf/sec.

Airflow capacity is a function of the resistance, or pressure drop across the filter and particle loading. As the dust cake forms on the filter, the resistance increases, and therefore the airflow rate decreases. Because the filter is not cleaned, the airflow rate continues to decrease as the system operates. After the pressure drop across the filter reaches a point that prevents adequate airflow, the filter must be replaced and disposed. For these reasons, HEPA and ULPA filters are used in applications that have low airflow rates or have low concentrations of particulates.

Temperatures are limited by the type of filter media and sealant used in the filter packs. Standard cartridges can accommodate gas temperatures up to about 200°F (95°C). With the appropriate construction materials, commercial HEPA filters can accept temperatures of up to 400°F (205°C). HEPA filters with ceramic or glass packing mechanical seals can accept temperatures up to 1000°F (540°C).

Spray coolers or dilution air can be used to lower the temperature of the pollutant stream. This prevents the temperature limits of the filter from being exceeded. However, lowering the temperature increases the humidity of the pollutant stream. HEPA and ULPA filters can tolerate some humidity. However, humidity higher than 95% can cause the filter media to plug, resulting in failure. Therefore, the minimum temperature of the pollutant stream must remain above the dewpoint of any condensable in the stream. The filter and associated ductwork should be insulated and possibly heated if condensation may occur.

Typical pollutant loading ranges from 6×10^{-5} to 2×10^{-3} lb/scf. Dust holding capacity compares the weight gain of the filter to the rise in pressure drop during a specific period of time (airflow volume). Typical inlet dust holding capacities range from 1 to 2 lb per 1000 scfm. HEPA and ULPA filters are best used in applications that have low concentrations of particulates or prohibit cleaning of the filter. ULPA filters require more frequent replacement than HEPA filters, due to the former's tendency to load more quickly. Moisture and corrosives content are the major gas stream characteristics requiring design consideration. As discussed previously, humidity up to 95% is acceptable with the proper filter media, coatings, and filter construction. Filters are available that can accommodate corrosive gas streams with concentrations up to several percent. These filters are constructed of special materials and are generally more expensive. (Refer to EPA-452/F-03-023, *Air Pollution Control Technology Fact Sheet – Fabric Filter – HEPA and ULPA Type* [EPA 2003g].)

Safe-change HEPA filter housings are designed and installed to facilitate changing filters while maintaining emissions and worker exposure to “as low as reasonably achievable” levels. Safe-change is a term used by WTP to describe a process to change HEPA filters, also known as a bag-in, bag-out filter change method. The process involves removing a spent filter into a plastic bag that has been secured to a filter housing access opening. The spent filter is moved to the bottom of the bag and the bag is cut to remove the spent filter for disposal. A new filter is installed using a similar process where a new filter is placed inside a new bag. This bag is placed over the same housing opening and the remnant of the first bag. Upon completing installation of the new filter, a bag remains in place (behind the filter housing door) to support the next filter change task. (Refer to 24590-WTP-RPT-ENV-01-005.)

Deep-Bed Sand and Glass Fiber Filters

Filters employed for removing small amounts of particles from large volumes of gas may be classified into two types: thin-bed and deep-bed. Thin-bed filters are units employing media such as paper, wool felt, and thin glass mats. Deep-bed filters, on the other hand, involve packings of granular or fibrous materials that are up to 9 ft deep. In this service, the total aerosol concentration is usually on the order of or less-than-normal atmospheric dust concentrations. Deep-bed aerosol filters have been used for many years in nuclear reprocessing industry. When an aerosol is passed through a packing, the suspended particles are caused to deposit on the surface of the packing by one of a number of mechanisms, which include interception based on size and inertia, diffusional migration, gravity settling, electrostatic attraction, and migration due to thermal gradient. In sand filters, which normally operate at superficial velocities approximately 5 ft/min and employ granules graded from as large as 3.5-inch diameter down to 50 mesh, the deposition mechanisms are primarily those of diffusion and gravity settling. Collection efficiency increases appreciably as superficial velocity is reduced. With fibrous filters, interception (both direct and inertial) may be a controlling factor, depending on the fiber sizes. Filters with fibers larger than

100 μm in diameter normally operate at superficial velocities in excess of 30 ft/min and generally show improved collection efficiency as the velocity is increased. Beds of fine fibers are usually operated at velocities of 5 to 50 ft/min and show a reduction of efficiency as velocity is increased. The factors that must be considered in the design of a deep-bed filter are collection efficiency or penetration, pressure drop, filter size and life, and available packing media. Removal efficiencies for sand filters up to 99.98% for aerosols have been reported under test conditions. Those for fiber filters are 91.5% (3 μm) to 99.999% (0.5 μm). Deep-bed sand filters tend to have higher pressure drops, lower removal efficiencies, require significantly more space than glass-bed fiber filters, and may present a remediation concern at their end of life. (Refer to 24590-WTP-RPT-ENV-01-005; and DOE-HDBK-1169-2003 [DOE 2003].)

4.2.2.4 Mist Eliminators

Mist eliminators consist of a packed fiber bed between two concentric screens or two flat parallel screens. Mist eliminators can also consist of baffled or zigzag blade modules, tailored for either vertical or horizontal flow installations. High-efficiency mist eliminators (HEME) claim removal efficiencies up to 99% for liquid particles as small as 1 μm , with specialized designs capable of removing submicron liquid particles. Features of mist eliminators include high collection efficiency, low installed cost, low pressure drop, and ready availability (off-the-shelf item). Mist eliminators are available in a variety of materials—including metal alloys, plastics, and fiber-reinforced plastic for the housing; and glass, ceramic, polypropylene, polytetrafluoroethylene, and polyester for the packing or mesh pad. (Refer to Bulletin MELLC-02, Rev 3, *Mist Elimination Liquid-Liquid Coalescing* [Koch-Glitsch 2015]; and *Mist Eliminators* [Vanaire].)

4.2.2.5 Scrubbers

Venturi Scrubber

A venturi scrubber accelerates the waste gas stream to atomize the scrubbing liquid and to improve gas-liquid contact. In a venturi scrubber, a “throat” section is built into the duct that forces the gas stream to accelerate as the duct narrows and then expands. As the gas enters the venturi throat, gas velocity and turbulence increase. Depending upon the scrubber design, the scrubbing liquid is sprayed into the gas stream before the gas encounters the venturi throat, or into the throat, or upwards against the gas flow in the throat. The scrubbing liquid is then atomized into small droplets by the turbulence in the throat, and droplet-particle interaction is increased. Some designs use supplemental hydraulically or pneumatically atomized sprays to augment droplet creation. The disadvantage of these designs is that clean liquid feed is required to avoid clogging. After the throat section, the mixture decelerates, and further impacts occur, causing the droplets to agglomerate. When the particles have been captured by the liquid, the wetted particulates and excess liquid droplets are separated from the gas stream by an entrainment section, which usually consists of a cyclonic separator and (or) a mist eliminator. Current designs for venturi scrubbers generally use the vertical downflow of gas through the venturi throat and incorporate three features: (1) a “wet-approach” or “flooded-wall” entry section to avoid a dust buildup at a wet-dry junction; (2) an adjustable throat for the venturi throat to provide for adjustment of the gas velocity and the pressure drop; and (3) a “flooded” elbow located below the venturi and ahead of the entrainment separator to reduce wear by abrasive particles. The venturi throat is sometimes fitted with a refractory lining to resist abrasion by dust particles.

Venturi scrubbers are primarily used to control PM_{10} . Venturi scrubber collection efficiencies for particulates range from 70 to greater than 99%, depending upon the application. Collection efficiencies are generally higher for particulates with aerodynamic diameters of approximately 0.5 to 5 μm . Some

venturi scrubbers are designed with an adjustable throat to control the velocity of the gas stream and the pressure drop. Increasing the venturi scrubber efficiency requires increasing the pressure drop, which in turn increases the energy consumption.

Venturi scrubbers have been applied to control particulate emissions from utility, industrial, commercial, and institutional boilers fired with coal, oil, wood, and liquid waste. They have also been applied to control emission sources in the chemical, mineral products, wood, pulp and paper, rock products, and asphalt manufacturing industries; lead, aluminum, iron and steel, and gray iron production industries; and municipal solid waste incinerators. Typically, venturi scrubbers are applied where it is necessary to obtain high collection efficiencies for fine particulates. Thus, they are applicable to controlling emission sources with high concentrations of submicron particulates. Typical gas flow rates for a single-throat venturi scrubber unit are 8 to 1700 scf/sec. Flows higher than this use either multiple venturi scrubbers in parallel or a multiple throated venturi. Inlet gas temperatures are usually in the range of 40 to 750°F (4 to 400°C). Waste gas pollutant loadings can range from 6×10^{-5} to 7×10^{-3} lb/scf. In situations where waste gas contains both particulates and gases, venturi scrubbers are sometimes used as a pretreatment device to remove particulates. This is to prevent clogging of a downstream device, such as a packed bed scrubber, which is designed to collect primarily gaseous pollutants. (Refer to EPA-452/F-03-017, *Air Pollution Control Technology Fact Sheet – Venturi Scrubber* [EPA 2003h].)

Hydrosonic Atomized Scrubbers (Air and Steam)

An air and steam atomized scrubber is a wet scrubbing system in which the energy for treating and pumping the offgas is provided by the flow of compressed air or steam from a supersonic ejector nozzle. The offgas stream is drawn into the device by the ejector nozzle, which is fitted with a water injector ring. The air or steam jet causes a violent shattering of the water droplets and subsequent turbulent mixing of the gas and water in a converging section of piping. By this means, extremely fine particulates are captured on the droplets. The gas then flows through a mixing tube where the droplets agglomerate. Separation of the cleaned gas from the entrained liquid is accomplished in a low-pressure cyclone, with liquid removed by gravity at the bottom. The removal efficiencies are approximately 99% for 0.1 to 10 μm particulates. Removal efficiencies can be limited by re-entrainment or stripping from the reservoir solution. Liquid is recirculated by a high-pressure pump with an attached filter required to prevent particles from blocking the nozzle. There are no moving parts to the scrubber, which can be used in series for higher removal efficiencies. Pressure drop across the scrubber is approximately 9 in. of water column. The scrubbers require periodic maintenance, and a high solids concentration in the water or scrubbing solution can cause plugging. The scrubbers are reliable and effective and have been extensively used in commercial applications and also at Savannah River's Defense Waste Processing Facility. (Refer to 24590-WTP-RPT-ENV-01-005; RPT-W375-EN00007, *Best Available Radionuclide Control Technology for the RPP-WTP*; and WHC-MR-0398, *Hanford Waste Vitrification Plant Technical Background Document for Toxics Best Available Control Technology Demonstration* [Westinghouse 1992].)

Impingement-Plate / Tray-Tower Scrubbers

An impingement-plate scrubber is a vertical chamber with plates mounted horizontally inside a hollow shell. Impingement-plate scrubbers operate as countercurrent PM collection devices. The scrubbing liquid flows down the tower while the gas stream flows upward. Contact between the liquid and the

particle-laden gas occurs on the plates. The plates are equipped with openings that allow the gas to pass through. Some plates are perforated or slotted, while more complex plates have valve-like openings.

The simplest impingement-plate scrubber is the sieve plate, which has round perforations. In this type of scrubber, the scrubbing liquid flows over the plates and the gas flows up through the holes. The gas velocity prevents the liquid from flowing down through the perforations. Gas-liquid-particle contact is achieved within the froth generated by the gas passing through the liquid layer. Complex plates, such as bubble cap or baffle plates, introduce an additional means of collecting particulates. The bubble caps and baffles placed above the plate perforations force the gas to turn before escaping the layer of liquid. While the gas turns to avoid the obstacles, most particulates cannot and are collected by impaction on the caps or baffles. Bubble caps and the like also prevent liquid from flowing down the perforations if the gas flow is reduced.

In all types of impingement-plate scrubbers, the scrubbing liquid flows across each plate and down the inside of the tower onto the plate below. After the bottom plate, the liquid and collected particulates flow out of the bottom of the tower. Impingement-plate scrubbers are usually designed to provide operator access to each tray, making them relatively easy to clean and maintain. Consequently, impingement-plate scrubbers are more suitable for PM collection than packed-bed scrubbers. Particles larger than 1 μm in aerodynamic diameter can be collected effectively by impingement-plate scrubbers, but many particles smaller than 1 μm in aerodynamic diameter will penetrate these devices.

Water is the most common solvent used to remove inorganic contaminants, though a caustic is used for acid-gas absorption. Removal efficiencies for particulates range from 50 to 99%. Typical gas flow rates for a single impingement-plate scrubber unit are 17 to 1250 scf/sec. Inlet gas temperature is limited to 40 to 700°F (4 to 370°C) for PM control. For gaseous pollutant control, the gas temperature ranges between 40 to 100°F (4 to 38°C). In general, the higher the gas temperature, the lower the absorption rate, and vice-versa. Higher temperatures can lead to loss of scrubbing liquid or solvent through evaporation. Impingement-plate scrubbers are easy to clean and maintain and are not subject to fouling, as packed-bed wet scrubbers are; hence, they are more suited to PM control, and there are no practical limits to inlet particulate concentrations. These scrubbers require a constant load and there is a high potential for corrosion problems. Short residence times will lower scrubber efficiency for small particles. Collection efficiencies for small particles (smaller than 1 μm in aerodynamic diameter) are low for these scrubbers; hence, they are not recommended for fine particulate control. (Refer to EPA-452/F-03-012, *Air Pollution Control Technology Fact Sheet – Impingement-Plate/Tray-Tower Scrubber* [EPA 2003].)

Mechanically Aided Scrubbers

Mechanical scrubbers are devices in which a power-driven rotor produces the fine spray and the contacting of gas and liquid. As in other types of scrubbers, the droplets are the principal collecting bodies for the dust particles. The rotor acts as a turbulence producer. An entrainment separator must be used to prevent carry-over of spray. The simplest commercial devices of this type are essentially fans upon which water is sprayed. Mechanically aided scrubber collection efficiencies range from 80 to 99% for particles down to 1 μm , depending upon the application. This type of scrubber relies almost exclusively on inertial interception for particulate collection, and is capable of high collection efficiencies, but only with commensurate high energy consumption.

Typical gas flow rates for a mechanically-aided scrubber units are 17 to 850 scf/sec. In general, mechanically-aided scrubbers can operate at temperatures up to approximately 300°F (150°C). Mechanically aided scrubbers can accept waste flows with particulate loadings up to 3×10^{-4} lb/scf;

however, higher loadings are possible with precleaning. Dust buildup on rotors can lead to imbalances, and there are typically higher maintenance requirements for these scrubbers. Mechanically aided scrubbers are usually preceded by a cyclone or other precleaner to remove coarse dust and larger debris. (Refer to EPA-452/F-03-013, *Air Pollution Control Technology Fact Sheet – Mechanically-Aided Scrubber* [EPA 2003j].)

Packed-Bed / Packed-Tower Scrubber

Packed-bed scrubbers consist of vertical towers filled with packing material. The packing material provides a large surface area for the offgas to contact the scrubbing solution. The scrubbing solution (typically water, caustic, or lime slurry) trickles down from the top of the tower through the packing, while the offgas moves countercurrently. Figure 4-5 provides an illustration of a packed-bed / packed-tower scrubber.

Moving-bed scrubbers and ionizing wet scrubbers are two subsets of the packed-bed scrubber. Moving-bed scrubbers incorporate a zone of movable packing where the gas and liquid can intimately mix. This type of scrubber uses packing consisting of low-density polyethylene or polypropylene spheres about 1.5 in. diameter, kept in continuous motion between the upper and lower retaining grids. This action keeps the spheres continually cleaned and considerably reduces the likelihood of bed plugging. Ionizing wet scrubbers use a high voltage to electrostatically charge particles in the gas stream. The particles then enter the packed scrubber section, where they are removed by attraction to neutral surfaces.

Although used primarily for acid gas control, removal efficiencies for PM as small as 2.5 μm range from 50 to 95% (refer to EPA-452/F-03-015, *Air Pollution Control Technology Fact Sheet – Packed-Bed/Packed-Tower Scrubber* [EPA 2003k]). The equipment can handle corrosive gases or aerosols and offers relatively low pressure drops and small space requirements. The process has high maintenance requirements, can be sensitive to temperature fluctuations, and is generally limited to gas streams with relatively low grain loadings. An ionizing wet scrubber has been used at the DOE Toxic Substances Control Act Incinerator in Oak Ridge to process uranium-contaminated hazardous organic wastes. (Refer to 24590-WTP-RPT-ENV-01-005.)

Spray-Chamber / Spray-Tower Scrubber

Spray scrubbers consist of empty cylindrical or rectangular chambers in which the gas stream is contacted with liquid droplets generated by spray nozzles. A common form is a spray tower, in which the gas flows upward through a bank or successive banks of spray nozzles. Similar arrangements are sometimes used in spray chambers with horizontal gas flow. Such devices have very low gas pressure drops, and all but a small part of the contacting power is derived from the liquid stream. The required contacting power is obtained from an appropriate combination of liquid pressure and flow rate. Physical absorption depends on properties of the gas stream and liquid solvent, such as density and viscosity, as well as specific characteristics of the pollutant(s) in the gas and the liquid stream (e.g., diffusivity, equilibrium solubility). These properties are temperature dependent, and lower temperatures generally favor absorption of gases by the solvent. Absorption is also enhanced by greater contacting surface, higher liquid-gas ratios, and higher concentrations in the gas stream. Chemical absorption may be limited by the rate of reaction, although the rate-limiting step is typically the physical absorption rate, not the chemical reaction rate. Figure 4-6 provides an illustration of a spray-chamber / spray-tower scrubber.

Spray tower scrubbers generally are not used for fine PM applications because high liquid-to-gas ratios (22.4 gal/1,000ft³) are required. Overall, collection efficiencies range from 70 to greater than 99%,

depending upon the application. The most efficient spray towers typically employ cyclonic techniques to enhance removal efficiency.

Typical gas flow rates for spray tower wet scrubbers are 25 to 1700 scf/sec. In general, the higher the gas temperature, the lower the absorption rate, and vice-versa. Excessively high gas temperatures also can lead to significant solvent or scrubbing liquid loss through evaporation. For waste gases in which the particulates are to be controlled, the temperature range is generally 40 to 700°F (5 to 370°C), and for gas absorption applications, 40 to 100°F (5 to 40°C). Typical gaseous pollutant concentrations range from 250 to 10,000 ppmv. Spray tower wet scrubbers are not as prone to fouling as other wet scrubber designs, but very high liquid-to-gas ratios may be necessary to capture fine particulates. (Refer to EPA-452/F-03-016, *Air Pollution Control Technology Fact Sheet – Spray-Tower Scrubber* [EPA 2003].)

Submerged Bed Scrubber

In an SBS, hot process offgas is passed through a bed of ceramic spheres or packing. A water spray with optional caustic injection floods the SBS to cool the offgas and scrub any particulates and acid gases present. The SBSs provide offgas cooling, condensation of steam and other condensables, removal of PM, and acid gas removal. The basic SBS equipment consists of a packed bed submerged in a process vessel containing scrubbing liquid. Gas to be cleaned enters at the bottom of the bed. Buoyancy drives liquid recirculation in concurrent flow with the gas as the system blowers pull the gas upward, with the gas exiting at the top of the scrubber. Condensate is continuously removed from the scrubber through an overflow line at the top of the liquid surface. The temperature of the scrubbing liquid is maintained by cooling coils located in the outer portion of the vessel and a cooling jacket. A large volume of cooled scrubbing solution acts as a heat sink so that the system can handle surges of hot offgas. Noncondensable material passes through. Captured aerosols are continuously removed from the system through an overflow line that also maintains the water level at a specified height. Figure 4-7 provides an illustration of an SBS.

Due to the internal circulation of the scrubbing liquid, no external pump or internal agitator is required. The scrubber tolerates variable operating conditions and has minimal maintenance requirements. There is a high pressure drop across the scrubber and the low circulation rate requires a large heat transfer surface area. The scrubbers are reliable and effective and have been extensively used in commercial applications and also at the West Valley Demonstration Project by West Valley Nuclear Services Company, Inc. Experiments performed on the behalf of DOE have shown that particulate removal efficiency can reach as high as 98% for particles in the range of 0.3 to 0.7 μm . (Refer to 24590-101-TSA-W000-0009-177-00001, *Final Report – Summary of DM1200 SBS History and Performance*; and PNL-6036, *Design Procedure for Sizing a Submerged-Bed Scrubber for Airborne Particulate Removal* [Battelle 1987]).

Cyclonic Wet Scrubbers

Cyclonic wet scrubbers work much like dry cyclones, with the exception that water is introduced into the cyclone. Particle-laden gas is introduced into the device where it is contacted by water sprays and the resulting droplets are impacted by centrifugal force onto the cyclone walls. The scrubbing liquid and the captured particles run down the walls and out the bottom of the scrubber. Particulate removal efficiencies reach as high as 95% for particles greater than 5 μm and from 60 to 75% for submicron particles. The pressure drop across the scrubber ranges from 2 to 8 in. water column. Gas flow rates range from 25 to 1700 scf/sec and power input for a cyclonic scrubber is generally 1 to 3.5 hp per 1000 cfm. Cyclonic wet scrubbers can handle high temperatures and high moisture gases and require minimal maintenance. Drawbacks to using these scrubbers are high operating costs and production of a liquid waste stream.

These scrubbers are generally used as a precleaning device and for various process applications where high removal efficiencies are not required. (Refer to 24590-WTP-RPT-ENV-01-005; and EPA/452/B-02-001, *EPA Air Pollution Control Cost Manual* [EPA 2002].)

4.3 Elimination of Technically Infeasible Options

Step 3 of the T-BACT process is to determine the technical feasibility of control technology options and to eliminate infeasible technologies from further consideration.

4.3.1 Qualitative Criteria for Control Technology Screening

Qualitative screening and elimination criteria were developed for the selective elimination of control technologies evaluated to be technically infeasible or not applicable for treatment of EMF emissions. The screening criteria were applied for the suite of control technologies documented in the report.

The screening criteria were based on TD8831N481990 (EPA 1990). If a control technology has been installed and operated successfully on emissions with similar chemical and physical characteristics to those from EMF processes, it is demonstrated and is technically feasible. An undemonstrated technology is also determined to be feasible if it is "available" and "applicable." A technology is considered "available" if it can be obtained commercially. A technology is considered "applicable" if it can be reasonably installed and operated for control of EMF process emissions. A technology is considered technically infeasible if there are unresolvable technical difficulties in applying the control (e.g., size of the unit, location of the proposed site, and operating problems related to specific circumstances of the EMF process emissions).

The screening criteria developed for application to the suite of control technologies are as follows:

- The control technology has not been demonstrated at the appropriate scale (too small or too large) for application to the EMF process offgases.
- The control technology introduces additional hazards above and beyond the primary control hazard.
- The control technology uses materials of construction that are unsuitable in a radiation field anticipated during operations and where no suitable alternative materials can be substituted.
- The control technology would be very difficult to modify for applicable operations and maintenance activities anticipated during operations.
- The control technology requires testability requirements where extraordinary measures would be required to ensure operational performance.

4.3.2 Development of Technology Short List

Using the qualitative criteria for control technology screening described in Section 4.3.1, the list of potential control technologies for application to EMF emissions was evaluated. Table 4-1 shows the potential toxic particulate and aerosol control technologies considered and the screening results. It includes whether each technology was determined to be applicable or not, and provides comments on why certain technologies were eliminated. Redundant technologies were eliminated. Only one of two control technologies that were essentially the same was retained as being applicable (e.g., spray-chamber / spray-tower wet scrubber was retained as being applicable, and spray tower scrubber was eliminated as being redundant).

The other primary reasons for elimination of technologies included not being proven at a scale applicable to the small flow requirements of the DVP system. The technologies eliminated due to unresolvable technical difficulties or poor compatibility with the scale of the EMF ventilation are described in the following paragraphs.

Baghouse (Fabric) Filters

Baghouse (fabric) filters were eliminated from further consideration. Baghouses consist of a large array of multiple filter bags necessary to provide sufficient control efficiency. These bags must be changed out frequently in order to maintain efficiency. Due to the small flow requirements of the DVP system, baghouse filters are eliminated.

High-Efficiency Metal Fiber Filter

HEMF filters were eliminated from further consideration. Disposal of a contaminated HEMF filter at the end of its usable life poses a challenge. Space requirements for disposal of spent HEMF filters is an issue especially when compared with traditional HEPA filters, which can be compacted upon disposal.

Ultra-Low Penetration Air Filters

ULPA filters were also eliminated from further consideration. These filters are primarily used for applications in the medical and electronic industries (i.e., clean rooms). They are used for offgas streams with very low particulate loadings, and they load up readily and require frequent replacement to maintain their efficiency. Excessive changeout requirements eliminate these filters from further consideration.

Deep-Bed Sand Filters

Deep-bed sand filters were eliminated from further consideration. Deep beds of sand can be used to provide particulate and aerosol control. Such beds are sized to accommodate the offgas flow and can be as large as a swimming pool. A separate large vault filled with filter media (sand and gravel) could be used. However, if any decrease in efficiency occurred due to channeling in the bed, the filter media would need to be changed out. The time to change out the large volume of filter media would greatly impact operations. End-of-life decommissioning of a vault containing large quantities of radioactively contaminated filter media would also present significant difficulties. Due to the small flow requirements of the DVP system, deep-bed sand filters are eliminated.

Impingement-Plate / Tray-Tower scrubbers and Mechanically Aided Scrubbers

Impingement-plate / tray-tower scrubbers and mechanically aided scrubbers were eliminated from further consideration. These scrubbers are not effective for removing submicron sized particles. In addition, mechanically aided scrubbers use a power-driven rotor to produce turbulence and increase contact between the offgas and the scrubbing solution. Moving parts wear and break down, requiring frequent maintenance to maintain their operational effectiveness; therefore, this control technology is not favorable compared to passive control technologies.

Table 4-2 provides a short list of control technologies for further T-BACT analysis. For control of particulates and aerosols, the following technologies were selected for further analysis: prefilter (roughing filter), HEMF filter, HEPA filter, deep-bed glass fiber filter, HEME, dry ESP, WESP, ejector venturi

scrubber, hydrosonic scrubber (HSS), packed-bed / packed-tower wet scrubber, spray-chamber / spray-tower wet scrubber, SBS, cyclonic wet scrubber, cyclone collector, and multicyclone.

4.4 Ranking of Remaining Control Technologies

Step 4 of the T-BACT process is to rank feasible control technologies by order of effectiveness. Effectiveness is defined by the ability of the control technology to reduce the post-treatment emission rate for toxic particulates and aerosols. An average removal efficiency was determined from documented ranges of removal efficiencies. Table 4-3 lists the control technologies for toxic particulates and aerosols in order of effectiveness. Technologies analyzed for the removal of toxic particulates and aerosols had removal efficiencies ranging from 72.5 to 99.9995%.

4.5 Evaluation of the Most Effective Control Technologies

Step 5 of the T-BACT process is evaluation of the most effective control technologies. The following section provides the methodology used to evaluate the most effective control technologies, taking into account the environmental, energy, and economic impacts.

4.5.1 Environmental, Energy and Economic Impacts

Step 5 of the T-BACT process is to evaluate the environmental, energy, and economic impacts of the potential control options, beginning with the most effective. Appendix B of 24590-WTP-RPT-ENV-01-005 provides data on the environmental, energy, and economic impacts for highly ranked applicable technologies for each unabated offgas stream analyzed during the previously completed T-BACT demonstration for the WTP. The results of the economic analyses are summarized as tables in 24590-WTP-RPT-ENV-01-005, Appendix B, Table B-2. The analyses concluded that HEPA filters, which are likewise the most effective feasible control technology for particulates and aerosols from the EMF, resulted in no unacceptable environmental, energy, or economic impacts. HEPA filters, in fact, tended to result in the least negative impacts of all control technologies proposed. Therefore, the conclusion reached through the analyses already performed for the existing T-BACT will be applied to the T-BACT for the EMF, because HEPA filters were the most efficient feasible control technology in both cases.

The economic analyses included factors for environmental impacts (secondary waste treatment and disposal costs) and energy impacts (utility costs). In addition, impacts on worker health and safety (e.g., potential worker exposures and labor for equipment maintenance) were included. The purpose of the economic evaluations was to compare “cost reasonableness” of the highly ranked technologies to determine whether environmental, energy, and economic impacts were acceptable. The economic evaluations were performed consistently across all technologies, and are rough order of magnitude cost estimates.

The economic analyses included evaluation of direct and indirect capital costs (equipment, installation, etc.), as well as annual operating costs (utilities, labor, and maintenance costs). To estimate the technology equipment costs, the equipment was sized based on the flow of each unabated offgas stream. The equipment cost estimates were based on EPA guidance documents and vendor information. Next, factors for fabrication from corrosion resistant materials and adaptation to hot cell operations and maintenance were applied, as shown in 24590-WTP-RPT-ENV-01-005, Appendix B, Table B-3. (**Note:** Hot cell operations and maintenance are not applicable to the EMF.) The economic analyses also included secondary waste treatment and disposal costs, except for secondary wastes suitable for recycle

within the WTP. The total annualized costs were based on a 40-year facility life and a 10% rate of return on capital investment.

The total annualized costs were then combined with the control efficiency data to provide an annual cost per ton of COPC reduction for each technology for each unabated offgas stream. From a determination of the “cost reasonableness” of these analyses (annual cost per ton of reduction), a determination was made that there were no unacceptable environmental, energy, or economic impact associated with the selection of HEPA filters, which are the control technology with the highest removal efficiency proposed as T-BACT in this analysis. Annual costs per ton of reduction in particulates and aerosols for dual-stage HEPA filtration ranged from \$220.00 to \$135 million. The cost of HEPA filtration for control of toxic particulates and aerosols is offset by the advantage of treating radionuclides with the same equipment. To maintain consistency with existing WTP facilities that have selected HEPA filters as T-BACT per the results of the previously completed economic analyses, the same conclusions shall be applied to the EMF in consideration to the environmental, energy, and economic impacts.

4.6 Proposed Best Available Control Technology for Toxic Air Pollutants

Dual-stage HEPA filters are the highest ranked proposed T-BACT control on the technology shortlist (Table 4-3) and do not result in any unacceptable environmental, energy, or economic impacts. Therefore, dual-stage HEPA filters are the proposed T-BACT for the control of particulate and aerosol emissions from the EMF. HEPA filters are particularly well suited for mitigation of particulates and aerosol emissions from the EMF process offgas because they are a passive control technology and do not result in any additional secondary liquid waste streams, such as those produced from technologies including wet scrubbers and WESPs. HEPA filters are a cost-effective, technically feasible control technology, and they have been proposed as T-BACT for other WTP process offgas systems in facilities throughout the Hanford Site.

Figure 4-8 provides a depiction of the DVP system exhaust with the proposed T-BACT in place.

24590-WTP-RPT-ENV-15-005, Rev 0
Best Available Control Technology Analysis for Toxic Air Pollutants for the WTP
Effluent Management Facility

Table 4-2 T-BACT Control Technology Screening for Control of Toxic Particulates and Aerosols

Description	Category	Media (being treated)		Screening Results	Comments
		Liquid	Solid		
Baghouse (Fabric) Filter	Filter		PM	Eliminated	Not applicable for low flow vessel vent system; large space requirement (multiple filter bags); frequent bag changeout to maintain efficiency
Prefilter (Roughing Filter)	Filter		PM	Applicable	
HEMF Filter	Filter	Aerosol	PM	Eliminated	No existing long-term, large-scale applications; free liquids with dissolved acid gases must be excluded for contact with the filters; high initial cost; repetitive cleaning efficiency not demonstrated
HEPA Filter	Filter	Aerosol	PM	Applicable	
ULPA Filter	Filter		PM	Eliminated	Not applicable for EMF emissions; frequent changing of filter media necessary to maintain efficiency; primarily applicable for medical and electronic clean room applications
Deep-Bed Sand Filter	Filter	Aerosol	PM	Eliminated	Not applicable for low flow vessel vent system; very large space requirement; bed channeling can reduce efficiency and require changeout of large quantity of filter media; significant decontamination and disposal impacts for large vault installations
Deep-Bed Glass Fiber Filter	Filter, Mist Eliminator		PM	Applicable	
HEME	Mist Eliminator	Aerosol	PM	Applicable	
Dry ESP	Precipitator		PM	Applicable	
WESP	Precipitator	Aerosol	PM	Applicable	
Ejector Venturi Scrubber	Scrubber	Aerosol	PM	Applicable	

Table 4-2 T-BACT Control Technology Screening for Control of Toxic Particulates and Aerosols

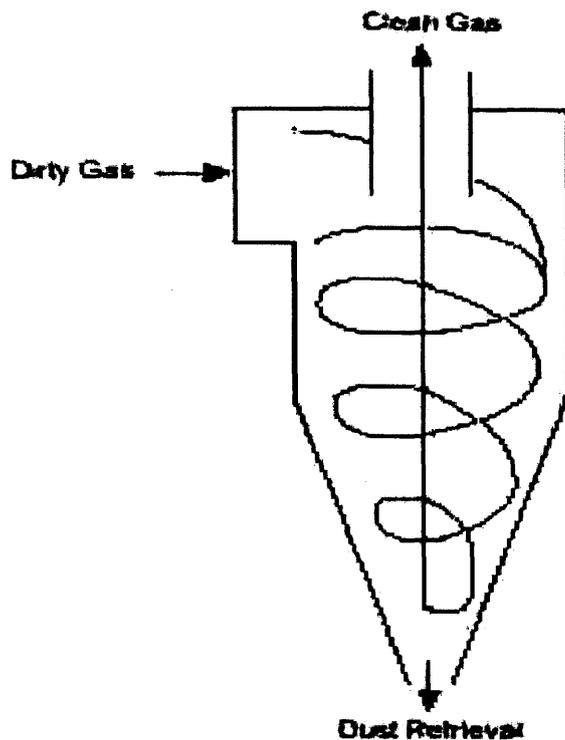
Description	Category	Media (being treated)		Screening Results	Comments
		Liquid	Solid		
Hydrosonic Air Atomized Scrubber	Scrubber	Aerosol	PM	Eliminated - redundant	Included under HSS
HSS	Scrubber	Aerosol	PM	Applicable	
Hydrosonic Steam Atomized Scrubber	Scrubber	Aerosol	PM	Eliminated - redundant	Included under HSS
Impingement Scrubber	Scrubber		PM	Eliminated - redundant	Included under impingement-plate / tray-tower scrubber
Impingement-Plate / Tray-Tower Scrubber	Scrubber		PM	Eliminated	Difficult due to frequent plugging and corrosion of trays/plates; not effective for submicron particulate removal
Mechanically-Aided Scrubber	Scrubber		PM	Eliminated	Operation difficult due to corrosion and problems with mechanical/moving parts; not effective for submicron particulate removal
Packed-Bed / Packed-Tower Wet Scrubber	Scrubber		PM	Applicable	
Spray Tower	Scrubber		PM	Eliminated - redundant	Included under spray-chamber / spray-tower wet scrubber
Spray-Chamber / Spray-Tower Wet Scrubber	Scrubber		PM	Applicable	
SBS	Scrubber	Aerosol	PM	Applicable	
Tray-Tower Scrubber	Scrubber		PM	Eliminated - redundant	Included under impingement-plate / tray-tower scrubber
Cyclonic Wet Scrubber	Scrubber		PM	Applicable	
Multiple Cyclone (Multicyclone)	Separator		PM	Applicable	
Cyclone Collector	Separator		PM	Applicable	

Table 4-3 T-BACT Technology Ranking by Effectiveness for Control of Toxic Particulates and Aerosols

Rank	Category	Control Technology	Average Removal Efficiency¹
1	Filter	Dual-Stage HEPA Filter	99.9995%
2	Precipitator	Dry ESP	99.45%
3	Precipitator	WESP	99.45%
4	Mist Eliminator	HEME	99%
5	Scrubber	HSS	99%
6	Scrubber	SBS	98%
7	Filter	Deep Bed Glass Fiber Filter	95.75%
8	Separator	Cyclone Collector	90%
9	Filter	Prefilter (Roughing Filter) (Group III – HIGH)	90%
10	Separator	Multiple Cyclones (Multicyclones)	87.5%
11	Scrubber	Ejector Venturi Scrubber	84.5%
12	Scrubber	Spray-Chamber/Spray-Tower Wet Scrubber	84.5%
13	Scrubber	Cyclonic Wet Scrubbers	78.5%
14	Scrubber	Packed-Bed / Packed-Tower Wet Scrubber	72.5%

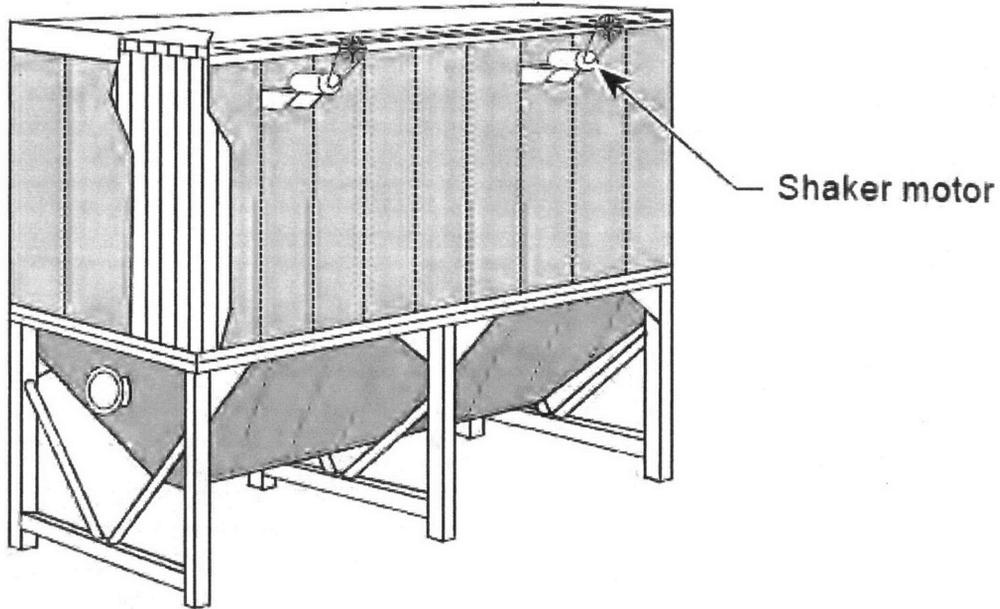
¹ Removal efficiencies represent the average of removal efficiencies documented in Section 4.2.2. Refer to Section 8 for a list of the literature sources.

Figure 4-1 Cyclone (Reverse-Flow Type)



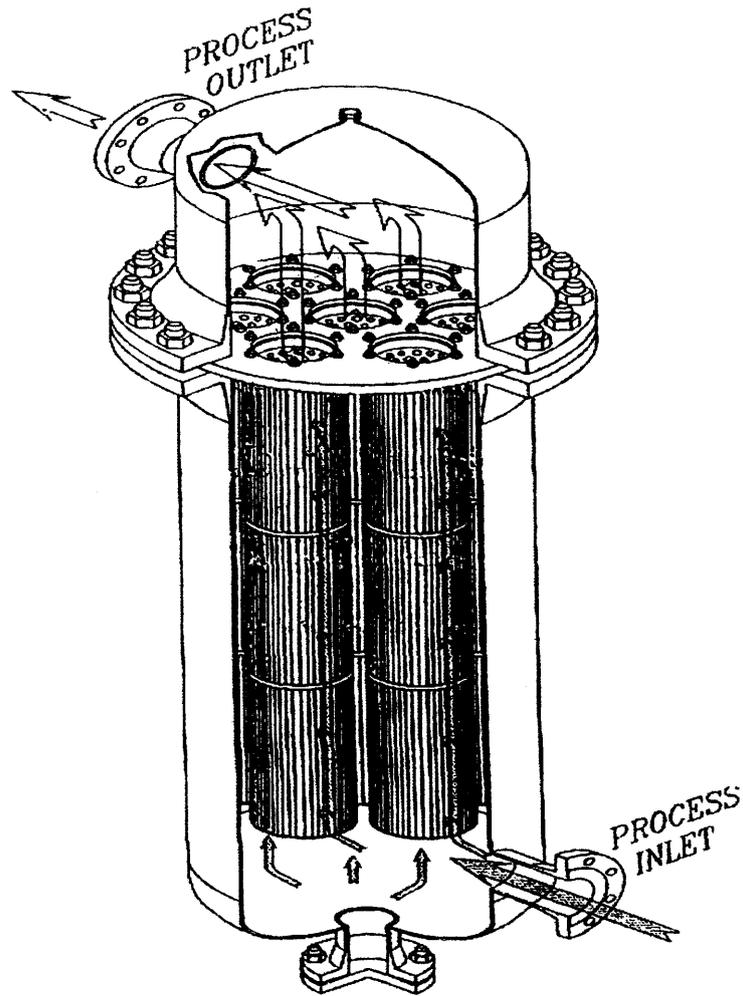
(Source: *Schematic of Cyclone* [EPA 2015a])

Figure 4-2 Baghouse Filter



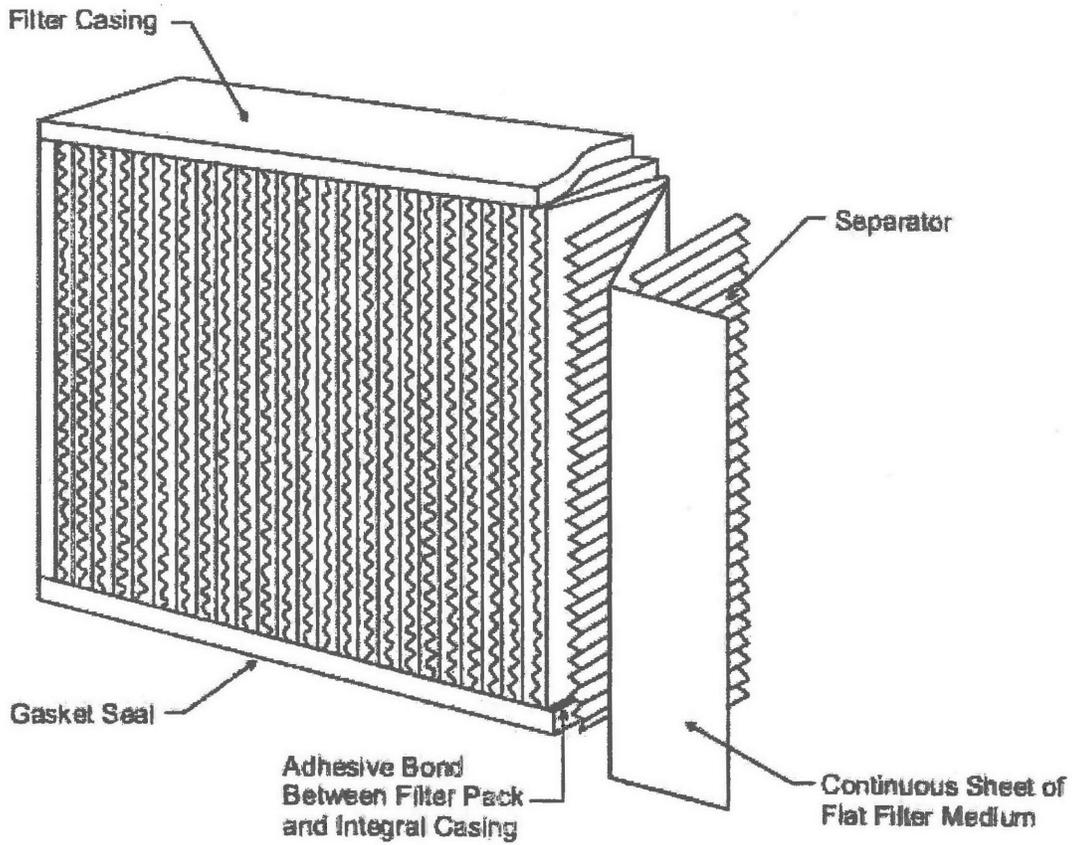
Typical Shaker Baghouse (Source: EPA/452/B-02-001 [EPA 2002], p 1-7)

Figure 4-3 High-Efficiency Metal Fiber Filter



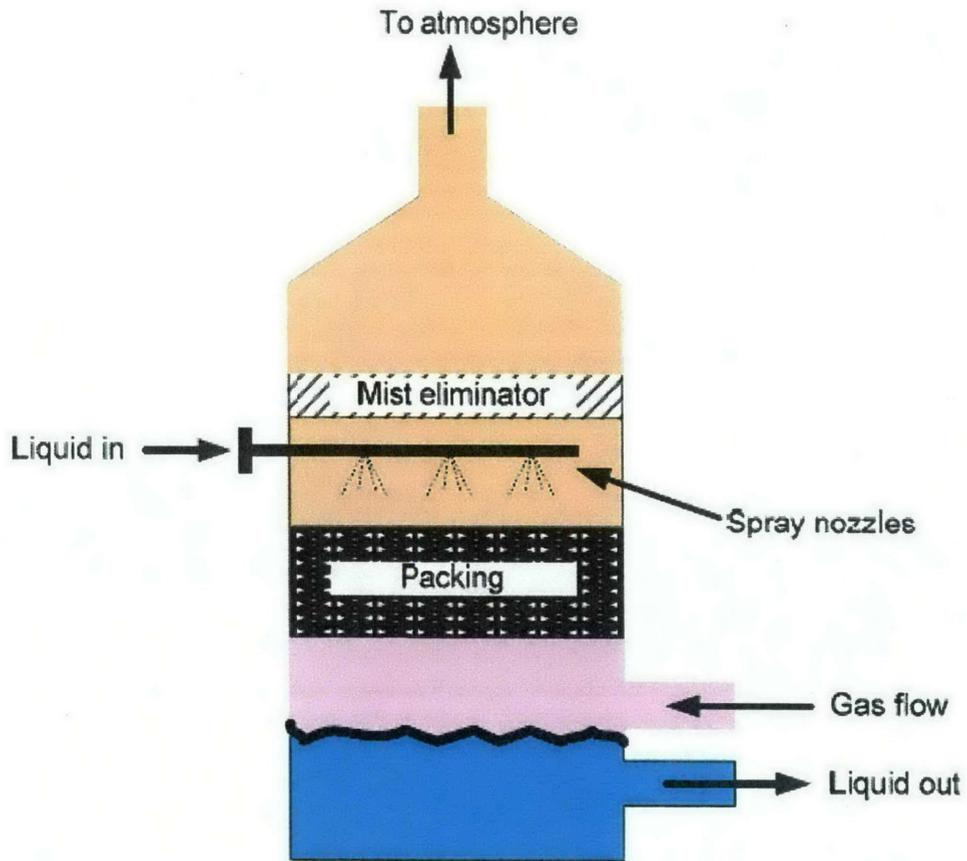
(Source: CCN 020413)

Figure 4-4 High-Efficiency Particulate Air Filters



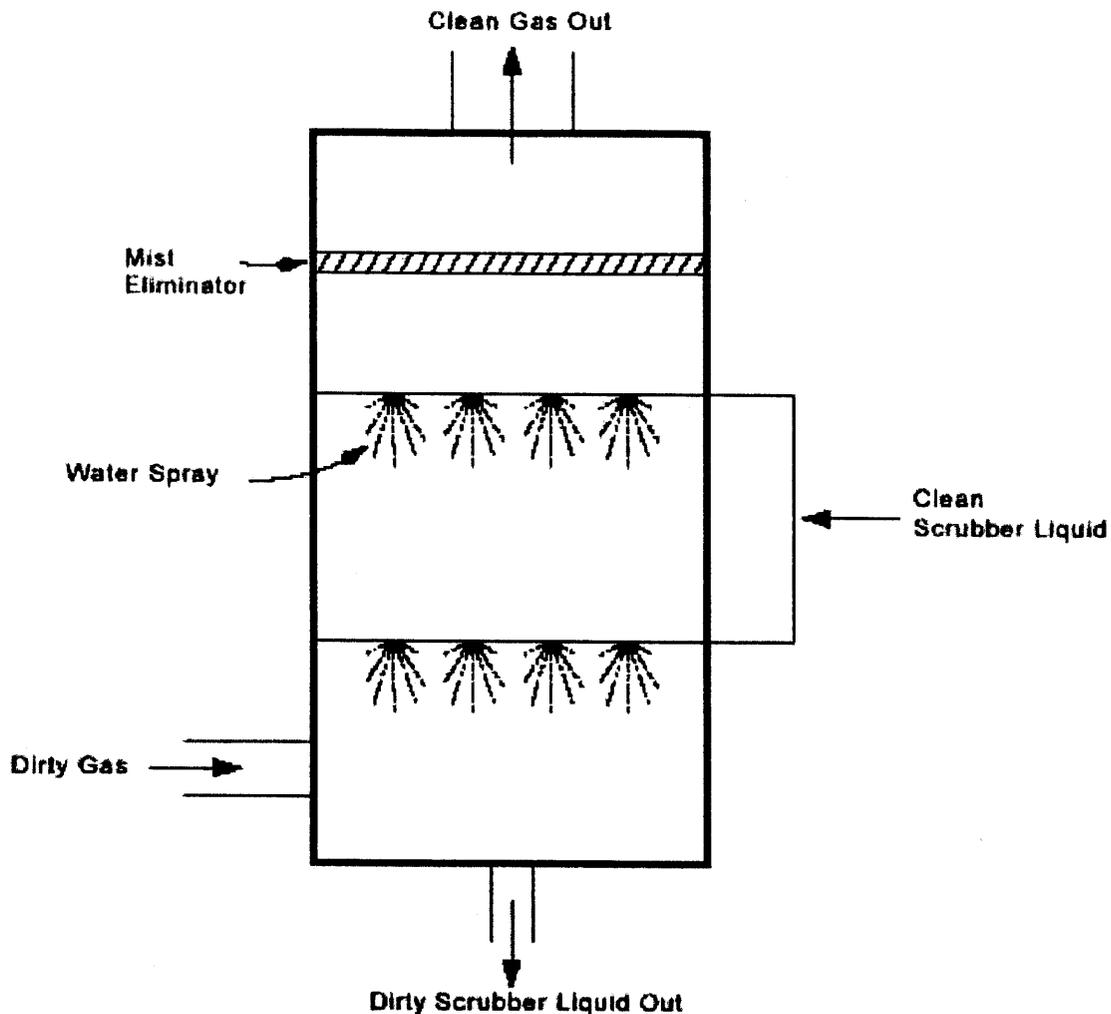
Open-Face, Deep-Pleat HEPA Filter – Type A Filter Pack (Source: DOE-HDBK-1169-2003 [DOE 2003], p 3-7)

Figure 4-5 Packed-Bed / Packed-Tower Scrubber



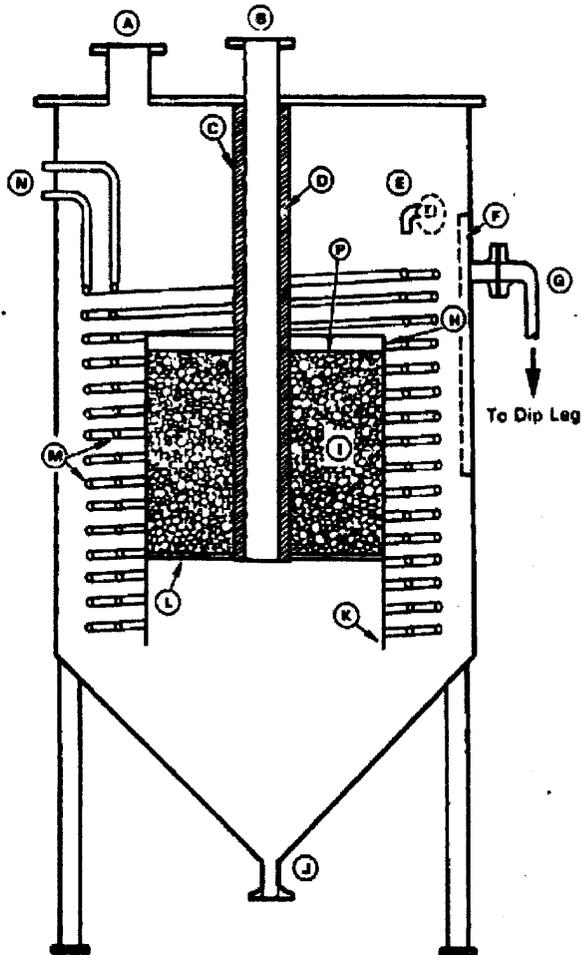
(Source: Schematic of Packed Bed Wet Scrubber [EPA 2015b])

Figure 4-6 Spray-Chamber / Spray-Tower Scrubber



(Source: *Schematic of Wet Scrubbers* [EPA 2015c])

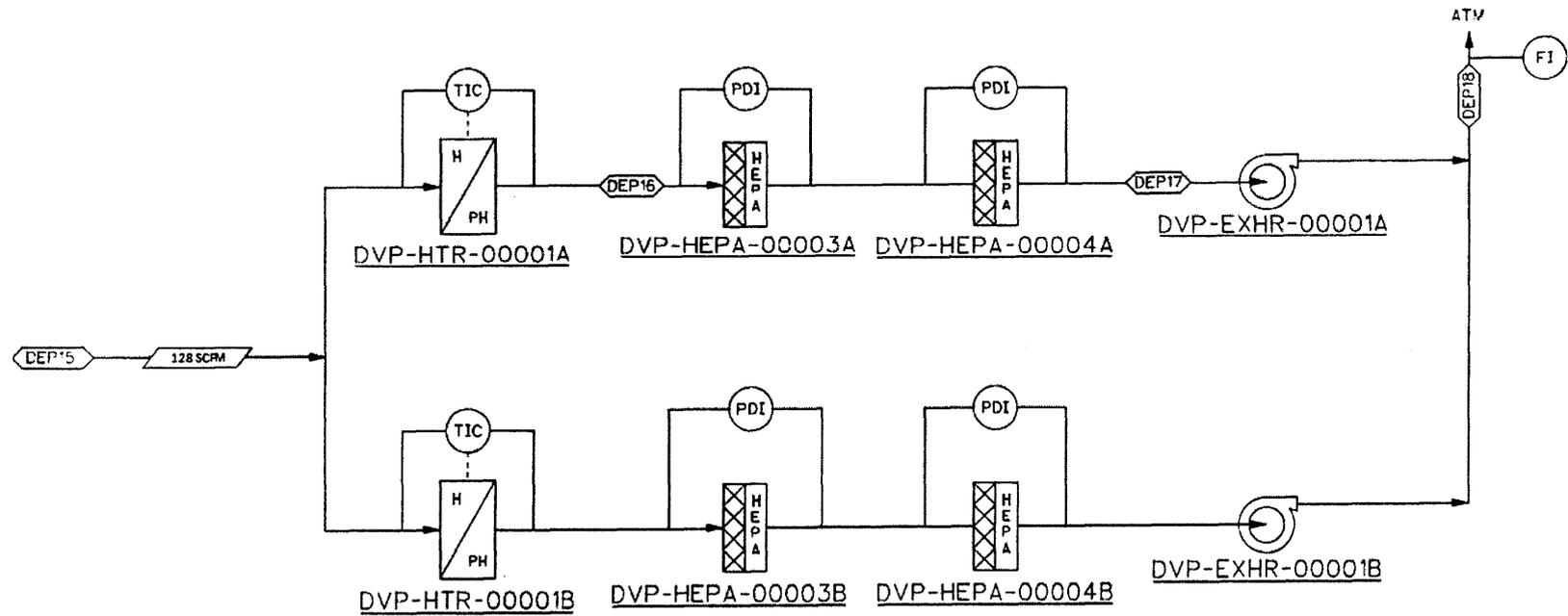
Figure 4-7 Submerged Bed Scrubber



- | | |
|------------------------|---------------------------------|
| (A) Exit Off-Gas Port | (H) Upper Skirt |
| (B) Inlet Off-Gas Port | (I) Packed Bed |
| (C) Downcomer Sleeve | (J) Drain |
| (D) Insulation | (K) Lower Skirt |
| (E) Makeup Water Port | (L) Bed Support/Gas Distributor |
| (F) Stilling Well | (M) Independent Cooling Coils |
| (G) Overflow Line | (N) Cooling Coil Inlet |
| | (P) Packing Hold-Down Screen |
- Note: Cooling coil outlets are not shown

Cross-Sectional View (Source: PNL-6036 [Battelle 1987], p 2.3)

Figure 4-8 Direct Feed LAW Effluent Management Facility Vessel Vent Process System Exhaust



Note: Stream DEP18 is vented to the EMF stack for monitoring prior to release to atmosphere. The EMF stack releases DEP18 and the EMF building ACV exhaust.

5 Inorganic Gases

5.1 Emissions Estimate of Gaseous Inorganic Compounds from the Effluent Management Facility

The emissions estimate for the EMF (24590-BOF-M4C-DEP-00001) has identified two gaseous inorganic compounds emitted from emissions unit EM-1 that are listed as TAPs and are subject to new source review requirements under WAC 173-460. Ammonia and dimethyl mercury are estimated to exceed the de minimis emission thresholds listed under WAC 173-460-150, subjecting these emissions to new source review requirements. Table 5-1 identifies the inorganic gaseous compounds subject to new source review requirements under WAC 173-460. Appendix A, Table A-3 provides a complete table of EMF emissions exceeding de minimis quantities.

Table 5-1 EMF Gaseous Inorganic TAP Emissions versus De Minimis Values

CAS #	COPC	De Minimis Value (lb per averaging period)	Averaging Period	Unabated Emissions (DEP15) Estimate (lb per averaging period)	New Source Review Required
7664-41-7	Ammonia	0.465	24 hours	19.2	Yes
593-74-8	Dimethyl Mercury	1.00×10^{-99}	24 hours	1.01×10^{-4}	Yes

5.2 Unabated Ammonia Emissions from the Effluent Management Facility

At an unabated emissions rate of 19.2 lb/day, the annual estimated emissions of ammonia from the EMF is 3.5 TPY (US tons per year). A recently completed T-BACT analysis performed by Washington River Protection Solutions, for emissions from the Hanford double shell tank farms (DST) primary ventilation systems, conducted an economic evaluation of the best available control technologies for emissions of ammonia vapors. They concluded that, at an estimated rate of 13.12 TPY ammonia, the annual cost of removal exceeded the maximum ceiling cost effectiveness threshold of \$105,000 per ton set by Ecology and EPA. The control technologies considered for T-BACT in this economic evaluation were thermal noncatalytic oxidation, activated carbon adsorption, and wet scrubber absorption. Cost of removal (cost per ton) for these technologies were estimated at \$223,000, \$392,000, and \$577,000, respectively (refer to CCN 285552, *Engineering Change Notice - TOC-ENV-NOC-5241*, Table ES-1). Therefore, at an emissions rate of 3.5 TPY ammonia from the EMF—which is approximately one quarter of that estimated from DST operations—the use of BACT for ammonia emissions is determined to be prohibitively expensive.

5.3 Unabated Dimethyl Mercury Emissions from the Effluent Management Facility

At an unabated emissions rate of 1.01×10^{-4} lb/day, the annual estimated emissions of dimethyl mercury from the EMF is 1.84×10^{-5} TPY (0.037 lb/yr). A recently completed T-BACT analysis (performed by Washington River Protection Solutions) for emissions from the Hanford DST primary ventilation systems

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conducted an economic evaluation of the BACT for emissions of gaseous dimethyl mercury. They concluded that, at an estimated rate of 2.61×10^{-4} TPY (0.52 lb/yr) dimethyl mercury, the annual cost of removal exceeded the maximum ceiling cost effectiveness threshold of \$105,000 per ton set by Ecology and EPA. The BACT considered in this economic evaluation was activated carbon adsorption treated with sulfur or iodine. The estimated cost of removal (cost per ton) using this technology was \$352 million (refer to CCN 285552, Table ES-1). Therefore, at an emissions rate of 1.84×10^{-5} TPY of dimethyl mercury from the EMF—which is one order of magnitude less than that estimated from DST operations—the use of the BACT for dimethyl mercury emissions is determined to be prohibitively expensive.

6 Volatile and Semivolatile Organic Compounds

6.1 Emissions Estimate of Volatile and Semivolatile Organic Compounds from the Effluent Management Facility

The emissions estimate for the EMF (24590-BOF-M4C-DEP-00001) has identified VOC/SVOCs emitted from emissions unit EM-1 that are listed as TAPs and are subject to new source review requirements under WAC 173-460. Table A-2 contains the emissions estimates of all organic COPCs from the EMF. Table A-3 contains a list of organic COPCs emitted from the EMF in quantities that exceed de minimis values. The total unabated emissions of all vapor phase organic COPCs from the EMF (including those that are not listed as TAPs under WAC 173-460-150) is 2.33×10^{-3} g/sec or 0.08 TPY. A recently completed T-BACT analysis performed by Washington River Protection Solutions, for emissions from the DST primary ventilation systems, investigated the cost per ton of removal of toxic organic compounds using BACT. The analysis concluded that removing 0.481 TPY toxic organic compounds would exceed the maximum ceiling cost effectiveness threshold (\$105,000) set by Ecology and EPA for the Hanford Site as economically justifiable. Thermal noncatalytic oxidation and activated carbon adsorption were the two BACT considered in the aforementioned economic evaluations, each with an anticipated removal efficiency of 99%. The estimated cost of removal (cost per ton) for these technologies were \$6.081 million/ton and \$1.643 million/ton, respectively (refer to CCN 285552, Table ES-1). Therefore, at an emissions rate of only 0.08 TPY from the EMF, (compared to the 0.481 TPY from DSTs) the use of the BACT for VOC/SVOCs is determined to be prohibitively expensive.

7 Best Available Control Technology for Toxic Air Pollutants Summary and Recommendations

The technology with the highest removal efficiency for toxic constituents was selected as proposed T-BACT for EMF emissions where no unacceptable environmental, energy, or economic impacts were determined.

It should be noted that in addition to this T-BACT report, a complementary best available radioactive control technology report (24590-WTP-RPT-ENV-15-004) was prepared. Requirements to minimize radionuclide air emissions from the EMF were also a major factor in the final selection of the air emissions control technologies to be installed at the EMF.

7.1 Particulates and Aerosols

Dual-stage HEPA filters are proposed as T-BACT for the controls of toxic particulates and aerosols. The T-BACT analysis was based on dual-stage HEPA filtration with a removal efficiency of 99.9995%. According to previous cost estimates conducted in support of 24590-WTP-RPT-ENV-01-005, annual costs per ton of reduction in toxic particulates and aerosols for HEPA filtration ranged from \$220.00 to \$135 million. The environmental, energy, and economic analyses for HEPA filtration resulted in no unacceptable impacts. The cost of HEPA filtration for control of toxic particulates and aerosols is offset by the advantage of treating radionuclides with the same equipment.

7.2 Toxic Inorganic Gases

Ammonia and dimethyl mercury emissions were estimated to be greater than the de minimis values for TAPs listed under WAC 173-460-150. It was determined that in order to remove these pollutants with best available technologies, the cost per ton to remove these pollutants would exceed the maximum ceiling cost effectiveness threshold of \$105,000 per ton previously set by Ecology and EPA (refer to CCN 285552). Therefore, due to the extremely low emissions rates and prohibitive cost per ton to remove these pollutants, no T-BACT is proposed for mitigation of these emissions.

7.3 Volatile Organic Compounds

Total VOC/SVOCs emitted from the EMF are estimated to be 0.08 TPY. It was determined that in order to remove these pollutants with best available technologies, the cost per ton to remove these pollutants would exceed the maximum ceiling cost effectiveness threshold of \$105,000 per ton previously set by Ecology and EPA (refer to CCN 285552). Therefore, due to the extremely low emissions rates and prohibitive cost per ton to remove these pollutants, no T-BACT is proposed to mitigate VOC/SVOC emissions.

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Appendix A

Constituents of Potential Concern Emissions Estimates for the Effluent Management Facility

Appendix A Constituents of Potential Concern Emissions Estimates for the Effluent Management Facility

Table A-1 Inorganic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC	Unabated Streams	Abated Streams	Phase
		DEP15	DEP18	
		DVP System	DVP System	
		g/sec	g/sec	
7440-22-4	Ag	1.92E-07	9.59E-13	Particle/Aerosol
7429-90-5	Al	2.12E-04	1.06E-09	Particle/Aerosol
7440-38-2	As	2.64E-07	1.32E-12	Particle/Aerosol
7440-39-3	Ba	4.56E-07	2.28E-12	Particle/Aerosol
7440-41-7	Be	2.39E-08	1.20E-13	Particle/Aerosol
24959-67-9	Br	5.36E-07	2.68E-12	Particle/Aerosol
7440-43-9	Cd	4.06E-07	2.03E-12	Particle/Aerosol
16887-00-6	Cl	2.02E-05	1.01E-10	Particle/Aerosol
57-12-5	CN	1.26E-04	1.26E-04	Vapor
7440-48-4	Co	8.02E-08	4.01E-13	Particle/Aerosol
7440-47-3	Cr	1.44E-05	7.20E-11	Particle/Aerosol
7440-50-8	Cu	1.46E-07	7.28E-13	Particle/Aerosol
16984-48-8	F	3.14E-05	1.57E-10	Particle/Aerosol
7439-89-6	Fe	3.09E-05	1.54E-10	Particle/Aerosol
7439-97-6	Hg	1.48E-07	7.38E-13	Particle/Aerosol
7439-93-2	Li	1.00E-07	5.01E-13	Particle/Aerosol
7439-95-4	Mg	1.13E-06	5.67E-12	Particle/Aerosol
7439-96-5	Mn	4.02E-06	2.01E-11	Particle/Aerosol
7439-98-7	Mo	3.35E-07	1.68E-12	Particle/Aerosol
7440-23-5	Na	1.21E-03	6.04E-09	Particle/Aerosol
7664-41-7	NH ₃	1.01E-01	1.01E-01	Vapor
7440-02-0	Ni	2.41E-06	1.20E-11	Particle/Aerosol
14797-65-0	NO ₂	2.90E-04	1.45E-09	Particle/Aerosol
14797-55-8	NO ₃	1.36E-03	6.81E-09	Particle/Aerosol
7723-14-0	P	0.00E+00	0.00E+00	Particle/Aerosol
7439-92-1	Pb	2.01E-06	1.01E-11	Particle/Aerosol
14265-44-2	PO ₄	1.26E-04	6.29E-10	Particle/Aerosol
7440-16-6	Rh	3.02E-07	1.51E-12	Particle/Aerosol
7704-34-9	S	0.00E+00	0.00E+00	Particle/Aerosol

Table A-1 Inorganic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC	Unabated Streams	Abated Streams	Phase
		DEP15	DEP18	
		DVP System	DVP System	
		g/sec	g/sec	
7440-36-0	Sb	2.08E-07	1.04E-12	Particle/Aerosol
7782-49-2	Se	2.94E-07	1.47E-12	Particle/Aerosol
7440-31-5	Sn	2.83E-07	1.41E-12	Particle/Aerosol
14808-79-8	SO ₄	9.39E-05	4.69E-10	Particle/Aerosol
7440-24-6	Sr	1.03E-06	5.16E-12	Particle/Aerosol
7440-25-7	Ta	9.83E-08	4.92E-13	Particle/Aerosol
7440-28-0	Tl	7.63E-07	3.81E-12	Particle/Aerosol
7440-61-1	UTOTAL	1.57E-05	7.87E-11	Particle/Aerosol
7440-62-2	V	1.33E-07	6.63E-13	Particle/Aerosol
7440-33-7	W	2.06E-06	1.03E-11	Particle/Aerosol
7440-65-5	Y	8.18E-08	4.09E-13	Particle/Aerosol
7440-66-6	Zn	2.87E-07	1.43E-12	Particle/Aerosol
7440-67-7	Zr	9.97E-06	4.98E-11	Particle/Aerosol
593-74-8	(CH ₃) ₂ Hg (Dimethyl mercury)	5.29E-07	5.29E-07	Vapor
10102-44-0	NO ₂	0.00E+00	0.00E+00	Vapor
124-38-9	CO ₂	0.00E+00	0.00E+00	Vapor
630-08-0	CO	0.00E+00	0.00E+00	Vapor
10028-15-6	O ₃	0.00E+00	0.00E+00	Vapor
7446-09-5	SO ₂	0.00E+00	0.00E+00	Vapor
7647-01-0	HCl	0.00E+00	0.00E+00	Vapor
7664-39-3	HF	0.00E+00	0.00E+00	Vapor
7782-41-4	F ₂	0.00E+00	0.00E+00	Vapor
7782-50-5	Cl ₂	0.00E+00	0.00E+00	Vapor
22967-92-6	CH ₃ Hg (Methyl mercury)	0.00E+00	0.00E+00	Particle/Aerosol
	Subtotal (Particle/Aerosol)	3.43E-03	1.72E-08	Particle/Aerosol
	Subtotal (Vapor)	1.01E-01	1.01E-01	Vapor
	TOTAL	1.04E-01	1.01E-01	

Source: 24590-BOF-M4C-DEP-00001

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
630-20-6	1,1,1,2-Tetrachloroethane	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
71-55-6	1,1,1-Trichloroethane	1.98E-10	0.00E+00	1.98E-10	1.98E-10	0.00E+00	1.98E-10
79-34-5	1,1,2,2-Tetrachloroethane	1.88E-10	0.00E+00	1.88E-10	1.88E-10	0.00E+00	1.88E-10
127-18-4	Tetrachloroethene	1.95E-10	0.00E+00	1.95E-10	1.95E-10	0.00E+00	1.95E-10
79-00-5	1,1,2-Trichloroethane	1.87E-10	0.00E+00	1.87E-10	1.87E-10	0.00E+00	1.87E-10
79-01-6	Trichloroethene	2.13E-10	4.31E-10	6.44E-10	2.13E-10	2.15E-15	2.13E-10
92-52-4	Biphenyl	3.73E-08	0.00E+00	3.73E-08	3.73E-08	0.00E+00	3.73E-08
75-34-3	1,1-Dichloroethane	1.60E-10	0.00E+00	1.60E-10	1.60E-10	0.00E+00	1.60E-10
75-35-4	1,1-Dichloroethene	2.52E-10	0.00E+00	2.52E-10	2.52E-10	0.00E+00	2.52E-10
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	4.89E-10	0.00E+00	4.89E-10	4.89E-10	0.00E+00	4.89E-10
120-82-1	1,2,4-Trichlorobenzene	1.18E-08	0.00E+00	1.18E-08	1.18E-08	0.00E+00	1.18E-08
95-50-1	1,2-Dichlorobenzene	1.54E-07	0.00E+00	1.54E-07	1.54E-07	0.00E+00	1.54E-07
107-06-2	1,2-Dichloroethane	1.87E-10	4.31E-10	6.18E-10	1.87E-10	2.15E-15	1.87E-10
78-87-5	1,2-Dichloropropane	1.60E-10	0.00E+00	1.60E-10	1.60E-10	0.00E+00	1.60E-10
106-88-7	1,2-Epoxybutane	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
156-60-5	1,2-trans-Dichloroethene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
106-99-0	1,3-Butadiene	5.37E-09	0.00E+00	5.37E-09	5.37E-09	0.00E+00	5.37E-09
541-73-1	1,3-Dichlorobenzene	7.76E-09	0.00E+00	7.76E-09	7.76E-09	0.00E+00	7.76E-09
106-46-7	1,4-Dichlorobenzene	1.01E-07	4.31E-10	1.02E-07	1.01E-07	2.15E-15	1.01E-07
123-91-1	1,4-Dioxane	5.91E-09	0.00E+00	5.91E-09	5.91E-09	0.00E+00	5.91E-09
75-01-4	Vinyl chloride	4.05E-10	0.00E+00	4.05E-10	4.05E-10	0.00E+00	4.05E-10
58-90-2	2,3,4,6-Tetrachlorophenol	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
95-95-4	2,4,5-Trichlorophenol	4.87E-05	0.00E+00	4.87E-05	4.87E-05	0.00E+00	4.87E-05
88-06-2	2,4,6-Trichlorophenol	1.68E-06	0.00E+00	1.68E-06	1.68E-06	0.00E+00	1.68E-06
120-83-2	2,4-Dichlorophenol	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
121-14-2	2,4-Dinitrotoluene	2.27E-08	1.32E-10	2.29E-08	2.27E-08	6.62E-16	2.27E-08
128-37-0	2,6-Bis(1,1-dimethylethyl)-4-methylphenol	2.83E-07	0.00E+00	2.83E-07	2.83E-07	0.00E+00	2.83E-07
78-93-3	2-Butanone	6.40E-08	4.31E-10	6.44E-08	6.40E-08	2.15E-15	6.40E-08
111-76-2	2-Butoxyethanol	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
91-58-7	2-Chloronaphthalene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
95-57-8	2-Chlorophenol	5.36E-05	0.00E+00	5.36E-05	5.36E-05	0.00E+00	5.36E-05
110-80-5	2-Ethoxyethanol	1.13E-04	0.00E+00	1.13E-04	1.13E-04	0.00E+00	1.13E-04
104-76-7	2-Ethyl-1-hexanol	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
591-78-6	2-Hexanone	2.55E-08	0.00E+00	2.55E-08	2.55E-08	0.00E+00	2.55E-08
126-98-7	2-Methyl-2-propenenitrile	5.91E-09	0.00E+00	5.91E-09	5.91E-09	0.00E+00	5.91E-09
78-83-1	Isobutanol	2.77E-04	0.00E+00	2.77E-04	2.77E-04	0.00E+00	2.77E-04
88-75-5	2-Nitrophenol	5.04E-05	4.31E-10	5.04E-05	5.04E-05	2.15E-15	5.04E-05
79-46-9	2-Nitropropane	3.95E-08	0.00E+00	3.95E-08	3.95E-08	0.00E+00	3.95E-08
67-64-1	Acetone	2.80E-07	4.31E-10	2.81E-07	2.80E-07	2.15E-15	2.80E-07
79-10-7	2-Propenoic acid	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
67-63-0	Isopropyl alcohol	1.65E-08	0.00E+00	1.65E-08	1.65E-08	0.00E+00	1.65E-08
107-05-1	3-Chloropropene	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
589-38-8	3-Hexanone	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
56-49-5	3-Methylcholanthrene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
72-55-9	4,4-DDE	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
101-55-3	4-Bromophenylphenyl ether	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
59-50-7	4-Chloro-3-methylphenol	5.19E-05	0.00E+00	5.19E-05	5.19E-05	0.00E+00	5.19E-05
100-40-3	4-Ethenylcyclohexene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
108-10-1	Hexone	2.09E-09	0.00E+00	2.09E-09	2.09E-09	0.00E+00	2.09E-09
3697-24-3	5-Methylchrysene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
602-87-9	5-Nitroacenaphthene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
83-32-9	Acenaphthene	5.66E-05	4.31E-10	5.66E-05	5.66E-05	2.15E-15	5.66E-05
208-96-8	Acenaphthylene	1.69E-05	4.31E-10	1.69E-05	1.69E-05	2.15E-15	1.69E-05
75-07-0	Acetaldehyde	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
60-35-5	Acetamide	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
141-78-6	Ethyl acetate	6.31E-10	0.00E+00	6.31E-10	6.31E-10	0.00E+00	6.31E-10
108-05-4	vinyl acetate	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
75-05-8	Acetonitrile	1.46E-07	4.31E-10	1.46E-07	1.46E-07	2.15E-15	1.46E-07
98-86-2	Acetophenone	3.73E-08	4.31E-10	3.77E-08	3.73E-08	2.15E-15	3.73E-08
107-02-8	Acrolein	8.68E-09	0.00E+00	8.68E-09	8.68E-09	0.00E+00	8.68E-09
107-13-1	Acrylonitrile	5.91E-09	4.31E-10	6.34E-09	5.91E-09	2.15E-15	5.91E-09
134-32-7	alpha-Naphthylamine	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
120-12-7	Anthracene	1.69E-05	4.88E-12	1.69E-05	1.69E-05	2.44E-17	1.69E-05
71-43-2	Benzene	5.05E-10	4.31E-10	9.36E-10	5.05E-10	2.15E-15	5.05E-10
50-32-8	Benzo(a)pyrene	6.77E-09	3.86E-11	6.81E-09	6.77E-09	1.93E-16	6.77E-09
191-24-2	Benzo(ghi)perylene	1.69E-05	2.28E-09	1.69E-05	1.69E-05	1.14E-14	1.69E-05

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
117-81-7	Bis(2-ethylhexyl)phthalate	1.69E-05	9.90E-10	1.69E-05	1.69E-05	4.95E-15	1.69E-05
75-27-4	Bromodichloromethane	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
74-83-9	Bromomethane	3.99E-10	4.31E-10	8.30E-10	3.99E-10	2.15E-15	3.99E-10
123-72-8	Butanal	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
85-68-7	Butylbenzylphthalate	1.04E-04	1.33E-08	1.04E-04	1.04E-04	6.66E-14	1.04E-04
56-23-5	Carbon tetrachloride	3.05E-10	4.31E-10	7.36E-10	3.05E-10	2.15E-15	3.05E-10
108-90-7	Chlorobenzene	1.93E-10	4.31E-10	6.23E-10	1.93E-10	2.15E-15	1.93E-10
75-45-6	Chlorodifluoromethane	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
75-00-3	Chloroethane	3.99E-10	0.00E+00	3.99E-10	3.99E-10	0.00E+00	3.99E-10
67-66-3	Chloroform	2.00E-10	4.31E-10	6.31E-10	2.00E-10	2.15E-15	2.00E-10
74-87-3	Chloromethane	7.95E-10	4.31E-10	1.23E-09	7.95E-10	2.15E-15	7.95E-10
10061-01-5	cis-1,3-Dichloropropene	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
108-39-4	m-Cresol	4.29E-05	0.00E+00	4.29E-05	4.29E-05	0.00E+00	4.29E-05
95-48-7	2-Methylphenol	5.96E-05	0.00E+00	5.96E-05	5.96E-05	0.00E+00	5.96E-05
98-82-8	Isopropylbenzene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
110-82-7	Cyclohexane	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
108-94-1	Cyclohexanone	5.77E-07	0.00E+00	5.77E-07	5.77E-07	0.00E+00	5.77E-07
226-36-8	Dibenz[a,h]acridine	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
53-70-3	Dibenz[a,h]anthracene	1.45E-09	2.37E-09	3.82E-09	1.45E-09	1.18E-14	1.45E-09
224-42-0	Dibenz[a,j]acridine	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
191-30-0	Dibenzo(a,l)pyrene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
192-65-4	Dibenzo[a,e]pyrene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
189-64-0	Dibenzo[a,h]pyrene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
189-55-9	Dibenzo[a,i]pyrene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
75-71-8	Dichlorodifluoromethane	4.95E-10	0.00E+00	4.95E-10	4.95E-10	0.00E+00	4.95E-10
75-09-2	Methylenechloride	1.18E-07	4.31E-10	1.19E-07	1.18E-07	2.15E-15	1.18E-07
84-66-2	Diethylphthalate	1.69E-05	4.31E-10	1.69E-05	1.69E-05	2.15E-15	1.69E-05
84-74-2	Di-n-butylphthalate	3.40E-04	4.79E-09	3.40E-04	3.40E-04	2.39E-14	3.40E-04
117-84-0	Di-n-octylphthalate	5.49E-05	2.22E-08	5.49E-05	5.49E-05	1.11E-13	5.49E-05
100-41-4	Ethylbenzene	3.34E-10	0.00E+00	3.34E-10	3.34E-10	0.00E+00	3.34E-10
60-29-7	Ethyl ether	2.22E-08	0.00E+00	2.22E-08	2.22E-08	0.00E+00	2.22E-08
106-93-4	Ethylene dibromide	1.60E-10	0.00E+00	1.60E-10	1.60E-10	0.00E+00	1.60E-10
75-21-8	Ethylene oxide (Oxirane)	3.44E-08	0.00E+00	3.44E-08	3.44E-08	0.00E+00	3.44E-08
206-44-0	Fluoranthene	5.57E-05	1.06E-09	5.57E-05	5.57E-05	5.32E-15	5.57E-05
86-73-7	Fluorene	1.69E-05	4.31E-10	1.69E-05	1.69E-05	2.15E-15	1.69E-05
75-02-5	Fluoroethene (vinyl fluoride)	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
50-00-0	Formaldehyde	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
87-68-3	Hexachlorobutadiene	1.01E-07	0.00E+00	1.01E-07	1.01E-07	0.00E+00	1.01E-07
67-72-1	Hexachloroethane	2.36E-06	0.00E+00	2.36E-06	2.36E-06	0.00E+00	2.36E-06
628-73-9	Hexanenitrile	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
193-39-5	Indeno(1,2,3-cd)pyrene	1.69E-05	2.43E-09	1.69E-05	1.69E-05	1.21E-14	1.69E-05
67-56-1	Methyl alcohol	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
1634-04-4	tert-Butyl methyl ether	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
122-39-4	Diphenyl amine	1.79E-08	0.00E+00	1.79E-08	1.79E-08	0.00E+00	1.79E-08

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
91-20-3	Naphthalene	5.29E-05	4.31E-10	5.29E-05	5.29E-05	2.15E-15	5.29E-05
109-74-0	Butanenitrile	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
71-36-3	1-Butanol	4.77E-07	0.00E+00	4.77E-07	4.77E-07	0.00E+00	4.77E-07
110-54-3	Hexane	3.12E-08	0.00E+00	3.12E-08	3.12E-08	0.00E+00	3.12E-08
98-95-3	Nitrobenzene	1.30E-07	4.31E-10	1.31E-07	1.30E-07	2.15E-15	1.30E-07
621-64-7	N-Nitroso-di-n-propylamine	4.89E-07	0.00E+00	4.89E-07	4.89E-07	0.00E+00	4.89E-07
10595-95-6	N-Nitrosomethylethylamine	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
59-89-2	Morpholine, 4-Nitroso-	1.21E-08	0.00E+00	1.21E-08	1.21E-08	0.00E+00	1.21E-08
62-75-9	N-Nitrosodimethylamine	2.10E-09	0.00E+00	2.10E-09	2.10E-09	0.00E+00	2.10E-09
87-86-5	Pentachlorophenol	9.76E-08	2.27E-13	9.76E-08	9.76E-08	1.14E-18	9.76E-08
110-59-8	Pentanenitrile	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
85-01-8	Phenanthrene	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
108-95-2	Phenol	1.34E-07	4.31E-10	1.34E-07	1.34E-07	2.15E-15	1.34E-07
100-21-0	Phthalic acid	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
100-02-7	4-Nitrophenol	4.92E-05	1.17E-10	4.92E-05	4.92E-05	5.85E-16	4.92E-05
1336-36-3	Aroclors (Total PCB)	2.59E-05	0.00E+00	2.59E-05	2.59E-05	0.00E+00	2.59E-05
107-12-0	Propionitrile	5.42E-08	0.00E+00	5.42E-08	5.42E-08	0.00E+00	5.42E-08
129-00-0	Pyrene	5.56E-05	7.95E-10	5.56E-05	5.56E-05	3.98E-15	5.56E-05
110-86-1	Pyridine	1.39E-07	0.00E+00	1.39E-07	1.39E-07	0.00E+00	1.39E-07
100-42-5	Styrene	1.60E-10	4.31E-10	5.91E-10	1.60E-10	2.15E-15	1.60E-10
108-88-3	Toluene	8.34E-10	4.31E-10	1.26E-09	8.34E-10	2.15E-15	8.34E-10
10061-02-6	trans-1,3-Dichloropropene	6.17E-10	0.00E+00	6.17E-10	6.17E-10	0.00E+00	6.17E-10

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
126-73-8	Tributyl phosphate	1.68E-05	1.57E-10	1.68E-05	1.68E-05	7.84E-16	1.68E-05
27154-33-2	Trichlorofluoroethane	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
75-69-4	Trichlorofluoromethane	4.86E-10	0.00E+00	4.86E-10	4.86E-10	0.00E+00	4.86E-10
75-50-3	Trimethylamine	1.69E-05	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
1330-20-7	Xylenes (total)	5.71E-08	4.31E-10	5.75E-08	5.71E-08	2.15E-15	5.71E-08
75-15-0	Carbon Disulfide	2.92E-07	4.31E-10	2.93E-07	2.92E-07	2.15E-15	2.92E-07
100-25-4	1,4-Dinitrobenzene	0.00E+00	2.44E-12	2.44E-12	0.00E+00	1.22E-17	1.22E-17
100-44-7	Benzyl chloride	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
100-47-0	Benzonitrile	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
100-51-6	Benzyl alcohol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
100-52-7	Benzaldehyde	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
101-77-9	4,4-Methylenedianiline	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
103-33-3	Azobenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
103-65-1	n-Propyl benzene (Isocumene)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
104-51-8	n-Butylbenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
106-43-4	4-Chlorotoluene (p-Tolyl chloride)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
106-44-5	p-Cresol (4-methyl phenol)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
106-47-8	p-Chloroaniline	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
106-49-0	p-Toluidine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
106-51-4	Quinone	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
106-89-8	Epichlorohydrin (1-chloro-2,3 epoxypropane)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
107-19-7	Propargyl alcohol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
107-21-1	Ethylene glycol (1,2-ethanediol)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
107-98-2	Propylene glycol monomethyl ether	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
108-60-1	bis (2-Chloroisopropyl)ether	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
108-67-8	1,3,5-Trimethylbenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
108-86-1	Bromobenzene (Phenyl bromide)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
108-87-2	Methylcyclohexane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
109-75-1	3-Butenenitrile	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
109-77-3	Malononitrile	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
109-86-4	2-Methoxyethanol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
109-99-9	Tetrahydrofuran	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
110-00-9	Furan	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
110-83-8	Cyclohexene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
111-15-9	Ethylene glycol monoethyl ether acetate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
111-44-4	Bis(2-chloroethyl)ether	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
111-65-9	n-Octane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
111-84-2	n-Nonane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
111-91-1	Bis(2-chloroethoxy)methane	0.00E+00	7.32E-12	7.32E-12	0.00E+00	3.66E-17	3.66E-17
1120-21-4	Undecane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
1120-71-4	1,3-Propane sultone	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
112-30-1	1-Decanol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
112-31-2	Decanal	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
112-40-3	Dodecane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
118-74-1	Hexachlorobenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
119-90-4	3,3'-Dimethoxybenzidine	0.00E+00	3.41E-10	3.41E-10	0.00E+00	1.71E-15	1.71E-15
122-66-7	1,2-Diphenylhydrazine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
123-33-1	Maleic hydrazide	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
123-38-6	Propionaldehyde	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
124-18-5	Decane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
124-48-1	Chlorodibromomethane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
131-11-3	Dimethyl Phthalate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
131-89-5	2-Cyclohexyl-4,6-dinitrophenol	0.00E+00	1.52E-09	1.52E-09	0.00E+00	7.62E-15	7.62E-15
132-64-9	Dibenzofuran	0.00E+00	8.25E-13	8.25E-13	0.00E+00	4.13E-18	4.13E-18
133-06-2	Captan	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
135-98-8	sec-Butylbenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
145-73-3	Endothall	0.00E+00	2.43E-09	2.43E-09	0.00E+00	1.21E-14	1.21E-14
156-59-2	cis-1,2-Dichloroethene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
1746-01-6	2,3,7,8-Tetrachlorodibenzo(p)dioxin (TCDD)	0.00E+00	5.65E-17	5.65E-17	0.00E+00	2.82E-22	2.82E-22
192-97-2	Benzo(e)pyrene	0.00E+00	2.61E-10	2.61E-10	0.00E+00	1.30E-15	1.30E-15
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin	0.00E+00	4.44E-16	4.44E-16	0.00E+00	2.22E-21	2.22E-21
205-82-3	Benzo[j]fluoranthene	0.00E+00	1.00E-09	1.00E-09	0.00E+00	5.00E-15	5.00E-15
205-99-2	Benzo(b)fluoranthene	0.00E+00	8.29E-11	8.29E-11	0.00E+00	4.15E-16	4.15E-16
207-08-9	Benzo(k)fluoranthene	0.00E+00	1.80E-09	1.80E-09	0.00E+00	9.02E-15	9.02E-15

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
218-01-9	Chrysene	0.00E+00	6.78E-10	6.78E-10	0.00E+00	3.39E-15	3.39E-15
2245-38-7	2,3,5-Trimethylnaphthalene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
23950-58-5	Pronamide	0.00E+00	1.24E-10	1.24E-10	0.00E+00	6.22E-16	6.22E-16
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl (PCB 118)	0.00E+00	7.13E-14	7.13E-14	0.00E+00	3.56E-19	3.56E-19
319-84-6	alpha-BHC	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
319-85-7	beta-BHC	0.00E+00	2.44E-12	2.44E-12	0.00E+00	1.22E-17	1.22E-17
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	0.00E+00	5.98E-15	5.98E-15	0.00E+00	2.99E-20	2.99E-20
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)	0.00E+00	3.04E-15	3.04E-15	0.00E+00	1.52E-20	1.52E-20
3268-87-9	Octachlorodibenzo(p)dioxin	0.00E+00	8.00E-11	8.00E-11	0.00E+00	4.00E-16	4.00E-16
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	0.00E+00	4.06E-17	4.06E-17	0.00E+00	2.03E-22	2.03E-22
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin	0.00E+00	7.83E-12	7.83E-12	0.00E+00	3.91E-17	3.91E-17
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	0.00E+00	1.94E-15	1.94E-15	0.00E+00	9.68E-21	9.68E-21
39001-02-0	Octachlorodibenzofuran	0.00E+00	3.41E-11	3.41E-11	0.00E+00	1.70E-16	1.70E-16
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin	0.00E+00	1.91E-16	1.91E-16	0.00E+00	9.55E-22	9.55E-22
39635-31-9	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	0.00E+00	5.96E-16	5.96E-16	0.00E+00	2.98E-21	2.98E-21
40321-76-4	1,2,3,7,8-Pentachlorodibenzo(p)dioxin	0.00E+00	1.25E-16	1.25E-16	0.00E+00	6.23E-22	6.23E-22
4170-30-3	Crotonaldehyde (Propylene aldehyde)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
41851-50-7	Chlorocyclopentadiene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
460-19-5	Cyanogen (oxalonitrile)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
4786-20-3	2-Butenenitrile	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
506-68-3	Cyanogen bromide (bromocyanide)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
506-77-4	Cyanogen chloride	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
510-15-6	Chlorobenzilate	0.00E+00	3.29E-10	3.29E-10	0.00E+00	1.65E-15	1.65E-15
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	0.00E+00	2.67E-11	2.67E-11	0.00E+00	1.34E-16	1.34E-16
51-28-5	2,4-Dinitrophenol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
51-79-6	Ethyl carbamate (urethane)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
52663-72-6	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	0.00E+00	1.03E-15	1.03E-15	0.00E+00	5.13E-21	5.13E-21
528-29-0	1,2-Dinitrobenzene (o-Dinitrobenzene)	0.00E+00	2.44E-12	2.44E-12	0.00E+00	1.22E-17	1.22E-17
532-27-4	2-Chloroacetophenone	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
534-52-1	4,6-Dinitro-o-cresol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
5385-75-1	Dibenzo(a,e)fluoranthene	0.00E+00	2.39E-09	2.39E-09	0.00E+00	1.20E-14	1.20E-14
540-59-0	1,2-Dichloroethene (total) (1,2-Dichloroethylene)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
540-73-8	1,2-Dimethylhydrazine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
540-84-1	2,2,4-Trimethylpentane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
542-75-6	1,3-Dichloropropene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
542-88-1	Bis(chloromethyl)ether	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.00E+00	1.53E-16	1.53E-16	0.00E+00	7.63E-22	7.63E-22
56-55-3	Benzo(a)anthracene	0.00E+00	1.29E-09	1.29E-09	0.00E+00	6.45E-15	6.45E-15
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	0.00E+00	2.44E-11	2.44E-11	0.00E+00	1.22E-16	1.22E-16
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	0.00E+00	6.67E-11	6.67E-11	0.00E+00	3.33E-16	3.33E-16
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	0.00E+00	1.02E-11	1.02E-11	0.00E+00	5.09E-17	5.09E-17
57-24-9	Strychnine	0.00E+00	2.42E-09	2.42E-09	0.00E+00	1.21E-14	1.21E-14

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
57465-28-8	3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	0.00E+00	1.35E-16	1.35E-16	0.00E+00	6.73E-22	6.73E-22
57653-85-7	1,2,3,6,7,8,-Hexachlorodibenzo(p)dioxin	0.00E+00	4.20E-16	4.20E-16	0.00E+00	2.10E-21	2.10E-21
57-74-9	Chlordane	0.00E+00	1.71E-11	1.71E-11	0.00E+00	8.54E-17	8.54E-17
581-42-0	2,6-Dimethylnaphthalene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
584-84-9	2,4-Toluene diisocyanate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
58-89-9	gamma-BHC (Lindane)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
591-50-4	Benzene, iodo-	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
593-60-2	Bromoethene (Vinyl bromide)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
60-11-7	Dimethyl aminoazobenzene	0.00E+00	1.12E-09	1.12E-09	0.00E+00	5.61E-15	5.61E-15
606-20-2	2,6-Dinitrotoluene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	0.00E+00	1.43E-16	1.43E-16	0.00E+00	7.14E-22	7.14E-22
608-93-5	Pentachlorobenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
61626-71-9	Dichloropentadiene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
624-83-9	Methyl isocyanate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
62-50-0	Ethyl methanesulfonate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
62-53-3	Aniline	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
64-18-6	Formic acid (methanoic acid)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	0.00E+00	9.52E-17	9.52E-17	0.00E+00	4.76E-22	4.76E-22
65-85-0	Benzoic acid	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.00E+00	2.12E-16	2.12E-16	0.00E+00	1.06E-21	1.06E-21
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	0.00E+00	6.16E-16	6.16E-16	0.00E+00	3.08E-21	3.08E-21
70-30-4	Hexachlorophene	0.00E+00	2.42E-09	2.42E-09	0.00E+00	1.21E-14	1.21E-14

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
70362-50-4	3,4,4',5-Tetrachlorobiphenyl (PCB 81)	0.00E+00	7.25E-17	7.25E-17	0.00E+00	3.62E-22	3.62E-22
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	0.00E+00	4.09E-11	4.09E-11	0.00E+00	2.04E-16	2.04E-16
72-43-5	Methoxychlor	0.00E+00	3.63E-10	3.63E-10	0.00E+00	1.82E-15	1.82E-15
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	0.00E+00	3.48E-13	3.48E-13	0.00E+00	1.74E-18	1.74E-18
74472-37-0	2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	0.00E+00	1.22E-16	1.22E-16	0.00E+00	6.12E-22	6.12E-22
74-88-4	Iodomethane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
74-95-3	Methylene bromide	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
74-97-5	Bromochloromethane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
75-25-2	Bromoform	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
75-29-6	2-Chloropropane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
75-44-5	Phosgene (hydrogen phosphide)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
76-01-7	Pentachloroethane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
764-41-0	1,4-Dichloro-2-butene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
76-44-8	Heptachlor	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
765-34-4	Glycidylaldehyde	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
77-47-4	Hexachlorocyclopentadiene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
77-78-1	Dimethyl sulfate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
80-62-6	Methyl methacrylate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
822-06-0	Hexamethylene-1,5-diisocyanate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
823-40-5	Toluene-2,6-diamine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
82-68-8	Pentachloronitrobenzene (PCNB)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
832-69-9	1-Methylphenanthrene	0.00E+00	7.07E-11	7.07E-11	0.00E+00	3.54E-16	3.54E-16

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
85-44-9	Phthalic anhydride (1,2-benzenedicarboxylic anhydride)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
87-61-6	1,2,3-Trichlorobenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
88-74-4	o-Nitroaniline (2-nitroaniline)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
90-04-0	o-Anisidine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
90-12-0	1-Methylnaphthalene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
91-22-5	Quinoline	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
91-57-6	2-Methylnaphthalene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
91-94-1	3,3'-Dichlorobenzidine	0.00E+00	1.26E-09	1.26E-09	0.00E+00	6.29E-15	6.29E-15
924-16-3	N-Nitroso-di-n-Buethylamine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
94-59-7	Safrole (5-(2-Propenyl)-1,3-benzodioxole)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
94-75-7	2,4-D	0.00E+00	1.24E-10	1.24E-10	0.00E+00	6.22E-16	6.22E-16
95-49-8	o-Chlorotoluene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
95-53-4	o-Toluidine	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
95-63-6	1,2,4-Trimethyl benzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
95-94-3	1,2,4,5-Tetrachlorobenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
96-12-8	1,2-Dibromo-3-chloropropane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
96-18-4	1,2,3-Trichloropropane	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
96-45-7	Ethylene thiourea	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
97-63-2	Ethyl methacrylate	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
98-01-1	Furfural	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
98-06-6	tert-Butyl benzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15

Table A-2 Organic COPCs Emissions Estimate from the Direct Feed LAW Effluent Management Facility Vessel Vent Process (DVP) System

CAS #	COPC (Note 1)	Unabated Streams			Abated Streams		
		DEP15			DEP18		
		DVP System			DVP System		
		Vapor	Particulate	Total	Vapor	Particulate	Total
		g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
98-07-7	Benzotrichloride	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
98-83-9	Methyl styrene (mixed isomers)	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
99-35-4	1,3,5-Trinitrobenzene	0.00E+00	1.95E-11	1.95E-11	0.00E+00	9.76E-17	9.76E-17
99-65-0	1,3-Dinitrobenzene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
99-87-6	p-Cymene	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
105-67-9	2,4-Dimethylphenol	0.00E+00	4.31E-10	4.31E-10	0.00E+00	2.15E-15	2.15E-15
	TOTAL	2.33E-03	1.32E-07	2.33E-03	2.33E-03	6.61E-13	2.33E-03

Source: 24590-BOF-M4C-DEP-00001

Note 1: Emissions rates for organic COPCs reported in Table A-2 represent the combined total of feed organic and PIC (product of incomplete combustion) COPCs reported in 24590-BOF-M4C-DEP-00001, Table 8-4 and Table 8-5

Table A-3 Effluent Management Facility Emissions Exceeding De Minimis Quantities

Pollutant	CAS #	Averaging Period	Unabated Emission Rate (lb/averaging period)	De Minimis (lb/averaging period)
Organics				
3-Methylcholanthrene	56-49-5	Annual	1.17E+00	1.53E-03
4,4-DDE	72-55-9	Annual	1.17E+00	9.88E-02
5-Methylchrysene	3697-24-3	Annual	1.17E+00	8.72E-03
5-Nitroacenaphthene	602-87-9	Annual	1.17E+00	2.59E-01
Acetamide	60-35-5	Annual	1.17E+00	4.80E-01
Bis(2-ethylhexyl)phthalate	117-81-7	Annual	1.17E+00	4.00E-01
Bromodichloromethane	75-27-4	Annual	1.17E+00	2.59E-01
Dibenz[a,h]acridine	226-36-8	Annual	1.17E+00	8.72E-02
Dibenz[a,j]acridine	224-42-0	Annual	1.17E+00	8.72E-02
Dibenzo(a,l)pyrene	191-30-0	Annual	1.17E+00	8.72E-04
Dibenzo[a,e]pyrene	192-65-4	Annual	1.17E+00	8.72E-03
Dibenzo[a,h]pyrene	189-64-0	Annual	1.17E+00	8.72E-04
Dibenzo[a,i]pyrene	189-55-9	Annual	1.17E+00	8.72E-04
Indeno(1,2,3-cd)pyrene	193-39-5	Annual	1.17E+00	8.72E-02
Naphthalene	91-20-3	Annual	3.68E+00	2.82E-01
N-Nitroso-di-n-propylamine	621-64-7	Annual	3.40E-02	4.80E-03
N-Nitrosomethylethylamine	10595-95-6	Annual	1.17E+00	1.53E-03
Aroclors (Total PCB)	1336-36-3	Annual	1.80E+00	1.68E-02
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	Annual	1.70E-06	5.05E-07
1,2,3,4,7,8-Hexachlorodibenzofuran	70648-26-9	Annual	2.84E-06	2.52E-06
Inorganics				
(CH ₃) ₂ Hg (Dimethyl Mercury)	593-74-8	24-hr	1.01E-04	1.00E-99
Cd	7440-43-9	Annual	2.82E-02	2.28E-03
NH ₃	7664-41-7	24-hr	1.92E+01	4.65E-01
Cr (VI) ⁽¹⁾	18540-29-9	Annual	1.00E+00	6.40E-05

Note 1: Conservatively assuming all chromium (CAS # 7440-47-3) emitted as more harmful chromium(VI) form.

Attachment 5
16-ECD-0032
(144 Pages Excluding Cover Sheet)

24590-BOF-M4C-DEP-00001,
DFLAW Effluent Management Facility Air Emissions Estimate



Calculation Cover Sheet

ISSUED BY
RPP-WTP PDC

Sheet i

RIVER PROTECTION PROJECT-WASTE TREATMENT PLANT		JOB NO.: 24590	
CALC NO. 24590-BOF-M4C-DEP-00001	GROUP Process Eng.	FACILITY BOF	
SUBJECT DFLAW Effluent Management Facility Air Emissions Estimate			
CALCULATION STATUS		BY: _____	
<input type="checkbox"/> PRELIMINARY	<input checked="" type="checkbox"/> COMMITTED	<input type="checkbox"/> CONFIRMED	
<input type="checkbox"/> SUPERSEDED		<input type="checkbox"/> CANCELLED	

SOFTWARE USED TO PERFORM CALCULATION

Check applicable boxes in this block to designate what General-Purpose Commercially-Available Software was used to perform calculation
Note: ID older versions used in unrevised portion(s) of calc in "Notes/Comments:" below.

Excel 2003 Excel 2007 Excel 2010 Excel 2013 Excel 2016 Mathcad 11.2a Mathcad 14 Mathcad 15 Mathematica 5.2

Other Software Used to Perform Calculation None

PROGRAM NAME	VERSION NO	UIF			COMPUTER PLATFORM		
		NO	REV	MICROPROCESSOR	OPERATING SYSTEM	JO#	

RECORD OF REVISIONS							
NO.	REASON FOR REVISION	TOTAL NO. OF SHEETS	LAST SHEET NO.	ORIGINATOR	CHECKED	APPROVED/ ACCEPTED	DATE
B	<ul style="list-style-type: none"> Added Annual Possession Quantities Added single-stage HEPA abated emissions for ACV exhaust system Updated entrainment factors for particulate emissions from DEP vessels and evaporator Editorial fixes 	143	G-3	William Hix <i>William Hix</i>	Seth Schreiber <i>[Signature]</i>	Robert Hanson <i>[Signature]</i>	6/8/2016
A	Initial issue	129	G-3	William Hix	Seth Schreiber	Robert Hanson	2/29/16

Notes/Comments:

Affected areas are identified by revision bars in the right margin.

For this revision, it has been confirmed that the inputs and assumptions are current and reflect the current issued state of design.

CALCULATION SHEET

BY: William Hix
DATE: 6/6/2016

PROJECT: RPP-WTP
JOB NO.: 24590
CALC NO.: 24590-BOF-M4C-DEP-00001
SHEET REV: B
SHEET NO.: 1

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

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CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

BY: William Hix

CALC NO.: 24590-BOF-M4C-DEP-00001

DATE: 6/6/2016

SHEET REV: B

SHEET NO.: 2

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

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CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 3

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

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CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 4

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

Acronyms and Abbreviations

ACV	- Active Confinement Ventilation
APQ	- Annual possession quantity
BOF	- Balance of Facilities
CAS	- Chemical Abstracts Service
CNP	- Cesium Nitric Acid Recovery Process system
COPC	- Constituents of Potential Concern
CRV	- Concentrate Receipt Vessel
DEP	- DFLAW EMF Process system
DF	- Decontamination factor
DFLAW	- Direct Feed Low Activity Waste
DVP	- DFLAW EMF Process Vessel Ventilation system
EMF	- Effluent Management Facility
ETF	- Effluent Treatment Facility
HEPA	- High Efficiency Particulate Air
HLW	- High Level Waste Facility
ICD	- Interface Control Document
LAW	- Low-Activity Waste Facility
LAWPS	- LAW Pretreatment System
LERF	- Liquid Effluent Retention Facility
LFP	- LAW Melter Feed Process system
LVP	- LAW Secondary Offgas/Vessel Vent Process system
MDR	- Mass distribution ratio
ORNL	- Oak Ridge National Laboratory
PFD	- Process flow diagram
PIC	- Product of incomplete combustion
PTF	- Pretreatment Facility
R&T	- Research and Technology
RAIS	- Risk Assessment Information System
RLD	- Radioactive Liquid Waste Disposal system
SBS	- Submerged bed scrubber
TAP	- Toxic air pollutant
TOC	- Total organic carbon
TRU	- Transuranic
VSL	- Vitreous State Laboratory of the Catholic University of America
WAC	- Washington Administrative Code
WESP	- Wet electrostatic precipitator
WTP	- Hanford Tank Waste Treatment and Immobilization Plant

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1 Objective

The objective of this calculation is to provide an air emissions estimate for the Direct Feed Low Activity Waste (DFLAW) Effluent Management Facility (EMF) at the Hanford Tank Waste Treatment and Immobilization Plant (WTP). This calculation estimates emissions for organic, inorganic, and radionuclide constituents of potential concern (COPCs) from the DFLAW EMF Process Vessel Ventilation system (DVP). Radionuclide COPC emissions from the Active Confinement Ventilation (ACV) exhaust system are also estimated. The annual possession quantities (APQs) for radionuclide COPCs in the DFLAW EMF Process (DEP) system are also estimated. Results are given in g/sec for organic and inorganic COPCs and Ci/yr for radionuclide COPCs.

2 Inputs

- 2.1 Specific activities of radionuclide COPCs in Ci/g are shown in Attachment B. The specific activities are found in the Oak Ridge National Laboratory (ORNL) *Risk Assessment Information System* (RAIS) (Ref. 10.1).
- 2.2 Table 2-1 shows the treated LAW waste acceptance limits for radionuclides established in *ICD-30 – Interface Control Document for Direct LAW Feed* (Ref. 9.3, Table 5).

Table 2-1 – ICD-30 Acceptance Limits for Radionuclide Concentrations

	ICD-30 Limits
	Concentration
¹³⁷ Cs	3.18E-05 Ci/mol sodium
¹⁵⁴ Eu	1.8E-05 Ci/L
⁶⁰ Co	1.1E-06 Ci/L
⁹⁰ Sr	1.19E-03 Ci/mol sodium
⁹⁹ Tc	4.8E-04 Ci/L
²³⁹ Pu	3.0E-05 Ci/L
²³³ U	1.6E-07 Ci/L
²³⁵ U	1.7E-09 Ci/L
TRU	1.30E-05 Ci/mol sodium
U fissile to U total ¹	0.96 wt%

Note 1: Total uranium is the sum of masses of ²³³U, ²³⁵U, and ²³⁸U (Ref. 9.3, Table 5, Note 16). Fissile uranium is calculated per Equation 6 in Section 5.1.1.1.3 of this calculation.

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- 2.3 The median entrainment factor for the free-fall spill of an aqueous solution (density $\sim 1.0 \text{ g/cm}^3$) is $4\text{E-}5 \text{ g entrained material / g air}$ (Ref. 10.2, Page 3-4).
- 2.4 The volume of the feed transfer line flush from Tank Farms LAW Pretreatment System (LAWPS) facility to the DFLAW EMF Process system (DEP) low point drain vessel (DEP-VSL-00001) is determined by the next planned transfer of feed (Ref. 9.3, Section 2.6.2):

If the next transfer of feed is expected in less than 72 hours, the Tank Operations Contractor will flush the transfer pipeline with a volume of water that is not more than the transfer pipeline volume (1500 gallons [5.68 m^3])

If the next transfer of feed is expected to be more than 72 hours later, then the Tank Operations Contractor will flush the transfer pipeline with a volume of water that is at least 1.5 times the transfer pipeline volume (2200 gallons [8.33 m^3])

- 2.5 The molecular weight of sodium (Na) is 22.9898 g/mol (Ref. 10.3, inside of back cover).
- 2.6 The molecular weight of carbon (C) is 12.01115 g/mol (Ref. 10.3, inside of back cover).
- 2.7 The molecular weight of water (H_2O) is 18.02 g/mol (Ref. 10.3, inside of back cover).
- 2.8 The average molecular weight of air is 28.97 g/mol (Ref. 10.3, Page 21-8)
- 2.9 The molecular weight of ammonia (NH_3) is 17.031 g/mol (Ref. 10.3, inside of back cover).
- 2.10 The molecular weight of mercury (Hg) is 200.59 g/mol (Ref. 10.3, inside of back cover).
- 2.11 Transuranic (TRU) radionuclides are defined as alpha-emitting radionuclides with an atomic number greater than 92 with half-life greater than 20 years (Ref. 10.4, Page C-119 Note 2).
- 2.12 The nominal diameter of the WTP portion of the feed transfer line from LAWPS to Low-Activity Waste Facility (LAW) is 3 inch Schedule 40 per ICD-30 (Ref. 9.3, Table 2). This corresponds to an inside diameter of 3.068 inches (Ref. 10.5, Page B-13).
- 2.13 De minimis values for the emissions of toxic air pollutants (TAPs) are provided in Washington Administrative Code (WAC) Section 173-460-150 (Ref. 10.7).
- 2.14 The density of the Radioactive Liquid Waste Disposal system stream (RLD21) is 62.6 lb/ft^3 , or 1002.8 g/L (Ref. 9.22, Table B-25).
- 2.15 The available batch volume of the Caustic Collection Tank (LVP-TK-00001) is 4,336 gallons (Ref. 9.26, Section 7.5.14 and Section 8).
- 2.16 The transfer frequency for LVP-TK-00001 is once every 10.7 hours (Ref. 9.26, Section 8).
- 2.17 The density of the LAW Secondary Offgas/Vessel Vent Process system stream (LVP21) is 65.8 lb/ft^3 , or 1054.0 g/L (Ref. 9.22, Table B-23).

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- 2.18 The Henry's Law constant for ammonia is $3.45E-6 \text{ atm}\cdot\text{m}^3/\text{mol}$ (Ref. 10.11).
- 2.19 The ICD-30 acceptance limit for mercury is $1.4E-5 \text{ mol Hg/mol Na}$ (Ref. 9.3, Table 5).
- 2.20 The release fraction (entrainment factor) for liquids or particulate solids provided in WAC 246-247-030 is $1E-3 \text{ g entrained material / g air}$ (Ref. 10.8, Section 21(a)).

3 Background

The list of COPCs for air permitting at WTP is compiled in 24590-WTP-RPT-ENV-10-001 – *Constituents of Potential Concern for the WTP Air and Dangerous Waste Permits* (Ref. 9.1). Table 2-1 in Ref. 9.1 shows the entire list of 409 compounds considered WTP COPCs, along with the source document justifying each compound's addition to the list. The following categorization summarizes the number and type of the COPCs (Ref. 9.1, Page 25).

- 309 organic COPCs, including:
 - 138 feed compounds
 - 171 stack emissions compounds
- 54 inorganic COPCs, including:
 - 43 feed compounds (11 with radioactive forms)
 - 11 stack emissions compounds
- 46 radionuclide COPCs (all feed constituents)

The stack emissions compounds are products of incomplete combustion (PICs) that are generated from the destruction of organics in the melter and not present in the feed stream.

The complete list of WTP COPCs evaluated for air emissions is shown in Attachment A.

The DFLAW EMF is being added to support DFLAW operations by handling secondary waste streams associated with the melter off-gas (i.e., submerged bed scrubber (SBS) condensate, wet electrostatic precipitator (WESP) drain, and caustic scrubber solution) and line flushes/drains. An evaporator is used to concentrate the SBS condensate/plant wash effluent and recycle the effluent concentrate to the front end of LAW (LCP-VSL-00001/2) to be incorporated into the glass during the vitrification process. The EMF evaporator overheads stream is combined with the LAW Caustic Scrubber effluent stream and then sent to the Liquid Effluent Retention Facility (LERF)/Effluent Treatment Facility (ETF) for final treatment prior to discharge to the environment. The EMF evaporator and other process components are part of a new system, the DEP system, which will be part of the Balance of Facilities (BOF).

Process flow diagrams (PFDs) for the DEP system are shown in References 9.5, 9.6, 9.7, and 9.8. The main process vessels in the DEP system are the low point drain vessel (DEP-VSL-00001), evaporator feed vessel (DEP-VSL-00002), evaporator concentrate vessels (DEP-VSL-00003A/B/C), overhead sampling vessels (DEP-VSL-00004A/B), and process condensate lag storage vessels (DEP-VSL-00005A/B), along with the DEP evaporator system, represented by the evaporator separator vessel (DEP-EVAP-00001), primary/inter/after-condensers (DEP-COND-00001/2/3), and reboiler (DEP-RBLR-00001).

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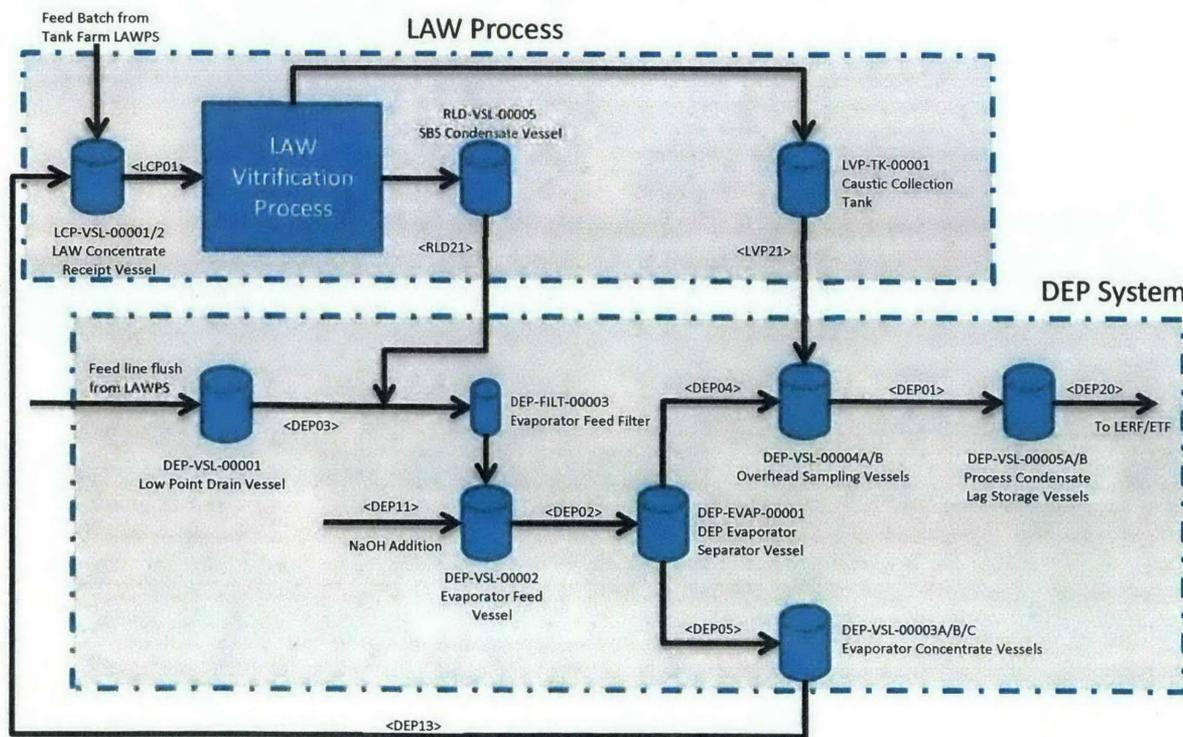
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The DVP system is comprised of two main parts, air supply and exhaust, and its purpose is to maintain hydrogen below dangerous levels in the vessel headspace. The inlet air, or purge air, is supplied by a passive system. For the DEP vessels in the LAW effluent process building, a purge air in-bleed is suitable for meeting the very low required flowrates. The vessel vent is the exhaust or discharge portion of the DVP system that provides the suction pressure on the vessel headspace, drawing in the purged air, and evacuates the hydrogen. The discharge air is sent through a preheater, two-stage high efficiency particulate air (HEPA) filters, and finally through an exhaust fan to discharge the air out of the EMF stack (Ref. 9.7).

Figure 3-1 and Figure 3-2 show a simplified flow diagram for the DEP system and DVP exhaust system, respectively

Figure 3-1 - DEP System - Simplified Flow Diagram



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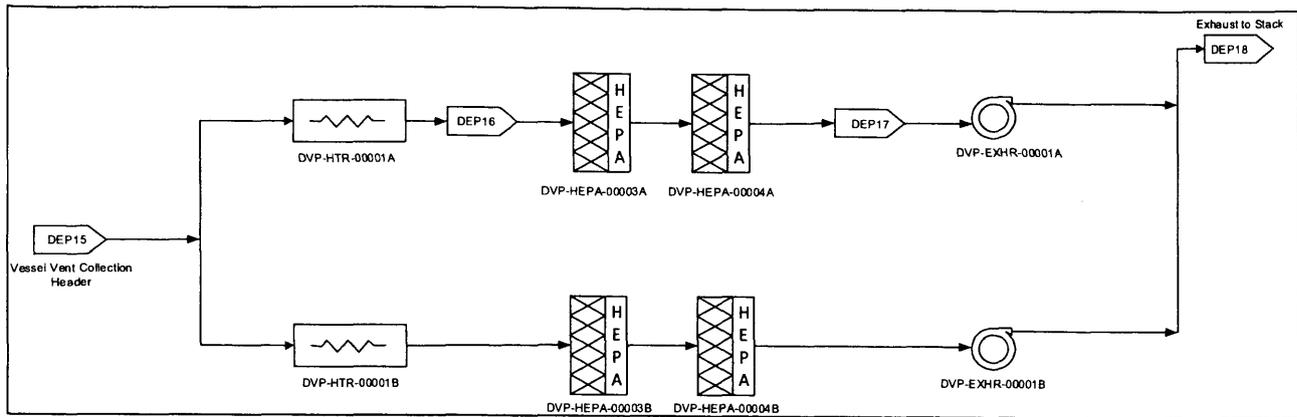
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Figure 3-2 - DVP Exhaust System - Simplified Flow Diagram



4 Applicable Codes and Standards

- 4.1 Washington Administrative Code (WAC) 173-460-150 - *Table of ASIL, SQER and de minimis emission values.*
- 4.2 Washington Administrative Code (WAC) 246-247-030 – *Definitions.*

5 Methodology

The methodology for estimating the emissions from the EMF is divided into three main sections: radionuclide COPCs, organic COPCs, and inorganic COPCs. The general approach within each section is to evaluate the COPCs based on their expected emission phase (i.e. vapor or particulate).

The main governing assumption for particulate emissions is that the mass fractions of COPCs emitted through entrainment are assumed to remain constant throughout the DEP system at the maximum feed vector batch mass fraction. For PICs, which are not present in the feed vector, the mass fractions of PIC COPCs emitted through entrainment are assumed to remain constant throughout the DEP system at the mass fraction received in the DEP system from Stream RLD21 (Assumption 6.1.1).

Additional key assumptions for entrainment are the applicability of the entrainment factors used for the DEP vessels (Assumption 6.2.3) and the DEP evaporator (Assumption 6.2.30).

The main governing assumption for vapor emissions is that the entire volatile fraction of a COPC received in the DEP system will be emitted in the vapor phase as it is processed through the DEP system (Assumptions 6.2.4, 6.2.16, and 6.2.23). Any special cases not following this assumption will be specifically mentioned and an alternative estimation method will be described.

The calculation spreadsheets and data files associated with 24590-WTP-RPT-ENV-16-001 - *Feed Vector Development In Support Of WTP Environmental Risk Assessment Activities* (Ref. 9.2) are accessible through 24590-RMCD-04893. The values associated with the DFLAW Bounding Feed Vector and Tank Farm Average ratios, that are used throughout this calculation, were accessed from Excel spreadsheets

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“*Bounding_DFLAW-batches-to-wtp.csv*” and “*COPC and non-COPC Organic Tank Farm Ratios.xlsx*” respectively.

5.1 Radionuclide COPC Emissions

Attachment A, Table A-1 shows the 46 radionuclides tracked as COPCs at WTP.

5.1.1 COPC Maximum Batch Activities

The maximum batch activity for the radionuclide COPCs is determined using the Tank Farms Average ratios (mCi COPC / g Na) and the DFLAW Bounding Feed Vector maximum sodium batch. The Tank Farms Average ratios are provided in Ref. 9.2. These Tank Farms Average ratios are assumed to be applicable to this analysis (Assumption 6.2.1). The DFLAW Bounding Feed Vector is provided in Ref. 9.2 and used in this calculation (Assumption 6.2.2). The values for the amount of sodium (in kmol) in each batch during the DFLAW campaign are extracted from the DFLAW Bounding Feed Vector and then the average, minimum, and maximum values are calculated.

The Tank Farms Average ratios are converted to the maximum batch activity of each radionuclide as follows:

$$A_i = r_i * n_{Na,max} * MW_{Na} * 1000 \frac{mol}{kmol} * \frac{1 Ci}{1000 mCi} \quad \text{Equation 1}$$

Where:

- A_i = Maximum feed vector batch activity of COPC i , in Ci
- r_i = Tank Farms Average ratio of COPC i , in mCi COPC / g Na (Ref. 9.2)
- $n_{Na,max}$ = Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmols (Attachment G)
- MW_{Na} = Molecular weight of sodium, in g/mol (Input 2.5)

5.1.1.1 ICD-30 Acceptance Limits

The maximum batch activities of radionuclides that have acceptance limits established in ICD-30, as shown in Input 2.2, are compared to their ICD-30 acceptance limit. If a limit is exceeded, the maximum batch activity is adjusted to equal the ICD-30 acceptance limit, since the Tank Operations Contractor must demonstrate compliance with the criteria in Table 5 of ICD-30 prior to WTP agreeing to receive a Treated LAW feed campaign from LAWPS (Ref. 9.3, Section 2.3).

5.1.1.1.1 Convert ICD-30 Acceptance Limits to Activities

All of the ICD-30 limits shown in Table 2-1 (except U fissile to U total) are converted to Curies.

Acceptance limits in units of Ci/L are multiplied by the maximum feed batch volume from the Bounding DFLAW feed vector to calculate the activity of a radionuclide at the ICD-30 limit. The batch volumes of

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each batch during DFLAW operation are extracted from the feed vector (Ref. 9.2) and then the average, minimum, and maximum values are calculated (Attachment G).

For ICD-30 acceptance limits given in Ci/L:

$$A_{i,limit} = c_{i,limit} * V_{max} * \frac{3.785 L}{1 gal} \quad \text{Equation 2}$$

Where:

- $A_{i,limit}$ = Activity of COPC *i* at ICD-30 limit, in Ci
- $c_{i,limit}$ = Concentration of COPC *i* at ICD-30 limit, in Ci/L (Input 2.2)
- V_{max} = Maximum feed batch volume, in gallons (Ref. 9.2)

Acceptance limits in units of Ci/mol Na are multiplied by the maximum batch amount of sodium, $n_{Na,max}$, to calculate the activity of a radionuclide at the ICD-30 limit.

For ICD-30 acceptance limits given in Ci/mol Na:

$$A_{i,limit} = c_{i,limit} * n_{Na,max} * 1000 \frac{mol}{kmol} \quad \text{Equation 3}$$

Where:

- $A_{i,limit}$ = Activity of COPC *i* at ICD-30 limit, in Ci
- $c_{i,limit}$ = Concentration of COPC *i* at ICD-30 limit, in Ci/mol Na (Input 2.2)
- $n_{Na,max}$ = Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmols (Ref. 9.2)

Note that there is an ICD-30 limit for total TRU radionuclides. This limit for total TRU needs to be broken out into individual limits for each of the TRU radionuclides. The TRU radionuclides are listed in Table 5-1. This list represents the radionuclide COPCs that meet the TRU criteria in Input 2.11 using radionuclide properties extracted from Ref. 10.6 as shown in Attachment D.

Table 5-1 – TRU Radionuclides

COPC	Atomic Number >92	Half-life > 20 years	Alpha Emitter?
²³⁷ Np	93 (Yes)	2.144E6 (Yes)	Yes
²³⁸ Pu	94 (Yes)	87.7 (Yes)	Yes
²³⁹ Pu	94 (Yes)	24110 (Yes)	Yes
²⁴⁰ Pu	94 (Yes)	6561 (Yes)	Yes
²⁴¹ Am	95 (Yes)	432.6 (Yes)	Yes
²⁴² Pu	94 (Yes)	3.75E5 (Yes)	Yes
²⁴³ Am	95 (Yes)	7370 (Yes)	Yes
²⁴³ Cm	96 (Yes)	29.1 (Yes)	Yes
²⁴⁴ Cm	96 (Yes)	18.1 (NO)	Yes

NOTE: ²⁴⁴Cm has a half-life less than 20 years, however it is included as a TRU radionuclide due to it meeting the other criteria.

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First, the fractional contribution of each TRU radionuclide in the maximum feed vector batch is calculated. Then, the total TRU limit is multiplied by the fractional contribution of each TRU radionuclide to get the individual limits.

$$y_i = \frac{A_i}{A_{TRU}} \quad \text{Equation 4}$$

Where:

- y_i = Fractional contribution of TRU radionuclide i to total TRU in the maximum feed vector batch
- A_i = Maximum feed vector batch activity of TRU radionuclide i , in Ci (Equation 1)
- A_{TRU} = $A_{237Np} + A_{238Pu} + A_{239Pu} + A_{240Pu} + A_{241Am} + A_{242Pu} + A_{243Am} + A_{243Cm} + A_{244Cm}$

$$A_{i,limit} = y_i * A_{TRU,limit} \quad \text{Equation 5}$$

Where:

- $A_{i,limit}$ = Activity of individual TRU radionuclide i at ICD-30 limit, in Ci
- $A_{TRU,limit}$ = Activity of total TRU at ICD-30 limit, in Ci (Equation 3)

5.1.1.1.2 Compare Maximum Feed Vector Batch Activities to ICD-30 Limit Activities

The maximum batch activities of radionuclides that have acceptance limits established in ICD-30, as shown in Input 2.2, are compared to the activities at the ICD-30 limit calculated using Equation 2, Equation 3, or Equation 5. If the maximum batch activity exceeds the ICD-30 limit activity, then the maximum batch activity is adjusted to equal the ICD-30 limit activity.

5.1.1.1.3 U Fissile to U Total Limit

The Uranium fissile to Uranium total limit is shown in Table 2-1 as a weight percent. Total uranium is the sum of ^{233}U , ^{235}U , and ^{238}U (Ref. 9.3, Table 5). Fissile uranium is calculated per the equation provided in Ref. 9.30, Section 4.1.2. The weight percent of Uranium fissile to Uranium total in the maximum feed batch is calculated using the following equation.

$$m_{U,fissile} = 1.25 * m_{233U} + m_{235U} \quad \text{Equation 6}$$

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$$X_{U \text{ fissile to } U \text{ total}} = \frac{m_{U, \text{fissile}}}{m_{233U} + m_{235U} + m_{238U}} * 100 \quad \text{Equation 7}$$

Where:

- $X_{U \text{ fissile to } U \text{ total}}$ = Weight percent of Uranium fissile to Uranium total
 $m_{U, \text{fissile}}$ = Mass of fissile Uranium, in g
 m_i = Maximum feed vector batch mass of COPC i , in g (Equation 8)

If $X_{U \text{ fissile to } U \text{ total}}$ exceeds the ICD-30 limit for U fissile to U total, then the masses will be adjusted to equal the ICD-30 limit.

5.1.2 COPC Maximum Batch Mass Fractions and Concentrations

The mass of each COPC in the maximum feed vector batch is calculated using the following equation:

$$m_i = \frac{A_i}{SA_i} \quad \text{Equation 8}$$

Where:

- m_i = Maximum feed vector batch mass of COPC i , in g
 A_i = Maximum feed vector batch activity of COPC i , in Ci (Equation 1)
 SA_i = Specific Activity of COPC i , in Ci/g (Input 2.1, Attachment B)

The average feed vector batch total mass is calculated using the average batch volume and density. Average values are used in Equation 9 through Equation 11 for conservatism (Assumption 6.1.34). The values for total volume (in gallons) and density (in g/cc) in each batch during the DFLAW operation are extracted from the DFLAW Bounding Feed Vector (Ref. 9.2) and then the average, minimum, and maximum values are calculated (Attachment G).

The average feed vector batch total mass is calculated as follows:

$$m_{\text{batch, avg}} = V_{\text{batch, avg}} * \rho_{\text{batch, avg}} * 3.785 \frac{L}{\text{gal}} * 1000 \frac{\text{cc}}{L} \quad \text{Equation 9}$$

Where:

- $m_{\text{batch, avg}}$ = Average total feed vector batch mass, in g
 $V_{\text{batch, avg}}$ = Average total feed vector batch volume, in gal (Attachment G)
 $\rho_{\text{batch, avg}}$ = Average total feed vector batch density, in g/cc (Attachment G)

A conservative value for the mass fraction of each radionuclide COPC is then calculated by dividing the maximum batch mass of each COPC by the average total batch mass.

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$$x_i = \frac{m_i}{m_{batch,avg}}$$

Equation 10

Where:

$$x_i = \text{Maximum feed vector batch mass fraction of COPC } i$$
$$m_{batch,avg} = \text{Average total feed vector batch mass, in g (Equation 9)}$$

A conservative value for the concentration of each radionuclide COPC is calculated by dividing the maximum batch mass of each COPC by the average total batch volume.

$$c_i = \frac{m_i}{V_{batch,avg}} * \frac{gal}{3.785 \text{ liters}}$$

Equation 11

Where:

$$c_i = \text{Maximum feed vector batch concentration of COPC } i, \text{ in g/L}$$
$$V_{batch,avg} = \text{Average total feed vector batch volume, in gal (Attachment G)}$$

5.1.3 Radionuclide COPC Emissions Due to Entrainment of Particles/Aerosols

CCN 129507 (Ref. 9.4) assigns vapor phase partitioning coefficient values, F_v , to all WTP COPCs. F_v is a unitless parameter defined as the fraction of a COPC that is in the vapor phase in an offgas stream. All radionuclide COPCs, except for Carbon-14 (^{14}C), Tritium (^3H), and Iodine-129 (^{129}I), are metals and nonvolatile, and are assigned a vapor phase partitioning coefficient, F_v , of 0 and assumed to exist entirely as particles in an offgas stream (Assumption 6.2.9). Particles in an offgas stream are abated by HEPA filtration (Assumption 6.2.10).

^{129}I is also treated as a particle/aerosol for emissions estimation (Assumption 6.2.8).

Emissions of radionuclide COPCs with an F_v of 0 are estimated using offgas entrainment factors. For the entrainment of radionuclides from DEP vessels, an entrainment factor of 4E-5 g entrained material / g air is used based on the median entrainment factor for a free-fall spill of an aqueous solution (Input 2.3). As a conservative and simplifying assumption for this calculation, this entrainment factor is applied to all vessels in the DEP system, except for the evaporator (Assumption 6.2.3). For the entrainment of radionuclides from the DEP evaporator, an entrainment factor of 1E-3 g entrained material / g air is used based on the release fraction prescribed in the WAC 246-247-030 (21)(a)(ii) for liquids and particulate solids (Input 2.20). This entrainment factor is applied to the DEP evaporator per Assumption 6.2.30.

The total mass flow rate of entrained material in the DVP system is calculated as follows:

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$$\bar{m}_{tot,entrained} = (\bar{m}_{ves,vent} * EF_{ves} + \bar{m}_{evap,vent} * EF_{evap}) * 453.5924 \frac{g}{lb} * \frac{1 \text{ hr}}{60 \text{ min}} \quad \text{Equation 12}$$

Where:

- $\bar{m}_{tot,entrained}$ = Total mass flowrate of entrained material, in g/min
- $\bar{m}_{ves,vent}$ = Total mass flowrate of the DVP system except for the evaporator, in lb/hr (Assumption 6.1.4)
- EF_{ves} = Entrainment factor for DEP vessels, in g entrained material / g air (Input 2.3)
- $\bar{m}_{evap,vent}$ = Mass flowrate of the evaporator vent stream, in lb/hr (Assumption 6.1.4)
- EF_{evap} = Entrainment factor for DEP evaporator, in g entrained material / g air (Input 2.20)

The mass fraction of each radionuclide COPC in each DEP vessel is assumed to be equal to the value for x_i calculated using Equation 10 (Assumption 6.1.1). With the COPC mass fractions assumed to be constant at the maximum value throughout the DEP system, the bounding value for COPC entrainment is calculated as follows:

$$\bar{m}_{i,entrained} = \bar{m}_{tot,entrained} * x_i \quad \text{Equation 13}$$

Where:

- $\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC i , in g/min
- $\bar{m}_{tot,entrained}$ = Total mass flowrate of entrained material, in g/min (Equation 12)
- x_i = Maximum feed vector batch mass fraction of COPC i (Equation 10)

The entrained mass flow rate is then converted to unabated activity emitted per year using the specific activity.

$$\bar{A}_{i,unabated} = \bar{m}_{i,entrained} * SA_i * 525,600 \frac{\text{min}}{\text{year}} \quad \text{Equation 14}$$

Where:

- $\bar{A}_{i,unabated}$ = Unabated activity of COPC i emitted per year, in Ci/year
- $\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC i , in g/min (Equation 13)
- SA_i = Specific Activity of COPC i , in Ci/g (Input 2.1, Attachment B)

The DEP vessel ventilation system includes a two-stage HEPA filtration system for removal of particulate prior to release from the EMF stack (Ref. 9.7). The decontamination factors (DFs) of the HEPA filters are given in Assumption 6.2.10. Using the HEPA filter DFs, the abated emissions of radionuclide COPC particles are calculated.

$$\bar{A}_{i,abated} = \frac{\bar{A}_{i,unabated}}{DF_{HEPA,primary} * DF_{HEPA,secondary}} \quad \text{Equation 15}$$

Where:

- $\bar{A}_{i,abated}$ = Abated activity of COPC i emitted per year, in Ci/year
- $DF_{HEPA,primary}$ = Decontamination factor of primary HEPA filter (Assumption 6.2.10)
- $DF_{HEPA,secondary}$ = Decontamination factor of secondary HEPA filter (Assumption 6.2.10)

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5.1.4 Vapor Phase Radionuclide COPCs

^{14}C is assumed to exist as $^{14}\text{CO}_2$ and emitted entirely in the vapor phase of an offgas stream (Assumption 6.2.6).

^3H is assumed to exist as tritiated water ($^3\text{H}_2\text{O}$) and emitted entirely in the vapor phase of an offgas stream (Assumption 6.2.7).

5.1.4.1 Sources of Vapor Phase Radionuclide COPCs

While the concentrations of particle phase radionuclides were assumed to be at the maximum feed vector batch mass fraction throughout the DEP system (Assumption 6.1.1), a different approach is warranted for the vapor phase radionuclides.

^{14}C and ^3H are not likely to reach their maximum feed vector batch mass fractions in the DEP system. Maximum feed vector batch mass fractions are only likely to be reached in the evaporator concentrate and, since volatile radionuclides will mostly partition to the evaporator overhead, ^{14}C and ^3H will not be concentrated in the evaporator bottoms like the other non-volatile radionuclides.

To establish the input concentrations for ^{14}C or ^3H , it is assumed that no ^{14}C or ^3H is transferred to the DEP system in the SBS condensate stream or Plant Wash Vessel effluent stream and that the only input stream to the EMF containing ^{14}C or ^3H is the LAW feed flush stream to the DEP-VSL-00001 (Assumption 6.1.5).

After completion of a batch transfer to LCP-VSL-00001/2, the transfer line will be flushed to the DEP-VSL-00001. The total transfer volume and stream density are monitored prior to reaching LCP-VSL-00001/2 in order to detect when the stream composition changes from LAW feed to flush water. When flush water is first detected prior to LCP-VSL-00001/2, the valve alignment is changed to divert the flush water to DEP-VSL-00001. When the flow of flush water is stopped, the transfer line drains by gravity to DEP-VSL-00001 (Ref. 9.3, Section 2.6.2).

Based on the assumed flushing frequency of 18.8 hrs (Assumption 6.1.3), the applicable feed line flush volume to DEP-VSL-00001 is 1500 gallons (Input 2.4). The volume of residual feed material in the flush to DEP-VSL-00001 is estimated by multiplying the total LAW feed line flush volume (Input 2.4) by an assumed flush dilution factor (Assumption 6.1.2).

$$V_{\text{residual feed}} = V_{\text{flush}} * \text{Dilution Factor} * 3.785 \frac{\text{liters}}{\text{gal}} \quad \text{Equation 16}$$

Where:

$$\begin{aligned} V_{\text{residual feed}} &= \text{Volume of residual feed in a LAW feed line flush, in L} \\ V_{\text{flush}} &= \text{Total volume of LAW feed line flush, in gal (Input 2.4)} \\ \text{Dilution Factor} &= \text{Flush dilution factor (Assumption 6.1.2)} \end{aligned}$$

The total mass of ^{14}C and ^3H flushed annually to DEP-VSL-00001 is then calculated as follows using the maximum batch concentration, c_i (Equation 11), and the frequency of flushing to DEP-VSL-00001

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(Assumption 6.1.3). It is also assumed that the flush occurs continuously at the set frequency throughout an entire year (Assumption 6.2.5), so that the total number of flushes annually is the number of hours in a year multiplied by the frequency.

$$\bar{m}_{i,flush} = V_{residual\ feed} * C_i * F_{flush} * 8760 \frac{hr}{yr} \quad \text{Equation 17}$$

Where:

- $\bar{m}_{i,flush}$ = Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr
- $V_{residual\ feed}$ = Volume of residual feed in a LAW feed line flush, in L (Equation 16)
- C_i = Maximum feed vector batch concentration of COPC i , in g/L (Equation 11)
- F_{flush} = Frequency of LAW feed line flush, in 1/hr (Assumption 6.1.3)

5.1.4.2 Vapor Phase Radionuclide COPC Emissions

5.1.4.2.1 ^{14}C Emissions

As a bounding assumption, it is assumed that the entire mass of ^{14}C received in DEP-VSL-00001 annually is emitted to the DEP vessel ventilation system as it is processed through the DEP system (Assumption 6.2.4). The unabated emissions of ^{14}C are then calculated as follows:

$$\bar{A}_{i,unabated} = \bar{m}_{i,flush} * SA_i \quad \text{Equation 18}$$

Where:

- $\bar{A}_{i,unabated}$ = Unabated activity of COPC i emitted per year, in Ci/year
- $\bar{m}_{i,flush}$ = Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr (Equation 17)
- SA_i = Specific Activity of COPC i , in Ci/g (Input 2.1, Attachment B)

For vapor phase COPCs with an F_v of 1, the DF is 1 through both the primary and secondary HEPA filter (Assumption 6.2.10). Therefore there is no emissions abatement provided by the HEPA filters for ^{14}C .

5.1.4.2.2 ^3H Emissions

The emissions of ^3H are assumed to be controlled by the evaporator/condenser mass distribution ratios (MDRs) for ^3H established in Ref. 9.19, Section 8 (Assumption 6.1.35). The MDR specifically represents the ratio of the evaporator/condenser overhead mass flowrate to the evaporator/condenser feed mass flowrate.

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$$MDR_i = \frac{\bar{m}_{overheads,i}}{\bar{m}_{feed,i}} \quad \text{Equation 19}$$

Where :

- MDR_i = Mass distribution ratio of COPC i
- $\bar{m}_{feed,i}$ = Mass flow rate for COPC i in the feed to the evaporator/condenser
- $\bar{m}_{overheads,i}$ = Mass flow rate for COPC i in the evaporator/condenser overheads flow

MDRs for the FEP and TLP evaporators/condensers are calculated in Ref. 9.19, Section 8. These MDRs are assumed to apply to the DEP evaporator system (Assumption 6.1.13). For estimating ^3H emissions, the value for $\bar{m}_{i,flush}$ will be used for the evaporator feed stream, so $\bar{m}_{feed,i} = \bar{m}_{i,flush}$ (Assumption 6.1.36). For the evaporator and two condensers in series, the combined MDR is calculated by multiplying the individual MDRs.

$$MDR_{3H,combined} = MDR_{3H,evaporator} * MDR_{3H,primary\ condenser} * MDR_{3H,inter-condenser} \quad \text{Equation 20}$$

Note: The MDR of the after-condenser is 1 (Ref. 9.19, Section 8).

The unabated emissions of ^3H are then calculated as follows:

$$\bar{A}_{i,unabated} = \bar{m}_{i,flush} * MDR_{3H,combined} * SA_i \quad \text{Equation 21}$$

Where:

- $\bar{A}_{i,unabated}$ = Unabated activity of COPC i emitted per year, in Ci/year
- $\bar{m}_{i,flush}$ = Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr (Equation 17)
- $MDR_{3H,combined}$ = Combined mass distribution ratio (Equation 20)
- SA_i = Specific Activity of COPC i , in Ci/g (Input 2.1, Attachment B)

For vapor phase COPCs with an F_v of 1, the DF is 1 through both the primary and secondary HEPA filters (Assumption 6.2.10). Therefore there is no emissions abatement provided by the HEPA filters for ^3H .

5.1.5 ACV Exhaust System Radionuclide COPC Emissions

Air supplied to the LAW effluent process building, the LAW effluent drain tank building, and the LAW effluent utility building by the ACV supply system is exhausted by the ACV exhaust system. The ACV exhaust passes through a HEPA filtration system before being released from the EMF stack (Ref. 9.36). The unabated emissions for radionuclide COPCs from the ACV exhaust system are estimated based on a 2 month release of the unabated DEP vessel ventilation emissions into the ACV area of the EMF (Assumption 6.2.11). Abated emissions from the ACV exhaust system are based on the same particle and vapor phase HEPA DFs used for the DEP vessel ventilation system emissions (Assumption 6.2.10). Abated emissions will be calculated for both a single-stage and dual-stage HEPA filtration system in order to compare the effect on the emissions from the ACV exhaust system.

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$$\bar{A}_{i,unabated,ACV} = \bar{A}_{i,unabated} * \frac{2 \text{ months}}{12 \text{ months}} \quad \text{Equation 22}$$

Where:

- $\bar{A}_{i,unabated,ACV}$ = Unabated activity of COPC *i* emitted per year from the ACV Exhaust system, in Ci/year
- $\bar{A}_{i,unabated}$ = Unabated activity of COPC *i* emitted per year, in Ci/year (as determined in previous sections)

Note that since the ACV radionuclide emissions are based on a 2 month release from the DVP system into the ACV area, the total emissions of the DVP and ACV combined will double count this 2 month period (i.e. the total annual emissions for DVP and ACV are 117% of their actual value because the 2 month release period is counted for both ventilation systems).

5.1.6 Annual Possession Quantities

The annual possession quantities (APQs) represent the total annual amount of a radionuclide received in a system.

As discussed in Section 5.1.3, the emissions of all radionuclide COPCs, except ¹⁴C and ³H, were estimated based on the entrainment of particles. The estimate for entrainment conservatively assumed that the mass fraction of each radionuclide COPC remained at its maximum feed mass fraction from the Tank Farms throughout the DEP system (Assumption 6.1.1). For determination of the APQs for these radionuclides, the radionuclide concentrations received into the DEP system are set at the maximum feed vector batch concentration, *c_i*. The annual throughput of the DEP system is estimated based on a feed rate to the DEP evaporator of 10 gpm (Assumption 6.1.7) and an assumed annual evaporator availability of 100% (Assumption 6.2.13). The following equations are used to calculate the APQs for radionuclide COPCs emitted through entrainment:

$$APQ_i = c_i * SA_i * V_{evap,throughput} \quad \text{Equation 23}$$

Where:

- APQ_i = Annual Possession Quantity of COPC *i*, Ci/yr
- c_i = Maximum feed vector batch concentration of COPC *i*, in g/L (Equation 11)
- SA_i = Specific Activity of COPC *i*, in Ci/g (Input 2.1)
- $V_{evap,throughput}$ = Annual volume processed through DEP evaporator, in L (Equation 24)

$$V_{evap,throughput} = V_{evap,feed} * \frac{3.785 \text{ L}}{\text{gal}} * \frac{525600 \text{ min}}{\text{year}} \quad \text{Equation 24}$$

Where:

- $V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm (Assumption 6.1.7)
- $V_{evap,throughput}$ = Annual volume processed through DEP evaporator, L (100% uptime based on Assumption 6.2.13)

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For vapor radionuclide COPC emissions, ^{14}C and ^3H , the mass flushed to DEP-VSL-00001 annually is calculated in Equation 17 and assumed to represent the entire amount of these COPCs received in the DEP system annually (Assumption 6.1.5). This mass is multiplied by the specific activity to determine the APQs for ^{14}C and ^3H .

$$APQ_i = \bar{m}_{i,flush} * SA_i \quad \text{Equation 25}$$

Where:

APQ_i	=	Annual Possession Quantity of COPC i , Ci/yr
$\bar{m}_{i,flush}$	=	Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr (Equation 17)
SA_i	=	Specific Activity of COPC i , in Ci/g (Input 2.1)

5.2 Organic COPC Emissions

Attachment A, Table A-2 shows the 309 organics tracked as COPCs at WTP, identified as feed compounds, PIC compounds, or both. The methodology for estimating feed organic emissions and PIC emissions will be described separately in the following sections.

5.2.1 Feed Organic COPC Emissions

Feed organic COPCs are organic compounds expected to be received in the waste feed from the Tank Farms. COPCs that are present in the feed and as PICs are evaluated as both (see Section 5.2.3).

5.2.1.1 Adjustment of Tank Farms Average Ratios

Ref. 9.2 provides Tank Farms Average ratios for feed organic COPCs, as well as 51 “non-COPC” organics, that were detected in tank farms sampling. The ratios are provided as g COPC / g TOC (total organic carbon) and as g COPC-as-Carbon / g TOC. An evaluation of the g COPC-as-Carbon / g TOC ratios for all organics (COPC and non-COPC) shows the ratios add up to 0.691 (Attachment C, Excel File “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*”, Worksheet “*Feed Organic COPCs - Calc*”, Cell D143), meaning the remaining fraction (0.309) of organic carbon is unaccounted for in the Tank Farms Average ratios. As an approximation to account for the unspciated organic carbon, the “COPC-as-Carbon” ratios are scaled by a factor of (0.691^{-1}) , i.e. the remaining unspciated organic carbon is assumed to be distributed proportionally to all of the organic compounds with ratios (Assumption 6.2.12).

$$\bar{c}_{i,scaled} = \frac{\bar{c}_i}{\sum \bar{c}_i} \quad \text{Equation 26}$$

Where:

$\bar{c}_{i,scaled}$	=	Scaled Tank Farms Average ratio for COPC i to account for unspciated organic carbon, g COPC-as-Carbon / g TOC
\bar{c}_i	=	Tank Farms Average ratio for COPC i , g COPC-as-Carbon / g TOC (Ref. 9.2)
$\sum \bar{c}_i$	=	Sum of all Tank Farms Average ratios (COPC and non-COPC) = 0.69

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Scaled values for the tank farm ratios, in units of g COPC / g TOC, are then calculated by multiplying $\bar{c}_{i,scaled}$ by the ratio of the mass of COPC i to the mass of COPC i as Carbon.

$$\bar{r}_{i,scaled} = \bar{c}_{i,scaled} * \frac{\bar{r}_i}{\bar{c}_i} \quad \text{Equation 27}$$

Where:

- $\bar{r}_{i,scaled}$ = Scaled Tank Farms Average ratio for COPC i to account for unspciated organic carbon, g COPC / g TOC
- \bar{r}_i = Tank Farms Average ratio for COPC i , g COPC / g TOC (Ref. 9.2)
- $\bar{c}_{i,scaled}$ = Scaled Tank Farms Average ratio for COPC i to account for unspciated organic carbon, g COPC-as-Carbon / g TOC (Equation 26)
- \bar{c}_i = Tank Farms Average ratio for COPC i , g COPC-as-Carbon / g TOC (Ref. 9.2)

There is a subset of feed organic COPCs that do not have Tank Farms Average ratios defined in Ref. 9.2, meaning these are COPCs for which no data is available. Therefore, this subset will have emissions of zero using the methodology based on Tank Farms Average ratios. However, this subset will be revisited in Section 5.2.4.2.2, in order to provide a bounding estimate of the emissions for these COPCs that is greater than zero.

5.2.1.2 Determination of Feed Vector TOC Values

The DFLAW Bounding Feed Vector includes separate values for TOC and oxalate ($C_2O_4^{2-}$). These values must be combined to have a true TOC value.

$$TOC_{adj} = (MW_c) * [(TOC_{batch}) + (\gamma) * (Ox_{batch})] * 1000 \frac{mol}{kmol} \quad \text{Equation 28}$$

Where:

- TOC_{adj} = Adjusted mass of TOC delivered to WTP in a feed vector batch, in g
- MW_c = Molecular weight of carbon g/mol (Input 2.6)
- TOC_{batch} = Moles of TOC delivered to WTP in a feed vector batch, in kmol (Ref. 9.2)
- γ = Moles of carbon per mole of oxalate (2 kmol/kmol)
- Ox_{batch} = Moles of oxalate delivered to WTP in a feed vector batch, in kmol (Ref. 9.2)

5.2.1.3 COPC Maximum Batch Masses, Mass Fractions, and Concentrations

Using the adjusted mass of TOC in each batch (Equation 28), the average, minimum, and maximum values for adjusted mass of TOC are calculated (Attachment G).

The maximum batch mass of each feed organic COPC is then calculated as follows:

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$$m_i = \bar{r}_{i,scaled} * TOC_{adj,max} \quad \text{Equation 29}$$

Where:

- m_i = Maximum feed vector batch mass of COPC i , in g
 $\bar{r}_{i,scaled}$ = Scaled Tank Farms Average ratio for COPC i to account for unspeci-ated organic carbon, g COPC / g TOC (Equation 27)
 $TOC_{adj,max}$ = Maximum batch adjusted mass of TOC delivered to WTP in a feed vector batch, in g (Equation 28)

The mass fraction, x_i , of each feed organic COPC is then calculated using Equation 10. For conservatism, $m_{batch,avg}$ is used in Equation 10 (Assumption 6.1.34).

The concentration, c_i , of each feed organic COPC is calculated using Equation 11. For conservatism, $V_{batch,avg}$ is used in Equation 11 (Assumption 6.1.34).

5.2.1.4 Other Physical Properties

One measure of the volatility of a COPC is the vapor phase partitioning coefficient, F_v , which is used to classify the phase type of COPCs in an off-gas stream as follows (Ref. 9.4, Section 4.0):

- $F_v = 1.0$; phase type = vapor
- $0.05 \leq F_v < 1.0$; phase type = particle-bound
- $F_v < 0.05$; phase type = particle

COPCs with particle-bound phase type will partition as both vapor and particle according to the F_v value. For example, F_v value of 0.95 indicates that the constituent is 95% vapor and 5% particle in an off-gas stream.

Physical properties for organic COPCs have been compiled in Ref. 9.15, Attachment A. The F_v values, molecular weights, and Henry's Law constants of the feed organic COPCs are extracted from Ref. 9.15, Attachment A for use in this calculation (Assumption 6.1.6).

5.2.1.5 Vapor Phase Feed Organic COPC Emissions

To establish the input concentrations for feed organic COPCs, it is assumed that no feed organics are transferred to the DEP system in the SBS condensate stream or Plant Wash Vessel effluent stream and that the only input stream to the EMF containing feed organics is the LAW feed flush stream to DEP-VSL-00001 (Assumption 6.1.37).

After completion of a batch transfer to LCP-VSL-00001/2, the transfer line will be flushed to DEP-VSL-00001. The total transfer volume and stream density are monitored prior to reaching LCP-VSL-00001/2 in order to detect when the stream composition changes from LAW feed to flush water. When flush water

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is first detected prior to LCP-VSL-00001/2, the valve alignment is changed to divert the flush water to DEP-VSL-00001. When the flow of flush water is stopped, the transfer line drains by gravity to DEP-VSL-00001 (Ref. 9.3, Section 2.6.2).

The volume of residual feed in the flush, $V_{residual\ feed}$, was previously calculated using Equation 16.

The total mass of each feed organic COPC flushed annually to DEP-VSL-00001, $\bar{m}_{i,flush}$, is then calculated using Equation 17.

As a bounding assumption, it is assumed that the entire vapor fraction of each feed organic COPC received in DEP-VSL-00001 annually is emitted to the DEP vessel ventilation system as it is processed through the DEP system (Assumption 6.2.16). The unabated emissions of feed organic COPCs is then calculated as follows:

$$\bar{m}_{i,vap,unabated} = \bar{m}_{i,flush} * F_{v,i} * \frac{1\ year}{31,536,000\ seconds} \quad \text{Equation 30}$$

Where:

$\bar{m}_{i,vap,unabated}$	=	Unabated vapor phase emissions of COPC i , in g/sec
$\bar{m}_{i,flush}$	=	Mass of COPC i flushed to DEP-VSL-00001 annually, in g/yr (Equation 17)
$F_{v,i}$	=	Vapor phase partitioning coefficient of COPC i (Section 5.2.1.4)

For vapor phase COPCs with an F_v of 1, the DF is 1 through both the primary and secondary HEPA filter (Assumption 6.2.10). Therefore there is no emissions abatement provided by the HEPA filters for feed organic COPCs emitted in the vapor phase ($\bar{m}_{i,vap,abated} = \bar{m}_{i,vap,unabated}$).

5.2.1.6 Particle Phase Feed Organic COPC Emissions

Feed organic COPCs with an F_v value less than 1 will have particulate phase emissions. For the estimation of particle emissions, the maximum feed vector batch mass fraction of COPC i , x_i , (calculated in Section 5.2.1.3) is conservatively assumed to represent the mass fraction of feed organic COPC i throughout the DEP system (Assumption 6.1.1). The entrained mass flowrate of feed organic COPCs from the DVP system are calculated using the total mass flowrate of entrained material (Equation 12) and the following equation:

$$\bar{m}_{i,entrained} = \bar{m}_{tot,entrained} * x_i * (1 - F_{v,i}) \quad \text{Equation 31}$$

Where:

$\bar{m}_{i,entrained}$	=	Entrained mass flowrate of COPC i , in g/min
$\bar{m}_{tot,entrained}$	=	Total mass flowrate of entrained material, in g/min (Equation 12)
$F_{v,i}$	=	Vapor phase partitioning coefficient of COPC i (Section 5.2.1.4)

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The value for $\bar{m}_{i,entrained}$ (in g/min) calculated from Equation 31 is converted to g/sec and represents the unabated particulate emissions of feed organic COPC i , $\bar{m}_{i,part,unabated}$.

$$\bar{m}_{i,part,unabated} = \bar{m}_{i,entrained} * \frac{1 \text{ min}}{60 \text{ sec}} \quad \text{Equation 32}$$

Where :

- $\bar{m}_{i,part,unabated}$ = Unabated particulate emissions of COPC i , in g/sec
 $\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC i , in g/min (Equation 31)

The abated emissions are then calculated using a modification to Equation 15, based on mass emitted instead of activity emitted.

$$\bar{m}_{i,part,abated} = \frac{\bar{m}_{i,part,unabated}}{DF_{HEPA,primary} * DF_{HEPA,secondary}} \quad \text{Equation 33}$$

Where:

- $\bar{m}_{i,part,abated}$ = Abated particulate emissions of COPC i , in g/sec
 $\bar{m}_{i,part,unabated}$ = Unabated particulate emissions of COPC i , in g/sec (Equation 32)
 $DF_{HEPA,primary}$ = Decontamination factor of primary HEPA filter (Assumption 6.2.10)
 $DF_{HEPA,secondary}$ = Decontamination factor of secondary HEPA filter (Assumption 6.2.10)

5.2.2 PIC COPC Emissions

PICs are COPCs generated in the melter through combustion of organic material in the melter feed. The following methodology is used to estimate the emissions of PICs from the DVP system.

5.2.2.1 PIC Generation Rates

The generation rates of PICs in the melter have been studied through R&T (Research and Technology) testing. Generation rates for PICs detected in testing at the Vitreous State Laboratory of the Catholic University of America (VSL) are reported in Ref. 9.15, Table 3. These generation rates are used to estimate the emissions of PICs from the DVP system (Assumption 6.2.26).

First, the list of PICs with generation rates in Ref. 9.15, Table 3 is cross referenced with the list of PIC COPCs in Attachment A, Table A-2, and generation rates are assigned to the COPCs that occur in both lists. Generation rates are given in units of mg generated / mg melter feed TOC. Values calculated in the Process Inputs Basis of Design (PIBOD) (Ref. 9.22) model runs for TOC in the LAW Melter Feed Process system stream (LFP04) were extracted for use in this calculation (Attachment F, Table F-1). The maximum value for melter feed TOC in Attachment F will be used to provide a conservative value for the amount of PIC generation. This LAW melter feed TOC value is assumed to apply to the DFLAW operating scenario (Assumption 6.1.15)

As an initial screening, PICs with an F_v value of 1 are assumed to pass through the SBS with a DF of 1 and are emitted entirely through the LAW offgas system (Assumption 6.2.15). This means these vapor phase PICs will not be captured in the SBS, and therefore not transferred to the DEP system through the

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SBS condensate stream (RLD21). Therefore, these vapor phase PICs will therefore have emissions of zero using the following methodology. However, these vapor phase PICs will be revisited in Section 5.2.4.2.1, in order to provide a bounding estimate of emissions for these COPCs that is greater than zero.

Next, the mass flowrates leaving the melter (in g/sec) are calculated for PIC COPCs that have generation rates reported in Ref. 9.15, Table 3.

$$\bar{m}_{melter,i} = GR_{PIC,i} * TOC_{MF,max} * \frac{1000 \text{ g}}{\text{kg}} * \frac{1 \text{ hr}}{3600 \text{ sec}} \quad \text{Equation 34}$$

Where :

- $\bar{m}_{melter,i}$ = Mass flowrate of PIC COPC *i* generated in the melter, in g/sec
- $GR_{PIC,i}$ = Generation rate of PIC COPC *i*, in mg (or g) PIC generated / mg (or g) melter feed TOC (Ref. 9.15, Table 3)
- $TOC_{MF,max}$ = Maximum mass flowrate of TOC in melter feed stream LFP04 from PIBOD model runs, in kg/hr (Assumption 6.1.15)

As a conservative assumption, if a particle or particle-bound PIC COPC does not have a generation rate in Ref. 9.15, Table 3, it is assigned the maximum $GR_{PIC,i}$ value for a particle or particle-bound PIC COPC for calculation of Equation 34 (Assumption 6.2.17).

5.2.2.2 PIC COPC Emissions

Next, the amount of each PIC COPC captured in the SBS as particulate is calculated. For conservatism, the entire fraction of each PIC COPC that exists as particulate, represented by $(1 - F_{v,i})$, is assumed to be captured in the SBS (Assumption 6.2.18).

$$\bar{m}_{SBS,i} = \bar{m}_{melter,i} * (1 - F_{v,i}) \quad \text{Equation 35}$$

Where :

- $\bar{m}_{SBS,i}$ = Mass flowrate of PIC COPC *i* captured in the SBS, in g/sec
- $\bar{m}_{melter,i}$ = Mass flowrate of PIC COPC *i* generated in the melter, in g/sec (Equation 34)
- $F_{v,i}$ = Vapor phase partitioning coefficient of COPC *i* (Section 5.2.1.4)

The SBS condensate is transferred from the SBS to RLD-VSL-00005. The contents of RLD-VSL-00005 are transferred once every 24 hours to DEP-VSL-00002 with a transfer volume of 10,700 gallons (Assumptions 6.2.19 and 6.2.20, respectively). This transfer stream is designated RLD21 in the PFD (Ref. 9.5). The mass flowrate of stream RLD21 is calculated, and then subsequently used to calculate the mass fraction of each PIC COPC in stream RLD21.

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$$\bar{m}_{RLD21} = V_{RLD21} * \rho_{RLD21} * F_{RLD21} * \frac{hr}{3600 sec} * \frac{3.785 L}{1 gal} \quad \text{Equation 36}$$

Where :

- \bar{m}_{RLD21} = Mass flowrate of stream RLD21, in g/sec
- V_{RLD21} = Transfer volume of stream RLD21, in gal (Assumption 6.2.20)
- ρ_{RLD21} = Density of stream RLD21 from PIBOD, in g/L (From Input 2.14)
- F_{RLD21} = Frequency of transfer from RLD-VSL-00005 to DEP-VSL-00002, in 1/hr (Assumption 6.2.19)

$$x_{RLD21,i} = \frac{\bar{m}_{SBS,i}}{\bar{m}_{RLD21}} \quad \text{Equation 37}$$

Where :

- $x_{RLD21,i}$ = Mass fraction of PIC COPC i in Stream RLD21
- \bar{m}_{RLD21} = Mass flowrate of stream RLD21, in g/sec (Equation 36)
- $\bar{m}_{SBS,i}$ = Mass flowrate of PIC COPC i captured in the SBS, in g/sec (Equation 35)

For the estimation of particle emissions, the mass fraction of PIC COPC i in Stream RLD21, $x_{RLD21,i}$, is assumed to represent the mass fraction of PIC COPC i throughout the DEP system (Assumption 6.1.1). The particulate emissions of PIC COPCs from the DVP system are calculated using Equation 12 and Equation 13, previously defined in Section 5.1.3. In Equation 13, $x_{RLD21,i}$ is substituted for x_i .

Next, values for $\bar{m}_{i,part,unabated}$ and $\bar{m}_{i,part,abated}$ are calculated using Equation 32 and Equation 33, previously defined in Section 5.2.1.6.

5.2.3 Feed/PIC Organic COPC Emissions

In Attachment A, Table A-2, a subset of organic COPCs are identified as being present as both Feed Organics and PICs. Feed/PIC COPCs with an F_v value less than 1 could have particulate emissions based on the methodology described in Sections 5.2.1.6 and 5.2.2.2. The particulate emissions reported in the results for these Feed/PIC COPCs will be the sum of the particulate emissions calculated in Sections 7.2.1.6 and 7.2.2.2.

5.2.4 Organic COPC Summary and Comparison to De Minimis Emissions Limits

The results from Sections 5.2.1, 5.2.2, and 5.2.3 are presented in summary tables (Table 8-4 and Table 8-5). The summary table for feed organic COPCs (Sections 5.2.1 and 5.2.3) shows results for vapor phase, particle phase, and total emissions for each feed organic COPC. The PIC COPC summary shows particle phase emissions.

Next, the total abated emissions values are compared to de minimis emissions limits for toxic air pollutants (TAPs) established in WAC 173-460-150 (Input 2.13). Each TAP has a de minimis value (lb/averaging period) and an averaging period (1-hour, 24-hours, or 1 year).

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De minimis emissions are defined in Ref. 10.8 as “trivial levels of emissions that do not pose a threat to human health or the environment. The de minimis emissions threshold values are listed in WAC 173-460-150.”

The de minimis values are all converted to units of lb/year.

$$\bar{m}_{i,dm\ standard} = \begin{cases} \bar{m}_{i,dm}, & \text{if averaging period} = 1 \text{ year} \\ \bar{m}_{i,dm} * 365, & \text{if averaging period} = 24 \text{ hours} \\ \bar{m}_{i,dm} * 8760, & \text{if averaging period} = 1 \text{ hour} \end{cases} \quad \text{Equation 38}$$

Where:

- $\bar{m}_{i,dm\ standard}$ = De minimis emissions limit for COPC i , standardized to lb/yr
- $\bar{m}_{i,dm}$ = De minimis emissions limit for COPC i , lb/averaging period (Input 2.13)

Next, the values for $\bar{m}_{i,total,unabated}$ (Table 8-4 and Table 8-5) converted from g/sec to lb/year, for a standard comparison with the de minimis values.

$$\bar{m}_{i,total,unabated} \left(\frac{lb}{yr} \right) = \bar{m}_{i,total,unabated} \left(\frac{g}{sec} \right) * \frac{31,536,000 \text{ seconds}}{1 \text{ year}} * \frac{lb}{453.5924 \text{ grams}}$$

If any values for $\bar{m}_{i,total,unabated} \left(\frac{lb}{yr} \right)$ are greater than $\bar{m}_{i,dm\ standard}$, that COPC is evaluated using a more rigorous approach for estimating the vapor emissions (Section 5.2.4.1).

5.2.4.1 Henry’s Law Analysis

The subset of feed organic COPCs that exceed their de minimis emissions limit, based on the first-pass bounding assumption of complete emission of the vapor fraction of the COPC mass received in the feed line flush (Assumption 6.2.16), are evaluated a second time using a Henry’s Law analysis.

First, the concentration of each feed organic COPC (in g/L) is calculated based on the amount received in the feed line flush to DEP-VSL-00001 and the DEP evaporator annual throughput volume. The annual throughput is determined based on Assumptions 6.1.7 and 6.2.13.

$$c_{i,flush} = \frac{\bar{m}_{i,flush}}{V_{evap,throughput}} \quad \text{Equation 39}$$

Where:

- $c_{i,flush}$ = Concentration of COPC i based on amount received in feed line flush, g/L
- $\bar{m}_{i,flush}$ = Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr (Equation 17)
- $V_{evap,throughput}$ = Annual volume processed through DEP evaporator, in L (Equation 24)

Each COPC is assumed to be at the concentration, $c_{i,flush}$, throughout the DEP system (Assumption 6.1.11).

The equation for Henry’s Law is (Ref. 10.9, Equation 1):

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$$k_{H,i} = \frac{c_i}{p_i} \quad \text{Equation 40}$$

Where:

$$k_H = \text{Henry's Law constant of COPC } i, \text{ in } \frac{\text{mol}}{\text{m}^3 \cdot \text{Pa}}$$

$$c_i = \text{Concentration of COPC } i \text{ in the aqueous phase, in mol/m}^3 \text{ (Equation 43)}$$

$$p_i = \text{Partial pressure of COPC } i \text{ in the vapor phase, in Pa (Equation 41)}$$

The equation for partial pressure using Dalton's Law is (Ref. 10.3, Page 43-2, Equation 43.11):

$$p_i = y_i * P \quad \text{Equation 41}$$

Where:

$$y_i = \text{Mole fraction COPC } i \text{ in the vapor phase}$$

$$P = \text{Total pressure of the vapor space, in Pa}$$

The Henry's Law constants used in this calculation (Section 5.2.1.4) have units of $\frac{\text{atm} \cdot \text{m}^3}{\text{mol}}$, which is the reciprocal of the units in Equation 40, therefore the equation for Henry's Law applicable to this calculation is:

$$k'_{H,i} = k_{H,i}^{-1} = \frac{p_i}{c_i}, \text{ using units of } \frac{\text{atm} \cdot \text{m}^3}{\text{mol}} \quad \text{Equation 42}$$

The concentration of COPC *i* in the aqueous phase, *c_i* (with units of mol/m³), can be defined based on other variables previously established in this calculation.

$$c_i = \frac{c_{i,flush}}{MW_i} * \frac{1000 \text{ liters}}{\text{m}^3} \quad \text{Equation 43}$$

Where:

$$c_{i,flush} = \text{Concentration of COPC } i \text{ based on amount received in feed line flush, g/L (Equation 39)}$$

$$MW_i = \text{Molecular weight of COPC } i, \text{ in g/mol (Ref. 9.15, Attachment A)}$$

Next, substitute Equation 41 and Equation 43 into Equation 42 and rearrange to solve for the vapor phase mole fraction, *y_i*.

$$k'_{H,i} = \frac{p_i}{c_i} = \frac{y_i * P}{\frac{c_{i,flush} * 1000 \text{ liters}}{MW_i} \cdot \frac{1}{\text{m}^3}}$$

$$y_i = \frac{k'_{H,i} * \frac{c_{i,flush} * 1000 \text{ liters}}{MW_i} \cdot \frac{1}{\text{m}^3}}{P} \quad \text{Equation 44}$$

Equation 44 is solved for two separate cases:

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Case 1: Vessel Vent Streams

Case 2: Evaporator Vent Stream

5.2.4.1.1 Case 1: Vessel Vent Streams

The vapor emissions from all vessel vent streams, except for the vent from the evaporator system, are estimated using a combined Henry's Law analysis. The pressure in the vapor space, P_{vessel} , for all DEP vessels is 0.9622 atm (Assumption 6.1.10). Equation 44 is solved for the vapor phase mole fractions, y_i , in the DEP vessel vapor spaces. Next, the combined mass flow rate of COPC i from all DEP vessel vents is calculated based on the total mass flow rate of the vessel vent system, $\bar{m}_{tot,vent}$.

$$\bar{m}_{vapor,vent,i} = \frac{\bar{m}_{tot,vent} * \frac{453.5924 \text{ g}}{\text{lb}} * \frac{\text{hour}}{3600 \text{ sec}}}{MW_{air}} * y_i * MW_i \quad \text{Equation 45}$$

Where:

$\bar{m}_{vapor,vent,i}$	= Vapor phase mass flow rate of COPC i in vessel vent stream, g/sec
$\bar{m}_{tot,vent}$	= Total mass flowrate of the DVP system, in lb/hr (Assumption 6.1.4)
MW_{air}	= Average molecular weight of air, g/mol (Input 2.8)
y_i	= Mole fraction COPC i in the vapor phase (From Equation 44)
MW_i	= Molecular weight of COPC i (Ref. 9.15, Attachment A)

Note: $\bar{m}_{tot,vent}$ is the total flow of the vessel vent exhaust stream and includes the vent stream from the evaporator system. The total flow is used in Equation 45 for conservatism (Assumption 6.1.12).

5.2.4.1.2 Case 2 Evaporator Vent Stream

The vapor emissions from the evaporator system vent are estimated separately from the vessel vent streams due to differing operating pressures and the inclusion of condensers in the evaporator system vent. The evaporator system vents from the after-condenser. The vapor emissions from the evaporator separator vessel are estimated using a Henry's Law analysis. The pressure, P_{evap} , in the evaporator vessel is 0.0967 atm (Assumption 6.1.9). Equation 44 is solved for the vapor phase mole fractions, y_i , in the evaporator vessel overheads stream. Next, the mass flow rate of COPC i in the evaporator overheads stream is calculated based on the total volumetric flow rate of the evaporator overheads stream.

$$\bar{m}_{vapor,evap,i} = \frac{\bar{V}_{tot,evap} * \frac{3.785 \text{ L}}{\text{gal}} * \rho_{water} * \frac{\text{min}}{60 \text{ sec}}}{MW_{water}} * y_i * MW_i \quad \text{Equation 46}$$

Where:

$\bar{m}_{vapor,evap,i}$	= Vapor phase mass flow rate of COPC i in evaporator overheads stream, in g/sec
$\bar{V}_{tot,evap}$	= Total volumetric flowrate of the evaporator overheads stream, in gpm (Assumption 6.1.8)
MW_{water}	= Molecular weight of water, in g/mol (Input 2.7)
ρ_{water}	= Density of water, in g/L (Equation 47)
y_i	= Mole fraction COPC i in the vapor phase (Equation 44)
MW_i	= Molecular weight of COPC i (Ref. 9.15, Attachment A)

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The density of water is calculated using the following correlation from Ref. 9.18, Section 8. The evaporator overheads stream is assumed to have the physical properties of water (Assumption 6.2.14).

$$\rho_{water} = -3.564E^{-3} * T_L^2 - 6.954E^{-2} * T_L + 1001 \quad \text{Equation 47}$$

Where:

$$\begin{aligned} \rho_{water} &= \text{Density of water, in kg/m}^3 \text{ or g/L} \\ T_{evap} &= \text{Normal operating temperature of the DEP evaporator, } ^\circ\text{C (Assumption 6.1.9)} \end{aligned}$$

Next, the separation in the primary, inter-, and after-condensers is approximated using condenser MDRs. MDRs for the FEP and TLP evaporators/condensers are calculated in Ref. 9.19, Section 8. These MDRs are assumed to apply to the DEP evaporator system (Assumption 6.1.13). The primary and inter-condenser MDRs for volatile organic compounds (VOCs) in Ref. 9.19 are assumed to apply to all COPCs being evaluated in Case 2 (Assumption 6.1.14). The feed stream to the primary condenser is the evaporator overheads stream, so $\bar{m}_{feed,i} = \bar{m}_{vapor,evap,i}$. For the two condensers in series, the combined MDR is calculated by multiplying the individual MDRs.

$$MDR_{VOC,combined} = MDR_{VOC,primary\ condenser} * MDR_{VOC,inter-condenser} \quad \text{Equation 48}$$

Note: The MDR of the after-condenser is 1 (Ref. 9.19, Section 8).

The mass flowrate of COPC i leaving in the evaporator system vent is then calculated as follows:

$$\bar{m}_{vapor,evap,tot,i} = MDR_{VOC,combined} * \bar{m}_{vapor,evap,i} \quad \text{Equation 49}$$

Where :

$$\begin{aligned} \bar{m}_{vapor,evap,vent,i} &= \text{Vapor phase mass flowrate of COPC } i \text{ in the evaporator vent stream, g/sec} \\ MDR_{VOC,combined} &= \text{VOCs combined mass distribution ratio for primary and inter-condensers} \\ &\quad \text{(Equation 48)} \\ \bar{m}_{vapor,evap,i} &= \text{Vapor phase mass flow rate of COPC } i \text{ in evaporator overheads stream, in g/sec} \\ &\quad \text{(Equation 46)} \end{aligned}$$

5.2.4.1.3 Henry's Law Analysis Emissions and Mass Check

The unabated vapor emissions based on the Henry's Law analyses from Case 1 and Case 2 are combined to give the total unabated vapor emissions.

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$$\bar{m}_{unabated, Henry, i} = \bar{m}_{vapor, vent, i} + \bar{m}_{vapor, evap_tot, i} \quad \text{Equation 50}$$

Where :

$\bar{m}_{unabated, Henry, i}$ = Unabated vapor emissions of COPC i , in g/sec

$\bar{m}_{vapor, evap_tot, i}$ = Vapor phase mass flowrate of COPC i in the evaporator vent stream, g/sec (Equation 49)

$\bar{m}_{vapor, vent, i}$ = Vapor phase mass flow rate of COPC i in vessel vent stream, g/sec (Equation 45)

In some cases, $\bar{m}_{unabated, Henry, i}$ may exceed $\bar{m}_{i, vap, unabated}$ (Equation 30). Since $\bar{m}_{i, vap, unabated}$ is based on the entire mass of the vapor phase of a COPC that is flushed to the DEP system being emitted, values of $\bar{m}_{unabated, Henry, i}$ that exceed $\bar{m}_{i, vap, unabated}$ will be capped at the value for $\bar{m}_{i, vap, unabated}$.

5.2.4.2 Adjustment of COPCs with Zero Emissions

There are two subsets of organic COPCs that have emissions reported as zero based on the methodology described in the preceding sections. The first subset is vapor phase PIC COPCs that are assumed to not be captured in the SBS, and therefore not transferred to the DEP system. The second subset is the feed organic COPCs that do not have Tank Farms Average Ratios defined in Ref. 9.2.

5.2.4.2.1 Adjustment of PIC COPCs with Zero Emissions

The subset of PIC COPCs with vapor phase type ($F_v = 1$) have emissions estimated as 0 g/sec based on Assumption 6.2.15. Assumption 6.2.15 states that vapor phase COPCs have a DF of 1 in the SBS, meaning the entire amount entering the SBS passes through the SBS without being scrubbed from the off-gas stream. Since these vapor phase PIC COPCs are not captured in the SBS, they are not transferred to the DEP system in the SBS condensate stream (RLD21).

In order to assign this subset of PIC COPCs a bounding emissions estimate greater than 0 g/sec, they are assumed to be emitted at the average unabated particulate emissions rate for PIC COPCs (Assumption 6.2.27). The unabated particulate emissions rate for PIC COPCs was calculated using Equation 32. The average of the non-zero unabated particulate emissions rates is calculated, and this average value is assigned to all vapor phase PIC COPCs.

5.2.4.2.2 Adjustment of Feed Organic COPCs with Zero Emissions

The subset of the feed organic COPCs that were not detected in Tank Farms sampling and therefore do not have Tank Farms Average Ratios defined in Ref. 9.2 initially have emissions estimates of 0 g/sec. In order to assign this subset of feed organic COPCs a bounding emissions estimate greater than 0 g/sec, they are assumed to be emitted at the average unabated vapor emissions rate for feed organic COPCs with Tank Farms Average Ratios (Assumption 6.2.28). The unabated vapor emissions rate for feed organic COPCs is reported in the Feed Organic COPC summary table (Table 8-4). In the summary table, feed organic COPCs with Tank Farms Average Ratios are identified as having non-zero values for vapor emissions. The average unabated vapor emissions rate for feed organic COPCs with Tank Farms Average

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Ratios is calculated, and this average value is assigned as the unabated vapor emissions rate for all feed organic COPCs without Tank Farms Average Ratios.

5.3 Inorganic COPC Emissions

Attachment A, Table A-3 shows the 54 inorganic compounds tracked as COPCs at WTP. Table A-3 designates each inorganic COPC as either a feed compound or a stack compound. Feed compounds are received in the waste feed stream to the plant, while stack compounds are generated during processing within the plant.

5.3.1 Feed Inorganic COPC Emissions

5.3.1.1 COPC Maximum Batch Masses, Mass Fractions, and Concentrations

The maximum batch mass for the feed inorganic COPCs is determined using the Tank Farms Average ratios (g COPC / g Na) and the DFLAW Bounding Feed Vector maximum sodium batch. The Tank Farms Average ratios (g COPC / g Na) are provided in Ref. 9.2. The Tank Farms Average ratios are assumed to be applicable to this analysis (Assumption 6.2.1). The DFLAW Bounding Feed Vector is provided in Ref. 9.2 and used in this calculation (Assumption 6.2.2). The values for the amount of sodium (in kmol) in each batch during the DFLAW campaign are extracted from the DFLAW Bounding Feed Vector and then the average, minimum, and maximum values are calculated.

The maximum batch mass of each feed inorganic COPC is calculated as follows:

$$m_i = r_i * n_{Na,max} * MW_{Na} * 1000 \frac{mol}{kmol} \quad \text{Equation 51}$$

Where:

- m_i = Maximum feed vector batch mass of COPC i , in g
- r_i = Tank Farms Average ratio of COPC i , in g COPC / g Na (Ref. 9.2)
- $n_{Na,max}$ = Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmols (Attachment G)
- MW_{Na} = Molecular weight of sodium, in g/mol (Input 2.5)

A conservative value for the mass fraction, x_i , of each feed inorganic COPC is then calculated using Equation 10.

A conservative value for the concentration, c_i , of each feed inorganic COPC is calculated using Equation 11.

5.3.1.2 Particle Phase Feed Inorganic COPC Emissions

Feed inorganic COPCs (with the exception of ammonia, mercury, and cyanide) are emitted through entrainment as particles (Assumption 6.2.21). For the estimation of particle emissions, the maximum feed vector batch mass fraction of COPC i , x_i , (calculated in Section 5.3.1.1) is conservatively assumed to represent the mass fraction of feed inorganic COPC i throughout the DEP system (Assumption 6.1.1).

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The particulate emissions of feed inorganic COPCs from the DVP system are calculated using Equation 12 and Equation 13 (previously defined in Section 5.1.3).

The value for $\bar{m}_{i,entrained}$ (in g/min) calculated from Equation 13 is converted to g/sec using Equation 32 (defined in Section 5.2.1.6) and represents the unabated particulate emissions of feed inorganic COPC i , $\bar{m}_{i,part,unabated}$.

The abated emissions are then calculated using Equation 33 (defined in Section 5.2.1.6).

5.3.1.2.1 Mercury

Mercury emissions depend on the speciation of the mercury in the waste streams. The main species present in the Tank Farms are elemental mercury (Hg), mercury oxide (HgO), mercury chloride (HgCl₂), and calomel (Hg₂Cl₂). Hg is a volatile metal, HgCl₂ is semivolatile, and HgO and Hg₂Cl₂ are non-volatile (Ref. 9.29, Section 7.2.3). In addition, monomethyl mercury (CH₃Hg⁺) and dimethyl mercury [(CH₃)₂Hg] have the potential to form in WTP waste streams due to the reaction between mercury and organic species, with monomethyl mercury being non-volatile and dimethyl mercury being volatile (Ref. 9.24).

The mercury received in the DEP system is assumed to be non-volatile (HgO) and emitted through entrainment (Assumption 6.1.32).

For the calculation of mercury emissions from the DEP system due to entrainment, a methodology similar to the one in Sections 5.3.1.1 and 5.3.1.2 for other particle phase feed inorganic COPCs is used. This includes an assumption that the mass fraction of Hg is constant throughout the DEP system at a maximum feed value (Assumption 6.1.33). Using this method, the maximum feed vector mass fraction, x_{Hg} , will be compared to the maximum feed mass fraction calculated using the ICD-30 limit for mercury and if the ICD-30 mass fraction is greater, it will be used for greater conservatism.

The maximum feed vector batch mass of Hg using the ICD-30 limit is calculated as follows:

$$m_{Hg,ICD30} = c_{Hg,ICD30} * n_{Na,max} * 1000 \frac{mol}{kmol} * MW_{Hg} \quad \text{Equation 52}$$

Where:

- $m_{Hg,ICD30}$ = Maximum feed vector batch mass of Hg using ICD-30 limit, in g
- $c_{Hg,ICD30}$ = ICD-30 limit for Hg, in mol Hg / mol Na (Input 2.19)
- $n_{Na,max}$ = Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmols (Attachment G)
- MW_{Hg} = Molecular weight of Hg, in g/mol (Input 2.10)

If $m_{Hg,ICD30}$ is greater than the mass of Hg calculated from Equation 51, then it is used in the calculation of emissions due to entrainment using Equation 13, Equation 32, and Equation 33.

Vapor emissions of dimethyl mercury will be calculated separately (see Section 5.3.1.3.3).

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5.3.1.3 Vapor Phase Feed Inorganic COPC Emissions

Ammonia, cyanide, carbon disulfide, and dimethyl mercury are emitted in the vapor phase (Assumptions 6.2.21, 6.2.16, and 6.2.23). Note that carbon disulfide is a feed organic COPC per Ref. 9.1 and has been evaluated as an organic COPC in past WTP emissions estimates (Ref. 9.14). The calculation of the emissions estimate for carbon disulfide will be conducted within the vapor phase feed inorganic COPC section because the Tank Farm Average ratio for carbon disulfide is reported as an inorganic COPC in Ref. 9.2, with units of g COPC / g Na. While the calculation for carbon disulfide will be carried out with the inorganic COPCs, the results for carbon disulfide will be reported with the feed organic COPC results.

5.3.1.3.1 Carbon Disulfide and Cyanide

Carbon disulfide (CS₂) and cyanide (CN) will be evaluated using the methodology for vapor phase feed organic COPCs described in Section 5.2.1.5. Also, as noted above, the results for carbon disulfide will be reported with feed organic COPCs and not feed inorganic COPCs.

5.3.1.3.2 Ammonia

Ammonia (NH₃) will be evaluated using the methodology for vapor phase feed organic COPCs described in Section 5.2.1.5, with an additional step to account for ammonia received in the caustic scrubber effluent stream (LVP21). The vapor phase emissions calculated using Section 5.2.1.5 represent complete emission of all NH₃ received in the feed line flush stream to DEP-VSL-00001. Since the caustic scrubber effluent is another DEP inlet stream containing appreciable amounts of NH₃, emissions of NH₃ from DEP-VSL-00004A/B and DEP-VSL-00005A/B must account for the additional NH₃.

Emissions of NH₃ from DEP-VSL-00004A/B and DEP-VSL-00005A/B will be estimated using a Henry's Law analysis.

The volume transferred annually from LVP-TK-00001 to DEP-VSL-00004A/B in stream LVP21 is calculated using the batch volume of LVP-TK-00001 and the transfer frequency.

$$V_{LVP21,annual} = V_{LVP21,batch} * F_{LVP} * 3.785 \frac{L}{gal} * 8760 \frac{hr}{year} \quad \text{Equation 53}$$

Where:

- $V_{LVP21,annual}$ = Annual volume transferred in LVP21, in L (Assumption 6.2.22)
- $V_{LVP21,batch}$ = Batch transfer volume from LVP-TK-00001 to DEP-VSL-00004A/B, in gal (Input 2.15)
- F_{LVP21} = Frequency of LVP-TK-00001 transfer, in 1/hr (Input 2.16)

The mass of NH₃ transferred annually to DEP-VSL-00004A/B is then calculated using the following equation:

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$$m_{LVP21,NH_3} = V_{LVP21,annual} * \rho_{LVP21} * x_{LVP21,NH_3} \quad \text{Equation 54}$$

Where:

- m_{LVP21,NH_3} = Annual mass of NH₃ in LVP21, in g
- $V_{LVP21,annual}$ = Annual volume transferred in LVP21, in L (Equation 53)
- ρ_{LVP21} = Density of LVP21, in g/L (Input 2.17)
- x_{LVP21,NH_3} = Mass fraction of NH₃ in LVP21 (Assumption 6.1.16) (Attachment F, Table F-2)

The volume of fluid received annually in DEP-VSL-00004A/B is calculated using the volume transferred in LVP21 and the volume of condensate received from DEP-EVAP-00001.

$$V_{DEPVSL4,annual} = V_{LVP21,annual} + V_{evap,feed} * 3.785 \frac{L}{gal} * (1 - \frac{1}{CF}) * 525600 \frac{min}{yr} \quad \text{Equation 55}$$

Where:

- $V_{DEPVSL4,annual}$ = Annual volume received in DEP-VSL-00004A/B, in L
- $V_{LVP21,annual}$ = Annual volume transferred in LVP21, in L (Equation 53)
- $V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm (Assumption 6.1.7)
- CF = Evaporator volumetric concentration factor (Assumption 6.1.17)

The concentration of NH₃ in DEP-VSL-00004A/B and DEP-VSL-00005A/B is then calculated using the results from Equation 54 and Equation 55.

$$c_{NH_3} = \frac{m_{LVP21,NH_3}}{V_{DEPVSL4,annual}} \quad \text{Equation 56}$$

Where:

- c_{NH_3} = Concentration of NH₃ in DEP-VSL-00004A/B and DEP-VSL-00005A/B, in g/L (Assumption 6.1.18)
- m_{LVP21,NH_3} = Annual mass of NH₃ in LVP21, in g (Equation 54)
- $V_{DEPVSL4,annual}$ = Annual volume received in DEP-VSL-00004A/B, in L (Equation 55)

Next, use Equation 44 (defined in Section 5.2.4.1.1) to determine the mole fraction of NH₃ in the vapor phase using Henry's Law.

$$y_{NH_3} = \frac{k'_{H,NH_3} * \frac{c_{NH_3}}{MW_{NH_3}} * \frac{1000 \text{ liters}}{m^3}}{P} \quad \text{Equation 44}$$

Where:

- y_{NH_3} = Mole fraction of NH₃ in the vapor phase
- k'_{H,NH_3} = Henry's Law constant for NH₃, in atm*m³/mol (Input 2.18)
- c_{NH_3} = Concentration of NH₃ in DEP-VSL-00004A/B, in g/L (Equation 56)
- MW_{NH_3} = Molecular weight of NH₃, in g/mol (Input 2.9)
- P = Vessel operating pressure, in atm (Assumption 6.1.10)

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The mass flowrate of NH₃ in the vessel vent streams from DEP-VSL-00004A/B and DEP-VSL-00005A/B is calculated using Equation 45 (defined in Section 5.2.4.1.1).

$$\bar{m}_{vapor,vent,NH_3} = \frac{\bar{m}_{vent} * \frac{453.5924 \text{ g} * \text{hour}}{\text{lb} * 3600 \text{ sec}}}{MW_{air}} * y_{NH_3} * MW_{NH_3} \quad \text{Equation 45}$$

Where:

- $\bar{m}_{vapor,vent,NH_3}$ = Vapor phase mass flow rate of NH₃ in vessel vent streams from DEP-VSL-00004A/B and DEP-VSL-00005A/B, in g/sec
- \bar{m}_{vent} = Mass flowrate of the vessel vent streams from DEP-VSL-00004A/B and DEP-VSL-00005A/B, in lb/hr (Assumption 6.1.19)
- MW_{air} = Average molecular weight of air, in g/mol (Input 2.8)
- y_{NH_3} = Mole fraction of NH₃ in the vapor phase (Equation 44)
- MW_{NH_3} = Molecular weight of NH₃, in g/mol (Input 2.9)

The total unabated emissions of NH₃ are then calculated by combining the unabated emissions for NH₃ received in the feed line flush calculated using the method from Section 5.2.1.5, Equation 30 and the value for $\bar{m}_{vapor,vent,i}$ calculated using Equation 45.

$$\bar{m}_{NH_3,tot,unabated} = \bar{m}_{vapor,vent,NH_3} + \bar{m}_{NH_3,flush,unabated} \quad \text{Equation 57}$$

Where:

- $\bar{m}_{NH_3,tot,unabated}$ = Total unabated emissions of NH₃, in g/sec
- $\bar{m}_{vapor,vent,NH_3}$ = Vapor phase mass flow rate of NH₃ in vessel vent streams from DEP-VSL-00004A/B and DEP-VSL-00005A/B, g/sec (Equation 45)
- $\bar{m}_{NH_3,flush,unabated}$ = Unabated vapor phase emissions of NH₃ in feed line flush, in g/sec (Equation 30)

For vapor phase COPCs with an F_v of 1, the DF is 1 through both the primary and secondary HEPA filter (Assumption 6.2.10). Therefore there is no emissions abatement provided by the HEPA filters for NH₃.

5.3.1.3.3 Dimethyl Mercury

Dimethyl Mercury [(CH₃)₂Hg] has the potential to form in WTP waste streams due to the reaction between mercury and organic species (Ref. 9.15, Section 4.1).

5.3.1.3.3.1 Mercury Concentrations

In order to calculate the amount of dimethyl mercury generated in each DEP process vessel, the maximum mercury concentrations in each vessel are needed.

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DEP-VSL-00001

The Hg concentration in DEP-VSL-00001 can be calculated using the following equation.

$$C_{Hg,flush} = C_{Hg,feed} * \frac{V_{residual\ feed}}{V_{flush} * 3.785 \frac{L}{gal}} \quad \text{Equation 58}$$

Where:

- $C_{Hg,flush}$ = Concentration of Hg in feed line flush to DEP-VSL-00001, in g/L
- $C_{Hg,feed}$ = Maximum feed vector batch concentration of Hg, in g/L (Equation 11)
- $V_{residual\ feed}$ = Volume of residual feed in a LAW feed line flush, in L (Equation 16)
- V_{flush} = Total volume of LAW feed line flush, in gal (Input 2.4, Assumption 6.1.3)

Note that if the ICD-30 limit for Hg is used in Section 5.3.1.2.1 for the emission of Hg in the particle phase, then $C_{Hg,feed}$ will be the Hg feed concentration at the ICD-30 limit.

DEP-VSL-00002

The Hg concentration in DEP-VSL-00002 is assumed to be the same as in DEP-VSL-00001 (Assumption 6.1.20).

DEP-EVAP-00001 & DEP-VSL-00003A/B/C

The Hg concentration in DEP-EVAP-00001 and DEP-VSL-00003A/B/C is determined based on the following equation:

$$C_{Hg,conc} = \frac{\text{mass rate of Hg in Evap. Conc.}}{\text{volume rate of Evap. Conc.}} = \frac{C_{Hg,flush} * V_{evap,feed} * (1 - MDR_{Evap,Hg})}{V_{evap,feed} * (\frac{1}{CF})} \quad \text{Equation 59}$$

Where:

- $C_{Hg,conc}$ = Concentration of Hg in evaporator concentrate, in g/L
- $C_{Hg,flush}$ = Concentration of Hg in feed line flush to DEP-VSL-00001, in g/L (Equation 58)
- $V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm (Assumption 6.1.7)
- $MDR_{Evap,Hg}$ = Mass distribution ratio of Hg in evaporator (Assumption 6.1.13)
- CF = Evaporator volumetric concentration factor (Assumption 6.1.17)

DEP-VSL-00004A/B & DEP-VSL-00005A/B

The Hg concentration in DEP-VSL-00004A/B and DEP-VSL-00005A/B is assumed to be at the concentration of Hg in the evaporator condensate (Assumption 6.1.21), which is determined based on the following equation:

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$$c_{Hg,cond} = \frac{\text{mass rate of Hg in Evap. Cond.}}{\text{volume rate of Evap. Cond.}} = \frac{c_{Hg,flush} * V_{evap,feed} * MDR_{Evap,Hg}}{V_{evap,feed} * (1 - \frac{1}{CF})} \quad \text{Equation 60}$$

Where:

- $c_{Hg,cond}$ = Concentration of Hg in evaporator condensate, in g/L
- $c_{Hg,flush}$ = Concentration of Hg in feed line flush to DEP-VSL-00001, in g/L (Equation 58)
- $V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm (Assumption 6.1.7)
- $MDR_{Evap,Hg}$ = Mass distribution ratio of Hg in evaporator (Assumption 6.1.13)
- CF = Evaporator volumetric concentration factor (Assumption 6.1.17)

5.3.1.3.3.2 Vessel Operating Temperatures

Vessel operating temperatures are used in the calculation of dimethyl mercury formation rates. The nominal temperatures established in DEP process calculations will be used as the operating temperatures for this calculation (Assumptions 6.1.22 through 6.1.27).

5.3.1.3.3.3 Vessel Residence Time

Vessel residence times are determined based on the vessel batch cycle times established in the DEP batch sizing calculation (Ref. 9.10) (Assumption 6.1.28). The maximum vessel residence time represents the amount of time between cycle start times for the vessel. For single vessels, the maximum residence time equals the cycle time. For paired vessels (i.e. DEP-VSL-00004A/B and DEP-VSL-00005A/B), the maximum residence time is the cycle time times two, since one of these vessels will be filled during the first cycle time and then drained during the second cycle time while the other vessel is being filled. For triple vessels (i.e. DEP-VSL-00003A/B/C), the maximum residence time is the cycle time times three. One vessel will be filled during the first cycle time, held for sampling during the second cycle time, and then drained during the third cycle time.

$$RT_j = CT_j * N_j \quad \text{Equation 61}$$

Where:

- RT_j = Residence time for vessel j , in hr
- CT_j = Vessel j batch cycle time, in hr (Assumption 6.1.28)
- N_j = Quantity of vessel j (e.g. $N_{DEP-VSL-4} = 2$)

The DEP evaporator is not included in the batch sizing calculation, so its residence time is based on the time to fill and drain the evaporator recirculation loop operating volume (Assumption 6.1.29) at the evaporator feed rate (Assumption 6.1.7).

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$$RT_{evap} = \frac{V_{evap,recirc}}{V_{evap,feed}} * 2 * \frac{1 \text{ hr}}{60 \text{ min}} \quad \text{Equation 62}$$

Where:

- RT_{evap} = Residence time for evaporator, in hr
- $V_{evap,recirc}$ = Volume of DEP evaporator recirculation loop, in gal (Assumption 6.1.29)
- $V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm (Assumption 6.1.7)

5.3.1.3.3.4 Rate of Dimethyl Mercury Formation

The rate constant for the formation of dimethyl mercury from mercury or its compounds in caustic salt solutions with organics can be estimated based on the following equation (Assumption 6.2.24):

$$k_j = e^{-\left(\frac{5886.9}{T_j} + 2.7037\right)} \quad \text{Equation 63}$$

Where:

- k_j = Rate constant for vessel j , in s^{-1}
- T_j = Vessel j Nominal Temperature, in K (Section 5.3.1.3.3.2)

The maximum concentration of dimethyl mercury reached in each vessel is then calculated:

$$c_{DMHg,j} = k_j * c_{Hg,j} * RT_j * \frac{3600 \text{ sec}}{\text{hr}} \quad \text{Equation 64}$$

Where:

- $c_{DMHg,j}$ = Concentration of dimethyl mercury in vessel j , in g/L
- k_j = Rate constant for vessel j , in s^{-1} (Equation 63)
- $c_{Hg,j}$ = Concentration of Hg in vessel j , in g/L (Section 5.3.1.3.3.1)
- RT_j = Vessel j residence time, in hr (Section 5.3.1.3.3.3)

As a bounding assumption, all dimethyl mercury formed in a vessel is assumed to be emitted from that vessel (Assumption 6.2.23). The annual vessel throughput for each DEP vessel is calculated using the vessel batch volumes, quantities, and residence times.

$$\bar{V}_j = V_{batch,j} * N_j * 3.785 \frac{\text{L}}{\text{gal}} * \frac{8760 \frac{\text{hr}}{\text{yr}}}{RT_j} \quad \text{Equation 65}$$

Where:

- \bar{V}_j = Annual vessel j throughput, in L
- $V_{batch,j}$ = Vessel j batch volume, in gal (Assumption 6.1.30)
- N_j = Quantity of vessel j (e.g. $N_{DEP-VSL-4} = 2$)
- RT_j = Vessel j residence time, in hr (Section 5.3.1.3.3.3)

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Note, there is not an established batch volume for DEP-EVAP-00001 in Ref. 9.10. The throughput of DEP-EVAP-00001 is represented by the evaporator concentrate stream that is transferred to DEP-VSL-00003A/B/C, therefore the throughput of DEP-EVAP-00001 is equal to DEP-VSL-00003A/B/C.

The unabated vapor phase emissions of dimethyl mercury from each DEP vessel is calculated using the results from Equation 64 and Equation 65, and then summed to give a total unabated vapor emission estimate for dimethyl mercury.

$$\bar{m}_{DMHg,unabated,j} = c_{DMHg,j} * \bar{V}_j * 3.1536E7 \frac{sec}{yr} \quad \text{Equation 66}$$

Where:

$\bar{m}_{DMHg,unabated,j}$ = Unabated vapor phase emissions of dimethyl mercury from vessel j , in g/sec
 $c_{DMHg,j}$ = Concentration of dimethyl mercury in vessel j , in g/L (Equation 64)
 \bar{V}_j = Annual vessel j throughput, in L (Equation 65)

$$\bar{m}_{DMHg,unabated,tot} = \sum \bar{m}_{DMHg,unabated,j} \quad \text{Equation 67}$$

Where:

$\bar{m}_{DMHg,unabated,tot}$ = Total unabated vapor phase emissions of dimethyl mercury from vessel j , in g/sec
 $\bar{m}_{DMHg,unabated,j}$ = Unabated vapor phase emissions of dimethyl mercury from vessel j , in g/sec (Equation 66)

For vapor phase COPCs with an F_v of 1, the DF is 1 through both the primary and secondary HEPA filter (Assumption 6.2.10). Therefore, there is no emissions abatement provided by the HEPA filters for dimethyl mercury.

5.3.2 Stack Inorganic COPC Emissions

In general, stack inorganics are not expected to be emitted from the DEP system in significant quantities. The justification for this will be discussed in Section 7.3.2.

Particulate matter is considered a stack inorganic COPC (Ref. 9.1), therefore the total particulate emissions summed from the results for particulate emissions of radionuclides, feed organics, PICs, and feed inorganics will be reported as the emissions estimate for particulate matter.

5.3.3 Inorganic COPC Summary and Comparison to De Minimis Emissions Limits

The results for unabated and abated inorganic COPC emissions are compiled in a summary table (Table 8-6). The unabated inorganic COPC emissions are compared to de minimis emissions limits for TAPs established in WAC 173-460-150 (Input 2.13), using the same method established for organic COPCs in Section 5.2.4.

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6 Assumptions

6.1 Assumptions Requiring Verification

6.1.1 Mass Fractions of COPCs Released by Entrainment

Assumption

For the calculation of COPCs emission through entrainment, the mass fractions of COPCs with F_v values less than 1, meaning the COPC will at least partially be emitted through entrainment, are assumed to remain constant throughout the DEP system at the maximum feed vector batch mass fraction, x_i . For PICs, which are not present in the feed vector, the mass fractions of PIC COPCs with F_v values less than 1 are assumed to remain constant throughout the DEP system at the mass fraction in Stream RLD21, $x_{RLD21,i}$.

Verification

It is conservative and bounding to assume the mass fractions of these COPCs do not decrease from the maximum expected feed value throughout the DEP system. This is a simplifying assumption to help calculate conservative values for the entrainment of COPCs. This assumption for mass fractions will be verified by DFLAW-specific emissions estimate model runs using the APPS model, which will provide mass fractions of the COPCs in each of the DEP streams.

6.1.2 Dilution Factor of Feed Line Flush to DEP-VSL-00001

Assumption

The dilution factor of the feed line flush to DEP-VSL-00001 is assumed to be $\frac{1}{30}$ (i.e. one thirtieth of the flush to DEP-VSL-00001 is assumed to be residual LAW feed and the remainder is flush water).

Verification

The dilution factor of $\frac{1}{30}$ will be verified by confirmed isometric drawings providing the length and volume for this dead legged section of piping.

The flush volume is 1500 gallons based on Input 2.4 and Assumption 6.1.3, so a dilution factor of $\frac{1}{30}$ means that there is 50 gallons (6.68 ft³) of residual feed flushed to DEP-VSL-00001 along with the flush water. Based on the 3.068 inch (0.2557 ft) inner diameter of the transfer line (Input 2.12), the length of pipe represented by the 50 gallon residual volume can be calculated using the following equation (Ref. 10.3, Page A-9):

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$$V_{pipe} = \frac{\pi * D^2}{4} * L$$

Equation 68

Where:

V_{pipe} = volume of pipe, in ft³

π = 3.14

D = inner diameter of pipe, in ft

L = length of pipe, in ft

Solving Equation 68 for L gives a pipe length of 130 feet, meaning that the volume of residual feed flushed to DEP-VSL-00001 represents a 130 ft length of the feed transfer line filled with residual feed being flushed to DEP-VSL-00001. This length of pipe flushed to DEP-VSL-00001 corresponds to the dead leg between the main feed transfer line to LCP-VSL-00001/2 and the entrance to DEP-VSL-00001. This length of pipe based on the assumed dilution factor is conservative for the expected length of the dead leg. In addition, very little residual feed is expected to be flushed from the main feed line to DEP-VSL-00001 based on this statement from ICD-30 (Ref. 9.3, Section 2.6.2):

When the flush water first reaches the CRV [Concentrate Receipt Vessel], the WTP Contractor will align valves to stop delivery to the CRV and send flush water to the low point drain vessel in the WTP effluent management facility (EMF). When the flow of flush water is stopped, the Tank Operations Contractor isolates the transfer pipeline from connected equipment, and the WTP Contractor drains the contents of the pipeline to the low point drain vessel.

Therefore the dilution factor of $\frac{1}{30}$ is considered a conservative value for the approximation of the amount of residual feed flushed to DEP-VSL-00001.

6.1.3 Frequency of Feed Line Flush to DEP-VSL-00001

Assumption

The flush frequency from LAWPS to DEP-VSL-00001 is 18.8 hours per 24590-BOF-MVC-DEP-00009 (Ref. 9.10, Section 7.1.2).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00009 (Ref. 9.10).

6.1.4 Mass Flowrate of the DVP System Exhaust Streams

Assumption

The vessel ventilation streams are collected in a common exhaust header (noted as Stream DEP15 in Ref. 9.7) before passing through the preheater, two-stage HEPA filters, and finally through an exhaust fan to discharge the air out of the EMF stack. The total mass flow rate of this exhaust header is 578 lb/hr according to calculation 24590-BOF-M6C-DVP-00001 (Ref. 9.11, Attachment D). Line number DVP-GV-00010/00013 in Ref. 9.11, Attachment D represents the common exhaust header, and the line

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numbers shown below DVP-GV-00010/00013 represent the DVP lines leading to the exhaust from the EMF stack. These lines in Ref. 9.11, Attachment D all have a mass flow rate of 578 lb/hr.

Line number DVP-GV-00005 in Ref. 9.11, Attachment D represents the evaporator vent stream coming off of DEP-COND-00003 with a mass flow rate of 50 lb/hr.

For the calculation of NH₃ emissions in Section 5.3.1.3.2, only the mass flowrates of the DEP-VSL-00004A/B and DEP-VSL-00005A/B vessel vent streams are needed. In Ref. 9.11, Attachment B, the line number DVP-GV-00004 represents the vessel vent header for these 4 vessels. Line number DVP-GV-00004 has a mass flowrate of 235 lb/hr in Ref. 9.11, Attachment D.

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-M6C-DVP-00001 (Ref. 9.11).

6.1.5 ¹⁴C or ³H Only Transferred to the DEP System in the Feed Line Flush

Assumption

It is assumed that ¹⁴C and ³H are only transferred to the DEP System in the feed line flush stream received in DEP-VSL-00001.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model. This is a simplifying assumption for the purpose of establishing the amount of ¹⁴C and ³H received in, and subsequently emitted by, the DEP system annually (Assumption 6.2.4). The only other waste streams entering the DEP system that may contain significant amounts of radionuclides are the SBS condensate stream (RLD21) and the Plant Wash Vessel effluent (RLD27) (Ref. 9.5). However, this assumption, combined with the conservatism in the other assumptions that support the calculation of the amounts of ¹⁴C and ³H flushed to DEP-VSL-00001 (See Assumptions 6.1.2, 6.2.1, and 6.2.5), is expected to bound the amounts of ¹⁴C and ³H expected to be received, under steady-state conditions, from all the expected input streams (Feed line flush, RLD21, and RLD27).

6.1.6 Organic COPC Physical Properties

Assumption

Physical properties of organic COPCs extracted from Ref. 9.15, Attachment A are used in this calculation. This includes F_v values, Henry's Law constants, Feed/PIC COPCs, and molecular weights.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model and the physical properties included in the APPS model.

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6.1.7 DEP Evaporator Feed Volumetric Flowrate

Assumption

The volumetric flowrate of the feed stream from the Evaporator Feed Vessel to the Evaporator is assumed to be 10 gpm. This value is based on the design feed rate for the Cesium Nitric Acid Recovery Process system (CNP) evaporator (Ref. 9.16, Section 6.1.1). Detailed design on the DEP evaporator system is ongoing, but the design up to this point has used the CNP evaporator equipment design as a basis (See Ref. 9.17, Section 3).

Verification

This assumption will be verified by the acceptance of a Code 1 vendor mass and energy balance calculation for the DEP evaporator system.

6.1.8 DEP Evaporator Overheads Stream Volumetric Flowrate

Assumption

The nominal volumetric flowrate of the DEP evaporator overheads stream is 9.5 gpm (Ref. 9.17, Section 7.2). This represents 9 gpm of feed evaporated and a 0.5 gpm demister spray stream (recycled from the condensate).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MEC-DEP-00001 (Ref. 9.17).

6.1.9 DEP Evaporator Nominal Operating Temperature and Pressure

Assumption

The nominal operating temperature and pressure of the DEP evaporator are 1.45 psia (0.0987 atm) and 116°F (46.7°C), respectively (Ref. 9.17, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MEC-DEP-00001 (Ref. 9.17).

6.1.10 DEP System Vessel Pressure

Assumption

The pressure in the main DEP system vessels is 14.14 psia (0.9622 atm). This is the minimum pressure of the vessel vent inlet for DEP vessels calculated in Ref. 9.11, Section 7.1.

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-M6C-DVP-00001 (Ref. 9.11).

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6.1.11 Concentrations of Feed Organic COPCs Used in Section 5.2.4.1

Assumption

For the Henry's Law analysis in Section 5.2.4.1, the concentrations of the feed organic COPCs evaluated are assumed to remain constant at the concentration in the feed line flush stream, $c_{i,flush}$ (Equation 39).

Verification

This is a simplifying assumption to help calculate vapor phase emissions using Henry's Law. This assumption for COPC concentrations will be verified by DFLAW-specific emissions estimate model runs using the APPS model, which will provide concentrations of COPCs in each of the DEP streams.

6.1.12 Total Vessel Vent System Flowrate Used in Section 5.2.4.1.1

Assumption

The total vessel vent system flowrate used in Section 5.2.4.1.1 to calculate vessel vent emissions based on Henry's Law from the main DEP vessels, excluding the DEP evaporator, is assumed to be the total vessel vent exhaust flowrate from Assumption 6.1.4. This assumption is conservative because this flowrate includes the vent stream from the DEP evaporator system (which is evaluated separately).

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.13 DEP Evaporator/Condenser MDRs

Assumption

The DEP evaporator/condenser MDRs are assumed to be the same as the FEP/TLP evaporator/condenser MDRs which are determined in 24590-WTP-M4C-V37T-00011, Rev. 0 - *FEP and TLP Evaporator and Condensers Decontamination Factor Calculation* (Ref. 9.19, Section 8, Tables 2 and 3).

Verification

The MDRs established in Ref. 9.19 for the FEP/TLP evaporators/condensers are based on operational data from the 242-A evaporator at the Tank Farms. The applicability of using the 242-A evaporator operational data is justified based on a comparison of the thermodynamic, configurational, and geometric similarities with the FEP/TLP evaporator designs (Ref. 9.19, Section 6.1). This assumption for DEP evaporator/condenser MDRs will be verified when the DEP evaporator design progresses to a point that a comparison can be made with the FEP/TLP evaporators.

6.1.14 Condenser MDRs for Feed Organic COPCs Evaluated in Section 5.2.4.1.2

Assumption

The primary and inter-condenser MDRs for VOCs (based on benzene) calculated in Ref. 9.19 (3.27E-3 and 1.06E-1, respectively) are assumed to apply to all Feed Organic COPCs evaluated in Section 5.2.4.1.2.

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Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.15 LAW Melter Feed Maximum TOC during DFLAW Operation

Assumption

The maximum TOC value for the LAW melter feed stream (LFP04) during DFLAW operations is assumed to be represented by the maximum TOC value for LFP04 calculated in the current PIBOD (Attachment F, Table F-1). Note: as shown in Attachment F, the maximum PIBOD value for TOC of 15.29 kg/hr will be rounded up to 20 kg/hr for use in this calculation.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.16 Mass Fraction of NH₃ in Stream LVP21 during DFLAW Operations

Assumption

The maximum mass fraction of NH₃ in the caustic scrubber effluent stream (LVP21) during DFLAW operations is assumed to be represented by the maximum value for LVP21 calculated in the current PIBOD (Attachment F, Table F-2). Note: as shown in Attachment F, the maximum PIBOD value for the mass fraction of NH₃ (0.0512) will be rounded up to 0.06 for use in this calculation.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.17 DEP Evaporator Volumetric Concentration Factor

Assumption:

Overconcentration of the evaporator concentrate will result in the formation of insoluble solids as chemical species reach their saturation point and precipitate from solution.

Initial testing at Savannah River National Laboratory demonstrated that a concentration factor of 17X at alkaline pH was possible without significant insoluble solids precipitation (Ref. 10.10, Page vii).

In order to mitigate the precipitation of solids in the evaporator, this calculation will use an assumed nominal concentration factor of 10X (meaning the volumetric flowrate of the evaporator feed stream is 10 times greater than the volumetric flowrate of the evaporator concentrate stream).

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Verification:

The concentration factor assumption will be verified as the detailed design of the DEP-EVAP-00001 progresses and bounding limits on the evaporator operation are established. The DFLAW-specific mass balance calculation (to be developed) will establish the basis for determining the steady-state properties of the evaporator concentrate based on operational constraints.

NOTE: This maximum concentration factor based on limiting formation of solids in the evaporator is not provided in this calculation to establish an operational constraint on the evaporator. The solubility of species in the waste is one factor that limits the concentration factor in the evaporator. Other factors include the concentrations of chloride and certain radionuclides. It is outside the scope of this calculation to develop a model for predicting the concentration limit for the DEP evaporator based on these factors.

6.1.18 Concentration of NH₃ in DEP-VSL-00004A/B and DEP-VSL-00005A/B

Assumption

The concentration of NH₃ in DEP-VSL-00004A/B and DEP-VSL-00005A/B is assumed to remain constant at the value calculated using Equation 56 (i.e. the concentration of NH₃ in DEP-VSL-00004A/B due to the receipt of stream LVP21 is assumed to remain the same when the contents of DEP-VSL-00004A/B are transferred to DEP-VSL-00005A/B).

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.19 Mass Flowrate of DEP-VSL-00004A/B and DEP-VSL-00005A/B Vessel Vent Header

Assumption

For the calculation of NH₃ emissions in Section 5.3.1.3.2, only the mass flowrates of the DEP-VSL-00004A/B and DEP-VSL-00005A/B vessel vent streams are needed. In Ref. 9.11, Attachment B, the line number DVP-GV-00004 represents the vessel vent header for these 4 vessels. Line number DVP-GV-00004 has a mass flowrate of 235 lb/hr (Ref. 9.11, Attachment D).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-M6C-DVP-00001 (Ref. 9.11).

6.1.20 Concentration of Hg in DEP-VSL-00002 for Dimethyl Mercury Formation

Assumption

For the calculation of dimethyl mercury formation in Section 5.3.1.3.3, the concentration of Hg in DEP-VSL-00002 is assumed to be the same as the Hg concentration in DEP-VSL-00001. As mentioned in Assumption 6.1.33, mercury has the potential to accumulate in the recycle from the DEP system to LAW during DFLAW operations, however developing a detailed model of this accumulation is outside the

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scope of this emissions estimate. Also, the PIBOD shows that there is no Hg in stream RLD21 due to a DF of 1 being applied in the SBS for mercury (Attachment F, Table F-3).

Therefore, the amount of Hg captured in the SBS condensate and transferred to the DEP system in stream RLD21 is not modeled in this emissions estimate and the concentration in DEP-VSL-00001 is assumed to represent the concentration in DEP-VSL-00002.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.21 Concentration of Hg in DEP-VSL-00004A/B and DEP-VSL-00005A/B for Dimethyl Mercury Formation

Assumption

For the calculation of dimethyl mercury formation in Section 5.3.1.3.3, the concentration of Hg in DEP-VSL-00004A/B and DEP-VSL-00005A/B is assumed to be the same as the Hg concentration in the evaporator condensate. This is a conservative assumption because the caustic scrubber effluent stream (LVP21) should have a negligible amount of Hg and therefore dilute the Hg concentration in DEP-VSL-00004A/B and DEP-VSL-00005A/B.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.22 DEP-VSL-00001 Nominal Temperature

Assumption

The nominal temperature of DEP-VSL-00001 is 67°F (Ref. 9.27, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00011 (Ref. 9.27).

6.1.23 DEP-VSL-00002 Nominal Temperature

Assumption

The nominal temperature of DEP-VSL-00001 is 124°F (Ref. 9.31, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00003.

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6.1.24 DEP-EVAP-00001 Nominal Temperature

Assumption

The nominal temperature of DEP-EVAP-00001 is 116°F (Ref. 9.17, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MEC-DEP-00001.

6.1.25 DEP-VSL-00003A/B/C Nominal Temperature

Assumption

The nominal temperature of DEP-VSL-00003A/B/C is 116°F (Ref. 9.32, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00010.

6.1.26 DEP-VSL-00004A/B Nominal Temperature

Assumption

The nominal temperature of DEP-VSL-00004A/B is 115°F (Ref. 9.33, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00007.

6.1.27 DEP-VSL-00005A/B Nominal Temperature

Assumption

The nominal temperature of DEP-VSL-00005A/B is 115°F (Ref. 9.34, Section 8).

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00008.

6.1.28 DEP Vessel Cycle Times

Assumption

The following vessel batch cycle times for DEP vessels are provided based on the vessel storage volumes established in Ref. 9.10, Section 8:

Vessel	Cycle Time
DEP-VSL-00001	48 hours
DEP-VSL-00002	48 hours
DEP-VSL-00003A/B/C	120 hours (5 days)
DEP-VSL-00004A/B	24 hours
DEP-VSL-00005A/B	96 hours (4 days)

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Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00009 (Ref. 9.10).

6.1.29 DEP-EVAP-00001 Recirculation Loop Operating Volume

Assumption

The DEP evaporator vessel, DEP-EVAP-00001 is assumed to have the same recirculation loop volume as the CNP evaporator. The CNP evaporator has a maximum recirculation loop volume of 2721 gallons (Ref. 9.28, Section 8.1)

Verification

This assumption will be verified by the acceptance of a Code 1 vendor design drawings for the DEP evaporator system.

6.1.30 DEP Vessel Batch Volumes

Assumption

The following vessel batch volumes for DEP vessels are provided in Ref. 9.10, Section 8:

Vessel	Batch Volume (gal)*
DEP-VSL-00001	6,300
DEP-VSL-00002	28,800
DEP-VSL-00003A/B/C	7,600
DEP-VSL-00004A/B	22,300
DEP-VSL-00005A/B	89,200

*The batch volumes are per vessel

Verification

This assumption will be verified by the confirmation of calculation 24590-BOF-MVC-DEP-00009 (Ref. 9.10).

6.1.31 Stack Inorganic COPC Emissions

Assumption

Stack inorganic COPCs, except for methyl mercury and particulate matter, are gases or acids that are mainly produced during chemical reactions or thermal decomposition. These COPCs are:

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Nitrogen dioxide
Carbon dioxide
Carbon monoxide
Ozone
Sulfur dioxide
Hydrogen chloride
Hydrogen Fluoride
Fluorine gas
Chlorine gas

The main source for these COPCs at WTP is the LAW and HLW melters. For example, in the existing WTP emissions estimate (Ref. 9.14, Table 18) the only streams with emissions of NO₂, CO, SO₂, HCl, and HF are the LAW and HLW offgas streams. Note that CO₂, O₃, F₂, and Cl₂ were not included in the existing WTP emissions estimate. It is assumed that there will not be the necessary thermal or kinetic conditions in the DEP system to produce significant amounts of the stack inorganic COPCs.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model

6.1.32 Mercury Speciation in the DEP System

Assumption

A detailed analysis of the speciation of mercury throughout the DEP system is outside the scope of this emissions estimate. As an assumption, mercury received in the DEP system is assumed to be a non-volatile form (HgO) and emitted through entrainment. This assumption will be used to estimate emissions of mercury compounds, except for dimethyl mercury which is estimated separately.

The potential inlet streams to the DEP system containing mercury are the SBS condensate stream (RLD21) and the feed line flush to DEP-VSL-00001. These two streams are the main process inlet streams to the DEP system. Trace amounts of mercury may be present in other inlet streams to the DEP system, such as the Plant Wash Vessel effluent stream (RLD27) and the LAB sink drain effluent (RLD41), however any potential contribution from these streams is bounded by Assumption 6.1.33.

Gaseous mercury in the melter offgas is either absorbed in the SBS as aqueous HgCl₂ or passed through as elemental Hg. The fraction captured as HgCl₂ in the SBS versus passing through as Hg is dependent on the Hg:Cl molar ratio in the melter feed. The aqueous mercury in the SBS stream is then converted to hydrated mercuric oxide (HgO·H₂O(s)) when the stream is neutralized (Ref. 9.15, Section 4).

Mercury speciation in the Tank Farms is expected to be mainly HgO, as sampling has shown that mercury in the tank supernate is negligible and most is associated with the sludge and saltcake (Ref. 9.29, Section 7.2.2).

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

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6.1.33 Mass Fraction of Mercury for Particle Emissions

Assumption

For the calculation of emissions of Hg due to entrainment, the mass fraction of Hg is assumed to remain constant throughout the DEP system at the maximum feed vector batch mass fraction, x_{Hg} , or the ICD-30 feed limit mass fraction, $x_{Hg,ICD30}$, depending on which is greater. This is a similar assumption to the one used for other COPCs emitted due to entrainment (Assumption 6.1.1).

Mercury has the potential to accumulate in the recycle stream from the DEP system back to LAW during DFLAW operations since mercury is not vitrified (DF of 1 in the LAW melter per Ref. 9.14, Table 14), is captured in the SBS (Assumption 6.1.32), and the non-volatile mercury species are concentrated in the DEP evaporator. However, a detailed analysis of the accumulation of mercury in the DEP system is outside the scope of this emissions estimate. Applying the maximum feed mass fraction across the entire DEP system should still be conservative because some tanks will have very low concentrations of mercury (i.e. DEP-VSL-00001, DEP-VSL-00004A/B, and DEP-VSL-00005A/B), while others will see higher concentrations (i.e. DEP-VSL-00002, and DEP-EVAP-00001, and DEP-VSL-00003A/B/C).

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.34 Average Feed Vector Batch Volumes, Densities, and Masses in Equation 9 through Equation 11

Assumption

Average feed vector batch volumes, densities, and masses are used in Equation 9 through Equation 11 to calculate conservative values for maximum feed vector batch mass fractions, x_i , and concentrations, c_i . Dividing the maximum feed vector batch mass, m_i , by average values instead of maximum values for mass and volume provide conservative results for x_i and c_i , respectively.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.35 ³H Emissions

Assumption

The emissions of ³H from the DEP system are assumed to be controlled by the evaporator/condenser MDRs established in Ref. 9.19. Since ³H is assumed to be present as tritiated water (Assumption 6.2.7), the emissions of ³H will follow the emissions of water vapor. Some water vapor (and therefore ³H₂O) will be released through the the evaporator vent stream. The evaporator/condenser MDRs for ³H will be used to estimate the amount of ³H that is not condensed in the condensers and is emitted to the DVP exhaust system.

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Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.36 ³H Emissions Evaporator Feed Mass Flowrate

Assumption

The calculation for ³H emissions, using the evaporator/condenser MDRs, will use the value for $\bar{m}_{i,flush}$, calculated in Equation 17, as the evaporator feed mass flowrate, $\bar{m}_{i,feed}$.

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.1.37 Vapor Phase Feed Organic COPCs Only Transferred to the DEP System in the Feed Line Flush

Assumption

It is assumed that vapor phase feed organic COPCs are only transferred to the DEP System in the feed line flush stream received in DEP-VSL-00001. Feed organic COPCs received in LAW are processed through the melters. Any portion of the organic COPCs that is not vitrified or destroyed in the melter enters the melter offgas stream. The vapor phase organic COPCs have a DF of 1 in the SBS (Assumption 6.2.15) and will, therefore, not be transferred to the DEP system in the SBS condensate stream (RLD21). Trace amounts of organics may be present in other inlet streams to the DEP system, such as the Plant Wash Vessel effluent stream (RLD27) and the LAB sink drain effluent (RLD41), however, this assumption, combined with the conservatism in the other assumptions that support the calculation of the amount of feed organic COPCs flushed to DEP-VSL-00001 (See Assumptions 6.1.2, 6.2.1, and 6.2.5), is expected to provide an amount of feed organic COPCs that bounds the amount expected to be received under steady-state conditions that account for all the expected input streams (Feed line flush, RLD21, RLD27, and RLD41).

Verification

This assumption will be verified by DFLAW-specific emissions estimate model runs using the APPS model.

6.2 Assumptions Not Requiring Verification

6.2.1 Applicability of the Tank Farms Average Ratios

Assumption

The Tank Farms Average ratios provided in Ref. 9.2 represent the distribution of COPCs as they currently exists in the Tank Farms, based on best available estimates. It is assumed that the waste received at LAW during DFLAW operations has the same distribution represented by these ratios.

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Justification

This assumption is conservative because it does not account for any change in the composition of the waste between when the samples underlying the ratios were collected in the Tank Farms and when the waste is actually received at LAW. This means chemical interactions such as precipitation, dissolution, or volatilization of species within the waste before it is received at WTP are not accounted for. In addition, for radionuclides this means the tank farm ratios do not account for the radioactive decay that will occur between the time of the sampling and the delivery of the waste. It also does not account for any of the pretreatment processing that will occur in the LAWPS facility (such as ultrafiltration or cesium removal).

Note that, while this assumption is justified in order to provide a conservative estimate of radionuclide concentrations received for processing and emitted from the DEP process, the feed concentrations are checked against the ICD-30 feed acceptance criteria for individual radionuclide COPCs and adjusted as required per Section 5.1.1.1.

6.2.2 DFLAW Bounding Feed Vector

Assumption

DFLAW feed vectors are provided for nominal and bounding conditions in Ref. 9.2. The DFLAW Bounding Feed Vector is used in conjunction with the Tank Farms Average ratios to determine the amount of each COPC received in the feed to LAW during DFLAW operations.

Justification

The use of the DFLAW Bounding Feed Vector is bounding compared to using the DFLAW Nominal Feed Vector.

6.2.3 Entrainment Factor Applicability for Particulate Emissions from DEP Vessels

Assumption

The entrainment factor of $4E-5$ g entrained material / g air provided in Input 2.3 is assumed to apply to all DEP vessels for the estimation of particulate emissions. The applicability of the entrainment factor for the DEP evaporator is discussed separately in Assumption 6.2.30.

Justification

The entrainment factor for free-falling aqueous solution was chosen as a representative entrainment factor because the streams will enter DEP vessels above the fluid surface. The nominal entrainment factor of $4E-5$ is used because the fluid transfers will not occur continuously, therefore the free-fall condition will not occur continuously and the nominal value is more representative than the bounding value.

The nominal free-fall entrainment factor is also more conservative and representative for DEP vessels compared to other potential entrainment factors in DOE-HDBK-3010-94, such as the bounding entrainment factor of $4E-7$ for aerodynamic entrainment and resuspension of fluid that is “indoors, on heterogeneous surface (stainless steel, concrete), low airspeeds up to normal facility ventilation flow; outdoors, pool for low windspeeds.” (Ref. 10.2, Page 3-5) and the bounding entrainment factor of $3E-5$ for “heating of aqueous solution in flowing air without surface rupture of bubbles” (Ref. 10.2, Page 3-1).

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Additionally, 24590-CM-HC4-W000-00193-01-00001 - *Report - Aerosol Production in WTP Process Vessels - A Review of Recent Aerosol Testing* recommends an entrainment factor of 4E-5 for sparged vessels (Ref. 9.37 Page 8). The nominal free-fall entrainment factor of 4E-5 from Ref. 10.2 is therefore conservative since DEP vessels are non-sparged.

6.2.4 ¹⁴C Emissions

Assumption

It is assumed that all ¹⁴C received in the EMF is emitted as it is processed through the DEP system.

Justification

This assumption is bounding since actual emissions of ¹⁴C cannot exceed this value. The actual emissions are dependent on the vapor-liquid equilibrium of each COPC in each of the DEP vessels and evaporator/condensers and are likely to be less than the total release established with this assumption.

6.2.5 Availability of Transfers from LAWPS to LAW

Assumption

Feed transfers from the LAWPS to LAW are assumed to occur continuously without a break between transfers (i.e. a transfer begins immediately after the preceding one is finished).

Justification

This assumption is conservative and bounding, since it provides the maximum number of annual feed transfers and therefore the maximum number of flushes to the low point drain vessel (DEP-VSL-00001).

6.2.6 Carbon-14 Phase Property

Assumption

¹⁴C is assumed to be emitted as a vapor phase COPC.

Justification

This assumption is consistent with existing WTP emissions estimates, where ¹⁴C is assumed to exist as ¹⁴CO₂ in the waste (Ref. 9.4, Section 4.4) and is treated as a vapor phase (Ref. 9.12, Table 11-1). In order to check that this assumption is conservative, a sensitivity analysis was completed to compare the unabated and abated emissions of ¹⁴C using the methodology for particle emissions and vapor emissions (Attachment E). This analysis shows that assuming ¹⁴C is emitted as a vapor phase COPC is significantly more conservative than if it was emitted as a particle COPC.

6.2.7 Tritium Phase Property

Assumption

³H is assumed to be emitted as a vapor phase COPC.

Justification

This assumption is consistent with existing WTP emissions estimates, where ³H is assumed to exist as tritiated water (³H₂O) in the waste (Ref. 9.14, Table 12 Note b) and is treated as a vapor phase emission

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(Ref. 9.12, Table 11-1). In order to check that this assumption is conservative, a sensitivity analysis was completed to compare the unabated emissions of ^3H using the methodology for particle emissions and vapor emissions (Attachment E). This analysis shows that assuming ^3H is emitted as a vapor phase COPC is equivalent to if it was emitted as a particle COPC for unabated emissions and significantly more conservative for abated emissions.

6.2.8 Iodine-129 Phase Property

Assumption

^{129}I is assumed to be emitted as a particle COPC.

Justification

^{129}I is a volatile radionuclide with an F_v of 1 (Ref. 9.4, Section 4.4). Existing emissions estimates have treated ^{129}I as a vapor phase emission in the LAW and High Level Waste Facility (HLW), reflecting its presence as iodine gas in the melter offgas streams (Ref. 9.12, Table 11-1). However, in the Pretreatment Facility (PTF) there is no melter and the process streams are caustic. Under these conditions, essentially all ^{129}I will be in the form of iodide and iodate anions and ^{129}I emissions are expected to be in the form of aerosols (Ref. 9.9, Section 7.3.3). For that reason, ^{129}I has been treated as a particle emission in existing emissions estimates for the PTF (Ref. 9.12, Table 11-1). The DEP system process conditions will more closely resemble the PTF conditions just described (caustic process streams and no melter offgas), therefore ^{129}I will be treated as a particle/aerosol for emissions estimation.

6.2.9 Radionuclide Phase Properties (excluding ^{14}C , ^3H , and ^{129}I)

Assumption

All radionuclide COPCs, excluding ^{14}C , ^3H , and ^{129}I , are assumed to be emitted as particles.

Justification

This assumption is consistent with existing WTP emissions estimates, where all radionuclide COPCs, except or ^{14}C , ^3H , and ^{129}I , are considered metals and nonvolatile, and are assigned a vapor phase partitioning coefficient, F_v , of 0 (Ref. 9.4, Section 4.4) and treated as a particle for emissions (Ref. 9.12, Table 11-1).

6.2.10 HEPA Filter Decontamination Factors

Assumption

The following DFs are assumed for HEPA filters:

	1 st Stage HEPA Filter DF	2 nd Stage HEPA Filter DF
Particulate	2,000	100
Vapor-phase	1	1

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Justification

These HEPA DFs are used in existing WTP emissions estimates and permitting documents for the other WTP facilities (e.g. Ref. 9.12, Section 6.1 and Ref. 9.14, Tables 12, 14, and 15) and will be used in this calculation for consistency.

6.2.11 Duration of Release from DVP System to ACV Exhaust System

Assumption

The annual radionuclide emissions from the ACV Exhaust System are estimated assuming a 2 month release from the DVP system exhaust stream. Calculation 24590-HAC-50-00005 estimates annual C5V emissions based on a 2 month release from the pretreatment vessel vent system or 16 hour release from the LAW and HLW vitrification process (Ref. 9.13, Assumptions 6.4.1 and 6.4.2). For the ACV Exhaust System, a 2 month release is conservatively assumed, as it is the greater of the two release durations assumed in Ref. 9.13.

Justification

The 2 month release duration is considered conservative and bounding for any anticipated accidental release or release due to maintenance activities. Note that the EMF will not contain a maintenance shop so other than routine plant operations (i.e., HEPA change outs, valve/pump replacement), maintenance of removed equipment will be performed at an alternate location in the LAW Facility.

6.2.12 Distribution of Unspeciated Organic Carbon in Tank Farms Average Ratios

Assumption

The unspiciated organic carbon is assumed to be distributed proportionally to all of the organic compounds with Tank Farms Average ratios in Ref. 9.2, as an approximation to account for the unspiciated organic carbon in tank farm samples.

Justification

This assumption is justified because the scaled Tank Farms Average ratios calculated to account for the unspiciated organic carbon bound the unscaled Tank Farms Average ratios provided in Ref. 9.2.

6.2.13 DEP Evaporator Annual Uptime

Assumption

The annual uptime of the DEP evaporator is assumed to be 100% with a constant feed rate based on Assumption 6.1.7.

Justification

This assumption is bounding for determination of the annual throughput of the DEP evaporator based on volumetric feed rate from Assumption 6.1.7.

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6.2.14 Physical Properties of Evaporator Overheads Stream

Assumption

The evaporator overheads stream is assumed to have the physical properties of water.

Justification

This assumption is justified because the overheads stream leaving the Evaporator Separator Vessel will be water with trace elements. This assumption is established in order to calculate the density of the evaporator overheads stream using a correlation between temperature and density for water (Equation 47).

The main function of DEP-EVAP-00001 is to concentrate the SBS and WESP condensates transferred from the LAW offgas system (Section 3). In the baseline WTP configuration, these LAW offgas condensates are evaporated in the TLP evaporator system. The function of the TLP evaporator system in the TLP system description is stated as the following (Ref. 9.35, Section 2):

“The TLP system reduces the volume of treated LAW waste and LAW offgas condensate streams by evaporating water.”

The presence of trace volatile compounds will not significantly affect the density, justifying the assumption that the overheads stream has the physical properties of water.

6.2.15 SBS DF for Vapor Phase Organic COPCs

Assumption

The SBS DF for vapor phase organic COPCs is assumed to be 1 (Ref. 9.14, Table 16).

Verification

This is the SBS DF used for vapor phase organic COPCs in existing WTP emissions estimates for the other WTP facilities (Ref. 9.14, Tables 16) and will be used in this calculation for consistency.

6.2.16 Vapor Phase Feed Organic COPC Emissions

Assumption

It is assumed that the entire vapor fraction of each feed organic COPC received in DEP-VSL-00001 annually is emitted to the DEP vessel ventilation system as it is processed through the DEP system.

Justification

This assumption is bounding since actual vapor phase emissions of feed organic COPCs cannot exceed this value. The actual emissions are dependent on the vapor-liquid equilibrium of each COPC in each of the DEP vessels and evaporator/condensers and, in various cases, are likely to be less than the total release established with this assumption. This assumption is not applied to the subset of feed organic COPCs that are evaluated using a Henry's Law analysis in Section 5.2.4.1.

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6.2.17 PIC Generation Rate for Particle or Particle-Bound PIC COPCs without Generation Rates from Testing

Assumption

Particle or particle-bound PIC COPCs that do not have generation rates reported in Ref. 9.15, Table 3 are assigned a generation rate equal to the maximum generation rate for a particle or particle-bound PIC COPC that does have a generation rate reported in Ref. 9.15, Table 3.

Justification

This assumption is established in order to provide a conservative generation rate for PIC COPCs without reported generation rates.

6.2.18 Fraction of PIC COPC Particulate Captured in the SBS

Assumption

The entire fraction of each PIC COPC that exists as particulate, represented by $(1 - F_{v,i})$, is assumed to be captured in the SBS.

Justification

Organic COPCs with an F_v value less than 1 are partially present in off-gas streams as particulate. These organic COPCs have SBS DFs assigned (for example, Dibutylphosphate in Ref. 9.14, Table 16 has a particle phase SBS DF of 20). This means that some fraction of particulate is not captured in the SBS and continues in the off-gas stream. For estimation of particulate emissions of PIC COPCs from the DEP system, it is conservative and bounding to assume the entire particle fraction of a PIC COPC is captured in the SBS and subsequently transferred to the DEP system.

6.2.19 Transfer Frequency of RLD-VSL-00005

Assumption

The transfer frequency for RLD-VSL-00005 is once every 24 hours (Ref. 9.20, Section 6.1.1).

Justification

This transfer frequency is included in an assumption not requiring verification in Ref. 9.20, which is a confirmed calculation.

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6.2.20 Batch Volume of RLD-VSL-00005

Assumption

The batch volume of RLD-VSL-00005 is 10,700 gal without contingency (Ref. 9.20, Section 7.1). Note that the volume without contingency shown in Ref. 9.20 is 10,900 gallons. The 10,700 gallon volume used here reflects the reduction in volume contribution from RLD-VSL-00004 from 4,700 gallons to 4,500 gallons determined in calculation 24590-LAW-MVC-RLD-00009 as modified by ECCN 24590-LAW-MVE-RLD-00001 (Ref. 9.21, Section 7.1.2). Ref. 9.20 has not been updated to reflect this change to an input value.

Justification

For the purpose of this calculation, the batch volume of RLD-VSL-00005 is used without contingency for the following reasons:

- Reference 9.20 reports a batch volume of 16,000 gal which includes 40% contingency for conservatism. Excessive conservatism in batch volumes upstream of the DEP vessels creates over-design of the DEP evaporator and associated support systems. Over-design can result in unnecessary costs to the facility and process issues due to improper sizing of pipes and pumps.
- The batch volume value of RLD-VSL-00004, used for input in RLD-VSL-00005, is for the high humidity case, not the normal operations case. From Reference 9.21, the high humidity case creates more condensation thus having an increased batch volume of 4,500 gal vs. 3,100 gal for the normal operations case.

6.2.21 Phase Property of Feed Inorganic COPCs

Assumption

The offgas phase type of feed inorganic COPCs are determined using the F_v values calculated in CCN 129507 (Ref. 9.4, Table 2). Most feed inorganic COPCs have an F_v value of 0 and are emitted as particles, with the following exceptions:

- Bromide has an F_v value of 0.017. Ref. 9.4, Section 4 states that COPCs with an F_v value < 0.05 are considered particles. Therefore bromide will be evaluated using the same method as the other feed inorganic COPCs with F_v values of 0.
- Ammonia and cyanide have F_v values of 1 and are emitted as vapor.
- The phase type for mercury depends on its speciation and will be handled as a special case.

Justification

This assumption is consistent with existing WTP emissions estimates (Ref. 9.14, Table 3).

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6.2.22 Transfers from LVP-TK-00001 to DEP-VSL-00004A/B are Continuous

Assumption

Transfers from LVP-TK-00001 to DEP-VSL-00004A/B are assumed to occur continuously, with no break or downtime between transfers (i.e. as soon as a transfer ends, the next transfer begins).

Justification

This assumption is bounding since it provides the maximum number of transfers annually, and therefore the maximum volume transferred annually, from LVP-TK-00001 to DEP-VSL-00004A/B.

6.2.23 Dimethyl Mercury Emissions

Assumption

It is assumed that all dimethyl mercury formed in a DEP vessel is emitted from that vessel in the vapor phase.

Justification

This assumption is bounding since actual emissions of dimethyl mercury cannot exceed this value. The actual emissions are dependent on the vapor-liquid equilibrium of dimethyl mercury in each of the DEP vessels and evaporator/condensers and are likely to be less than the total release established with this assumption.

6.2.24 Dimethyl Mercury Formation Rate Constant

Assumption

The rate constant for the formation of dimethyl mercury from mercury or its compounds in caustic salt solutions in the presence of organics is assumed to be represented by the rate equation reported in CCN 160522 (Ref. 9.24, Figure 1).

$$k = e^{-\left(\frac{5886.9}{T} + 2.7037\right)}$$

Where:

k = Rate constant in a first order rate equation, in s^{-1}
 T = Temperature, in K

Justification

This rate equation represents the best available information on the formation of dimethyl mercury in WTP waste streams. This rate equation forms the basis for the current WTP estimate of dimethyl mercury concentrations (Ref. 9.25, Section 5.5).

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6.2.25 Monomethyl Mercury Emissions

Assumption

Monomethyl mercury emissions are included with the total mercury emissions calculated according the methodology in Section 5.3.1.2.1.

Justification

Monomethyl mercury is nonvolatile and should be considered to exist mainly in the liquid phase within WTP waste streams (Ref. 9.24, Page 10). Therefore, monomethyl mercury emissions are include with the total emissions of mercury and not estimated separately like dimethyl mercury.

6.2.26 PIC Generation Rates

Assumption

The PIC generation rates detected in testing at the VSL are reported in Ref. 9.15, Table 3 will be used as the basis for estimating emissions of PICs from the DVP system.

Justification

These PIC generation rates are the best available testing results from testing and will not be verified.

6.2.27 Non-zero Emission Rates for Vapor Phase PIC COPCs

Assumption

The subset of PIC COPCs with vapor phase type ($F_v = 1$) are assumed to be emitted at the average unabated particulate emissions rate for PIC COPCs. The abated emissions of this subset is then determined based on the HEPA filter particulate DFs.

Justification

This subset of PIC COPCs have emissions estimated as 0 g/sec based on Assumption 6.2.15. Assumption 6.2.15 states that vapor phase COPCs have a DF of 1 in the SBS, meaning the entire amount entering the SBS passes through the SBS without being scrubbed from the off-gas stream. Since these vapor phase PIC COPCs are not captured in the SBS, they are not transferred to the DEP system in the SBS condensate stream (RLD21).

In order to assign this subset of PIC COPCs a bounding emissions estimate greater than 0 g/sec, they are assumed to be emitted at the average unabated particulate emissions rate for PIC COPCs.

6.2.28 Non-zero Emission Rates for Feed Organic COPCs without Tank Farms Average Ratios

Assumption

The subset of feed organic COPCs that do not have available data from Tank Farms sampling and therefore do not have Tank Farms Average Ratios defined in Ref. 9.2 are assumed to be emitted at the average unabated vapor emissions rate for feed organic COPCs with Tank Farms Average Ratios.

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Justification

This subset of the feed organic COPCs initially have emissions estimates of 0 g/sec, using the methodology based on Tank Farms Average Ratios. In order to assign this subset of feed organic COPCs a bounding emissions estimate greater than 0 g/sec, they are assumed to be emitted at the average unabated vapor emissions rate for feed organic COPCs with Tank Farms Average Ratios.

6.2.29 Chromium (VI) De Minimis Comparison

Assumption

For the purpose of comparing chromium (VI) emissions to the de minimis limit for chromium (VI) in WAC 173-460-150, it is assumed that all chromium emitted is chromium (VI). The emissions estimate evaluates total chromium (without specifying oxidation state) with CAS # 7440-47-3 as a feed inorganic COPC (Attachment A, Table A-3). The TAPs list in WAC 173-460-150 includes chromium (VI) with CAS # 18540-29-9 (Ref. 10.7).

Justification

The fraction of chromium present as chromium (VI) in the waste depends on the speciation of chromium compounds, however assuming that all chromium emitted is chromium (VI), for the purpose of making a comparison to the de minimis limit, is a bounding and conservative assumption.

6.2.30 Entrainment Factor Applicability for Particulate Emissions from DEP Evaporator

Assumption

The entrainment factor of 1E-3 g entrained material / g air provided in Input 2.20 is assumed to apply to the DEP evaporator for the estimation of particulate emissions.

Justification

The evaporator will be heated and under boiling conditions for water. For this reason the release fraction of 1E-3 from WAC 246-247-030 (21)(a)(ii) (Ref. 10.8) is used to estimate the entrainment of particulate from the evaporator. This value adds additional conservatism compared to the 4E-5 used for the DEP vessels. This value also does not account for any removal of particulate that will occur prior to reaching the vent system due to the presence of a bubble-cap tray, two demister pads, and three condensers in the vent path. Therefore, application of the 1E-3 entrainment factor for particulate emissions is conservative and bounding for the normal operation of the DEP evaporator.

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7 Calculations

The emissions estimate is calculated in a series of Excel spreadsheets. The Excel spreadsheet files are located in Attachment C (24590-RMCD-04955).

7.1 Radionuclide COPC Emissions

The radionuclide COPC emissions estimate calculation spreadsheet with the file name “*DFLAW Radionuclide COPC Emissions Estimate.xlsx*” is included in Attachment C. The following section describes how the spreadsheet is used to estimate organic COPC emissions.

7.1.1 COPC Maximum Batch Activities

The maximum batch activity of each radionuclide is calculated using the Excel spreadsheet titled “*DFLAW Radionuclide COPC Emissions Estimate.xlsx*” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

Table 7-1 “*DFLAW Radionuclide COPC Emissions Estimate.xlsx*” Calculation of Batch Activities

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Radionuclide COPCs – Calc</i>	B5:B50	COPC i	--	Radionuclide COPCs identified in Attachment A
<i>Radionuclide COPCs – Calc</i>	C5:C50	r_i = Tank Farms Average ratio of COPC i , in mCi COPC / g Na	--	Tank farm average ratios from Ref. 9.2
<i>Radionuclide COPCs – Calc</i>	AF5	$n_{Na,max}$ = Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmols	Attachment G	Sodium amounts in each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
<i>Radionuclide COPCs – Calc</i>	AF6	MW_{Na} = Molecular weight of sodium, in g/mol	--	Input 2.5
<i>Radionuclide COPCs – Calc</i>	E5:E50	A_i = Maximum feed vector batch activity of COPC i , in Ci	Equation 1	Unadjusted values, see Section 7.1.1.1 for calculation of adjusted values

7.1.1.1 ICD-30 Acceptance Limits

The values for A_i calculated in Cells E5:E50 have not been adjusted to not exceed the ICD-30 acceptance limits shown in Input 2.2. The applicable values for A_i are compared to their ICD-30 limit and adjusted as needed.

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The following Excel spreadsheet images show how this comparison and adjustment is done per the methodology in Section 5.1.1.1.

Figure 7-1 – ICD-30 Acceptance Limits Calculation Spreadsheet

	A	B	C	D	E	F
1						
2	V_{max} (L)	100349.78	Attachment G			
3	$n_{Na,max}$ (kmol)	3063.63	Attachment G			
4						
5						
6	Activity Comparison/Adjustment					
7		$C_{i,limit}$ (Ci/L)		$A_{i,limit}$ (Ci)	A_i (Ci)	A_i (Ci)
8		Input 2.2		Equation 2	Equation 1	Adjusted to not exceed ICD-30 limit, if necessary
9	154Eu	1.80E-05		6.84E+00	7.53E+01	6.84E+00
10	60Co	1.10E-06		4.18E-01	5.82E+00	4.18E-01
11	99Tc	4.80E-04		1.82E+02	3.76E+01	3.76E+01
12	239Pu	3.00E-05		1.14E+01	7.02E+01	1.14E+01
13	233U	1.60E-07		6.08E-02	9.26E-01	6.08E-02
14	235U	1.70E-09		6.46E-04	1.38E-02	6.46E-04
15						
16		$C_{i,limit}$ (Ci/mol Na)		$A_{i,limit}$ (Ci)	A_i (Ci)	A_i (Ci)
17		Input 2.2		Equation 3	Equation 1	Adjusted to not exceed ICD-30 limit, if necessary
18	137Cs	3.18E-05		9.74E+01	5.57E+04	9.74E+01
19	90Sr	1.19E-03		3.65E+03	6.77E+04	3.65E+03
20	TRU	1.30E-05		3.98E+01	See next table below	3.98E+01
21						
22		A_i (Ci)	y_i	$A_{i,limit}$ (Ci)	A_i (Ci)	A_i (Ci)
23		Equation 1	Equation 4	Equation 5	Equation 1	Adjusted to not exceed ICD-30 limit, if necessary
24	237Np	1.63E-01	5.21E-04	2.08E-02	1.63E-01	2.08E-02
25	238Pu	3.74E+00	1.20E-02	4.77E-01	3.74E+00	4.77E-01
26	239Pu	7.02E+01	2.25E-01	8.95E+00	7.02E+01	8.95E+00
27	240Pu	1.54E+01	4.92E-02	1.96E+00	1.54E+01	1.96E+00
28	241Am	2.22E+02	7.12E-01	2.83E+01	2.22E+02	2.83E+01
29	242Pu	1.17E-03	3.76E-06	1.50E-04	1.17E-03	1.50E-04
30	243Am	1.03E-01	3.29E-04	1.31E-02	1.03E-01	1.31E-02
31	243Cm	1.92E-02	6.15E-05	2.45E-03	1.92E-02	2.45E-03
32	244Cm	4.24E-01	1.36E-03	5.40E-02	4.24E-01	5.40E-02
33	Total	3.12E+02				
34						
35						
36	U Fissile to U Total Comparison					
37		m_i (g)				
38		Equation 7				
39	233U			6.30E+00		
40	235U			2.99E+02		
41	238U			9.11E+05		
42						
43	$X_{U \text{ fissile to U total}}$			0.03%		

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Figure 7-2 – ICD-30 Acceptance Limits Calculation Spreadsheet with Formulas

A	B	C	D	E	F
1					
2	V _{max} (L)	=100349.780368373	Attachment G		
3	D _{0,avg} (km/d)	3063.63209607692	Attachment G		
4					
5					
6	Activity Comparison/Adjuster				
7		Q _{limit} (Ci/L)	A _{limit} (Ci)	A _i (Ci)	A _i (Ci)
8		Input 2.2	Equation 2	Equation 1	Adjusted to not exceed ICD-30 limit, if necessary
9	154Eu	0.000018	=B9*\$B\$2*3.785	=VLOOKUP(A9,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E9>D9,D9,E9)
10	60Co	0.0000011	=B10*\$B\$2*3.785	=VLOOKUP(A10,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E10>D10,D10,E10)
11	99Tc	0.00048	=B11*\$B\$2*3.785	=VLOOKUP(A11,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E11>D11,D11,E11)
12	239Pu	0.00003	=B12*\$B\$2*3.785	=VLOOKUP(A12,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E12>D12,D12,E12)
13	233U	0.00000016	=B13*\$B\$2*3.785	=VLOOKUP(A13,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E13>D13,D13,E13)
14	235U	0.000000017	=B14*\$B\$2*3.785	=VLOOKUP(A14,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E14>D14,D14,E14)
15					
16		Q _{limit} (Ci/mol Na)	A _{limit} (Ci)	A _i (Ci)	A _i (Ci)
17		Input 2.2	Equation 3	Equation 1	Adjusted to not exceed ICD-30 limit, if necessary
18	137Cs	0.0000318	=B18*\$B\$3*1000	=VLOOKUP(A18,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E18>D18,D18,E18)
19	90Sr	0.00119	=B19*\$B\$3*1000	=VLOOKUP(A19,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E19>D19,D19,E19)
20	TRU	0.000013	=B20*\$B\$3*1000	See next table below	=IF(E20>D20,D20,E20)
21					
22		A _i (Ci)	A _{limit} (Ci)	A _i (Ci)	A _i (Ci)
23		Equation 1	Equation 4	Equation 1	Adjusted to not exceed ICD-30 limit, if necessary
24	237Np	=VLOOKUP(A24,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B24*\$B\$3	=VLOOKUP(A24,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E24>D24,D24,E24)
25	238Pu	=VLOOKUP(A25,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B25*\$B\$3	=VLOOKUP(A25,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E25>D25,D25,E25)
26	239Pu	=VLOOKUP(A26,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B26*\$B\$3	=VLOOKUP(A26,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E26>D26,D26,E26)
27	240Pu	=VLOOKUP(A27,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B27*\$B\$3	=VLOOKUP(A27,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E27>D27,D27,E27)
28	241Am	=VLOOKUP(A28,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B28*\$B\$3	=VLOOKUP(A28,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E28>D28,D28,E28)
29	242Pu	=VLOOKUP(A29,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B29*\$B\$3	=VLOOKUP(A29,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E29>D29,D29,E29)
30	243Am	=VLOOKUP(A30,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B30*\$B\$3	=VLOOKUP(A30,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E30>D30,D30,E30)
31	243Cm	=VLOOKUP(A31,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B31*\$B\$3	=VLOOKUP(A31,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E31>D31,D31,E31)
32	244Cm	=VLOOKUP(A32,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=B32*\$B\$3	=VLOOKUP(A32,'Radionuclide COPCs - Calc'!\$B\$5:\$E\$50,4,FALSE)	=IF(E32>D32,D32,E32)
33	Total	=SUM(B24:B32)			
34					
35					
36	U Fissile to U Total Comparison				
37		m (g)			
38		Equation 7			
39	233U	=Radionuclide COPCs - Calc'!G25			
40	235U	=Radionuclide COPCs - Calc'!G27			
41	238U	=Radionuclide COPCs - Calc'!G31			
42					
43	X _{U Fissile to U total}	=(1.25*B39+B40)/(B39+B40+B41)			

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If the ICD-30 limit is exceeded, the adjusted values are substituted for the original values in the main "Radionuclide COPCs – Calc" worksheet.

Table 7-2 "DFLAW Radionuclide COPC Emissions Estimate.xlsx" Substitution of Adjusted Values as Needed

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	F5:F50	Adjusted values of A_i , as needed, so that ICD-30 limits are not exceeded. Values that do not require adjustment are equal to the value calculated in Column E	Figure 7-1, Figure 7-2	

Note that ^{137m}Ba and ^{90}Y are daughter products of ^{137}Cs and ^{90}Sr , respectively. Since ^{137}Cs and ^{90}Sr require adjustment to their ICD-30 limits, as shown in Figure 7-1 and Figure 7-2, ^{137m}Ba and ^{90}Y also require adjustment. The daughter products are adjusted so that their adjusted values are the same proportion to their parent as it was for the unadjusted activity. The values/formulas for ^{137m}Ba and ^{90}Y in Column F reflect this proportional adjustment.

7.1.2 COPC Maximum Batch Mass Fractions and Concentrations

The maximum batch mass fraction and concentration of each radionuclide is calculated using the Excel spreadsheet titled "DFLAW Radionuclide COPC Emissions Estimate.xlsx" shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

CALCULATION SHEET

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JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

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Table 7-3 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of Batch Mass Fractions and Concentrations

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	D5:D50	SA_i , specific activity of COPC i , in Ci/g	Attachment B	Specific activities of radionuclide COPCs provided in Input 2.1
Radionuclide COPCs – Calc	G5:G50	m_i = Maximum feed vector batch mass of COPC i , in g	Equation 8	
Radionuclide COPCs – Calc	AF7	$V_{batch,avg}$ = Average total feed vector batch volume, in gal	Attachment G	Volumes of each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
Radionuclide COPCs – Calc	AF8	$\rho_{batch,avg}$ = Average total vector batch density, in g/cc	Attachment G	Densities of each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
Radionuclide COPCs – Calc	AF9	$m_{batch,avg}$ = Average total feed vector batch mass, in g	Equation 9	
Radionuclide COPCs – Calc	H5:H50	x_i = Maximum feed vector batch mass fraction of COPC i	Equation 10	
Radionuclide COPCs – Calc	I5:I50	c_i = Maximum feed vector batch concentration of COPC i , in g/L	Equation 11	

7.1.3 Radionuclide COPC Emissions Due to Entrainment of Particles/Aerosols

The unabated and abated emissions of radionuclide COPCs emitted due to entrainment are calculated using the Excel spreadsheet titled “DFLAW Radionuclide COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-4 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of Radionuclide COPC Emissions Due to Entrainment

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	AF10	$\bar{m}_{ves,vent}$ = Total mass flowrate of the DVP system except for evaporator, in lb/hr	Assumption 6.1.4	
Radionuclide COPCs – Calc	AF11	EF_{ves} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.3	Assumption 6.2.3
Radionuclide COPCs – Calc	AF12	$\bar{m}_{evap,vent}$ = Mass flowrate of the evaporator vent stream, in lb/hr	Assumption 6.1.4	
Radionuclide COPCs – Calc	AF13	EF_{evap} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.20	Assumption 6.2.30
Radionuclide COPCs – Calc	AF14	$\bar{m}_{tot,entrained}$ = Total mass flowrate of entrained material, in g/min	Equation 12	
Radionuclide COPCs – Calc	K5:K50 (except K13 and K41)	$\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC i , in g/min	Equation 13	Emissions of vapor phase radionuclide COPCs (^{14}C and ^3H) are calculated in Section 7.1.4
Radionuclide COPCs – Calc	L5:L50 (except L13 and L41)	$\bar{A}_{i,unabated}$ = Unabated activity of COPC i emitted per year, in Ci/year	Equation 14	Emissions of vapor phase radionuclide COPCs (^{14}C and ^3H) are calculated in Section 7.1.4
Radionuclide COPCs – Calc	AF15	$DF_{HEPA,primary}$ = Decontamination factor of primary HEPA filter	Assumption 6.2.10	
Radionuclide COPCs – Calc	AF16	$DF_{HEPA,secondary}$ = Decontamination factor of secondary HEPA filter	Assumption 6.2.10	
Radionuclide COPCs – Calc	N5:N50 (except N13 and N41)	$\bar{A}_{i,abated}$ = Abated activity of COPC i emitted per year, in Ci/year	Equation 15	Emissions of vapor phase radionuclide COPCs (^{14}C and ^3H) are calculated in Section 7.1.4

7.1.4 Vapor Phase Radionuclide COPCs

7.1.4.1 Sources of Vapor Phase Radionuclide COPCs

The volume of residual feed material in the flush to DEP-VSL-00001 and the total mass of ^{14}C and ^3H flushed annually to DEP-VSL-00001 are calculated using the Excel spreadsheet titled “DFLAW Radionuclide COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-5 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of Sources of Vapor Phase Radionuclide COPCs

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	AF17	V_{flush} = Total volume of LAW feed line flush, in gal	Input 2.4, Assumption 6.1.3	
Radionuclide COPCs – Calc	AF18	Dilution Factor = Flush dilution factor	Assumption 6.1.2	
Radionuclide COPCs – Calc	AF19	$V_{residual\ feed}$ = Volume of residual feed in a LAW feed line flush, in L	Equation 16	
Radionuclide COPCs – Calc	AF20	F_{flush} = Frequency of LAW feed line flush, in 1/hr	Assumption 6.1.3	
Radionuclide COPCs – Calc	Q13 and Q41	$\bar{m}_{i,flush}$ = Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr	Equation 17	

7.1.4.2 Vapor Phase Radionuclide COPC Emissions

7.1.4.2.1 ¹⁴C Emissions

The unabated and abated emissions of ¹⁴C are calculated using the Excel spreadsheet titled “DFLAW Radionuclide COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

Table 7-6 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of ¹⁴C Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	R13	$\bar{A}_{i,unabated}$ = Unabated activity of COPC i emitted per year, in Ci/year	Equation 18	
Radionuclide COPCs – Calc	S13	$\bar{A}_{i,abated}$ = Abated activity of COPC i emitted per year, in Ci/year	Equal to Cell R13	Vapor phase DF through HEPA filter is 1 (Assumption 6.2.10)

7.1.4.2.2 ³H Emissions

The unabated and abated emissions of ³H are calculated using the Excel spreadsheet titled “DFLAW Radionuclide COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-7 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of ³H Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Radionuclide COPCs – Calc</i>	AF21	$MDR_{3H, evaporator}$ = Evaporator MDR for ³ H	Assumption 6.1.35	
<i>Radionuclide COPCs – Calc</i>	AF22	$MDR_{3H, primary condenser}$ = Primary condenser MDR for ³ H	Assumption 6.1.35	
<i>Radionuclide COPCs – Calc</i>	AF23	$MDR_{3H, inter-condenser}$ = Inter condenser MDR for ³ H	Assumption 6.1.35	
<i>Radionuclide COPCs – Calc</i>	AF24	$MDR_{3H, combined}$ = Combined MDR for ³ H	Equation 20	
<i>Radionuclide COPCs – Calc</i>	R41	$\bar{A}_{i, unabated}$ = Unabated activity of COPC <i>i</i> emitted per year, in Ci/year	Equation 21	
<i>Radionuclide COPCs – Calc</i>	S41	$\bar{A}_{i, abated}$ = Abated activity of COPC <i>i</i> emitted per year, in Ci/year	Equal to Cell R41	Vapor phase DF through HEPA filter is 1 (Assumption 6.2.10)

7.1.5 ACV Exhaust System Radionuclide COPC Emissions

The unabated and abated emissions of radionuclide COPCs from the ACV exhaust system are calculated using the Excel spreadsheet titled “DFLAW Radionuclide COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

CALCULATION SHEET

PROJECT: RPP-WTP

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BY: William Hix

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Table 7-8 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of ACV Exhaust System Radionuclide COPC Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	V5:V50	$\bar{A}_{i,unabated,ACV}$ = Unabated activity of COPC <i>i</i> emitted per year from the ACV Exhaust system, in Ci/year	Equation 22	
Radionuclide COPCs – Calc	W5:W50	$\bar{A}_{i,abated,ACV}$ = Abated activity of COPC <i>i</i> emitted per year from the ACV Exhaust system (Single-stage HEPA), in Ci/year	Apply DF of 2000 for entrained emissions and DF of 1 for vapor emissions (Assumption 6.2.10)	
Radionuclide COPCs – Calc	X5:X50	$\bar{A}_{i,abated,ACV}$ = Abated activity of COPC <i>i</i> emitted per year from the ACV Exhaust system (Dual-stage HEPA), in Ci/year	Apply DF of 200,000 for entrained emissions and DF of 1 for vapor emissions (Assumption 6.2.10)	

7.1.6 Annual Possession Quantities

The APQs for radionuclide COPCs in the DEP system are calculated using the Excel spreadsheet titled “DFLAW Radionuclide COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

Table 7-9 “DFLAW Radionuclide COPC Emissions Estimate.xlsx” Calculation of APQs

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Radionuclide COPCs – Calc	AF25	$V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm	Assumption 6.1.7	
Radionuclide COPCs – Calc	AF26	$V_{evap,throughput}$ = Annual volume processed through DEP evaporator, L	Equation 24	100% uptime based on Assumption 6.2.13
Radionuclide COPCs – Calc	Z5:Z50 (except Z13, Z41)	APQ_i = Annual Possession Quantity of COPC <i>i</i> , in Ci/yr	Equation 23	
Radionuclide COPCs – Calc	Z13, Z41	APQ_i = Annual Possession Quantity of COPC <i>i</i> , in Ci/yr	Equation 25	

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7.2 Organic COPC Emissions

The organic COPC emissions estimate calculation spreadsheet with the file name “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” is included in Attachment C. The following section describes how the spreadsheet is used to estimate organic COPC emissions.

7.2.1 Feed Organic COPC Emissions

7.2.1.1 Adjustment of Tank Farms Average Ratios

The Tank Farms Average ratios are adjusted per the methodology in Section 5.2.1.1 using the Excel spreadsheet titled “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

Table 7-10 “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” Adjustment of Tank Farms Average Ratios

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Organic COPCs – Calc</i>	C5:C141	r_i = Tank farm ratio for COPC i , g COPC / g TOC		Ref. 9.2
<i>Feed Organic COPCs – Calc</i>	D5:D141	\bar{c}_i = Tank Farms Average ratio for COPC i , in g COPC-as-Carbon / g TOC (include non-COPC ratios)		Ref. 9.2
<i>Non-COPCs Organics</i>	D5:D58			
<i>Feed Organic COPCs – Calc</i>	D143	$\sum \bar{c}_i$ = Sum of all Tank Farms Average ratios (COPC and non-COPC) = 0.691		
<i>Feed Organic COPCs – Calc</i>	E5:E141	$\bar{c}_{i,scaled}$ = Scaled Tank Farms Average ratio for COPC i to account for unspiciated organic carbon, g COPC-as-Carbon / g TOC	Equation 26	Assumption 6.2.12
<i>Non-COPCs Organics</i>	E5:E58			
<i>Feed Organic COPCs – Calc</i>	F5:F141	$\bar{r}_{i,scaled}$ = Scaled tank farm ratio for COPC i to account for unspiciated organic carbon, g COPC / g TOC	Equation 27	

7.2.1.2 Determination of Feed Vector TOC Values

The adjusted batch TOC values in the DFLAW Bounding Feed Vector are calculated using the Excel spreadsheet titled “*Bounding_DFLAW-batches-to-wtp_TOTALS.xlsx*” shown in Attachment C. The DFLAW Bounding Feed Vector batch information is also shown in Attachment G. The following table describes how these values are calculated within the spreadsheet:

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Table 7-11 “Bounding_DFLAW-batches-to-wtp_TOTALS.xlsx” Calculation of Adjusted TOC Values

Worksheet Title	Cell Location	Property	Calculation Method	Notes
TOTALS	G4:G180	TOC_{batch} = moles of TOC delivered to WTP in a feed vector batch, in kmol		Provided in Ref. 9.2
TOTALS	H4:H180	Ox_{batch} = moles of oxalate delivered to WTP in a feed vector batch, in kmol		Provided in Ref. 9.2
TOTALS	N3	MW_c = Molecular weight of carbon, g/mol	Input 2.6	
TOTALS	N4	γ = moles of carbon per mole of oxalate		2 moles of Carbon for every 1 mole of oxalate ($C_2O_4^{2-}$)
TOTALS	I4:I180	TOC_{adj} = adjusted mass of TOC delivered to WTP in a feed vector batch, in kg	Equation 28	The maximum value for TOC_{adj} is shown in Cell I181

7.2.1.3 COPC Maximum Batch Masses, Mass Fractions, and Concentrations

Maximum batch masses, mass fractions, and concentrations are calculated using the Excel spreadsheet titled “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-12 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Calculation of Maximum Batch Masses, Mass Fractions, and Concentrations

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Organic COPCs – Calc</i>	AA5	$TOC_{adj,max}$ = Maximum batch adjusted mass of TOC delivered to WTP in a feed vector batch, in g	Equation 28	Value copied from “ <i>Bounding_DFLAW-batches-to-wtp_TOTALS.xlsx</i> ” Worksheet “ <i>TOTALS</i> ” Cell I183
<i>Feed Organic COPCs – Calc</i>	G5:G141	m_i = Maximum feed vector batch mass of COPC <i>i</i> , in g	Equation 29	
<i>Feed Organic COPCs – Calc</i>	AA6	$V_{batch,avg}$ = Average total feed vector batch volume, in gal	Attachment G	Volumes of each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
<i>Feed Organic COPCs – Calc</i>	AA7	$\rho_{batch,avg}$ = Average total vector batch density, in g/cc	Attachment G	
<i>Feed Organic COPCs – Calc</i>	AA8	$m_{batch,avg}$ = Average total feed vector batch mass, in g	Equation 9	
<i>Feed Organic COPCs – Calc</i>	H5:H141	x_i = Maximum feed vector batch mass fraction of COPC <i>i</i>	Equation 10	
<i>Feed Organic COPCs – Calc</i>	I5:I141	c_i = Maximum feed vector batch concentration of COPC <i>i</i> , in g/L	Equation 11	

7.2.1.4 Other Physical Properties

Physical properties for organic COPCs have been compiled in Ref. 9.15, Attachment A. Certain physical properties of the feed organic COPCs were extracted from Ref. 9.15, Attachment A for use in the Excel spreadsheet titled “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” shown in Attachment C. The worksheet titled “*COPC Data*” within “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” contains the physical property tables from Ref. 9.15, Attachment A in spreadsheet form. The Vlookup function in Excel is used to search the “*COPC Data*” worksheet by each COPC’s Chemical Abstracts Service (CAS) number and import the desired physical property into the “*Feed Organic COPCs – Calc*” worksheet. The following table describes where these values are located within the spreadsheet:

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Table 7-13 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Other Physical Properties

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Organic COPCs – Calc</i>	J5:J141	$F_{v,i}$ = Vapor phase partitioning coefficient of COPC i	Vlookup of Column AD in “COPC Data” worksheet	
<i>Feed Organic COPCs – Calc</i>	K5:K141	Phase type based on F_v value	$F_v = 1.0$; phase type = vapor $0.05 \leq F_v < 1.0$; phase type = particle-bound $F_v < 0.05$; phase type = particle	
<i>Feed Organic COPCs – Calc</i>	L5:L141	$k'_{H,i}$ = Henry’s Law constant for COPC i , in atm*m ³ /mol	Vlookup of Column X in “COPC Data” worksheet	
<i>Feed Organic COPCs – Calc</i>	M5:M141	MW_i = Molecular weight of COPC	Vlookup of Column M in “COPC Data” worksheet	
<i>Feed Organic COPCs – Calc</i>	N5:N141	Feed or Feed/PIC COPC	Vlookup of Column F in “COPC Data” worksheet	

7.2.1.5 Vapor Phase Feed Organic COPC Emissions

The vapor phase feed organic COPC emissions are calculated using the Excel spreadsheet titled “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” shown in Attachment C . The following table describes how these values are calculated within the spreadsheet:

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Table 7-14 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Vapor Phase Feed Organic COPC Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Organic COPCs – Calc</i>	AA9	V_{flush} = Total volume of LAW feed line flush, in gal	Input 2.4, Assumption 6.1.3	
<i>Feed Organic COPCs – Calc</i>	AA10	<i>Dilution Factor</i> = Flush dilution factor	Assumption 6.1.2	
<i>Feed Organic COPCs – Calc</i>	AA11	$V_{residual\ feed}$ = Volume of residual feed in a LAW feed line flush, in L	Equation 16	
<i>Feed Organic COPCs – Calc</i>	AA12	F_{flush} = Frequency of LAW feed line flush, in hr	Assumption 6.1.3	
<i>Feed Organic COPCs – Calc</i>	P5:P141	$\bar{m}_{i,flush}$ = Mass of COPC <i>i</i> flushed to DEP-VSL-0001 annually, in g/yr	Equation 17	
<i>Feed Organic COPCs – Calc</i>	Q5:Q141	$\bar{m}_{i,vap,unabated}$ = Unabated vapor phase emissions of COPC <i>i</i> , in g/sec	Equation 30	
<i>Feed Organic COPCs – Calc</i>	R5:R141	$\bar{m}_{i,vap,abated}$ = Abated vapor phase emissions of COPC <i>i</i> , in g/sec	Same as $\bar{m}_{i,vap,unabated}$	Assumption 6.2.10

7.2.1.6 Particle Phase Feed Organic COPC Emissions

The particle phase feed organic COPC emissions are calculated using the Excel spreadsheet titled “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” shown in Attachment C . The following table describes how these values are calculated within the spreadsheet:

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Table 7-15 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Particle Phase Feed Organic COPC Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Organic COPCs – Calc</i>	AA13	$\bar{m}_{ves,vent}$ = Total mass flowrate of the DVP system except for evaporator, in lb/hr	Assumption 6.1.4	
<i>Feed Organic COPCs – Calc</i>	AA14	EF_{ves} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.3	Assumption 6.2.3
<i>Feed Organic COPCs – Calc</i>	AA15	$\bar{m}_{evap,vent}$ = Mass flowrate of the evaporator vent stream, in lb/hr	Assumption 6.1.4	
<i>Feed Organic COPCs – Calc</i>	AA16	EF_{evap} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.20	Assumption 6.2.30
<i>Feed Organic COPCs – Calc</i>	AA17	$\bar{m}_{tot,entrained}$ = Total mass flowrate of entrained material, in g/min	Equation 12	
<i>Feed Organic COPCs – Calc</i>	T5:T141	$\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC <i>i</i> , in g/min	Equation 31	
<i>Feed Organic COPCs – Calc</i>	U5:U141	$\bar{m}_{i,part,unabated}$ = Unabated particulate emissions of COPC <i>i</i> , in g/sec	Equation 32	
<i>Feed Organic COPCs – Calc</i>	AA18	$DF_{HEPA,primary}$ = Decontamination factor of primary HEPA filter	Assumption 6.2.10	
<i>Feed Organic COPCs – Calc</i>	AA19	$DF_{HEPA,secondary}$ = Decontamination factor of secondary HEPA filter	Assumption 6.2.10	
<i>Feed Organic COPCs – Calc</i>	V5:V141	$\bar{m}_{i,part,abated}$ = Abated particulate emissions of COPC <i>i</i> , in g/sec	Equation 33	

7.2.2 PIC COPC Emissions

7.2.2.1 PIC Generation Rates

The PIC generation rates are calculated using the Excel spreadsheet titled “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” shown in Attachment C . The following table describes how these values are calculated within the spreadsheet:

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Table 7-16 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” PIC Generation Rates

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>PIC COPCs – Calc</i>	D5:D213	$F_{v,i}$ = Vapor phase partitioning coefficient of COPC i	Vlookup of Column AD in “COPC Data” worksheet	
<i>PIC COPCs – Calc</i>	E5:E213	Phase type based on F_v value	$F_v = 1.0$; phase type = vapor $0.05 \leq F_v < 1.0$; phase type = particle-bound $F_v < 0.05$; phase type = particle	
<i>PIC COPCs – Calc</i>	F5:F213	$GR_{PIC,i}$ = Generation rate of PIC COPC i , in mg (or g) PIC generated / mg (or g) melter feed TOC	Vlookup of Column C in “VSL PIC Data” worksheet	Assumptions 6.2.17, 6.2.26
<i>PIC COPCs – Calc</i>	Q5	$TOC_{MF,max}$ = Maximum mass flowrate of TOC in melter feed stream LFP04 from PIBOD model runs, in kg/hr	Maximum LFP04 TOC value rounded up to 20 kg/hr See Attachment F values extracted from PIBOD runs	Assumption 6.1.15
<i>PIC COPCs – Calc</i>	G5:G213	$\bar{m}_{melter,i}$ = Mass flowrate of PIC COPC i generated in the melter, in g/sec	Equation 34	

7.2.2.2 PIC COPC Emissions

The PIC COPC emissions are calculated using the Excel spreadsheet titled “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-17 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” PIC COPC Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
PIC COPCs – Calc	H5:H213	$\bar{m}_{SBS,i}$ = Mass flowrate of PIC COPC <i>i</i> captured in the SBS, in g/sec	Equation 35	
PIC COPCs – Calc	Q6	V_{RLD21} = Transfer volume of stream RLD21, in gallons	Assumption 6.2.20	
PIC COPCs – Calc	Q7	ρ_{RLD21} = Density of stream RLD21 from PIBOD, in g/L	Input 2.14	
PIC COPCs – Calc	Q8	F_{RLD21} = Frequency of transfer from RLD-VSL-00005 to DEP-VSL-00002, in 1/hr	Assumption 6.2.19	
PIC COPCs – Calc	Q9	\bar{m}_{RLD21} = Mass flowrate of stream RLD21, in g/sec	Equation 36	
PIC COPCs – Calc	I5:I213	$x_{RLD21,i}$ = Mass fraction of PIC COPC <i>i</i> in Stream RLD21	Equation 37	
PIC COPCs – Calc	Q10	$\bar{m}_{ves,vent}$ = Total mass flowrate of the DVP system except for evaporator, in lb/hr	Assumption 6.1.4	
PIC COPCs – Calc	Q11	EF_{ves} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.3	Assumption 6.2.3
PIC COPCs – Calc	Q12	$\bar{m}_{evap,vent}$ = Mass flowrate of the evaporator vent stream, in lb/hr	Assumption 6.1.4	
PIC COPCs – Calc	Q13	EF_{evap} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.20	Assumption 6.2.30
PIC COPCs – Calc	Q14	$\bar{m}_{tot,entrained}$ = Total mass flowrate of entrained material, in g/min	Equation 12	
PIC COPCs – Calc	J5:J213	$\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC <i>i</i> , in g/min	Equation 13	
PIC COPCs – Calc	K5:K213	$\bar{m}_{i,part,unabated}$ = Unabated particulate emissions of COPC <i>i</i> , in g/sec	Equation 32	
PIC COPCs – Calc	Q15	$DF_{HEPA,primary}$ = Decontamination factor of primary HEPA filter	--	Assumption 6.2.10
PIC COPCs – Calc	Q16	$DF_{HEPA,secondary}$ = Decontamination factor of secondary HEPA filter	--	Assumption 6.2.10
PIC COPCs – Calc	L5:L213	$\bar{m}_{i,part,abated}$ = Abated particulate emissions of COPC <i>i</i> , in g/sec	Equation 33	

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7.2.3 Feed/PIC Organic COPC Emissions

Particulate emissions for the subset of organic COPCs identified as being present as both Feed Organics and PICs will be the sum of the particulate emissions calculated in Sections 7.2.1.6 and 7.2.2.2. This is reflected in the following section describing how the results are summarized.

7.2.4 Organic COPC Summary and Comparison to De Minimis Emissions Limits

The results from Sections 7.2.1, 7.2.2, and 7.2.3 are presented in summary tables. The summary table for feed organic COPCs is contained in “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” Worksheet “*Organic Summary Table*” shown in Attachment C. The PIC COPC summary table is contained in Worksheet “*PIC Summary Table*”. The following table describes how these values are calculated within the spreadsheet:

Table 7-18 “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” Summary Tables

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Organic Summary Table</i>	D7:D143	Feed or Feed/PIC COPC	Vlookup of Column N in “ <i>Feed Organic COPCs - Calc</i> ” worksheet	
<i>Organic Summary Table</i>	E7:E143	$\bar{m}_{i,vap,unabated}$, in g/sec	Vlookup of Column Q in “ <i>Feed Organic COPCs - Calc</i> ” worksheet	Results before any Henry’s Law Adjustment
<i>Organic Summary Table</i>	F7:F143	$\bar{m}_{i,vap,unabated}$, in g/sec	Vlookup of Column Q in “ <i>Organic COPCs - Calc</i> ” worksheet or value from “ <i>Henry’s Law</i> ” worksheet (see Section 7.2.4.1.3)	Results after any Henry’s Law Adjustment Values initially shown as 0 g/s in this column (representing feed organic COPCs without Tank Farms Average Ratios) will be adjusted to bounding emissions estimates as described in Section 7.2.4.2.2.

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Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Organic Summary Table</i>	H7:H143	$\bar{m}_{i,part,unabated}$, in g/sec	Vlookup of Column U in " <i>Feed Organic COPCs - Calc</i> " worksheet OR IF the COPC is a Feed/PIC THEN the sum of Vlookup of Column U in " <i>Feed Organic COPCs - Calc</i> " worksheet AND Vlookup of Column K in " <i>PIC COPCs - Calc</i> " worksheet	Values initially shown as 0 g/s for Feed/PIC COPCs in this column will be adjusted to bounding emissions estimates as described in Section 7.2.4.2.1.
<i>Organic Summary Table</i>	J7:J143	$\bar{m}_{i,total,unabated}$, in g/sec	Sum of unabated vapor and particle emissions	
<i>Organic Summary Table</i>	K7:K143	$\bar{m}_{i,vap,abated}$, in g/sec	Vlookup of Column R in " <i>Feed Organic COPCs - Calc</i> " worksheet	Results before any Henry's Law Adjustment
<i>Organic Summary Table</i>	L7:L143	$\bar{m}_{i,vap,abated}$, in g/sec	Vlookup of Column R in " <i>Feed Organic COPCs - Calc</i> " worksheet or value from " <i>Henry's Law</i> " worksheet (see Section 7.2.4.1.3)	Results after any Henry's Law Adjustment
<i>Organic Summary Table</i>	M7:M143	$\bar{m}_{i,part,abated}$, in g/sec	Equation 30	
<i>Organic Summary Table</i>	N7:N143	$\bar{m}_{i,total,abated}$, in g/sec	Sum of abated vapor and particle emissions	
<i>PIC Summary Table</i>	D7:D216	PIC or Feed/PIC COPC	Vlookup of Column C in " <i>PIC COPCs - Calc</i> " worksheet	

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Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>PIC Summary Table</i>	E7:E177	$\bar{m}_{i,part,unabated}$, in g/sec	Vlookup of Column K in " <i>PIC COPCs - Calc</i> " worksheet	Feed/PIC COPCs have been sorted to the bottom of the table and their results are reported with the feed organic COPCs as described in Section 7.2.3 Values initially shown as 0 g/s for PIC COPCs in this column will be adjusted to bounding emissions estimates as described in Section 7.2.4.2.1
<i>PIC Summary Table</i>	G7:G177	$\bar{m}_{i,part,abated}$, in g/sec	Vlookup of Column L in " <i>PIC COPCs - Calc</i> " worksheet	Feed/PIC COPCs have been sorted to the bottom of the table and their results are reported with the feed organic COPCs as described in Section 7.2.3

Note that Row 144 of the "*Organic Summary Table*" worksheet contains the results for carbon disulfide, copied from the Excel spreadsheet "*DFLAW Inorganic COPC Emissions Estimate.xlsx*".

Next, the total abated emissions values are compared to de minimis emissions limits for TAPs established in WAC 173-460-150 (Input 2.13), using the worksheet "*WAC 173-460-150*".

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Table 7-19 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” De Minimis Value Comparison

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>WAC 173-460-150</i>	G5:G400	$\bar{m}_{i,dm}$ = de minimis emissions limit for COPC <i>i</i> , lb/averaging period	Input 2.13	
<i>WAC 173-460-150</i>	I5:I400	$\bar{m}_{i,dm\ standard}$ = de minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Equation 38	
<i>WAC 173-460-150</i>	J5:J400	$\bar{m}_{i,total,unabated}$ Feed organic COPCs – Total Abated Emissions of COPC <i>i</i> , in lb/yr	Vlookup of Column H in “Organic Summary Table” worksheet	Converted from g/sec to lb/yr
<i>WAC 173-460-150</i>	K5:K400	$\bar{m}_{i,total,unabated}$ PIC COPCs – Total Abated Emissions of COPC <i>i</i> , in lb/yr	Vlookup of Column E in “Organic Summary Table” worksheet	Converted from g/sec to lb/yr
<i>WAC 173-460-150</i>	M5:M400	Difference: Feed Organic COPC minus de minimis, in lb/yr	Column J minus Column I	If value is positive, vapor emissions of COPC will be reevaluated using Henry's Law Analysis
<i>WAC 173-460-150</i>	N5:N400	Difference: PIC COPC minus de minimis, in lb/yr	Column K minus Column I	No positive values in Column N, meaning all PIC COPC unabated emissions are below the de minimis value

The comparison in worksheet “*WAC 173-460-150*” did not find any PIC COPCs that exceeded their de minimis values.

The comparison did find seven feed organic COPCs with unabated emissions that exceed their de minimis values. These COPCs, shown in the following table, will be reevaluated using a Henry’s Law method for estimating the vapor phase emissions in place of Assumption 6.2.16 that the entire vapor phase is emitted during processing.

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Table 7-20 Feed Organic COPCs that Exceed De Minimis Value

CAS #	COPC	De minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Feed Organic COPCs - Total Unabated Emissions of COPC <i>i</i> , in lb/yr	Difference: Feed Organic COPC minus de minimis, in lb/yr
88-06-2	2,4,6-Trichlorophenol	4.80E-01	3.46E+00	2.98E+00
121-14-2	2,4-Dinitrotoluene	1.07E-01	3.94E+00	3.83E+00
91-20-3	Naphthalene	2.82E-01	3.68E+00	3.40E+00
62-75-9	n-Nitrosodimethylamine	2.08E-03	1.85E-02	1.64E-02
621-64-7	n-Nitrosodi-n-propylamine	4.80E-03	3.49E+00	3.49E+00
59-89-2	n-Nitrosomorpholine	5.05E-03	7.96E+00	7.95E+00
1336-36-3	Polychlorinated Biphenyls, NOS	1.68E-02	1.80E+00	1.79E+00

7.2.4.1 Henry's Law Analysis

The subset of feed organic COPCs in Table 7-20 that exceed their de minimis emissions limit are evaluated a second time using a Henry's Law analysis. This analysis is shown in the Excel spreadsheet titled "DFLAW Organic and PIC COPC Emissions Estimate.xlsx" Worksheet "Henry's Law" shown in Attachment C.

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Table 7-21 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Henry’s Law Analysis Setup

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Henry’s Law</i>	U5	$V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm	Assumption 6.1.7	
<i>Henry’s Law</i>	U6	$V_{evap,throughput}$ = Annual volume processed through DEP evaporator, L	Equation 24	100% uptime based on Assumption 6.2.13
<i>Henry’s Law</i>	C5:C11	$\bar{m}_{i,flush}$ = Mass of COPC <i>i</i> flushed to DEP-VSL-0001 annually, in g/yr	Vlookup of Column P in “Feed Organic COPCs - Calc” worksheet	
<i>Henry’s Law</i>	D5:D11	$c_{i,flush}$ = Concentration of COPC <i>i</i> based on amount received in feed line flush, g/L	Equation 39	
<i>Henry’s Law</i>	E5:E11	$k'_{H,i}$ = Henry’s Law constant for COPC <i>i</i> , in atm*m ³ /mol	Vlookup of Column L in “Feed Organic COPCs - Calc” worksheet	
<i>Henry’s Law</i>	F5:F11	MW_i = Molecular weight of COPC <i>i</i> , in g/mol	Vlookup of Column M in “Feed Organic COPCs - Calc” worksheet	

7.2.4.1.1 Case 1: Vessel Vent Streams

The vapor emissions from the all vessel vent streams, except for the vent from the evaporator system, are estimated using a combined Henry’s Law analysis.

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Table 7-22 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Case 1: Vessel Vent Streams

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Henry's Law	U7	P_{vessel} = DEP system vessel pressure, in atm	Assumption 6.1.10	
Henry's Law	H5:H11	y_i = Mole fraction COPC i in the vapor phase	Equation 44	
Henry's Law	U8	$\bar{m}_{tot,vent}$ = Total mass flowrate of the DVP system, in lb/hr	Assumption 6.1.4	
Henry's Law	U9	MW_{air} = Average molecular weight of air, g/mol	Input 2.8	
Henry's Law	I5:I11	$\bar{m}_{vapor,vent,i}$ = Vapor phase mass flow rate of COPC i in vessel vent stream, in g/sec	Equation 45	

7.2.4.1.2 Case 2: Evaporator Vent Stream

The vapor emissions from the evaporator system vent are estimated separately from the vessel vent streams due to differing operating pressure and the inclusion of condensers in the evaporator overheads. The evaporator system vents from the after-condenser. The vapor emissions from the evaporator separator vessel are estimated using a Henry's Law analysis.

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Table 7-23 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Case 2: Evaporator Vent Stream

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Henry's Law	U10	P_{evap} = DEP Evaporator nominal operating pressure, in atm	Assumption 6.1.9	
Henry's Law	K5:K11	y_i = Mole fraction COPC i in the vapor phase	Equation 44	
Henry's Law	U14	$\bar{V}_{tot,evap}$ = Total volumetric flowrate of the evaporator overheads stream, in gpm	Assumption 6.1.8	
Henry's Law	U12	MW_{water} = Molecular weight of water, in g/mol	Input 2.7	
Henry's Law	U13	ρ_{water} = Density of water, in g/L	Equation 47	
Henry's Law	U11	T_{evap} = Normal operating temperature of the DEP evaporator, °C	Assumption 6.1.9	
Henry's Law	L5:L11	$\bar{m}_{vapor,evap,i}$ = Vapor phase mass flow rate of COPC i in evaporator overheads stream, in g/sec	Equation 46	
Henry's Law	U15	$MDR_{VOC,primary\ condenser}$ = VOCs MDR for primary condenser	Assumption 6.1.14	
Henry's Law	U16	$MDR_{VOC,inter-condenser}$ = VOCs MDR for inter-condenser	Assumption 6.1.14	
Henry's Law	U17	$MDR_{VOC,combined}$ = VOCs MDR for primary condenser	Equation 48	
Henry's Law	M5:M11	$\bar{m}_{vapor,evap,tot,i}$ = Vapor phase mass flowrate of COPC i in the evaporator vent stream, g/sec	Equation 49	

7.2.4.1.3 Henry's Law Analysis Emissions and Mass Check

The unabated emissions based on the Henry's Law analyses from Case 1 and Case 2 are combined to give the total unabated emissions. In some cases, $\bar{m}_{unabated,Henry,i}$ may exceed $\bar{m}_{i,vap,unabated}$ (from Equation 30 in Section 7.2.1.5). Since $\bar{m}_{i,vap,unabated}$ is based on the emission of the entire mass of the vapor phase of a COPC that is flushed to the DEP system, values of $\bar{m}_{unabated,Henry,i}$ that exceed $\bar{m}_{i,vap,unabated}$ will be capped at the value for $\bar{m}_{i,vap,unabated}$.

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Table 7-24 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Case 1: Vessel Vent Streams

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Henry's Law	O5:O11	$\bar{m}_{unabated, Henry, i}$ = Unabated vapor emissions of COPC <i>i</i> , in g/sec	Equation 50	If $\bar{m}_{unabated, Henry, i}$ is greater than $\bar{m}_{i, vap, unabated}$ (from Worksheet “Feed Organic COPCs – Calc” Column Q) then limit value to $\bar{m}_{i, vap, unabated}$.
Henry's Law	P5:P11	$\bar{m}_{abated, Henry, i}$ = Abated vapor phase emissions of COPC <i>i</i> , in g/sec	Same as $\bar{m}_{unabated, Henry, i}$	Assumption 6.2.10

The values for $\bar{m}_{unabated, Henry, i}$ and $\bar{m}_{abated, Henry, i}$ for the COPCs evaluated in the “Henry's Law” worksheet are manually entered in the corresponding cells in Columns F and J of Worksheet “Organic Summary Table”. Then the total unabated emissions of these COPCs are compared again to the WAC 173-460-150 de minimis values. The following table shows the results:

Table 7-25 Post Henry's Law Comparison to De Minimis Values

CAS #	COPC	De minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Feed Organic COPCs - Total Unabated Emissions of COPC <i>i</i> , in lb/yr	Difference: Feed Organic COPC minus de minimis, in lb/yr
88-06-2	2,4,6-Trichlorophenol	4.80E-01	1.17E-01	-3.63E-01
121-14-2	2,4-Dinitrotoluene	1.07E-01	1.58E-03	-1.05E-01
91-20-3	Naphthalene	2.82E-01	3.68E+00	3.40E+00
62-75-9	n-Nitrosodimethylamine	2.08E-03	1.46E-04	-1.93E-03
621-64-7	n-Nitrosodi-n-propylamine	4.80E-03	3.40E-02	2.92E-02
59-89-2	n-Nitrosomorpholine	5.05E-03	8.43E-04	-4.21E-03
1336-36-3	Polychlorinated Biphenyls, NOS	1.68E-02	1.80E+00	1.79E+00

The comparison shows that Naphthalene (91-20-3), n-Nitrosodi-n-propylamine (621-64-7), and Total PCBs (1336-36-3) are the only organic COPCs that exceed their de minimis values.

7.2.4.2 Adjustment of COPCs with Zero Emissions

7.2.4.2.1 Adjustment of PIC COPCs with Zero Emissions

To calculate the average non-zero unabated particulate emissions rate for PIC COPCs, first Column E in “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Worksheet “PIC COPCs – Calc” is filtered to hide the PIC COPCs with a vapor phase type. The average unabated particulate emissions (Column K) of the remaining particle/particle-bound PIC COPCs is calculated in Cell K215. The resulting average value is then assigned in Column K to each of the vapor phase type PIC COPCs and subsequently treated

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as a particulate emission for calculation of abated emissions in Column L (Assumption 6.2.27). These adjusted results are then reported on the PIC COPC summary table (Table 8-5) for PIC COPCs and the feed organic COPC summary table (Table 8-4) for Feed/PIC COPCs.

7.2.4.2.2 Adjustment of Feed Organic COPCs with Zero Emissions

To calculate the average non-zero unabated vapor emissions rate for feed COPCs, first Column F in “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” Worksheet “*Organic Summary Table*” is filtered to hide the feed COPCs without Tank Farm Average Ratios, indicated by a vapor emissions rate of 0 g/s in Column F. The average unabated vapor emissions rate of the remaining feed organic COPCs in Column F is calculated in Cell F152. The resulting average value is then assigned in Column F to each of the feed organic COPCs without Tank Farm Average Ratios (Assumption 6.2.28). These adjusted results are then used to determine the unabated total emissions and abated vapor/total emissions for these COPCs.

7.2.4.2.3 Exceeded De Minimis Values

Due to the adjustments of PICs and feed organic COPCs with zero emissions, some of the adjusted COPCs have unabated total emissions exceeding the de minimis emissions limits for TAPs established in WAC 173-460-150 (Input 2.13), based on a comparison to the limits using the worksheet “*WAC 173-460-150*”.

The following table shows the adjusted feed organic COPCs with unabated total emissions exceeding the de minimis emissions limits.

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Table 7-26 Adjusted Feed Organic COPCs Exceeding De Minimis Values

CAS #	COPC	De minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Feed Organic COPCs - Total Unabated Emissions of COPC <i>i</i> , in lb/yr	Difference: Feed Organic COPC minus de minimis, in lb/yr
56-49-5	3-Methylcholanthrene	1.53E-03	1.17E+00	1.17E+00
3697-24-3	5-Methylchrysene	8.72E-03	1.17E+00	1.16E+00
602-87-9	5-Nitroacenaphthene	2.59E-01	1.17E+00	9.14E-01
60-35-5	Acetamide	4.80E-01	1.17E+00	6.93E-01
75-27-4	Bromodichloromethane	2.59E-01	1.17E+00	9.14E-01
72-55-9	DDE	9.88E-02	1.17E+00	1.07E+00
117-81-7	Di(2-ethylhexyl)phthalate	4.00E-01	1.17E+00	7.73E-01
226-36-8	Dibenz[a,h]acridine	8.72E-02	1.17E+00	1.09E+00
224-42-0	Dibenz[a,j]acridine	8.72E-02	1.17E+00	1.09E+00
192-65-4	Dibenzo[a,e]pyrene	8.72E-03	1.17E+00	1.16E+00
189-64-0	Dibenzo[a,h]pyrene	8.72E-04	1.17E+00	1.17E+00
189-55-9	Dibenzo[a,i]pyrene	8.72E-04	1.17E+00	1.17E+00
191-30-0	Dibenzo[a,l]pyrene	8.72E-04	1.17E+00	1.17E+00
193-39-5	Indeno[1,2,3-cd]pyrene	8.72E-02	1.17E+00	1.09E+00
10595-95-6	n-Nitroso-n-methylethylamine	1.53E-03	1.17E+00	1.17E+00
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	5.05E-07	1.70E-06	1.19E-06
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	2.52E-06	2.84E-06	3.21E-07

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7.3 Inorganic COPC Emissions

The inorganic COPC emissions estimate calculation Excel spreadsheet with the file name "*DFLAW Inorganic and PIC COPC Emissions Estimate.xlsx*" is included in Attachment C. The following section describes how the spreadsheet is used to estimate organic COPC emissions.

7.3.1 Feed Inorganic COPC Emissions

7.3.1.1 COPC Maximum Batch Masses, Mass Fractions, and Concentrations

The maximum batch mass fraction and concentration of each feed inorganic COPC is calculated using the Excel spreadsheet titled "*DFLAW Inorganic COPC Emissions Estimate.xlsx*" shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-27 “DFLAW Inorganic COPC Emissions Estimate.xlsx” Calculation of Maximum Batch Masses, Mass Fractions, and Concentrations

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Inorganic COPCs – Calc</i>	C5:C47	r_i = Tank farm ratio for COPC i , g COPC / g Na		Ref. 9.2
<i>Feed Inorganic COPCs – Calc</i>	S5	$n_{Na,max}$ = Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmols	Attachment G	Sodium amounts in each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
<i>Feed Inorganic COPCs – Calc</i>	S6	MW_{Na} = Molecular weight of sodium, in g/mol	Input 2.5	
<i>Feed Inorganic COPCs – Calc</i>	D5:D47	m_i = Maximum feed vector batch mass of COPC i , in g	Equation 51	For Hg (Cell D20) see Section 7.3.1.2.1
<i>Feed Inorganic COPCs – Calc</i>	S7	$V_{batch,avg}$ = Average total feed vector batch volume, in gal	Attachment G	Volumes of each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
<i>Feed Inorganic COPCs – Calc</i>	S8	$\rho_{batch,avg}$ = Average total vector batch density, in g/cc	Attachment G	Densities of each DFLAW feed batch from the bounding DFLAW Feed Vector provided in Ref. 9.2
<i>Feed Inorganic COPCs – Calc</i>	S9	$m_{batch,avg}$ = Average total feed vector batch mass, in g	Equation 9	
<i>Feed Inorganic COPCs – Calc</i>	E5:E47	x_i = Maximum feed vector batch mass fraction of COPC i	Equation 10	
<i>Feed Inorganic COPCs – Calc</i>	F5:F47	c_i = Maximum feed vector batch concentration of COPC i , in g/L	Equation 11	

7.3.1.2 Particle Phase Feed Inorganic COPC Emissions

The particle phase feed inorganic COPC emissions are calculated using the Excel spreadsheet titled “DFLAW Inorganic COPC Emissions Estimate.xlsx” shown in Attachment C . The following table describes how these values are calculated within the spreadsheet:

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JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

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Table 7-28 “DFLAW Organic and PIC COPC Emissions Estimate.xlsx” Particle Phase Feed Inorganic COPC Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
Feed Inorganic COPCs – Calc	S10	$\bar{m}_{ves,vent}$ = Total mass flowrate of the DVP system except for evaporator, in lb/hr	Assumption 6.1.4	
Feed Inorganic COPCs – Calc	S11	EF_{ves} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.3	Assumption 6.2.3
Feed Inorganic COPCs – Calc	S12	$\bar{m}_{evap,vent}$ = Mass flowrate of the evaporator vent stream, in lb/hr	Assumption 6.1.4	
Feed Inorganic COPCs – Calc	S13	EF_{evap} = Entrainment factor for DEP vessels, in g entrained material / g air	Input 2.20	Assumption 6.2.30
Feed Inorganic COPCs – Calc	S14	$\bar{m}_{tot,entrained}$ = Total mass flowrate of entrained material, in g/min	Equation 12	
Feed Inorganic COPCs – Calc	H5:H47 (Except H11, H14, H26)	$\bar{m}_{i,entrained}$ = Entrained mass flowrate of COPC <i>i</i> , in g/min	Equation 31	Emissions of CS ₂ , CN, and NH ₃ are evaluated separately
Feed Inorganic COPCs – Calc	I5:I47 (Except I11, I14, I26)	$\bar{m}_{i,part,unabated}$ = Unabated particulate emissions of COPC <i>i</i> , in g/sec	Equation 32	Emissions of CS ₂ , CN, and NH ₃ are evaluated separately
Feed Inorganic COPCs – Calc	S15	$DF_{HEPA,primary}$ = Decontamination factor of primary HEPA filter	Assumption 6.2.10	
Feed Inorganic COPCs – Calc	S16	$DF_{HEPA,secondary}$ = Decontamination factor of secondary HEPA filter	Assumption 6.2.10	
Feed Inorganic COPCs – Calc	J5:J47 (Except J11, J14, J26)	$\bar{m}_{i,part,abated}$ = Abated particulate emissions of COPC <i>i</i> , in g/sec	Equation 33	Emissions of CS ₂ , CN, and NH ₃ are evaluated separately

7.3.1.2.1 Mercury

First the mass of Hg using Equation 51 is calculated.

$$m_{Hg} = r_{Hg} * n_{Na,max} * MW_{Na} * 1000 \frac{mol}{kmol} = 4.18E-5 \frac{g Hg}{g Na} * 3063.6 kmol Na * 22.9898 \frac{g}{mol} * 1000 \frac{mol}{kmol}$$

$$m_{Hg} = 2.94E3 g$$

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CALC NO.: 24590-BOF-M4C-DEP-00001

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Next the mass of Hg at the ICD-30 limit is calculated using Equation 52.

$$m_{Hg,ICD30} = c_{Hg,ICD30} * n_{Na,max} * MW_{Hg} * 1000 \frac{mol}{kmol} = 1.4E-5 \frac{mol Hg}{mol Na} * 3063.6 kmol Na * 200.59 \frac{g}{mol} Hg * 1000 \frac{mol}{kmol}$$
$$m_{Hg,ICD30} = 8.60E3 g$$

Since $m_{Hg,ICD30}$ is greater than m_{Hg} , it will be used to estimate emissions through entrainment. The value for $m_{Hg,ICD30}$ is entered into Cell D20 of Excel spreadsheet “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*Feed Inorganic COPCs – Calc*” and the emissions of Hg through entrainment are calculated using the same method as other particle phase inorganic feed COPCs.

7.3.1.3 Vapor Phase Feed Inorganic COPC Emissions

Ammonia, carbon disulfide, and cyanide are emitted in the vapor phase (Assumption 6.2.21 and 6.2.16). As noted in Section 5.3.1.3, carbon disulfide is a feed organic COPC and its emissions will be reported with feed organic COPCs and not feed inorganic COPCs.

7.3.1.3.1 Carbon Disulfide, Ammonia, and Cyanide in the Feed Flush Line

The vapor phase feed inorganic COPC emissions are calculated using the Excel spreadsheet titled “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” shown in Attachment C . The following table describes how these values are calculated within the spreadsheet:

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

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Table 7-29 “DFLAW Inorganic COPC Emissions Estimate.xlsx” Vapor Phase Feed Inorganic COPC Emissions

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>Feed Inorganic COPCs – Calc</i>	S17	V_{flush} = Total volume of LAW feed line flush, in gal	Input 2.4, Assumption 6.1.3	
<i>Feed Inorganic COPCs – Calc</i>	S18	<i>Dilution Factor</i> = Flush dilution factor	Assumption 6.1.2	
<i>Feed Inorganic COPCs – Calc</i>	S19	$V_{residual\ feed}$ = Volume of residual feed in a LAW feed line flush, in L	Equation 16	
<i>Feed Inorganic COPCs – Calc</i>	S20	F_{flush} = Frequency of LAW feed line flush, in 1/hr	Assumption 6.1.3	
<i>Feed Inorganic COPCs – Calc</i>	L11, L14, L26	$\bar{m}_{i,flush}$ = Mass of COPC <i>i</i> flushed to DEP-VSL-0001 annually, in g/yr	Equation 17	
<i>Feed Inorganic COPCs – Calc</i>	M11, M14, M26	$\bar{m}_{i,vap,unabated}$ = Unabated vapor phase emissions of COPC <i>i</i> , in g/sec	Equation 30	
<i>Feed Inorganic COPCs – Calc</i>	N11, N14, N26	$\bar{m}_{i,vap,abated}$ = Abated vapor phase emissions of COPC <i>i</i> , in g/sec	Same as $\bar{m}_{i,vap,unabated}$	Assumption 6.2.10

7.3.1.3.2 Ammonia Emissions due to Caustic Scrubber Effluent

The vapor phase emissions due to NH₃ in the feed line flush are accounted for in Table 7-29 above with the cell locations associated with Row 26.

The vapor phase emissions from DEP-VSL-00004A/B and DEP-VSL-00005A/B due to NH₃ received from the caustic scrubber effluent are estimated using a Henry’s Law analysis. This analysis is shown in the Excel spreadsheet titled “DFLAW Inorganic COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

Table 7-30 “DFLAW Inorganic COPC Emissions Estimate.xlsx” NH₃ Emissions due to Caustic Scrubber Effluent

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>LVP21 NH3</i>	F4	$V_{LVP21,batch}$ = Batch transfer volume from LVP-TK-00001 to DEP-VSL-00004A/B, in gal	Input 2.15	
<i>LVP21 NH3</i>	F5	F_{LVP21} = Frequency of LVP-TK-00001 transfer, in 1/hr	Input 2.16	
<i>LVP21 NH3</i>	F6	$V_{LVP21,annual}$ = Annual volume transferred in LVP21, in L	Equation 53	Assumption 6.2.22

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Worksheet Title	Cell Location	Property	Calculation Method	Notes
LVP21 NH3	F7	ρ_{LVP21} = Density of LVP21, in g/L	Input 2.17	
LVP21 NH3	F8	x_{LVP21,NH_3} = Mass fraction of NH ₃ in LVP21	Attachment F, Table F-2	Assumption 6.1.16
LVP21 NH3	F9	m_{LVP21,NH_3} = Annual mass of NH ₃ in LVP21, in g	Equation 54	
LVP21 NH3	F10	$V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm	Assumption 6.1.7	
LVP21 NH3	F11	CF = Evaporator volumetric concentration factor	Assumption 6.1.17	
LVP21 NH3	F12	$V_{DEPVSL4,annual}$ = Annual volume received in DEP-VSL-00004A/B, in gal	Equation 55	
LVP21 NH3	F13	c_{NH_3} = Concentration of NH ₃ in DEP-VSL-00004A/B, in g/L	Equation 56	Assumption 6.1.18
LVP21 NH3	F14	k'_{H,NH_3} = Henry's Law constant for NH ₃ , in atm*m ³ /mol	Input 2.18	
LVP21 NH3	F15	MW_{NH_3} = Molecular weight of NH ₃ , in g/mol	Input 2.9	
LVP21 NH3	F16	P = Vessel operating pressure, in atm	Assumption 6.1.10	
LVP21 NH3	F17	y_{NH_3} = Mole fraction of NH ₃ in the vapor phase	Equation 44	
LVP21 NH3	F18	\bar{m}_{vent} = Mass flowrate of the vessel vent streams from DEP-VSL-00004A/B and DEP-VSL-00005A/B, in lb/hr	Assumption 6.1.19	
LVP21 NH3	F19	MW_{air} = Average molecular weight of air, in g/mol	Input 2.8	
LVP21 NH3	F20	$\bar{m}_{vapor,vent,NH_3}$ = Vapor phase mass flow rate of NH ₃ in vessel vent streams from DEP-VSL-00004A/B and DEP-VSL-00005A/B, in g/sec	Equation 45	

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Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>LVP21 NH3</i>	F21	$\bar{m}_{NH_3, flush, unabated}$ = Unabated vapor phase emissions of NH ₃ in feed line flush, in g/sec	Equation 30	Value calculated in worksheet <i>Feed Organic COPCs – Calc Cell M26</i>
<i>LVP21 NH3</i>	F22	$\bar{m}_{NH_3, tot, unabated}$ = Total unabated emissions of NH ₃ , in g/sec	Equation 57	This value will be reported in the results for NH ₃ emissions
<i>LVP21 NH3</i>	F23	$\bar{m}_{NH_3, tot, abated}$ = Total abated emissions of NH ₃ , in g/sec	Same as $\bar{m}_{NH_3, tot, unabated}$	Assumption 6.2.10 This value will be reported in the results for NH ₃ emissions

7.3.1.3.3 Dimethyl Mercury

Dimethyl Mercury [(CH₃)₂Hg] has the potential to form in WTP waste streams due to the reaction between mercury and organic species (Ref. 9.15, Section 4.1).

7.3.1.3.3.1 Mercury Concentrations

The maximum mercury concentrations in each vessel are calculated using the Excel spreadsheet titled “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

CALCULATION SHEET

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Table 7-31 “DFLAW Inorganic COPC Emissions Estimate.xlsx” Mercury Concentrations

Worksheet Title	Cell Location	Property	Calculation Method	Notes
DMHg	S4	$c_{Hg,feed}$ = Maximum feed vector batch concentration of Hg, in g/L	Equation 11	
DMHg	S5	$V_{residual\ feed}$ = Volume of residual feed in a LAW feed line flush, in L	Equation 16	
DMHg	S6	V_{flush} = Total volume of LAW feed line flush, in gal	Input 2.4, Assumption 6.1.3	
DMHg	C5, C6	$c_{Hg,flush}$ = Concentration of Hg in feed line flush to DEP-VSL-00001, in g/L	Equation 58	Assumption 6.1.20 Concentration of DEP-VSL-00001 and DEP-VSL-00002
DMHg	S7	$V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm	Assumption 6.1.7	
DMHg	S8	$MDR_{Evap,Hg}$ = Mass distribution ratio of Hg in evaporator	Assumption 6.1.13	
DMHg	S9	CF = Evaporator volumetric concentration factor	Assumption 6.1.17	
DMHg	C7, C8	$c_{Hg,conc}$ = Concentration of Hg in evaporator concentrate, in g/L	Equation 59	Concentration of DEP-EVAP-00001 and DEP-VSL-00003A/B/C
DMHg	C9, C10	$c_{Hg,cond}$ = Concentration of Hg in evaporator condensate, in g/L	Equation 60	Assumption 6.1.21 Concentration of DEP-VSL-00004A/B and DEP-VSL-00005A/B

7.3.1.3.3.2 Vessel Operating Temperatures

The DEP vessel nominal operating temperatures are used in the Excel spreadsheet titled “DFLAW Inorganic COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are used within the spreadsheet:

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Table 7-32 “DFLAW Inorganic COPC Emissions Estimate.xlsx” Vessel Temperatures

Worksheet Title	Cell Location	Property	Calculation Method	Notes
DMHg	D5:D10	T_j = Vessel j Nominal Temperature, in °F	Assumptions 6.1.22 through 6.1.27	
DMHg	E5:E10	T_j = Vessel j Nominal Temperature, in K	Convert °F to K	

7.3.1.3.3.3 Vessel Residence Time

The vessel residence times are calculated using the Excel spreadsheet titled “DFLAW Inorganic COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

Table 7-33 “DFLAW Inorganic COPC Emissions Estimate.xlsx” Mercury Concentrations

Worksheet Title	Cell Location	Property	Calculation Method	Notes
DMHg	F5:F10, except F7	CT_j = Vessel j batch cycle time, in hr	Assumption 6.1.28	
DMHg	G5:G10	N_j = Quantity of vessel j		e.g. $N_{DEP-VSL-4} = 2$
DMHg	H5:H10, except H7	RT_j = Residence time for vessel j , in hr	Equation 61	
DMHg	S10	$V_{evap,recirc}$ = Volume of DEP evaporator recirculation loop, in gal	Assumption 6.1.29	
DMHg	S7	$V_{evap,feed}$ = Volumetric flowrate of DEP evaporator feed stream, in gpm	Assumption 6.1.7	
DMHg	H7	RT_{evap} = Residence time for evaporator, in hr	Equation 62	

7.3.1.3.3.4 Rate of Dimethyl Mercury Formation

The formation and emission rates of dimethyl mercury are calculated using the Excel spreadsheet titled “DFLAW Inorganic COPC Emissions Estimate.xlsx” shown in Attachment C. The following table describes how these values are calculated within the spreadsheet:

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Table 7-34 “DFLAW Inorganic COPC Emissions Estimate.xlsx” Dimethyl Mercury Formation and Emission

Worksheet Title	Cell Location	Property	Calculation Method	Notes
DMHg	I5:I10	k_j = Rate constant for vessel j , in s^{-1}	Equation 63	
DMHg	J5:J10	$c_{DMHg,j}$ = Concentration of dimethyl mercury in vessel j , in g/L	Equation 64	
DMHg	K5:K10	$V_{batch,j}$ = Vessel j batch volume, in gal	Assumption 6.1.30	$V_{batch,evap} = V_{batch,DEP-VSL-3}$
DMHg	L5:L10	\bar{V}_j = Annual vessel j throughput, in L	Equation 65	
DMHg	M5:M10	$\bar{m}_{DMHg,unabated,j}$ = Unabated vapor phase emissions of dimethyl mercury from vessel j , in g/sec	Equation 66	
DMHg	M11	$\bar{m}_{DMHg,unabated,tot}$ = Total unabated vapor phase emissions of dimethyl mercury from vessel j , in g/sec	Equation 67	
DMHg	N5:N10	$\bar{m}_{DMHg,abated,j}$ = Abated vapor phase emissions of dimethyl mercury from vessel j , in g/sec	Same as $\bar{m}_{DMHg,unabated,j}$	Assumption 6.2.10 This value will be reported in the results for dimethyl mercury emissions
DMHg	N11	$\bar{m}_{DMHg,abated,tot}$ = Total abated vapor phase emissions of dimethyl mercury from vessel j , in g/sec	Same as $\bar{m}_{DMHg,unabated,tot}$	Assumption 6.2.10 This value will be reported in the results for dimethyl mercury emissions

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7.3.2 Stack Inorganic COPC Emissions

Stack inorganic COPCs, except for particulate matter and methyl mercury, are gases or acids that are mainly produced during chemical reactions or thermal decomposition. These COPCs are:

- Nitrogen dioxide
- Carbon dioxide
- Carbon monoxide
- Ozone
- Sulfur dioxide
- Hydrogen chloride
- Hydrogen Fluoride
- Fluorine gas
- Chlorine gas

The main source for these COPCs at WTP is the LAW and HLW melters. For example, in the existing WTP emissions estimate (Ref. 9.14, Table 18) the only streams with emissions of NO₂, CO, SO₂, HCl, and HF are the LAW and HLW offgas streams. Note that CO₂, O₃, F₂, and Cl₂ were not included in the existing WTP emissions estimate. It is assumed that there will not be the necessary thermal or kinetic conditions in the DEP system to produce significant amounts of the stack inorganic COPCs (Assumption 6.1.31). Therefore emissions of these COPCs are zero.

Monomethyl mercury is assumed to exist primarily in the liquid phase at WTP and its emissions are therefore grouped with the overall mercury emissions calculated in Section 7.3.1.2.1 (Assumption 6.2.25).

Total particulate matter emissions are the sum of the results for particulate emissions of radionuclides, feed organics, PICs, and feed inorganics. The total particulate emissions are reported in the “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*Inorganic Summary Table*” shown in Attachment C.

Total unabated particulate emissions of feed inorganic COPCs are the sum of Column I ($\bar{m}_{i,part,unabated}$) in the “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*Feed Inorganic COPCs - Calc*”. Total abated particulate emissions of inorganic COPCs are the sum of Column J ($\bar{m}_{i,abated}$) in the “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*Feed Inorganic COPCs - Calc*”.

Total unabated particulate emissions of radionuclide COPCs on a mass basis are the sum of Column K ($\bar{m}_{i,entrained}$) in the “*DFLAW Radionuclide COPC Emissions Estimate.xlsx*” Worksheet “*Radionuclide COPCs - Calc*”. Total abated particulate emissions of radionuclide COPCs on a mass basis are the total unabated particulate emissions divided by $DF_{HEPA,primary}$ and $DF_{HEPA,secondary}$ (similar to Equation 33).

Total unabated particulate emissions of feed organic COPCs are the sum of Column G ($\bar{m}_{i,part,unabated}$) in the “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” Worksheet “*Organic Summary Table*”. Total abated particulate emissions of inorganic COPCs are the sum of Column K ($\bar{m}_{i,part,abated}$) in the “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*Organic Summary Table*”.

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Total unabated particulate emissions of PIC COPCs are the sum of Column E ($\bar{m}_{i,part,unabated}$) in the “*DFLAW Organic and PIC COPC Emissions Estimate.xlsx*” Worksheet “*PIC Summary Table*”. Total abated particulate emissions of inorganic COPCs are the sum of Column F ($\bar{m}_{i,part,abated}$) in the “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*PIC Summary Table*”.

7.3.3 Inorganic COPC Summary and Comparison to De Minimis Emissions Limits

The results from Sections 7.3.1 and 7.3.2 are summarized in “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” Worksheet “*Inorganic Summary Table*” shown in Attachment C.

The total unabated emissions values are compared to de minimis emissions limits for TAPs established in WAC 173-460-150 (Input 2.13), using the worksheet “*WAC 173-460-150*”.

Table 7-35 “*DFLAW Inorganic COPC Emissions Estimate.xlsx*” De Minimis Value Comparison

Worksheet Title	Cell Location	Property	Calculation Method	Notes
<i>WAC 173-460-150</i>	G5:G400	$\bar{m}_{i,am}$ = de minimis emissions limit for COPC <i>i</i> , lb/averaging period	Input 2.13	
<i>WAC 173-460-150</i>	I5:I400	$\bar{m}_{i,am\ standard}$ = de minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Equation 38	
<i>WAC 173-460-150</i>	J5:J400	$\bar{m}_{i,total,unabated}$ Inorganic COPCs – Total Unabated Emissions of COPC <i>i</i> , in lb/yr	Vlookup of Column D in “ <i>Inorganic Summary Table</i> ” worksheet	Converted from g/sec to lb/yr
<i>WAC 173-460-150</i>	L5:L400	Difference: Feed Inorganic COPC minus de minimis, in lb/yr	Column J minus Column I	

The comparison in worksheet “*WAC 173-460-150*” showed that ammonia, cadmium, dimethyl mercury, and chromium (VI) exceed their de minimis values.

Ammonia was already evaluated using a Henry’s Law method (Section 7.3.1.3.2) so it will not be reevaluated using Henry’s Law like the feed organic COPCs in Section 7.2.4.1. Cadmium will not be reevaluated using Henry’s Law because it is nonvolatile and emitted through entrainment. Dimethyl mercury will also not be reevaluated, because the de minimis value of 3.65E-97 lb/yr is essentially zero and a reevaluation will not reduce the emissions to below that limit.

Chromium (VI) is listed as a TAP in WAC 173-460-150, however only generic total chromium (without a specified oxidation state) is evaluated as a COPC in the emissions estimate. In order to provide a bounding estimate for chromium (VI) emissions to compare to the de minimis value, it is assumed that all chromium emitted is chromium (VI) (Assumption 6.2.29). Therefore, the total unabated emissions estimate for chromium is assigned to chromium (VI) and is shown in the table below as exceeding the de minimis value.

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Table 7-36 Inorganic COPCs that Exceed De Minimis Value

CAS #	COPC	De minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Feed Organic COPCs - Total Unabated Emissions of COPC <i>i</i> , in lb/yr	Difference: Feed Organic COPC minus de minimis, in lb/yr
7664-41-7	Ammonia	1.70E+02	7.00E+03	6.83E+03
7440-43-9	Cadmium & Compounds	2.28E-03	2.82E-02	2.59E-02
18540-29-9	Chromium (VI)	6.40E-05	1.00E+00	1.00E+00
593-74-8	Dimethyl mercury	3.65E-97	3.67E-02	3.67E-02

8 Results and Conclusions

8.1 Discussion of Margin and Conservatism

In the absence of DFLAW-specific emissions estimates using the APPS model, this calculation uses a series of simplifying assumptions to provide a conservative estimate of the emissions of radionuclides from the DVP and ACV exhaust systems. These results will be verified by the results from the DFLAW-specific APPS model runs when they become available. The steady-state model will provide a stream-by-stream mass balance to estimate the emissions.

Typically there is no margin included in process calculations. This calculation does apply conservatism in several places in order to bound the possible results from the DFLAW-specific APPS model runs. The main conservatisms included in this calculation are the following:

- Use of the Tank Farm Average ratios and DFLAW Bounding Feed Vector to estimate COPC inventory received (Assumptions 6.2.1 and 6.2.2)
- It is conservative and bounding to assume the mass fractions of COPCs emitted by entrainment do not decrease from the maximum expected feed value throughout the DEP system (Assumption 6.1.1, Assumption 6.1.33).
- The nominal entrainment factor for free-falling aqueous solution ($4E-5$) is a conservative and representative for estimating particulate emissions from the DEP vessels, except for the evaporator (Assumption 6.2.3).
- The entrainment factor prescribed in WAC 246-247-030 (21)(a)(ii) for liquids and particulate solids ($1E-3$) is conservative and bounding for the estimation of particulate emissions from the DEP evaporator (Assumption 6.2.30).
- The dilution factor of $\frac{1}{30}$ is considered a conservative value for the approximation of the amount of residual feed flushed to DEP-VSL-00001 (Assumption 6.1.2).
- It is assumed that all ^{14}C received in the EMF is emitted as it is processed through the DEP system (Assumption 6.2.4).
- It is assumed that the entire vapor fraction of each feed organic COPC received in DEP-VSL-00001 annually is emitted to the DEP vessel ventilation system as it is processed through the DEP system (Assumption 6.2.16).

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- Feed transfers from the LAWPS to LAW are assumed to occur continuously without a break between transfers (i.e. a transfer begins immediately after the preceding one is finished) (Assumption 6.2.5).
- The two month duration of release used from Ref. 9.13 to estimate ACV Exhaust system emissions is conservative and bounding (Assumption 6.2.11).
- Particle or particle-bound PIC COPCs that do not have generation rates reported in Ref. 9.15, Table 3 are assigned a generation rate equal to the maximum generation rate for a particle or particle-bound PIC COPC that does have a generation rate reported in Ref. 9.15, Table 3 (Assumption 6.2.17)
- For ammonia emissions, the transfers from LVP-TK-00001 to DEP-VSL-00004A/B are assumed to occur continuously at the specified frequency and batch volume (Assumption 6.2.22).
- Average feed vector batch volumes, densities, and masses are used in Equation 9 through Equation 11 to calculate conservative values for maximum feed vector batch mass fractions, x_i , and concentrations, c_i . (Assumption 6.1.34).
- In order to assign a bounding emissions estimate greater than 0 g/sec for the subset of PIC COPCs that have a vapor phase type, these COPCs are assumed to be emitted at the average non-zero unabated particulate emissions rate for PIC COPCs (Assumption 6.2.27).
- In order to assign a bounding emissions estimate greater than 0 g/sec for the subset of feed organic COPCs without Tank Farms Average Ratios, these COPCs are assumed to be emitted at the average unabated vapor emissions rate for feed organic COPCs with Tank Farms Average Ratios (Assumption 6.2.28).
- In order to compare estimated chromium (VI) emissions to the de minimis limit for chromium (VI), it is assumed that all chromium emitted is chromium (VI) (Assumption 6.2.29).

8.2 Emissions Summary

The results for the emissions of radionuclide COPCs are summarized in Table 8-8 summarizes the COPCs with unabated emissions estimates that exceed the WAC de minimis value.

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Table 8-1 and Table 8-2. APQs for radionuclide COPCs are summarized in Table 8-3.

The results for the emissions of feed organic and PIC COPCs are summarized in Table 8-4 and Table 8-5 respectively.

The results for the emissions of inorganic COPCs are summarized in Table 8-6 and Table 8-7 .

Table 8-8 summarizes the COPCs with unabated emissions estimates that exceed the WAC de minimis value.

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 107

BY: William Hix

DATE: 6/6/2016

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Table 8-1 – Radionuclide COPC Emissions from DVP System

CAS #	COPC	Unabated Stream		Abated Stream	
		DEP15		DEP18	
		DEP Vessel Vent		DEP Vessel Vent	
		Ci/yr	% Contribution	Ci/yr	% Contribution
13967-48-1	106Ru	9.19E-06	0%	4.60E-11	0%
378253-44-2	113mCd	2.99E-03	0%	1.50E-08	0%
14234-35-6	125Sb	3.18E-03	0%	1.59E-08	0%
15832-50-5	126Sn	3.01E-04	0%	1.50E-09	0%
15046-84-1	129I	2.27E-05	0%	1.13E-10	0%
13967-70-9	134Cs	5.49E-04	0%	2.75E-09	0%
10045-97-3	137Cs	5.27E-02	1%	2.64E-07	0%
378253-40-8	137mBa	4.98E-02	1%	2.49E-07	0%
14762-75-5	14C (Note 1)	1.82E-01	3%	1.82E-01	99%
15715-94-3	151Sm	2.75E+00	38%	1.37E-05	0%
14683-23-9	152Eu	6.97E-04	0%	3.49E-09	0%
15585-10-1	154Eu	3.70E-03	0%	1.85E-08	0%
14391-16-3	155Eu	1.96E-02	0%	9.82E-08	0%
13982-63-3	226Ra	7.64E-09	0%	3.82E-14	0%
14952-40-0	227Ac	2.92E-06	0%	1.46E-11	0%
15262-20-1	228Ra	5.11E-06	0%	2.56E-11	0%
15594-54-4	229Th	1.05E-06	0%	5.26E-12	0%
14331-85-2	231Pa	3.92E-06	0%	1.96E-11	0%
7440-29-1	232Th	5.11E-06	0%	2.56E-11	0%
14158-29-3	232U	6.49E-06	0%	3.24E-11	0%
13968-55-3	233U	3.29E-05	0%	1.64E-10	0%
13966-29-5	234U	1.82E-04	0%	9.10E-10	0%
15117-96-1	235U	3.49E-07	0%	1.75E-12	0%
13982-70-2	236U	5.00E-06	0%	2.50E-11	0%
13994-20-2	237Np	1.12E-05	0%	5.62E-11	0%
13981-16-3	238Pu	2.58E-04	0%	1.29E-09	0%
7440-61-1R	238U	1.66E-04	0%	8.28E-10	0%
15117-48-3	239Pu	4.84E-03	0%	2.42E-08	0%
14119-33-6	240Pu	1.06E-03	0%	5.31E-09	0%
14596-10-2	241Am	1.53E-02	0%	7.67E-08	0%
14119-32-5	241Pu	6.45E-02	1%	3.22E-07	0%
15510-73-3	242Cm	9.39E-05	0%	4.70E-10	0%
13982-10-0	242Pu	8.11E-08	0%	4.05E-13	0%
14993-75-0	243Am	7.09E-06	0%	3.55E-11	0%
15757-87-6	243Cm	1.33E-06	0%	6.63E-12	0%
13981-15-2	244Cm	2.92E-05	0%	1.46E-10	0%
10028-17-8	3H (Note 1)	2.17E-03	0%	2.17E-03	1%
14336-70-0	59Ni	1.24E-03	0%	6.18E-09	0%
10198-40-0	60Co	2.26E-04	0%	1.13E-09	0%
13981-37-8	63Ni	1.10E-01	2%	5.52E-07	0%
15758-45-9	79Se	1.10E-04	0%	5.52E-10	0%
10098-97-2	90Sr	1.97E+00	27%	9.87E-06	0%
10098-91-6	90Y	1.97E+00	27%	9.87E-06	0%
378782-82-2	93mNb	2.44E-03	0%	1.22E-08	0%
15751-77-6	93Zr	2.87E-03	0%	1.44E-08	0%
14133-76-7	99Tc	2.03E-02	0%	1.02E-07	0%
	Total	7.24E+00	100%	1.85E-01	100%

Note 1: COPC emitted in the vapor phase

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BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

Table 8-2 - Radionuclide COPC Emissions from ACV Exhaust System

CAS #	COPC	Unabated Stream		Abated Stream		Abated Stream	
		ACV Exhaust		ACV Exhaust (single-stage HEPA)		ACV Exhaust (dual-stage HEPA)	
		Ci/yr	% Contribution	Ci/yr	% Contribution	Ci/yr	% Contribution
13967-48-1	106Ru	1.53E-06	0%	7.66E-10	0%	7.66E-12	0%
378253-44-2	113mCd	4.98E-04	0%	2.49E-07	0%	2.49E-09	0%
14234-35-6	125Sb	5.30E-04	0%	2.65E-07	0%	2.65E-09	0%
15832-50-5	126Sn	5.01E-05	0%	2.51E-08	0%	2.51E-10	0%
15046-84-1	129I	3.78E-06	0%	1.89E-09	0%	1.89E-11	0%
13967-70-9	134Cs	9.15E-05	0%	4.58E-08	0%	4.58E-10	0%
10045-97-3	137Cs	8.79E-03	1%	4.39E-06	0%	4.39E-08	0%
378253-40-8	137mBa	8.30E-03	1%	4.15E-06	0%	4.15E-08	0%
14762-75-5	14C (Note 1)	3.04E-02	3%	3.04E-02	97%	3.04E-02	99%
15715-94-3	151Sm	4.58E-01	38%	2.29E-04	1%	2.29E-06	0%
14683-23-9	152Eu	1.16E-04	0%	5.81E-08	0%	5.81E-10	0%
15585-10-1	154Eu	6.17E-04	0%	3.08E-07	0%	3.08E-09	0%
14391-16-3	155Eu	3.27E-03	0%	1.64E-06	0%	1.64E-08	0%
13982-63-3	226Ra	1.27E-09	0%	6.37E-13	0%	6.37E-15	0%
14952-40-0	227Ac	4.87E-07	0%	2.44E-10	0%	2.44E-12	0%
15262-20-1	228Ra	8.52E-07	0%	4.26E-10	0%	4.26E-12	0%
15594-54-4	229Th	1.75E-07	0%	8.77E-11	0%	8.77E-13	0%
14331-85-2	231Pa	6.53E-07	0%	3.27E-10	0%	3.27E-12	0%
7440-29-1	232Th	8.52E-07	0%	4.26E-10	0%	4.26E-12	0%
14158-29-3	232U	1.08E-06	0%	5.41E-10	0%	5.41E-12	0%
13968-55-3	233U	5.48E-06	0%	2.74E-09	0%	2.74E-11	0%
13966-29-5	234U	3.03E-05	0%	1.52E-08	0%	1.52E-10	0%
15117-96-1	235U	5.82E-08	0%	2.91E-11	0%	2.91E-13	0%
13982-70-2	236U	8.33E-07	0%	4.17E-10	0%	4.17E-12	0%
13994-20-2	237Np	1.87E-06	0%	9.36E-10	0%	9.36E-12	0%
13981-16-3	238Pu	4.31E-05	0%	2.15E-08	0%	2.15E-10	0%
7440-61-1R	238U	2.76E-05	0%	1.38E-08	0%	1.38E-10	0%
15117-48-3	239Pu	8.07E-04	0%	4.04E-07	0%	4.04E-09	0%
14119-33-6	240Pu	1.77E-04	0%	8.85E-08	0%	8.85E-10	0%
14596-10-2	241Am	2.56E-03	0%	1.28E-06	0%	1.28E-08	0%
14119-32-5	241Pu	1.07E-02	1%	5.37E-06	0%	5.37E-08	0%
15510-73-3	242Cm	1.57E-05	0%	7.83E-09	0%	7.83E-11	0%
13982-10-0	242Pu	1.35E-08	0%	6.75E-12	0%	6.75E-14	0%
14993-75-0	243Am	1.18E-06	0%	5.91E-10	0%	5.91E-12	0%
15757-87-6	243Cm	2.21E-07	0%	1.11E-10	0%	1.11E-12	0%
13981-15-2	244Cm	4.87E-06	0%	2.44E-09	0%	2.44E-11	0%
10028-17-8	3H (Note 1)	3.62E-04	0%	3.62E-04	1%	3.62E-04	1%
14336-70-0	59Ni	2.06E-04	0%	1.03E-07	0%	1.03E-09	0%
10198-40-0	60Co	3.77E-05	0%	1.88E-08	0%	1.88E-10	0%
13981-37-8	63Ni	1.84E-02	2%	9.20E-06	0%	9.20E-08	0%
15758-45-9	79Se	1.84E-05	0%	9.21E-09	0%	9.21E-11	0%
10098-97-2	90Sr	3.29E-01	27%	1.64E-04	1%	1.64E-06	0%
10098-91-6	90Y	3.29E-01	27%	1.64E-04	1%	1.64E-06	0%
378782-82-2	93mNb	4.07E-04	0%	2.03E-07	0%	2.03E-09	0%
15751-77-6	93Zr	4.79E-04	0%	2.39E-07	0%	2.39E-09	0%
14133-76-7	99Tc	3.39E-03	0%	1.70E-06	0%	1.70E-08	0%
	Total	1.21E+00	100%	3.13E-02	100%	3.08E-02	100%

Note 1: COPC emitted in the vapor phase

CALCULATION SHEET

BY: William Hix
DATE: 6/6/2016

PROJECT: RPP-WTP
JOB NO.: 24590
CALC NO.: 24590-BOF-M4C-DEP-00001
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SHEET NO.: 109

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

Table 8-3 – Radionuclide COPC Annual Possession Quantities

CAS #	COPC	Annual Possession Quantities
		DEP
		Ci/yr
13967-48-1	106Ru	8.91E-01
378253-44-2	113mCd	2.90E+02
14234-35-6	125Sb	3.08E+02
15832-50-5	126Sn	2.92E+01
15046-84-1	129I	2.20E+00
13967-70-9	134Cs	5.32E+01
10045-97-3	137Cs	5.11E+03
378253-40-8	137mBa	4.83E+03
14762-75-5	14C	1.82E-01
15715-94-3	151Sm	2.67E+05
14683-23-9	152Eu	6.76E+01
15585-10-1	154Eu	3.59E+02
14391-16-3	155Eu	1.90E+03
13982-63-3	226Ra	7.41E-04
14952-40-0	227Ac	2.83E-01
15262-20-1	228Ra	4.96E-01
15594-54-4	229Th	1.02E-01
14331-85-2	231Pa	3.80E-01
7440-29-1	232Th	4.96E-01
14158-29-3	232U	6.29E-01
13968-55-3	233U	3.19E+00
13966-29-5	234U	1.76E+01
15117-96-1	235U	3.39E-02
13982-70-2	236U	4.85E-01
13994-20-2	237Np	1.09E+00
13981-16-3	238Pu	2.51E+01
7440-61-1R	238U	1.61E+01
15117-48-3	239Pu	4.70E+02
14119-33-6	240Pu	1.03E+02
14596-10-2	241Am	1.49E+03
14119-32-5	241Pu	6.25E+03
15510-73-3	242Cm	9.11E+00
13982-10-0	242Pu	7.86E-03
14993-75-0	243Am	6.88E-01
15757-87-6	243Cm	1.29E-01
13981-15-2	244Cm	2.84E+00
10028-17-8	3H	9.33E-01
14336-70-0	59Ni	1.20E+02
10198-40-0	60Co	2.19E+01
13981-37-8	63Ni	1.07E+04
15758-45-9	79Se	1.07E+01
10098-97-2	90Sr	1.91E+05
10098-91-6	90Y	1.91E+05
378782-82-2	93mNb	2.37E+02
15751-77-6	93Zr	2.78E+02
14133-76-7	99Tc	1.97E+03
	Total	6.84E+05

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PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

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SHEET NO.: 110

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

Table 8-4 – Feed Organic COPC Emissions from DVP System

CAS #	COPC	Feed or Feed/PIC (Note 1)	Unabated Streams			Abated Streams		
			DEP15			DEP18		
			DEP Vessel Vent			DEP Vessel Vent		
			Vapor	Particulate	Total	Vapor	Particulate	Total
			g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
630-20-6	1,1,1,2-Tetrachloroethane	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
71-55-6	1,1,1-Trichloroethane	Feed	1.98E-10	0.00E+00	1.98E-10	1.98E-10	0.00E+00	1.98E-10
79-34-5	1,1,2,2-Tetrachloroethane	Feed	1.88E-10	0.00E+00	1.88E-10	1.88E-10	0.00E+00	1.88E-10
127-18-4	Tetrachloroethene	Feed	1.95E-10	0.00E+00	1.95E-10	1.95E-10	0.00E+00	1.95E-10
79-00-5	1,1,2-Trichloroethane	Feed	1.87E-10	0.00E+00	1.87E-10	1.87E-10	0.00E+00	1.87E-10
79-01-6	Trichloroethene	Feed/PIC	2.13E-10	4.31E-10 (Note 5)	6.44E-10	2.13E-10	2.15E-15	2.13E-10
92-52-4	Biphenyl	Feed	3.73E-08	0.00E+00	3.73E-08	3.73E-08	0.00E+00	3.73E-08
75-34-3	1,1-Dichloroethane	Feed	1.60E-10	0.00E+00	1.60E-10	1.60E-10	0.00E+00	1.60E-10
75-35-4	1,1-Dichloroethene	Feed	2.52E-10	0.00E+00	2.52E-10	2.52E-10	0.00E+00	2.52E-10
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	Feed	4.89E-10	0.00E+00	4.89E-10	4.89E-10	0.00E+00	4.89E-10
120-82-1	1,2,4-Trichlorobenzene	Feed	1.18E-08	0.00E+00	1.18E-08	1.18E-08	0.00E+00	1.18E-08
95-50-1	1,2-Dichlorobenzene	Feed	1.54E-07	0.00E+00	1.54E-07	1.54E-07	0.00E+00	1.54E-07
107-06-2	1,2-Dichloroethane	Feed/PIC	1.87E-10	4.31E-10 (Note 5)	6.18E-10	1.87E-10	2.15E-15	1.87E-10
78-87-5	1,2-Dichloropropane	Feed	1.60E-10	0.00E+00	1.60E-10	1.60E-10	0.00E+00	1.60E-10
106-88-7	1,2-Epoxybutane	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
156-60-5	1,2-trans-Dichloroethene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
106-99-0	1,3-Butadiene	Feed	5.37E-09	0.00E+00	5.37E-09	5.37E-09	0.00E+00	5.37E-09
541-73-1	1,3-Dichlorobenzene	Feed	7.76E-09	0.00E+00	7.76E-09	7.76E-09	0.00E+00	7.76E-09
106-46-7	1,4-Dichlorobenzene	Feed/PIC	1.01E-07	4.31E-10 (Note 5)	1.02E-07	1.01E-07	2.15E-15	1.01E-07
123-91-1	1,4-Dioxane	Feed	5.91E-09	0.00E+00	5.91E-09	5.91E-09	0.00E+00	5.91E-09
75-01-4	Vinyl chloride	Feed	4.05E-10	0.00E+00	4.05E-10	4.05E-10	0.00E+00	4.05E-10
58-90-2	2,3,4,6-Tetrachlorophenol	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
95-95-4	2,4,5-Trichlorophenol	Feed	4.87E-05	0.00E+00	4.87E-05	4.87E-05	0.00E+00	4.87E-05
88-06-2	2,4,6-Trichlorophenol	Feed	1.68E-06 (Note 2)	0.00E+00	1.68E-06	1.68E-06	0.00E+00	1.68E-06
120-83-2	2,4-Dichlorophenol	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
121-14-2	2,4-Dinitrotoluene	Feed/PIC	2.27E-08 (Note 2)	1.32E-10	2.29E-08	2.27E-08	6.62E-16	2.27E-08
128-37-0	2,6-Bis(1,1-dimethylethyl)-4-methylphenol	Feed	2.83E-07	0.00E+00	2.83E-07	2.83E-07	0.00E+00	2.83E-07
78-93-3	2-Butanone	Feed/PIC	6.40E-08	4.31E-10 (Note 5)	6.44E-08	6.40E-08	2.15E-15	6.40E-08
111-76-2	2-Butoxyethanol	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
91-58-7	2-Chloronaphthalene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
95-57-8	2-Chlorophenol	Feed	5.36E-05	0.00E+00	5.36E-05	5.36E-05	0.00E+00	5.36E-05
110-80-5	2-Ethoxyethanol	Feed	1.13E-04	0.00E+00	1.13E-04	1.13E-04	0.00E+00	1.13E-04
104-76-7	2-Ethyl-1-hexanol	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
591-78-6	2-Hexanone	Feed	2.55E-08	0.00E+00	2.55E-08	2.55E-08	0.00E+00	2.55E-08
126-98-7	2-Methyl-2-propenenitrile	Feed	5.91E-09	0.00E+00	5.91E-09	5.91E-09	0.00E+00	5.91E-09
78-83-1	Isobutanol	Feed	2.77E-04	0.00E+00	2.77E-04	2.77E-04	0.00E+00	2.77E-04
88-75-5	2-Nitrophenol	Feed/PIC	5.04E-05	4.31E-10 (Note 5)	5.04E-05	5.04E-05	2.15E-15	5.04E-05
79-46-9	2-Nitropropane	Feed	3.95E-08	0.00E+00	3.95E-08	3.95E-08	0.00E+00	3.95E-08
67-64-1	Acetone	Feed/PIC	2.80E-07	4.31E-10 (Note 5)	2.81E-07	2.80E-07	2.15E-15	2.80E-07
79-10-7	2-Propenoic acid	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
67-63-0	Isopropyl alcohol	Feed	1.65E-08	0.00E+00	1.65E-08	1.65E-08	0.00E+00	1.65E-08
107-05-1	3-Chloropropene	Feed	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
589-38-8	3-Hexanone	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
56-49-5	3-Methylcholanthrene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
72-55-9	4,4-DDE	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
101-55-3	4-Bromophenylphenyl ether	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
59-50-7	4-Chloro-3-methylphenol	Feed	5.19E-05	0.00E+00	5.19E-05	5.19E-05	0.00E+00	5.19E-05
100-40-3	4-Ethenylcyclohexene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
108-10-1	Hexone	Feed	2.09E-09	0.00E+00	2.09E-09	2.09E-09	0.00E+00	2.09E-09
3697-24-3	5-Methylchrysene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
602-87-9	5-Nitroacenaphthene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 111

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

CAS #	COPC	Feed or Feed/PIC (Note 1)	Unabated Streams			Abated Streams		
			DEP15			DEP18		
			DEP Vessel Vent			DEP Vessel Vent		
			Vapor	Particulate	Total	Vapor	Particulate	Total
			g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
83-32-9	Acenaphthene	Feed/PIC	5.66E-05	4.31E-10 (Note 5)	5.66E-05	5.66E-05	2.15E-15	5.66E-05
208-96-8	Acenaphthylene	Feed/PIC	1.69E-05 (Note 4)	4.31E-10 (Note 5)	1.69E-05	1.69E-05	2.15E-15	1.69E-05
75-07-0	Acetaldehyde	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
60-35-5	Acetamide	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
141-78-6	Ethyl acetate	Feed	6.31E-10	0.00E+00	6.31E-10	6.31E-10	0.00E+00	6.31E-10
108-05-4	vinyl acetate	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
75-05-8	Acetonitrile	Feed/PIC	1.46E-07	4.31E-10 (Note 5)	1.46E-07	1.46E-07	2.15E-15	1.46E-07
98-86-2	Acetophenone	Feed/PIC	3.73E-08	4.31E-10 (Note 5)	3.77E-08	3.73E-08	2.15E-15	3.73E-08
107-02-8	Acrolein	Feed	8.68E-09	0.00E+00	8.68E-09	8.68E-09	0.00E+00	8.68E-09
107-13-1	Acrylonitrile	Feed/PIC	5.91E-09	4.31E-10 (Note 5)	6.34E-09	5.91E-09	2.15E-15	5.91E-09
134-32-7	alpha-Naphthylamine	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
120-12-7	Anthracene	Feed/PIC	1.69E-05 (Note 4)	4.88E-12	1.69E-05	1.69E-05	2.44E-17	1.69E-05
71-43-2	Benzene	Feed/PIC	5.05E-10	4.31E-10 (Note 5)	9.36E-10	5.05E-10	2.15E-15	5.05E-10
50-32-8	Benzo(a)pyrene	Feed	6.77E-09	3.86E-11	6.81E-09	6.77E-09	1.93E-16	6.77E-09
191-24-2	Benzo(ghi)perylene	Feed/PIC	1.69E-05 (Note 4)	2.28E-09	1.69E-05	1.69E-05	1.14E-14	1.69E-05
117-81-7	Bis(2-ethylhexyl)phthalate	Feed/PIC	1.69E-05 (Note 4)	9.90E-10	1.69E-05	1.69E-05	4.95E-15	1.69E-05
75-27-4	Bromodichloromethane	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
74-83-9	Bromomethane	Feed/PIC	3.99E-10	4.31E-10 (Note 5)	8.30E-10	3.99E-10	2.15E-15	3.99E-10
123-72-8	Butanal	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
85-68-7	Butylbenzylphthalate	Feed/PIC	1.04E-04	1.33E-08	1.04E-04	1.04E-04	6.66E-14	1.04E-04
56-23-5	Carbon tetrachloride	Feed/PIC	3.05E-10	4.31E-10 (Note 5)	7.36E-10	3.05E-10	2.15E-15	3.05E-10
108-90-7	Chlorobenzene	Feed/PIC	1.93E-10	4.31E-10 (Note 5)	6.23E-10	1.93E-10	2.15E-15	1.93E-10
75-45-6	Chlorodifluoromethane	Feed	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
75-00-3	Chloroethane	Feed	3.99E-10	0.00E+00	3.99E-10	3.99E-10	0.00E+00	3.99E-10
67-66-3	Chloroform	Feed/PIC	2.00E-10	4.31E-10 (Note 5)	6.31E-10	2.00E-10	2.15E-15	2.00E-10
74-87-3	Chloromethane	Feed/PIC	7.95E-10	4.31E-10 (Note 5)	1.23E-09	7.95E-10	2.15E-15	7.95E-10
10061-01-5	cis-1,3-Dichloropropene	Feed	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
108-39-4	m-Cresol	Feed	4.29E-05	0.00E+00	4.29E-05	4.29E-05	0.00E+00	4.29E-05
95-48-7	2-Methylphenol	Feed	5.96E-05	0.00E+00	5.96E-05	5.96E-05	0.00E+00	5.96E-05
98-82-8	Isopropylbenzene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
110-82-7	Cyclohexane	Feed	5.91E-10	0.00E+00	5.91E-10	5.91E-10	0.00E+00	5.91E-10
108-94-1	Cyclohexanone	Feed	5.77E-07	0.00E+00	5.77E-07	5.77E-07	0.00E+00	5.77E-07
226-36-8	Dibenz[a,h]acridine	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
53-70-3	Dibenz[a,h]anthracene	Feed/PIC	1.45E-09	2.37E-09	3.82E-09	1.45E-09	1.18E-14	1.45E-09
224-42-0	Dibenz[a,j]acridine	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
191-30-0	Dibenzo(a,l)pyrene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
192-65-4	Dibenzo[a,e]pyrene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
189-64-0	Dibenzo[a,h]pyrene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
189-55-9	Dibenzo[a,i]pyrene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
75-71-8	Dichlorodifluoromethane	Feed	4.95E-10	0.00E+00	4.95E-10	4.95E-10	0.00E+00	4.95E-10
75-09-2	Methylenechloride	Feed/PIC	1.18E-07	4.31E-10 (Note 5)	1.19E-07	1.18E-07	2.15E-15	1.18E-07
84-66-2	Diethylphthalate	Feed/PIC	1.69E-05 (Note 4)	4.31E-10 (Note 5)	1.69E-05	1.69E-05	2.15E-15	1.69E-05
84-74-2	Di-n-butylphthalate	Feed/PIC	3.40E-04	4.79E-09	3.40E-04	3.40E-04	2.39E-14	3.40E-04
117-84-0	Di-n-octylphthalate	Feed	5.49E-05	2.22E-08	5.49E-05	5.49E-05	1.11E-13	5.49E-05
100-41-4	Ethylbenzene	Feed	3.34E-10	0.00E+00	3.34E-10	3.34E-10	0.00E+00	3.34E-10
60-29-7	Ethyl ether	Feed	2.22E-08	0.00E+00	2.22E-08	2.22E-08	0.00E+00	2.22E-08
106-93-4	Ethylene dibromide	Feed	1.60E-10	0.00E+00	1.60E-10	1.60E-10	0.00E+00	1.60E-10
75-21-8	Ethylene oxide (Oxirane)	Feed	3.44E-08	0.00E+00	3.44E-08	3.44E-08	0.00E+00	3.44E-08
206-44-0	Fluoranthene	Feed/PIC	5.57E-05	1.06E-09	5.57E-05	5.57E-05	5.32E-15	5.57E-05
86-73-7	Fluorene	Feed/PIC	1.69E-05 (Note 4)	4.31E-10 (Note 5)	1.69E-05	1.69E-05	2.15E-15	1.69E-05
75-02-5	Fluoroethene (vinyl fluoride)	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
50-00-0	Formaldehyde	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
87-68-3	Hexachlorobutadiene	Feed	1.01E-07	0.00E+00	1.01E-07	1.01E-07	0.00E+00	1.01E-07

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 112

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

CAS #	COPC	Feed or Feed/PIC (Note 1)	Unabated Streams			Abated Streams		
			DEP15			DEP18		
			DEP Vessel Vent			DEP Vessel Vent		
			Vapor	Particulate	Total	Vapor	Particulate	Total
			g/sec	g/sec	g/sec	g/sec	g/sec	g/sec
67-72-1	Hexachloroethane	Feed	2.36E-06	0.00E+00	2.36E-06	2.36E-06	0.00E+00	2.36E-06
628-73-9	Hexanenitrile	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
193-39-5	Indeno(1,2,3-cd)pyrene	Feed/PIC	1.69E-05 (Note 4)	2.43E-09	1.69E-05	1.69E-05	1.21E-14	1.69E-05
67-56-1	Methyl alcohol	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
1634-04-4	tert-Butyl methyl ether	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
122-39-4	Diphenyl amine	Feed	1.79E-08	0.00E+00	1.79E-08	1.79E-08	0.00E+00	1.79E-08
91-20-3	Naphthalene	Feed/PIC	5.29E-05 (Note 2)	4.31E-10 (Note 5)	5.29E-05	5.29E-05	2.15E-15	5.29E-05
109-74-0	Butanenitrile	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
71-36-3	1-Butanol	Feed	4.77E-07	0.00E+00	4.77E-07	4.77E-07	0.00E+00	4.77E-07
110-54-3	Hexane	Feed	3.12E-08	0.00E+00	3.12E-08	3.12E-08	0.00E+00	3.12E-08
98-95-3	Nitrobenzene	Feed/PIC	1.30E-07	4.31E-10 (Note 5)	1.31E-07	1.30E-07	2.15E-15	1.30E-07
621-64-7	N-Nitroso-di-n-propylamine	Feed	4.89E-07 (Note 2)	0.00E+00	4.89E-07	4.89E-07	0.00E+00	4.89E-07
10595-95-6	N-Nitrosomethylethylamine	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
59-89-2	Morpholine, 4-Nitroso-	Feed	1.21E-08 (Note 2)	0.00E+00	1.21E-08	1.21E-08	0.00E+00	1.21E-08
62-75-9	N-Nitrosodimethylamine	Feed	2.10E-09 (Note 2)	0.00E+00	2.10E-09	2.10E-09	0.00E+00	2.10E-09
87-86-5	Pentachlorophenol	Feed	9.76E-08	2.27E-13	9.76E-08	9.76E-08	1.14E-18	9.76E-08
110-59-8	Pentanenitrile	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
85-01-8	Phenanthrene	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
108-95-2	Phenol	Feed/PIC	1.34E-07	4.31E-10 (Note 5)	1.34E-07	1.34E-07	2.15E-15	1.34E-07
100-21-0	Phthalic acid	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
100-02-7	4-Nitrophenol	Feed/PIC	4.92E-05	1.17E-10	4.92E-05	4.92E-05	5.85E-16	4.92E-05
1336-36-3	Aroclors (Total PCB)	Feed	2.59E-05 (Note 2)	0.00E+00	2.59E-05	2.59E-05	0.00E+00	2.59E-05
107-12-0	Propionitrile	Feed	5.42E-08	0.00E+00	5.42E-08	5.42E-08	0.00E+00	5.42E-08
129-00-0	Pyrene	Feed/PIC	5.56E-05	7.95E-10	5.56E-05	5.56E-05	3.98E-15	5.56E-05
110-86-1	Pyridine	Feed	1.39E-07	0.00E+00	1.39E-07	1.39E-07	0.00E+00	1.39E-07
100-42-5	Styrene	Feed/PIC	1.60E-10	4.31E-10 (Note 5)	5.91E-10	1.60E-10	2.15E-15	1.60E-10
108-88-3	Toluene	Feed/PIC	8.34E-10	4.31E-10 (Note 5)	1.26E-09	8.34E-10	2.15E-15	8.34E-10
10061-02-6	trans-1,3-Dichloropropene	Feed	6.17E-10	0.00E+00	6.17E-10	6.17E-10	0.00E+00	6.17E-10
126-73-8	Tributyl phosphate	Feed	1.68E-05	1.57E-10	1.68E-05	1.68E-05	7.84E-16	1.68E-05
27154-33-2	Trichlorofluoroethane	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
75-69-4	Trichlorofluoromethane	Feed	4.86E-10	0.00E+00	4.86E-10	4.86E-10	0.00E+00	4.86E-10
75-50-3	Trimethylamine	Feed	1.69E-05 (Note 4)	0.00E+00	1.69E-05	1.69E-05	0.00E+00	1.69E-05
1330-20-7	Xylenes (total)	Feed/PIC	5.71E-08	4.31E-10 (Note 5)	5.75E-08	5.71E-08	2.15E-15	5.71E-08
75-15-0	Carbon Disulfide (Note 3)	Feed/PIC	2.92E-07	4.31E-10 (Note 5)	2.93E-07	2.92E-07	2.15E-15	2.92E-07
		TOTAL	2.33E-03	6.23E-08	2.33E-03	2.33E-03	3.12E-13	2.33E-03

Note 1: Particulate emissions of Organic COPCs that are present in both the feed and as a PIC will be reported with the Organic COPC results. If a Feed/PIC COPC has estimated particulate emissions using both the PIC emissions methodology and the feed organics methodology then the emissions estimate will be the sum of the results from the two methods.

Note 2: The unabated vapor emissions for these COPCs were evaluated using the Henry's Law method in Section 5.2.4.1

Note 3: Carbon disulfide emissions were calculated using the methodology for feed inorganic COPCs (Section 5.3.1) because the Tank Farm Feed ratio for carbon disulfide is provided in the units used for inorganic COPCs (g COPC / g Na). The results for carbon disulfide are listed with the feed organic COPCs because that is how it is classified per Ref. 9.1

Note 4: For feed organic COPCs without Tank Farms Average Ratios, the unabated vapor emissions rate represents the adjusted emissions rate assigned pre Assumption 6.2.28 based on the average non-zero unabated feed organic COPC vapor emissions rate.

Note 5: For Feed/PIC COPCs that are emitted as vapor phase type, the emissions reported as particulate represent the adjusted emissions rate assigned per Assumption 6.2.27 based on the average non-zero unabated PIC COPC particulate emissions rate.

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 113

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

Table 8-5 – PIC COPC Emissions from DVP System

CAS #	COPC	PIC or Feed/PIC	Unabated Streams	Abated Streams
			DEP15	DEP18
			DEP Vessel Vent Particulate	DEP Vessel Vent Particulate
			g/sec	g/sec
100-25-4	1,4-Dinitrobenzene	PIC	2.44E-12	1.22E-17
100-44-7	Benzyl chloride	PIC	4.31E-10 (Note 2)	2.15E-15
100-47-0	Benzonitrile	PIC	4.31E-10 (Note 2)	2.15E-15
100-51-6	Benzyl alcohol	PIC	4.31E-10 (Note 2)	2.15E-15
100-52-7	Benzaldehyde	PIC	4.31E-10 (Note 2)	2.15E-15
101-77-9	4,4-Methylenedianiline	PIC	4.31E-10 (Note 2)	2.15E-15
103-33-3	Azobenzene	PIC	4.31E-10 (Note 2)	2.15E-15
103-65-1	n-Propyl benzene (Isocumene)	PIC	4.31E-10 (Note 2)	2.15E-15
104-51-8	n-Butylbenzene	PIC	4.31E-10 (Note 2)	2.15E-15
106-43-4	4-Chlorotoluene (p-Tolyl chloride)	PIC	4.31E-10 (Note 2)	2.15E-15
106-44-5	p-Cresol (4-methyl phenol)	PIC	4.31E-10 (Note 2)	2.15E-15
106-47-8	p-Chloroaniline	PIC	4.31E-10 (Note 2)	2.15E-15
106-49-0	p-Toluidine	PIC	4.31E-10 (Note 2)	2.15E-15
106-51-4	Quinone	PIC	4.31E-10 (Note 2)	2.15E-15
106-89-8	Epichlorohydrin (1-chloro-2,3 epoxypropane)	PIC	4.31E-10 (Note 2)	2.15E-15
107-19-7	Propargyl alcohol	PIC	4.31E-10 (Note 2)	2.15E-15
107-21-1	Ethylene glycol (1,2-ethanediol)	PIC	4.31E-10 (Note 2)	2.15E-15
107-98-2	Propylene glycol monomethyl ether	PIC	4.31E-10 (Note 2)	2.15E-15
108-60-1	bis (2-Chloroisopropyl)ether	PIC	4.31E-10 (Note 2)	2.15E-15
108-67-8	1,3,5-Trimethylbenzene	PIC	4.31E-10 (Note 2)	2.15E-15
108-86-1	Bromobenzene (Phenyl bromide)	PIC	4.31E-10 (Note 2)	2.15E-15
108-87-2	Methylcyclohexane	PIC	4.31E-10 (Note 2)	2.15E-15
109-75-1	3-Butenenitrile	PIC	4.31E-10 (Note 2)	2.15E-15
109-77-3	Malononitrile	PIC	4.31E-10 (Note 2)	2.15E-15
109-86-4	2-Methoxyethanol	PIC	4.31E-10 (Note 2)	2.15E-15
109-99-9	Tetrahydrofuran	PIC	4.31E-10 (Note 2)	2.15E-15
110-00-9	Furan	PIC	4.31E-10 (Note 2)	2.15E-15
110-83-8	Cyclohexene	PIC	4.31E-10 (Note 2)	2.15E-15
111-15-9	Ethylene glycol monoethyl ether acetate	PIC	4.31E-10 (Note 2)	2.15E-15
111-44-4	Bis(2-chloroethyl)ether	PIC	4.31E-10 (Note 2)	2.15E-15
111-65-9	n-Octane	PIC	4.31E-10 (Note 2)	2.15E-15
111-84-2	n-Nonane	PIC	4.31E-10 (Note 2)	2.15E-15
111-91-1	Bis(2-chloroethoxy)methane	PIC	7.32E-12	3.66E-17
1120-21-4	Undecane	PIC	4.31E-10 (Note 2)	2.15E-15
1120-71-4	1,3-Propane sultone	PIC	4.31E-10 (Note 2)	2.15E-15
112-30-1	1-Decanol	PIC	4.31E-10 (Note 2)	2.15E-15
112-31-2	Decanal	PIC	4.31E-10 (Note 2)	2.15E-15
112-40-3	Dodecane	PIC	4.31E-10 (Note 2)	2.15E-15
118-74-1	Hexachlorobenzene	PIC	4.31E-10 (Note 2)	2.15E-15
119-90-4	3,3'-Dimethoxybenzidine	PIC	3.41E-10	1.71E-15
122-66-7	1,2-Diphenylhydrazine	PIC	4.31E-10 (Note 2)	2.15E-15
123-33-1	Maleic hydrazide	PIC	4.31E-10 (Note 2)	2.15E-15
123-38-6	Propionaldehyde	PIC	4.31E-10 (Note 2)	2.15E-15
124-18-5	Decane	PIC	4.31E-10 (Note 2)	2.15E-15
124-48-1	Chlorodibromomethane	PIC	4.31E-10 (Note 2)	2.15E-15
131-11-3	Dimethyl Phthalate	PIC	4.31E-10 (Note 2)	2.15E-15
131-89-5	2-Cyclohexyl-4,6-dinitrophenol	PIC	1.52E-09	7.62E-15
132-64-9	Dibenzofuran	PIC	8.25E-13	4.13E-18
133-06-2	Captan	PIC	4.31E-10 (Note 2)	2.15E-15
135-98-8	sec-Butylbenzene	PIC	4.31E-10 (Note 2)	2.15E-15
145-73-3	Endothall	PIC	2.43E-09	1.21E-14
156-59-2	cis-1,2-Dichloroethene	PIC	4.31E-10 (Note 2)	2.15E-15
1746-01-6	2,3,7,8-Tetrachlorodibenzo(p)dioxin (TCDD)	PIC	5.65E-17	2.82E-22
192-97-2	Benzo(e)pyrene	PIC	2.61E-10	1.30E-15
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin	PIC	4.44E-16	2.22E-21
205-82-3	Benzo(j)fluoranthene	PIC	1.00E-09	5.00E-15
205-99-2	Benzo(b)fluoranthene	PIC	8.29E-11	4.15E-16
207-08-9	Benzo(k)fluoranthene	PIC	1.80E-09	9.02E-15
218-01-9	Chrysene	PIC	6.78E-10	3.39E-15
2245-38-7	2,3,5-Trimethylnaphthalene	PIC	4.31E-10 (Note 2)	2.15E-15
23950-58-5	Pronamide	PIC	1.24E-10	6.22E-16
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl (PCB 118)	PIC	7.13E-14	3.56E-19
319-84-6	alpha-BHC	PIC	4.31E-10 (Note 2)	2.15E-15
319-85-7	beta-BHC	PIC	2.44E-12	1.22E-17

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

BY: William Hix
DATE: 6/6/2016

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 114

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

CAS #	COPC	PIC or Feed/PIC	Unabated Streams	Abated Streams
			DEP15	DEP18
			DEP Vessel Vent Particulate	DEP Vessel Vent Particulate
			g/sec	g/sec
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	PIC	5.98E-15	2.99E-20
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)	PIC	3.04E-15	1.52E-20
3268-87-9	Octachlorodibenzo(p)dioxin	PIC	8.00E-11	4.00E-16
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	PIC	4.06E-17	2.03E-22
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin	PIC	7.83E-12	3.91E-17
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	PIC	1.94E-15	9.68E-21
39001-02-0	Octachlorodibenzofuran	PIC	3.41E-11	1.70E-16
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin	PIC	1.91E-16	9.55E-22
39635-31-9	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	PIC	5.96E-16	2.98E-21
40321-76-4	1,2,3,7,8-Pentachlorodibenzo(p)dioxin	PIC	1.25E-16	6.23E-22
4170-30-3	Crotonaldehyde (Propylene aldehyde)	PIC	4.31E-10 (Note 2)	2.15E-15
41851-50-7	Chlorocyclopentadiene	PIC	4.31E-10 (Note 2)	2.15E-15
460-19-5	Cyanogen (oxalonitrile)	PIC	4.31E-10 (Note 2)	2.15E-15
4786-20-3	2-Butenenitrile	PIC	4.31E-10 (Note 2)	2.15E-15
506-68-3	Cyanogen bromide (bromocyanide)	PIC	4.31E-10 (Note 2)	2.15E-15
506-77-4	Cyanogen chloride	PIC	4.31E-10 (Note 2)	2.15E-15
510-15-6	Chlorobenzilate	PIC	3.29E-10	1.65E-15
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	PIC	2.67E-11	1.34E-16
51-28-5	2,4-Dinitrophenol	PIC	4.31E-10 (Note 2)	2.15E-15
51-79-6	Ethyl carbamate (urethane)	PIC	4.31E-10 (Note 2)	2.15E-15
52663-72-6	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	PIC	1.03E-15	5.13E-21
528-29-0	1,2-Dinitrobenzene (o-Dinitrobenzene)	PIC	2.44E-12	1.22E-17
532-27-4	2-Chloroacetophenone	PIC	4.31E-10 (Note 2)	2.15E-15
534-52-1	4,6-Dinitro-o-cresol	PIC	4.31E-10 (Note 2)	2.15E-15
5385-75-1	Dibenzo(a,e)fluoranthene	PIC	2.39E-09	1.20E-14
540-59-0	1,2-Dichloroethene (total) (1,2-Dichloroethylene)	PIC	4.31E-10 (Note 2)	2.15E-15
540-73-8	1,2-Dimethylhydrazine	PIC	4.31E-10 (Note 2)	2.15E-15
540-84-1	2,2,4-Trimethylpentane	PIC	4.31E-10 (Note 2)	2.15E-15
542-75-6	1,3-Dichloropropene	PIC	4.31E-10 (Note 2)	2.15E-15
542-88-1	Bis(chloromethyl)ether	PIC	4.31E-10 (Note 2)	2.15E-15
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	PIC	1.53E-16	7.63E-22
56-55-3	Benzo(a)anthracene	PIC	1.29E-09	6.45E-15
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	PIC	2.44E-11	1.22E-16
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	PIC	6.67E-11	3.33E-16
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	PIC	1.02E-11	5.09E-17
57-24-9	Strychnine	PIC	2.42E-09	1.21E-14
57465-28-8	3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	PIC	1.35E-16	6.73E-22
57653-85-7	1,2,3,6,7,8,-Hexachlorodibenzo(p)dioxin	PIC	4.20E-16	2.10E-21
57-74-9	Chlordane	PIC	1.71E-11	8.54E-17
581-42-0	2,6-Dimethylnaphthalene	PIC	4.31E-10 (Note 2)	2.15E-15
584-84-9	2,4-Toluene diisocyanate	PIC	4.31E-10 (Note 2)	2.15E-15
58-89-9	gamma-BHC (Lindane)	PIC	4.31E-10 (Note 2)	2.15E-15
591-50-4	Benzene, iodo-	PIC	4.31E-10 (Note 2)	2.15E-15
593-60-2	Bromoethene (Vinyl bromide)	PIC	4.31E-10 (Note 2)	2.15E-15
60-11-7	Dimethyl aminoazobenzene	PIC	1.12E-09	5.61E-15
606-20-2	2,6-Dinitrotoluene	PIC	4.31E-10 (Note 2)	2.15E-15
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	PIC	1.43E-16	7.14E-22
608-93-5	Pentachlorobenzene	PIC	4.31E-10 (Note 2)	2.15E-15
61626-71-9	Dichloropentadiene	PIC	4.31E-10 (Note 2)	2.15E-15
624-83-9	Methyl isocyanate	PIC	4.31E-10 (Note 2)	2.15E-15
62-50-0	Ethyl methanesulfonate	PIC	4.31E-10 (Note 2)	2.15E-15
62-53-3	Aniline	PIC	4.31E-10 (Note 2)	2.15E-15
64-18-6	Formic acid (methanoic acid)	PIC	4.31E-10 (Note 2)	2.15E-15
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	PIC	9.52E-17	4.76E-22
65-85-0	Benzoic acid	PIC	4.31E-10 (Note 2)	2.15E-15
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	PIC	2.12E-16	1.06E-21
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	PIC	6.16E-16	3.08E-21
70-30-4	Hexachlorophene	PIC	2.42E-09	1.21E-14
70362-50-4	3,4,4',5-Tetrachlorobiphenyl (PCB 81)	PIC	7.25E-17	3.62E-22
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	PIC	4.09E-11	2.04E-16
72-43-5	Methoxychlor	PIC	3.63E-10	1.82E-15
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	PIC	3.48E-13	1.74E-18
74472-37-0	2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	PIC	1.22E-16	6.12E-22
74-88-4	Iodomethane	PIC	4.31E-10 (Note 2)	2.15E-15
74-95-3	Methylene bromide	PIC	4.31E-10 (Note 2)	2.15E-15

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 115

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

CAS #	COPC	PIC or Feed/PIC	Unabated Streams	Abated Streams
			DEP15	DEP18
			DEP Vessel Vent Particulate	DEP Vessel Vent Particulate
			g/sec	g/sec
74-97-5	Bromochloromethane	PIC	4.31E-10 (Note 2)	2.15E-15
75-25-2	Bromoform	PIC	4.31E-10 (Note 2)	2.15E-15
75-29-6	2-Chloropropane	PIC	4.31E-10 (Note 2)	2.15E-15
75-44-5	Phosgene (hydrogen phosphide)	PIC	4.31E-10 (Note 2)	2.15E-15
76-01-7	Pentachloroethane	PIC	4.31E-10 (Note 2)	2.15E-15
764-41-0	1,4-Dichloro-2-butene	PIC	4.31E-10 (Note 2)	2.15E-15
76-44-8	Heptachlor	PIC	4.31E-10 (Note 2)	2.15E-15
765-34-4	Glycidylaldehyde	PIC	4.31E-10 (Note 2)	2.15E-15
77-47-4	Hexachlorocyclopentadiene	PIC	4.31E-10 (Note 2)	2.15E-15
77-78-1	Dimethyl sulfate	PIC	4.31E-10 (Note 2)	2.15E-15
80-62-6	Methyl methacrylate	PIC	4.31E-10 (Note 2)	2.15E-15
822-06-0	Hexamethylene-1,5-diisocyanate	PIC	4.31E-10 (Note 2)	2.15E-15
823-40-5	Toluene-2,6-diamine	PIC	4.31E-10 (Note 2)	2.15E-15
82-68-8	Pentachloronitrobenzene (PCNB)	PIC	4.31E-10 (Note 2)	2.15E-15
832-69-9	1-Methylphenanthrene	PIC	7.07E-11	3.54E-16
85-44-9	Phthalic anhydride (1,2-benzenedicarboxylic anhydride)	PIC	4.31E-10 (Note 2)	2.15E-15
87-61-6	1,2,3-Trichlorobenzene	PIC	4.31E-10 (Note 2)	2.15E-15
88-74-4	o-Nitroaniline (2-nitroaniline)	PIC	4.31E-10 (Note 2)	2.15E-15
90-04-0	o-Anisidine	PIC	4.31E-10 (Note 2)	2.15E-15
90-12-0	1-Methylnaphthalene	PIC	4.31E-10 (Note 2)	2.15E-15
91-22-5	Quinoline	PIC	4.31E-10 (Note 2)	2.15E-15
91-57-6	2-Methylnaphthalene	PIC	4.31E-10 (Note 2)	2.15E-15
91-94-1	3,3'-Dichlorobenzidine	PIC	1.26E-09	6.29E-15
924-16-3	N-Nitroso-di-n-Buetylamine	PIC	4.31E-10 (Note 2)	2.15E-15
94-59-7	Safrole (5-(2-Propenyl)-1,3-benzodioxole)	PIC	4.31E-10 (Note 2)	2.15E-15
94-75-7	2,4-D	PIC	1.24E-10	6.22E-16
95-49-8	o-Chlorotoluene	PIC	4.31E-10 (Note 2)	2.15E-15
95-53-4	o-Toluidine	PIC	4.31E-10 (Note 2)	2.15E-15
95-63-6	1,2,4-Trimethyl benzene	PIC	4.31E-10 (Note 2)	2.15E-15
95-94-3	1,2,4,5-Tetrachlorobenzene	PIC	4.31E-10 (Note 2)	2.15E-15
96-12-8	1,2-Dibromo-3-chloropropane	PIC	4.31E-10 (Note 2)	2.15E-15
96-18-4	1,2,3-Trichloropropane	PIC	4.31E-10 (Note 2)	2.15E-15
96-45-7	Ethylene thiourea	PIC	4.31E-10 (Note 2)	2.15E-15
97-63-2	Ethyl methacrylate	PIC	4.31E-10 (Note 2)	2.15E-15
98-01-1	Furfural	PIC	4.31E-10 (Note 2)	2.15E-15
98-06-6	tert-Butyl benzene	PIC	4.31E-10 (Note 2)	2.15E-15
98-07-7	Benzotrichloride	PIC	4.31E-10 (Note 2)	2.15E-15
98-83-9	Methyl styrene (mixed isomers)	PIC	4.31E-10 (Note 2)	2.15E-15
99-35-4	1,3,5-Trinitrobenzene	PIC	1.95E-11	9.76E-17
99-65-0	1,3-Dinitrobenzene	PIC	4.31E-10 (Note 2)	2.15E-15
99-87-6	p-Cymene	PIC	4.31E-10 (Note 2)	2.15E-15
105-67-9	2,4-Dimethylphenol	PIC	4.31E-10 (Note 2)	2.15E-15
		Total	6.99E-08	3.50E-13
100-02-7	p-Nitrophenol	Feed/PIC	Note 1	
100-42-5	Styrene	Feed/PIC		
106-46-7	1,4-Dichlorobenzene	Feed/PIC		
107-06-2	1,2-Dichloroethane	Feed/PIC		
107-13-1	Acrylonitrile	Feed/PIC		
108-88-3	Toluene	Feed/PIC		
108-90-7	Chlorobenzene	Feed/PIC		
108-95-2	Phenol	Feed/PIC		
117-81-7	bis(2-Ethylhexyl)phthalate	Feed/PIC		
120-12-7	Anthracene	Feed/PIC		
121-14-2	2,4-Dinitrotoluene	Feed/PIC		
129-00-0	Pyrene	Feed/PIC		
1330-20-7	Xylenes (total)	Feed/PIC		
191-24-2	Benzo(g,h,i)perylene	Feed/PIC		
193-39-5	Indeno(1,2,3-cd)pyrene	Feed/PIC		
206-44-0	Fluoranthene	Feed/PIC		
208-96-8	Acenaphthylene	Feed/PIC		
53-70-3	Dibenz[a,h]anthracene	Feed/PIC		
56-23-5	Carbon tetrachloride	Feed/PIC		
67-64-1	2-Propanone (Acetone)	Feed/PIC		
67-66-3	Chloroform	Feed/PIC		
71-43-2	Benzene	Feed/PIC		
74-83-9	Bromomethane	Feed/PIC		
74-87-3	Chloromethane	Feed/PIC		

CALCULATION SHEET

PROJECT: RPP-WTP

JOB NO.: 24590

CALC NO.: 24590-BOF-M4C-DEP-00001

SHEET REV: B

SHEET NO.: 116

BY: William Hix

DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

CAS #	COPC	PIC or Feed/PIC	Unabated Streams	Abated Streams
			DEP15	DEP18
			DEP Vessel Vent	DEP Vessel Vent
			Particulate	Particulate
			g/sec	g/sec
75-05-8	Acetonitrile	Feed/PIC		
75-09-2	Dichloromethane (Methylene Chloride)	Feed/PIC		
75-15-0	Carbon disulfide	Feed/PIC		
78-93-3	2-Butanone	Feed/PIC		
79-01-6	1,1,2-Trichloroethylene	Feed/PIC		
83-32-9	Acenaphthene	Feed/PIC		
84-66-2	Diethyl phthalate	Feed/PIC		
84-74-2	Di-n-butylphthalate	Feed/PIC		
85-68-7	Butylbenzylphthalate	Feed/PIC		
86-73-7	Fluorene	Feed/PIC		
88-75-5	2-Nitrophenol	Feed/PIC		
91-20-3	Naphthalene	Feed/PIC		
98-86-2	Acetophenone	Feed/PIC		
98-95-3	Nitrobenzene	Feed/PIC		

Note 1: Particulate emissions of Organic COPCs that are present in both the feed and as a PIC will be reported with the Organic COPC results. If a Feed/PIC COPC has estimated particulate emissions using both the PIC emissions methodology and the feed organics methodology then the emissions estimate will be the sum of the results from the two methods.

Note 2: For PIC COPCs that are emitted as vapor phase type, the emissions reported as particulate represent the adjusted emissions rate assigned per Assumption 6.2.27 based on the average non-zero unabated PIC COPC particulate emissions rate.

CALCULATION SHEET

PROJECT: RPP-WTP

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DATE: 6/6/2016

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

Table 8-6 – Inorganic COPC Emissions from DVP System

CAS #	COPC	Unabated Streams	Abated Streams
		DEP15	DEP18
		DEP Vessel Vent	DEP Vessel Vent
		g/sec	g/sec
7440-22-4	Ag	1.92E-07	9.59E-13
7429-90-5	Al	2.12E-04	1.06E-09
7440-38-2	As	2.64E-07	1.32E-12
7440-39-3	Ba	4.56E-07	2.28E-12
7440-41-7	Be	2.39E-08	1.20E-13
24959-67-9	Br	5.36E-07	2.68E-12
7440-43-9	Cd	4.06E-07	2.03E-12
16887-00-6	Cl	2.02E-05	1.01E-10
57-12-5	CN ^(c)	1.26E-04	1.26E-04
7440-48-4	Co	8.02E-08	4.01E-13
7440-47-3	Cr	1.44E-05	7.20E-11
7440-50-8	Cu	1.46E-07	7.28E-13
16984-48-8	F	3.14E-05	1.57E-10
7439-89-6	Fe	3.09E-05	1.54E-10
7439-97-6	Hg	1.48E-07	7.38E-13
7439-93-2	Li	1.00E-07	5.01E-13
7439-95-4	Mg	1.13E-06	5.67E-12
7439-96-5	Mn	4.02E-06	2.01E-11
7439-98-7	Mo	3.35E-07	1.68E-12
7440-23-5	Na	1.21E-03	6.04E-09
7664-41-7	NH3 ^(c)	1.01E-01	1.01E-01
7440-02-0	Ni	2.41E-06	1.20E-11
14797-65-0	NO2	2.90E-04	1.45E-09
14797-55-8	NO3	1.36E-03	6.81E-09
7723-14-0	P	0.00E+00	0.00E+00
7439-92-1	Pb	2.01E-06	1.01E-11
14265-44-2	PO4	1.26E-04	6.29E-10
7440-16-6	Rh	3.02E-07	1.51E-12
7704-34-9	S	0.00E+00	0.00E+00
7440-36-0	Sb	2.08E-07	1.04E-12
7782-49-2	Se	2.94E-07	1.47E-12
7440-31-5	Sn	2.83E-07	1.41E-12
14808-79-8	SO4	9.39E-05	4.69E-10
7440-24-6	Sr	1.03E-06	5.16E-12
7440-25-7	Ta	9.83E-08	4.92E-13
7440-28-0	Tl	7.63E-07	3.81E-12
7440-61-1	UTOTAL	1.57E-05	7.87E-11
7440-62-2	V	1.33E-07	6.63E-13
7440-33-7	W	2.06E-06	1.03E-11
7440-65-5	Y	8.18E-08	4.09E-13
7440-66-6	Zn	2.87E-07	1.43E-12
7440-67-7	Zr	9.97E-06	4.98E-11
593-74-8	Dimethyl Mercury ^(c)	5.29E-07	5.29E-07
10102-44-0	Nitrogen dioxide ^(a)	0.00E+00	0.00E+00
124-38-9	Carbon dioxide ^(a)	0.00E+00	0.00E+00
630-08-0	Carbon monoxide ^(a)	0.00E+00	0.00E+00
10028-15-6	Ozone ^(a)	0.00E+00	0.00E+00
7446-09-5	Sulfur dioxide ^(a)	0.00E+00	0.00E+00
7647-01-0	Hydrogen chloride ^(a)	0.00E+00	0.00E+00
7664-39-3	Hydrogen Fluoride ^(a)	0.00E+00	0.00E+00
7782-41-4	Fluorine gas ^(a)	0.00E+00	0.00E+00
7782-50-5	Chlorine ^(a)	0.00E+00	0.00E+00
22967-92-6	Methyl mercury ^(b)	0.00E+00	0.00E+00
	TOTAL	1.04E-01	1.01E-01

(a) Emissions of these stack inorganic COPCs are zero (Assumption 6.1.31).

(b) Methyl mercury emissions are grouped with total mercury emissions (Assumption 6.2.25)

(c) COPCs emitted in vapor phase

Table 8-7 – Total Particulate Emissions from DVP System

	Unabated Streams	Abated Streams
	DEP15	DEP18
	DEP Vessel Vent	DEP Vessel Vent
	g/sec	g/sec
Feed Inorganic Particulate	3.43E-03	1.72E-08
Radionuclide Particulate	1.72E-05	8.60E-11
Feed Organic Particulate	6.23E-08	3.12E-13
PIC Particulate	6.99E-08	3.50E-13
TOTAL Particulate	3.45E-03	1.73E-08

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Table 8-8 – Summary of COPC Unabated Emissions Exceeding De Minimis Values

CAS #	COPC	De minimis emissions limit for COPC <i>i</i> , standardized to lb/yr	Feed Organic COPCs - Total Unabated Emissions of COPC <i>i</i> , in lb/yr	Difference: Feed Organic COPC minus de minimis, in lb/yr
91-20-3	Naphthalene	2.82E-01	3.68E+00	3.40E+00
621-64-7	n-Nitrosodi-n-propylamine	4.80E-03	3.40E-02	2.92E-02
1336-36-3	Polychlorinated Biphenyls, NOS	1.68E-02	1.80E+00	1.79E+00
56-49-5	3-Methylcholanthrene	1.53E-03	1.17E+00	1.17E+00
3697-24-3	5-Methylchrysene	8.72E-03	1.17E+00	1.16E+00
602-87-9	5-Nitroacenaphthene	2.59E-01	1.17E+00	9.14E-01
60-35-5	Acetamide	4.80E-01	1.17E+00	6.93E-01
75-27-4	Bromodichloromethane	2.59E-01	1.17E+00	9.14E-01
72-55-9	DDE	9.88E-02	1.17E+00	1.07E+00
117-81-7	Di(2-ethylhexyl)phthalate	4.00E-01	1.17E+00	7.73E-01
226-36-8	Dibenz[a,h]acridine	8.72E-02	1.17E+00	1.09E+00
224-42-0	Dibenz[a,j]acridine	8.72E-02	1.17E+00	1.09E+00
192-65-4	Dibenzo[a,e]pyrene	8.72E-03	1.17E+00	1.16E+00
189-64-0	Dibenzo[a,h]pyrene	8.72E-04	1.17E+00	1.17E+00
189-55-9	Dibenzo[a,i]pyrene	8.72E-04	1.17E+00	1.17E+00
191-30-0	Dibenzo[a,l]pyrene	8.72E-04	1.17E+00	1.17E+00
193-39-5	Indeno[1,2,3-cd]pyrene	8.72E-02	1.17E+00	1.09E+00
10595-95-6	n-Nitroso-n-methylethylamine	1.53E-03	1.17E+00	1.17E+00
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	5.05E-07	1.70E-06	1.19E-06
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	2.52E-06	2.84E-06	3.21E-07
7664-41-7	Ammonia	1.70E+02	7.00E+03	6.83E+03
7440-43-9	Cadmium & Compounds	2.28E-03	2.82E-02	2.59E-02
18540-29-9	Chromium (VI)	6.40E-05	1.00E+00	1.00E+00
593-74-8	Dimethyl mercury	3.65E-97	3.67E-02	3.67E-02

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9 Tracked References

- 9.1 24590-WTP-RPT-ENV-10-001, Rev. 0 – *Constituents of Potential Concern for the WTP Air and Dangerous Waste Permits*
- 9.2 24590-WTP-RPT-ENV-16-001, Rev. 0 – *Feed Vector Development in Support of WTP Environmental Risk Assessment Activities*
- 9.3 24590-WTP-ICD-MG-01-030, Rev. 0 - *ICD 30 – Interface Control Document for Direct LAW Feed*
- 9.4 CCN 129507, Rev. N/A - *Update 2: Vapor Phase Partitioning Coefficients*
- 9.5 24590-BOF-M5-V17T-00011, Rev. 0 - *Process Flow Diagram Direct Feed Effluent Transfer (System DEP)*
- 9.6 24590-BOF-M5-V17T-00012, Rev. 0 - *Process Flow Diagram Direct Feed Effluent Evaporator (System DEP)*
- 9.7 24590-BOF-M5-V17T-00013, Rev. 0 - *Process Flow Diagram Direct Feed Concentrate Transfer (System DEP)*
- 9.8 24590-BOF-M5-V17T-00014, Rev. 0 - *Process Flow Diagram Direct Feed Process Condensate Transfer (System DEP)*
- 9.9 24590-WTP-RPT-ENV-01-004, Rev. 1 – *Best Available Radionuclide Control Technology Analysis for the WTP*
- 9.10 24590-BOF-MVC-DEP-00009, Rev. B - *Batch Sizing Calculation of DEP (Direct Feed LAW Effluent Management Facility Process System) Vessels: DEP-VSL-00001, -00002, -00003A/B/C, -00004A/B, -00005A/B*
- 9.11 24590-BOF-M6C-DVP-00001, Rev. A - *DFLAW EMF Vessel Vent Process System (DVP) Line Sizing*
- 9.12 24590-WTP-RPT-ENV-01-008, Rev. 4 - *Radioactive Air Emissions Notice of Construction Permit Application for the Hanford Tank Waste Treatment and Immobilization Plant*
- 9.13 24590-WTP-HAC-50-00005, Rev. D - *Calculations for Annual Possession Quantity, Emission Rates, and Dose Rate Estimates for Pretreatment, LAW Vitrification, and HLW Vitrification Plants Supporting Air Permitting Activities*
- 9.14 24590-WTP-RPT-PO-03-008, Rev. 2 – *Integrated Emissions Baseline Report for the Hanford Tank Waste Treatment and Immobilization Plant*
- 9.15 24590-WTP-RPT-PE-11-010, Rev. 0 – *WTP Feed and Organic Generation Rates and Decontamination Factors for 2011-2012 Emissions Report*

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- 9.16 24590-PTF-3YD-CNP-00001, Rev. 2 – *System Description for the Cesium Nitric Acid Recovery Process – System CNP*
- 9.17 24590-BOF-MEC-DEP-00001, Rev. A - *DFLAW EMF Process System (DEP) Evaporator Operating Conditions, Heating/Cooling Duty, and Utility Requirements*
- 9.18 24590-WTP-M3C-50-00001, Rev. 1 – *Physical Properties Equations for Liquid Water*
- 9.19 24590-WTP-M4C-V37T-00011, Rev. 0, *FEP and TLP Evaporator and Condensers Decontamination Factor Calculation*
- 9.20 24590-LAW-MVC-RLD-00007, Rev. 0 - *Process Data Input for LAW SBS Condensate Collection Vessel, RLD-VSL-00005 and Discharge Pumps (RLD-PMP-00003A/B)*
- 9.21 24590-LAW-MVC-RLD-00009, Rev. 0 - *Process Data Input for LAW C3/C5 Drains/Sump Collection Vessel (RLD-VSL-00004) and Transfer Pumps (RLD-PMP-00002A/B) as modified by the following ECCNs:*
- (1) 24590-LAW-MVE-RLD-00001 - *Change to Safety Factor Value for the High Humidity Case Listed in Calculation 24590-LAW-MVC-RLD-00009*
 - (2) 24590-LAW-MVE-RLD-00002 - *Provide Adequate and Proper Verification on document 24590-LAW-MVC-RLD-00009*
- 9.22 24590-WTP-DB-PET-09-001, Rev. 1 - *Process Inputs Basis of Design (PIBOD)*
- 9.23 24590-WTP-M4C-V11T-00012, Rev. 2 – *Calculation of Process Stream Properties for the WTP*
- 9.24 CCN 160522, Rev. N/A - *SRNL Letter "Input for Dimethylmercury Formation and Partitioning"*
- 9.25 24590-WTP-M4C-V11T-00013, Rev. A – *Estimated Concentrations of Dimethylmercury in WTP Process Streams*
- 9.26 24590-LAW-MVC-LVP-00001, Rev. 2, *Sizing Calculation for Caustic Collection Tank LVP-TK-00001*
- 9.27 24590-BOF-MVC-DEP-00011, Rev. B - *Process Data for the Low Point Drain Vessel, DEP-VSL-00001, and Pumps, DEP-PMP-00001A/B*
- 9.28 24590-PTF-MEC-CNP-00004, Rev. B – *Loop Volume Calculation for CNP Evaporator Recirculation Loop*
- 9.29 24590-WTP-RPT-PR-01-011, Rev. 0 – *Mercury Pathway and Treatment Assessment for the WTP*
- 9.30 24590-WTP-CSER-ENS-08-0001, Rev. 0b – *Preliminary Criticality Safety Evaluation Report for the WTP*
- 9.31 24590-BOF-MVC-DEP-00003, Rev. A - *Process Data for the Evaporator Feed Vessel (DEP-VSL-00002), Transfer Pumps (DEP-PMP-00002A/B), and Recirculation Pumps (DEP-PMP-00012A/B/C)*
- 9.32 24590-BOF-MVC-DEP-00010, Rev. A - *Process Data for the Evaporator Concentrate Vessels, DEP-VSL-00003A/B/C, and Pumps, DEP-PMP-00003A/B*

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- 9.33 24590-BOF-MVC-DEP-00007, Rev. A - *Process Data for the Overhead Sampling Vessels (DEP-VSL-00004A/B) and Pumps (DEP-PMP-00004A/B/C)*
- 9.34 24590-BOF-MVC-DEP-00008, Rev. A - *Process Data for the Process Condensate Lag Storage Vessels (DEP-VSL-00005A/B), Transfer Pumps (DEP-PMP-00005A/B), and Recirculation Pumps (DEP-PMP-00015A/B/C)*
- 9.35 24590-PTF-3YD-TLP-00001, Rev. 2 - *System Description for the Treated LAW Evaporation Process (TLP)*
- 9.36 24590-BOF-M8-C3V-00002001, Rev. A - *BOF/EMF Utility/Process Bldgs - Plant Room V&ID ACV Exhaust System*
- 9.37 24590-CM-HC4-W000-00193-01-00001, Rev. A, Report - *Aerosol Production in WTP Process Vessels - A Review of Recent Aerosol Testing*

10 References

- 10.1 *Risk Assessment Information System*. Oak Ridge National Laboratory. http://rais.ornl.gov/cgi-bin/tools/TOX_search?select=rad_spef (Accessed 05/27/2016, see Attachment B).
- 10.2 DOE-HDBK-3010-94 - *DOE Handbook Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities Volume I - Analysis of Experimental Data*. Department of Energy. December 1994, Reaffirmed 2013.
- 10.3 Lindeburg, Michael R. 2013. *Chemical Engineering Reference Manual for the PE Exam*. Seventh Edition. Professional Publications, Inc., Belmont, CA.
- 10.4 DOE 2000. DOE Contract, DE-AC27-01RV14136, US Department of Energy, Office of River Protection, Richland, WA, USA.
- 10.5 *Flow of Fluids through Valves, Fittings, and Pipe*, Crane Co., Technical Paper No. 410. 2011.
- 10.6 Nudat 2.6. National Nuclear Data Center, Brookhaven National Laboratory. <http://www.nndc.bnl.gov/nudat2/> (Accessed 05/27/2016, see Attachment D).
- 10.7 Washington Administrative Code (WAC) 173-460-150 - *Table of ASIL, SQER and de minimis emission values*.
- 10.8 Washington Administrative Code (WAC) 246-247-030 - *Definitions*.
- 10.9 Sander, Rolf. 1999. *Compilation of Henry's Law Constants for Inorganic and Organic Species of Potential Importance in Environmental Chemistry*. Max-Planck Institute of Chemistry. Mainz, Germany. <http://www.henrys-law.org/henry-3.0.pdf> (Accessed 05/27/2016)
- 10.10 Adamson D, Nash C, McCabe D, et al. 2014. SRNL-STI-2013-00713, Rev. 0, *Laboratory Evaporation Testing of Hanford Waste Treatment Plant Low Activity Waste Off-Gas Condensate Simulant*. Savannah

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<http://www.chemspider.com/Chemical-Structure.217.html?rid=b473eee8-4999-4b4a-85a9-c50b710ea68d>
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11 Attachments

Attachment A - WTP COPCs Complete List

Attachment B - Radionuclide COPC Specific Activities

Attachment C – Media File 24590-RMCD-04955

Attachment D - Extracted Radionuclide Properties from NuDat 2.6 Database (Ref. 10.6)

Attachment E - Phase Emissions Sensitivity Analysis for ^{14}C and ^3H

Attachment F - Stream Properties Extracted from PIBOD Runs

Attachment G - DFLAW Bounding Feed Vector Batch Properties

Attachment A - WTP COPCs Complete List

The following tables list the chemicals and radionuclides considered COPCs for WTP per Ref. 9.1 Table 2-1.

Table A-1 – WTP Radionuclide COPCs

CAS #	COPC
13967-48-1	106Ru
378253-44-2	113mCd
14234-35-6	125Sb
15832-50-5	126Sn
15046-84-1	129I
13967-70-9	134Cs
10045-97-3	137Cs
378253-40-8	137mBa
14762-75-5	14C
15715-94-3	151Sm
14683-23-9	152Eu
15585-10-1	154Eu
14391-16-3	155Eu
13982-63-3	226Ra
14952-40-0	227Ac
15262-20-1	228Ra
15594-54-4	229Th
14331-85-2	231Pa
7440-29-1	232Th
14158-29-3	232U
13968-55-3	233U
13966-29-5	234U
15117-96-1	235U
13982-70-2	236U
13994-20-2	237Np
13981-16-3	238Pu
7440-61-1R	238U
15117-48-3	239Pu
14119-33-6	240Pu
14596-10-2	241Am
14119-32-5	241Pu
15510-73-3	242Cm
13982-10-0	242Pu
14993-75-0	243Am
15757-87-6	243Cm
13981-15-2	244Cm
10028-17-8	3H
14336-70-0	59Ni
10198-40-0	60Co
13981-37-8	63Ni
15758-45-9	79Se
10098-97-2	90Sr
10098-91-6	90Y
378782-82-2	93mNb
15751-77-6	93Zr
14133-76-7	99Tc

Table A-2 – WTP Organic COPCs

CAS #	COPC	Feed Organic	PIC	Feed/PIC ^(a)
630-20-6	1,1,1,2-Tetrachloroethane	X		
71-55-6	1,1,1-Trichloroethane	X		
79-34-5	1,1,2,2-Tetrachloroethane	X		
127-18-4	Tetrachloroethene	X		
79-00-5	1,1,2-Trichloroethane	X		
79-01-6	Trichloroethene			X
92-52-4	Biphenyl	X		
75-34-3	1,1-Dichloroethane	X		
75-35-4	1,1-Dichloroethene	X		
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	X		
120-82-1	1,2,4-Trichlorobenzene	X		
95-50-1	1,2-Dichlorobenzene	X		
107-06-2	1,2-Dichloroethane			X
78-87-5	1,2-Dichloropropane	X		
106-88-7	1,2-Epoxybutane	X		
156-60-5	1,2-trans-Dichloroethene	X		
106-99-0	1,3-Butadiene	X		
541-73-1	1,3-Dichlorobenzene	X		
106-46-7	1,4-Dichlorobenzene			X
123-91-1	1,4-Dioxane	X		
75-01-4	Vinyl chloride	X		
58-90-2	2,3,4,6-Tetrachlorophenol	X		
95-95-4	2,4,5-Trichlorophenol	X		
88-06-2	2,4,6-Trichlorophenol	X		
120-83-2	2,4-Dichlorophenol	X		
121-14-2	2,4-Dinitrotoluene			X
128-37-0	2,6-Bis(1,1-dimethylethyl)-4-methylphenol	X		
78-93-3	2-Butanone			X
111-76-2	2-Butoxyethanol	X		
91-58-7	2-Chloronaphthalene	X		
95-57-8	2-Chlorophenol	X		
110-80-5	2-Ethoxyethanol	X		
104-76-7	2-Ethyl-1-hexanol	X		
591-78-6	2-Hexanone	X		
126-98-7	2-Methyl-2-propenenitrile	X		
78-83-1	Isobutanol	X		
88-75-5	2-Nitrophenol			X
79-46-9	2-Nitropropane	X		
67-64-1	Acetone			X
79-10-7	2-Propenoic acid	X		
67-63-0	Isopropyl alcohol	X		
107-05-1	3-Chloropropene	X		
589-38-8	3-Hexanone	X		
56-49-5	3-Methylcholanthrene	X		
72-55-9	4,4-DDE	X		
101-55-3	4-Bromophenylphenyl ether	X		
59-50-7	4-Chloro-3-methylphenol	X		
100-40-3	4-Ethenylcyclohexene	X		
108-10-1	Hexone	X		
3697-24-3	5-Methylchrysene	X		
602-87-9	5-Nitroacenaphthene	X		
83-32-9	Acenaphthene			X
208-96-8	Acenaphthylene			X

CAS #	COPC	Feed Organic	PIC	Feed/PIC ^(*)
75-07-0	Acetaldehyde	X		
60-35-5	Acetamide	X		
141-78-6	Ethyl acetate	X		
108-05-4	vinyl acetate	X		
75-05-8	Acetonitrile			X
98-86-2	Acetophenone			X
107-02-8	Acrolein	X		
107-13-1	Acrylonitrile			X
134-32-7	alpha-Naphthylamine	X		
120-12-7	Anthracene			X
71-43-2	Benzene			X
50-32-8	Benzo(a)pyrene	X		
191-24-2	Benzo(ghi)perylene			X
117-81-7	Bis(2-ethylhexyl)phthalate			X
75-27-4	Bromodichloromethane	X		
74-83-9	Bromomethane			X
123-72-8	Butanal	X		
85-68-7	Butylbenzylphthalate			X
56-23-5	Carbon tetrachloride			X
108-90-7	Chlorobenzene			X
75-45-6	Chlorodifluoromethane	X		
75-00-3	Chloroethane	X		
67-66-3	Chloroform			X
74-87-3	Chloromethane			X
10061-01-5	cis-1,3-Dichloropropene	X		
108-39-4	m-Cresol	X		
95-48-7	2-Methylphenol	X		
98-82-8	Isopropylbenzene	X		
110-82-7	Cyclohexane	X		
108-94-1	Cyclohexanone	X		
226-36-8	Dibenz[a,h]acridine	X		
53-70-3	Dibenz[a,h]anthracene			X
224-42-0	Dibenz[a,j]acridine	X		
191-30-0	Dibenzo(a,l)pyrene	X		
192-65-4	Dibenzo[a,e]pyrene	X		
189-64-0	Dibenzo[a,h]pyrene	X		
189-55-9	Dibenzo[a,i]pyrene	X		
75-71-8	Dichlorodifluoromethane	X		
75-09-2	Methylenechloride			X
84-66-2	Diethylphthalate			X
84-74-2	Di-n-butylphthalate			X
117-84-0	Di-n-octylphthalate	X		
100-41-4	Ethylbenzene	X		
60-29-7	Ethyl ether	X		
106-93-4	Ethylene dibromide	X		
75-21-8	Ethylene oxide (Oxirane)	X		
206-44-0	Fluoranthene			X
86-73-7	Fluorene			X
75-02-5	Fluoroethene (vinyl fluoride)	X		
50-00-0	Formaldehyde	X		
87-68-3	Hexachlorobutadiene	X		
67-72-1	Hexachloroethane	X		
628-73-9	Hexanenitrile	X		
193-39-5	Indeno(1,2,3-cd)pyrene			X

CAS #	COPC	Feed Organic	PIC	Feed/PIC ^(a)
67-56-1	Methyl alcohol	X		
1634-04-4	tert-Butyl methyl ether	X		
122-39-4	Diphenyl amine	X		
91-20-3	Naphthalene			X
109-74-0	Butanenitrile	X		
71-36-3	1-Butanol	X		
110-54-3	Hexane	X		
98-95-3	Nitrobenzene			X
621-64-7	N-Nitroso-di-n-propylamine	X		
10595-95-6	N-Nitrosomethylethylamine	X		
59-89-2	Morpholine, 4-Nitroso-	X		
62-75-9	N-Nitrosodimethylamine	X		
87-86-5	Pentachlorophenol	X		
110-59-8	Pentanenitrile	X		
85-01-8	Phenanthrene	X		
108-95-2	Phenol			X
100-21-0	Phthalic acid	X		
100-02-7	4-Nitrophenol			X
1336-36-3	Aroclors (Total PCB)	X		
107-12-0	Propionitrile	X		
129-00-0	Pyrene			X
110-86-1	Pyridine	X		
100-42-5	Styrene			X
108-88-3	Toluene			X
10061-02-6	trans-1,3-Dichloropropene	X		
126-73-8	Tributyl phosphate	X		
27154-33-2	Trichlorofluoroethane	X		
75-69-4	Trichlorofluoromethane	X		
75-50-3	Trimethylamine	X		
1330-20-7	Xylenes (total)			X
75-15-0	Carbon disulfide			X
100-25-4	1,4-Dinitrobenzene		X	
100-44-7	Benzyl chloride		X	
100-47-0	Benzonitrile		X	
100-51-6	Benzyl alcohol		X	
100-52-7	Benzaldehyde		X	
101-77-9	4,4-Methylenedianiline		X	
103-33-3	Azobenzene		X	
103-65-1	n-Propyl benzene (Isocumene)		X	
104-51-8	n-Butylbenzene		X	
106-43-4	4-Chlorotoluene (p-Tolyl chloride)		X	
106-44-5	p-Cresol (4-methyl phenol)		X	
106-47-8	p-Chloroaniline		X	
106-49-0	p-Toluidine		X	
106-51-4	Quinone		X	
106-89-8	Epichlorohydrin (1-chloro-2,3 epoxypropane)		X	
107-19-7	Propargyl alcohol		X	
107-21-1	Ethylene glycol (1,2-ethanediol)		X	
107-98-2	Propylene glycol monomethyl ether		X	
108-60-1	bis (2-Chloroisopropyl)ether		X	
108-67-8	1,3,5-Trimethylbenzene		X	
108-86-1	Bromobenzene (Phenyl bromide)		X	
108-87-2	Methylcyclohexane		X	
109-75-1	3-Butenenitrile		X	

CAS #	COPC	Feed Organic	PIC	Feed/PIC ^(a)
109-77-3	Malononitrile		X	
109-86-4	2-Methoxyethanol		X	
109-99-9	Tetrahydrofuran		X	
110-00-9	Furan		X	
110-83-8	Cyclohexene		X	
111-15-9	Ethylene glycol monoethyl ether acetate		X	
111-44-4	Bis(2-chloroethyl)ether		X	
111-65-9	n-Octane		X	
111-84-2	n-Nonane		X	
111-91-1	Bis(2-chloroethoxy)methane		X	
1120-21-4	Undecane		X	
1120-71-4	1,3-Propane sultone		X	
112-30-1	1-Decanol		X	
112-31-2	Decanal		X	
112-40-3	Dodecane		X	
118-74-1	Hexachlorobenzene		X	
119-90-4	3,3'-Dimethoxybenzidine		X	
122-66-7	1,2-Diphenylhydrazine		X	
123-33-1	Maleic hydrazide		X	
123-38-6	Propionaldehyde		X	
124-18-5	Decane		X	
124-48-1	Chlorodibromomethane		X	
131-11-3	Dimethyl Phthalate		X	
131-89-5	2-Cyclohexyl-4,6-dinitrophenol		X	
132-64-9	Dibenzofuran		X	
133-06-2	Captan		X	
135-98-8	sec-Butylbenzene		X	
145-73-3	Endothall		X	
156-59-2	cis-1,2-Dichloroethene		X	
1746-01-6	2,3,7,8-Tetrachlorodibenzo(p)dioxin (TCDD)		X	
192-97-2	Benzo(e)pyrene		X	
19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo(p)dioxin		X	
205-82-3	Benzo[j]fluoranthene		X	
205-99-2	Benzo(b)fluoranthene		X	
207-08-9	Benzo(k)fluoranthene		X	
218-01-9	Chrysene		X	
2245-38-7	2,3,5-Trimethylnaphthalene		X	
23950-58-5	Pronamide		X	
31508-00-6	2,3',4,4',5-Pentachlorobiphenyl (PCB 118)		X	
319-84-6	alpha-BHC		X	
319-85-7	beta-BHC		X	
32598-13-3	3,3',4,4'-Tetrachlorobiphenyl (PCB 77)		X	
32598-14-4	2,3,3',4,4'-Pentachlorobiphenyl (PCB 105)		X	
3268-87-9	Octachlorodibenzo(p)dioxin		X	
32774-16-6	3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)		X	
35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo(p)dioxin		X	
38380-08-4	2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)		X	
39001-02-0	Octachlorodibenzofuran		X	
39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo(p)dioxin		X	
39635-31-9	2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)		X	
40321-76-4	1,2,3,7,8-Pentachlorodibenzo(p)dioxin		X	
4170-30-3	Crotonaldehyde (Propylene aldehyde)		X	
41851-50-7	Chlorocyclopentadiene		X	
460-19-5	Cyanogen (oxalonitrile)		X	

CAS #	COPC	Feed Organic	PIC	Feed/PIC ^(a)
4786-20-3	2-Butenenitrile		X	
506-68-3	Cyanogen bromide (bromocyanide)		X	
506-77-4	Cyanogen chloride		X	
510-15-6	Chlorobenzilate		X	
51207-31-9	2,3,7,8-Tetrachlorodibenzofuran		X	
51-28-5	2,4-Dinitrophenol		X	
51-79-6	Ethyl carbamate (urethane)		X	
52663-72-6	2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)		X	
528-29-0	1,2-Dinitrobenzene (o-Dinitrobenzene)		X	
532-27-4	2-Chloroacetophenone		X	
534-52-1	4,6-Dinitro-o-cresol		X	
5385-75-1	Dibenzo(a,e)fluoranthene		X	
540-59-0	1,2-Dichloroethene (total) (1,2-Dichloroethylene)		X	
540-73-8	1,2-Dimethylhydrazine		X	
540-84-1	2,2,4-Trimethylpentane		X	
542-75-6	1,3-Dichloropropene		X	
542-88-1	Bis(chloromethyl)ether		X	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran		X	
56-55-3	Benzo(a)anthracene		X	
57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran		X	
57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran		X	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran		X	
57-24-9	Strychnine		X	
57465-28-8	3,3',4,4',5-Pentachlorobiphenyl (PCB 126)		X	
57653-85-7	1,2,3,6,7,8,-Hexachlorodibenzo(p)dioxin		X	
57-74-9	Chlordane		X	
581-42-0	2,6-Dimethylnaphthalene		X	
584-84-9	2,4-Toluene diisocyanate		X	
58-89-9	gamma-BHC (Lindane)		X	
591-50-4	Benzene, iodo-		X	
593-60-2	Bromoethene (Vinyl bromide)		X	
60-11-7	Dimethyl aminoazobenzene		X	
606-20-2	2,6-Dinitrotoluene		X	
60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran		X	
608-93-5	Pentachlorobenzene		X	
61626-71-9	Dichloropentadiene		X	
624-83-9	Methyl isocyanate		X	
62-50-0	Ethyl methanesulfonate		X	
62-53-3	Aniline		X	
64-18-6	Formic acid (methanoic acid)		X	
65510-44-3	2',3,4,4',5-Pentachlorobiphenyl (PCB 123)		X	
65-85-0	Benzoic acid		X	
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran		X	
69782-90-7	2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)		X	
70-30-4	Hexachlorophene		X	
70362-50-4	3,4,4',5-Tetrachlorobiphenyl (PCB 81)		X	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran		X	
72-43-5	Methoxychlor		X	
72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran		X	
74472-37-0	2,3,4,4',5-Pentachlorobiphenyl (PCB 114)		X	
74-88-4	Iodomethane		X	
74-95-3	Methylene bromide		X	
74-97-5	Bromochloromethane		X	
75-25-2	Bromoform		X	

CAS #	COPC	Feed Organic	PIC	Feed/PIC ^(a)
75-29-6	2-Chloropropane		X	
75-44-5	Phosgene (hydrogen phosphide)		X	
76-01-7	Pentachloroethane		X	
764-41-0	1,4-Dichloro-2-butene		X	
76-44-8	Heptachlor		X	
765-34-4	Glycidylaldehyde		X	
77-47-4	Hexachlorocyclopentadiene		X	
77-78-1	Dimethyl sulfate		X	
80-62-6	Methyl methacrylate		X	
822-06-0	Hexamethylene-1,5-diisocyanate		X	
823-40-5	Toluene-2,6-diamine		X	
82-68-8	Pentachloronitrobenzene (PCNB)		X	
832-69-9	1-Methylphenanthrene		X	
85-44-9	Phthalic anhydride (1,2-benzenedicarboxylic anhydride)		X	
87-61-6	1,2,3-Trichlorobenzene		X	
88-74-4	o-Nitroaniline (2-nitroaniline)		X	
90-04-0	o-Anisidine		X	
90-12-0	1-Methylnaphthalene		X	
91-22-5	Quinoline		X	
91-57-6	2-Methylnaphthalene		X	
91-94-1	3,3'-Dichlorobenzidine		X	
924-16-3	N-Nitroso-di-n-Buetylamine		X	
94-59-7	Safrole (5-(2-Propenyl)-1,3-benzodioxole)		X	
94-75-7	2,4-D		X	
95-49-8	o-Chlorotoluene		X	
95-53-4	o-Toluidine		X	
95-63-6	1,2,4-Trimethyl benzene		X	
95-94-3	1,2,4,5-Tetrachlorobenzene		X	
96-12-8	1,2-Dibromo-3-chloropropane		X	
96-18-4	1,2,3-Trichloropropane		X	
96-45-7	Ethylene thiourea		X	
97-63-2	Ethyl methacrylate		X	
98-01-1	Furfural		X	
98-06-6	tert-Butyl benzene		X	
98-07-7	Benzotrichloride		X	
98-83-9	Methyl styrene (mixed isomers)		X	
99-35-4	1,3,5-Trinitrobenzene		X	
99-65-0	1,3-Dinitrobenzene		X	
99-87-6	p-Cymene		X	
105-67-9	2,4-Dimethylphenol		X	

(a) Feed/PIC designation from Ref. 9.15, Attachment A

Table A-3 – WTP Inorganic COPCs

CAS #	COPC	Feed	Stack
7440-22-4	Ag	X	
7429-90-5	Al	X	
7440-38-2	As	X	
7440-39-3	Ba	X	
7440-41-7	Be	X	
24959-67-9	Br	X	
7440-43-9	Cd	X	
16887-00-6	Cl	X	
57-12-5	CN	X	
7440-48-4	Co	X	
7440-47-3	Cr	X	
7440-50-8	Cu	X	
16984-48-8	F	X	
7439-89-6	Fe	X	
7439-97-6	Hg	X	
7439-93-2	Li	X	
7439-95-4	Mg	X	
7439-96-5	Mn	X	
7439-98-7	Mo	X	
7440-23-5	Na	X	
7664-41-7	NH3	X	
7440-02-0	Ni	X	
14797-65-0	NO2	X	
14797-55-8	NO3	X	
7723-14-0	P	X	
7439-92-1	Pb	X	
14265-44-2	PO4	X	
7440-16-6	Rh	X	
7704-34-9	S	X	
7440-36-0	Sb	X	
7782-49-2	Se	X	
7440-31-5	Sn	X	
14808-79-8	SO4	X	
7440-24-6	Sr	X	
7440-25-7	Ta	X	
7440-28-0	Tl	X	
7440-61-1	UTOTAL	X	
7440-62-2	V	X	
7440-33-7	W	X	
7440-65-5	Y	X	
7440-66-6	Zn	X	
7440-67-7	Zr	X	
593-74-8	Dimethyl Mercury	X	
10102-44-0	Nitrogen dioxide		X

BY: William Hix DATE: 6/6/2016

CALCULATION SHEET

CALC NO.: 24590-BOF-M4C-DEP-00001

SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

SHEET REV: B SHEET NO.: A-9

CAS #	COPC	Feed	Stack
124-38-9	Carbon dioxide		X
630-08-0	Carbon monoxide		X
10028-15-6	Ozone		X
7446-09-5	Sulfur dioxide		X
7647-01-0	Hydrogen chloride		X
7664-39-3	Hydrogen Fluoride		X
7782-41-4	Fluorine gas		X
7782-50-5	Chlorine		X
22967-92-6	Methyl mercury		X
N/A	Particulate matter		X

Attachment B - Radionuclide COPC Specific Activities

The following table of specific activities for WTP radionuclide COPCs was extracted from the *Risk Assessment Information System* database (Ref. 10.1)

Radionuclide	Specific Activity (Ci/g)
Ac-227	7.24E+01
Am-241	3.43E+00
Am-243	2.00E-01
Ba-137m	5.34E+08
C-14	4.48E+00
Cd-113m	2.23E+02
Cm-242	3.31E+03
Cm-243	5.05E+01
Cm-244	8.09E+01
Co-60	1.11E+03
Cs-134	1.28E+03
Cs-137	8.59E+01
Eu-152	1.73E+02
Eu-154	2.69E+02
Eu-155	4.82E+02
H-3	9.62E+03
I-129	1.75E-04
Nb-93m	2.39E+02
Ni-59	5.91E-02
Ni-63	5.59E+01
Np-237	7.04E-04
Pa-231	4.72E-02
Pu-238	1.71E+01
Pu-239	6.20E-02
Pu-240	2.27E-01
Pu-241	1.03E+02
Pu-242	3.94E-03
Ra-226	9.89E-01
Ra-228	2.73E+02
Ru-106	3.27E+03
Sb-125	1.03E+03
Se-79	1.52E-02
Sm-151	2.62E+01
Sn-126	1.22E-02
Sr-90	1.37E+02
Tc-99	1.70E-02
Th-229	2.13E-01

Radionuclide	Specific Activity (Ci/g)
Th-232	1.10E-07
U-232	2.24E+01
U-233	9.64E-03
U-234	6.22E-03
U-235	2.16E-06
U-236	6.47E-05
U-238	3.36E-07
Y-90	5.38E+05
Zr-93	2.49E-03

BY: William Hix _ DATE: 6/6/2016
SUBJECT: DFLAW Effluent Management Facility Air Emissions Estimate

CALCULATION SHEET

CALC NO.: 24590-BOF-M4C-DEP-00001
SHEET REV: B SHEET NO.: C-1

Attachment C – Media File 24590-RMCD-04955

Excel spreadsheets used in this calculation are attached to Media File 24590-RMCD-04955.

Attachment D- Extracted Radionuclide Properties from NuDat 2.6 Database (Ref. 10.6)

Ground and isomeric state information for ²³⁷ ₉₃ Np				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	5/2+	44.8746	2.144E+6 y 7	α : 100.00 % SF ≤ 2E-10 %

Ground and isomeric state information for ²³⁸ ₉₄ Pu				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	0+	46.1661	87.7 y 1	α : 100.00 % SF : 1.9E-7 %

Ground and isomeric state information for ²³⁹ ₉₄ Pu				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	1/2+	48.5912	24110 y 30	α : 100.00 % SF : 3.E-10 %

Ground and isomeric state information for ²⁴⁰ ₉₄ Pu				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	0+	50.1283	6561 y 7	α : 100.00 % SF : 5.7E-6 %

Ground and isomeric state information for ²⁴¹ ₉₅ Am				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	5/2-	52.9373	432.6 y 6	α : 100.00 % SF : 4E-10 %

Ground and isomeric state information for ²⁴² ₉₄ Pu				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	0+	54.7196	3.75E+5 y 2	α : 100.00 % SF : 5.5E-4 %

Ground and isomeric state information for ²⁴³ ₉₅ Am				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	5/2-	57.1774	7370 y 40	α : 100.00 % SF : 3.7E-9 %

Ground and isomeric state information for ²⁴³ ₉₆ Cm				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	5/2+	57.1849	29.1 y 1	α : 99.71 % ε : 0.29 % SF : 5.3E-9 %

Ground and isomeric state information for ²⁴⁴ ₉₆ Cm				
E(level) (MeV)	J _π	Δ(MeV)	T _{1/2}	Decay Modes
0.0	0+	58.4550	18.1 y 1	α : 100.00 % SF : 1.4E-4 %
1.0402	6+	59.4952	34 ms 2	IT : 100.00 %

Attachment E- Phase Emissions Sensitivity Analysis for ¹⁴C and ³H

In order to check that Assumptions 6.2.6 and 6.2.7 conservatively assume that ¹⁴C and ³H (respectively) are emitted entirely in the vapor phase, the results using the methodologies for particle emissions and vapor emissions were compared using the worksheet "14C and 3H Sensitivity" in "DFLAW Radionuclide COPC Emissions Estimate.xlsx". For the sensitivity analysis, all radionuclide COPCs, except ¹⁴C and ³H, were removed from the workset and the calculation was completed for particle emissions and vapor emissions. The results are shown in Figure E-1 below. The results show that assuming unabated vapor emissions greatly exceeds unabated particle emissions for ¹⁴C (Cell R5 > Cell L5) and are equal for ³H (Cell R6 = Cell L6).

Figure E-1 - Phase Emissions Sensitivity Analysis for ¹⁴C and ³H

CAS #	COPC	Tank Farms Average ratio of COPC i, in mCi COPC / g Na	Specific Activity of COPC i, in Ci/g	Maximum feed vector batch activity of COPC i, in Ci	Maximum feed vector batch activity of COPC i, in Ci	Maximum feed vector batch mass of COPC i, in g	Maximum feed vector batch mass fraction of COPC i	Maximum feed vector batch concentration of COPC i, in g/L	Entrained Emissions			Vapor Emissions			ACV Exhaust System Emissions			APQs	Additional Inputs and Assumptions			
									Entrained mass flowrate of COPC i, in g/min	Unabated activity of COPC i emitted per year, in Ci/year	Abated activity of COPC i emitted per year, in Ci/year	Mass of COPC i flushed to DEP-VSL-0001 annually, in g/yr	Unabated activity of COPC i emitted per year, in Ci/year	Abated activity of COPC i emitted per year, in Ci/year	Unabated activity of COPC i emitted per year from the ACV Exhaust system, in Ci/year	Abated activity of COPC i emitted per year from the ACV Exhaust system (Single-stage HEPA), in Ci/year	Abated activity of COPC i emitted per year from the ACV Exhaust system (Dual-stage HEPA), in Ci/year					
		r _i	SA _i	A _i	A _i	m _i	x _i	c _i	$\dot{m}_{i,entrained}$	$\dot{A}_{i,unabated}$	$\dot{A}_{i,abated}$	$\dot{M}_{i,flush}$	$\dot{A}_{i,unabated}$	$\dot{A}_{i,abated}$	$\dot{A}_{i,unabated,ACV}$	$\dot{A}_{i,abated,ACV}$	$\dot{A}_{i,abated,HEPA}$	APQ _i				
Ref. 9.1	Ref. 9.1	Ref. 9.2	Input 2.1	Equation 1	Adjusted values per Section 7.1.1.1 in grey	Equation 8	Equation 10	Equation 11	Equation 13	Equation 14	Equation 15	Equation 17	Equation 18 (14C) or Equation 21 (3H)	Same as $\dot{A}_{i,unabated}$	Equation 22	Apply DF of 2000 for entrained emissions and DF of 1 for vapor emissions	Apply DF of 200,000 for entrained emissions and DF of 1 for vapor emissions	Equation 23 (entrained) Equation 25 (vapor)	Additional Inputs and Assumptions			
14762-79-5	14C	1.11E-05	4.49E+00	7.84E-01	7.84E-01	1.75E-01	3.35E-10	4.62E-07	1.80E-10	4.24E-04	2.12E-09	4.07E-02	1.82E-01	1.82E-01	3.04E-02	3.04E-02	3.04E-02	1.82E-01	Maximum batch amount of Na in DFLAW Bounding Feed Vector, in kmol	$n_{Na,max}$	Attachment G	3063.6321
10028-17-9	3H	5.69E-05	9.62E+03	4.01E+00	4.01E+00	4.17E-04	7.99E-13	1.10E-09	4.29E-13	2.17E-03	1.09E-08	9.70E-05	2.17E-03	2.17E-03	3.62E-04	3.62E-04	3.62E-04	9.33E-01	Molecular weight of sodium, in kg/kmol	MW _{Na}	Input 2.5	22.9898
																			Average total feed vector batch volume, in gal	V _{batch,avg}	Attachment G	100152.8804
																			Average total vector batch density, in g/cc	$\rho_{batch,avg}$	Attachment G	1.3773
																			Average total feed vector batch mass, in g	m _{batch,avg}	Equation 9	522090816.9
																			Total mass flowrate of the DVP system except for the evaporator, in lb/hr	$\dot{m}_{DVP,excl}$	Assumption 6.1.4	828
																			Entrainment factor for DEP vessels, in g entrained material / g air	EF _{vess}	Input 2.3 Assumption 6.2.3	4.00E-05
																			Mass flowrate of the evaporator vent stream, in lb/hr	$\dot{m}_{evap,vent}$	Assumption 6.1.4	50
																			Entrainment factor for DEP evaporator, in g entrained material / g air	EF _{evap}	Input 2.20 Assumption 6.2.30	1.00E-03
																			Total mass flowrate of entrained material, in g/min	$\dot{m}_{tot,entrained}$	Equation 12	5.36E-01
																			Decontamination Factor of primary HEPA filter	DF _{HEPA,primary}	Assumption 6.2.10	2000
																			Decontamination Factor of secondary HEPA filter	DF _{HEPA,secondary}	Assumption 6.2.10	100
																			Total volume of LAW feed line flush, in gal	V _{flush}	Input 2.4, Assumption 6.1.3	1500
																			Flush Dilution Factor	Dilution Factor	Assumption 6.1.2	0.033333333
																			Volume of residual feed in a LAW feed line flush, in L	V _{residual,flush}	Equation 16	189.25
																			Frequency of LAW feed line flush, in 1/hr	f _{flush}	Assumption 6.1.3	0.053191489
																			Evaporator MDR	MDR _{evap}	Assumption 6.1.35	6.00E-01
																			Primary Condenser MDR	MDR _{cond}	Assumption 6.1.35	1.75E-02
																			Inter-condenser MDR	MDR _{int}	Assumption 6.1.35	2.22E-01
																			Combined MDR	MDR _{comb}	Equation 20	2.33E-03
																			Volumetric flowrate of DEP evaporator feed stream, in gpm	V _{evap,feed}	Assumption 6.1.7	19
																			Annual volume processed through DEP evaporator, L	V _{evap,annual}	Equation 24	19893960

Attachment F – Stream Properties Extracted from PIBOD Runs

The values for the mass flowrate of TOC in the LAW melter feed stream (LFP04) were extracted from the PIBOD model run results documented in calculation 24590-WTP-M4C-V11T-00012 (Ref. 9.23). The model run results for Ref. 9.23 are contained in 24590-RMVD-00357-02, Folder “*PIBOD Runs*”.

Table F-1 – Stream LFP04 TOC

PIBOD Model Run #	TOC (kg/hr)
1	10.92
2	10.23
3	9.99
4	10.50
5	12.43
6	9.55
7	12.46
8	11.00
9	11.19
10	7.79
11	7.75
12	15.29
13	11.08
14	10.22
15	13.80
16	12.35
17	11.41
18	12.32
19	9.79
20	8.00
21	8.20
22	14.06
23	11.75
Average	10.96
Maximum	15.29

The maximum value of 15.29 kg/hr will be rounded up to 20 kg/hr for use in this calculation as variable $TOC_{MF,max}$.

The values for the NH_4^+ and total mass flowrate in LVP21 were extracted from the PIBOD model run results documented in calculation 24590-WTP-M4C-V11T-00012 (Ref. 9.23). The model run results for Ref. 9.23 are contained in 24590-RMVD-00357-02, Folder “PIBOD Runs”. The model runs report ammonia in the aqueous phase as the ammonium ion (NH_4^+), therefore the amount of NH_3 transferred in LVP21 is estimated using the results for NH_4^+ . The mass fraction of NH_4^+ in LVP21 was calculated by dividing the NH_4^+ mass flowrate by the total mass flowrate.

Table F-2 – Stream LVP21 NH_3 Mass Fraction

PIBOD Model Run #	NH_4^+ (kg/hr)	Total (kg/hr)	Mass Fraction
1	0.271	5.292	0.0511
2	0.251	4.903	0.0511
3	0.261	5.120	0.0510
4	0.269	5.254	0.0511
5	0.331	6.473	0.0511
6	0.244	4.776	0.0511
7	0.332	6.489	0.0511
8	0.288	5.636	0.0511
9	0.295	5.770	0.0511
10	0.195	3.816	0.0511
11	0.204	3.993	0.0512
12	0.385	7.516	0.0512
13	0.298	5.838	0.0511
14	0.273	5.333	0.0511
15	0.359	7.014	0.0511
16	0.327	6.403	0.0511
17	0.289	5.662	0.0510
18	0.317	6.204	0.0511
19	0.254	4.974	0.0511
20	0.210	4.128	0.0510
21	0.216	4.245	0.0510
22	0.368	7.207	0.0511
23	0.300	5.875	0.0511
Average	0.284	5.562	0.0511
Maximum	0.385	7.516	0.0512

The maximum value of 0.0512 will be rounded up to 0.06 for use in this calculation as variable x_{LVP21, NH_3} .

The values for mercury in the SBS condensate transfer stream (RLD21) were extracted from the PIBOD model run results documented in calculation 24590-WTP-M4C-V11T-00012 (Ref. 9.23). The model run results for Ref. 9.23 are contained in 24590-RMVD-00357-02, Folder "PIBOD Runs".

Table F-3 – Stream RLD21 Hg

PIBOD Model Run #	Hg (kg/hr)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0

CALCULATION SHEET

Attachment G – DFLAW Bounding Feed Vector Batch Properties

The following table shows the values extracted for each batch in the DFLAW Bounding Feed Vector included as part of Ref. 9.2. These values were calculated in Excel Spreadsheet “*Bounding_DFLAW-batches-to-wtp_TOTALS.xlsx*” Worksheet “*TOTALS*”.

Date	Batch #	Batch Volume Gallons	Batch Density g/cc	Sodium kmol	TOC kmol	Oxalate (C2O4-2) kmol	Adjusted TOC (TOC+Oxalate) kg
							Equation 21
1/14/2022 15:36	1	100084	1.32225	3059.52	1.24E+02	4.07E+00	1582.14
1/31/2022 14:44	2	100100	1.32225	3060.01	1.24E+02	4.07E+00	1582.39
2/19/2022 2:20	3	100069	1.32225	3059.05	1.24E+02	4.07E+00	1581.89
3/9/2022 13:16	4	100068	1.32225	3059.03	1.24E+02	4.07E+00	1581.89
3/27/2022 9:04	5	100050	1.32225	3058.49	1.24E+02	4.07E+00	1581.61
4/15/2022 3:08	6	100167	1.32225	3062.06	1.24E+02	4.07E+00	1583.45
5/3/2022 23:52	7	100097	1.32225	3059.92	1.24E+02	4.07E+00	1582.35
5/21/2022 6:36	8	100051	1.32225	3058.50	1.24E+02	4.07E+00	1581.61
6/8/2022 19:52	9	100129	1.32225	3060.89	1.24E+02	4.07E+00	1582.85
6/27/2022 1:44	10	100151	1.32225	3061.57	1.24E+02	4.07E+00	1583.20
7/15/2022 7:52	11	100219	1.32225	3063.63	1.24E+02	4.08E+00	1584.27
9/2/2022 15:04	12	100006	1.36606	3045.48	1.12E+02	4.53E+00	1454.71
9/20/2022 18:44	13	100075	1.39020	3041.96	1.06E+02	4.78E+00	1386.30
10/9/2022 11:28	14	100220	1.39144	3046.05	1.06E+02	4.80E+00	1384.73
10/28/2022 7:20	15	100339	1.39177	3049.59	1.06E+02	4.81E+00	1385.43
11/16/2022 1:08	16	100127	1.39180	3043.13	1.05E+02	4.80E+00	1382.42
12/4/2022 15:52	17	100065	1.39180	3041.26	1.05E+02	4.80E+00	1381.55
12/23/2022 16:32	18	100072	1.39181	3041.47	1.05E+02	4.80E+00	1381.65
1/10/2023 18:36	19	100103	1.39181	3042.40	1.05E+02	4.80E+00	1382.07
1/29/2023 14:16	20	100087	1.39181	3041.93	1.05E+02	4.80E+00	1381.86
2/17/2023 5:04	21	100078	1.39181	3041.63	1.05E+02	4.80E+00	1381.72
3/9/2023 5:12	22	100253	1.39107	3043.71	9.79E+01	4.98E+00	1295.52
3/28/2023 3:44	23	100340	1.38954	3039.58	8.18E+01	5.34E+00	1110.82
4/16/2023 11:12	24	100288	1.38943	3037.52	8.06E+01	5.36E+00	1096.67
5/4/2023 21:48	25	100019	1.38940	3029.28	8.01E+01	5.36E+00	1090.41
5/23/2023 1:20	26	100009	1.38940	3028.97	8.00E+01	5.36E+00	1090.16
6/10/2023 6:00	27	100192	1.38940	3034.50	8.02E+01	5.37E+00	1092.11
6/28/2023 20:40	28	100058	1.38940	3030.45	8.01E+01	5.36E+00	1090.65
7/18/2023 5:04	29	100146	1.38940	3033.09	8.02E+01	5.36E+00	1091.60
8/5/2023 0:12	30	100031	1.38940	3029.63	8.01E+01	5.36E+00	1090.36
8/23/2023 14:12	31	100185	1.38940	3034.28	8.02E+01	5.37E+00	1092.03
9/12/2023 14:44	32	100094	1.39360	3030.48	8.46E+01	5.47E+00	1147.95
10/1/2023 2:28	33	100287	1.40067	3034.58	9.24E+01	5.65E+00	1246.16
10/19/2023 22:40	34	100230	1.40113	3032.74	9.29E+01	5.66E+00	1251.69
11/7/2023 6:04	35	100112	1.40125	3029.13	9.29E+01	5.66E+00	1251.83
12/13/2023 11:12	36	100176	1.40125	3031.07	9.30E+01	5.66E+00	1252.72
1/1/2024 10:24	37	100052	1.40125	3027.31	9.29E+01	5.65E+00	1251.18
1/19/2024 19:08	38	100218	1.40126	3032.35	9.30E+01	5.66E+00	1253.27
2/7/2024 4:56	39	100282	1.40126	3034.27	9.31E+01	5.67E+00	1254.06
2/27/2024 16:00	40	100038	1.40197	3029.28	9.39E+01	5.88E+00	1268.69
3/16/2024 1:40	41	100098	1.40499	3041.70	9.80E+01	6.86E+00	1341.86
4/4/2024 1:08	42	100072	1.40550	3042.92	9.86E+01	7.03E+00	1353.15
4/23/2024 2:00	43	100253	1.40558	3048.74	9.89E+01	7.07E+00	1357.29
5/12/2024 3:48	44	100048	1.40558	3042.53	9.87E+01	7.05E+00	1354.62
5/31/2024 1:56	45	100011	1.40559	3041.39	9.86E+01	7.05E+00	1354.13
6/18/2024 21:36	46	100155	1.40559	3045.78	9.88E+01	7.06E+00	1356.09
7/7/2024 3:12	47	100088	1.40559	3043.76	9.87E+01	7.06E+00	1355.19
7/26/2024 0:32	48	100338	1.40559	3051.36	9.90E+01	7.07E+00	1358.58
8/14/2024 0:28	49	100138	1.40559	3045.27	9.88E+01	7.06E+00	1355.87
9/4/2024 2:04	50	100167	1.39834	3044.47	9.33E+01	6.46E+00	1276.21
9/22/2024 5:56	51	100204	1.37503	3042.25	7.56E+01	4.76E+00	1022.36
10/10/2024 12:56	52	100098	1.37183	3039.10	7.30E+01	4.58E+00	987.18
10/28/2024 19:08	53	100108	1.37134	3039.47	7.26E+01	4.56E+00	981.98
11/16/2024 17:40	54	100071	1.37132	3038.36	7.26E+01	4.56E+00	981.46
12/4/2024 18:16	55	100255	1.37131	3043.94	7.27E+01	4.57E+00	983.18
12/22/2024 22:52	56	100248	1.37131	3043.73	7.27E+01	4.57E+00	983.11
1/10/2025 10:44	57	100075	1.37131	3038.47	7.26E+01	4.56E+00	981.41
1/28/2025 7:56	58	100172	1.37131	3041.44	7.27E+01	4.57E+00	982.36
2/15/2025 17:16	59	100238	1.37131	3043.43	7.27E+01	4.57E+00	983.01
3/7/2025 10:36	60	100075	1.37333	3037.34	6.33E+01	4.54E+00	869.03
3/24/2025 2:08	61	100143	1.37769	3035.41	4.25E+01	4.52E+00	618.85
4/11/2025 16:48	62	100228	1.37807	3037.31	4.06E+01	4.53E+00	596.34
4/30/2025 7:20	63	100173	1.37814	3035.50	4.02E+01	4.53E+00	591.21
5/17/2025 22:12	64	100241	1.37815	3037.55	4.02E+01	4.53E+00	591.44
6/5/2025 4:04	65	100299	1.37815	3039.29	4.02E+01	4.53E+00	591.71
6/23/2025 11:56	66	100004	1.37815	3030.38	4.01E+01	4.52E+00	589.97

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Date	Batch #	Batch Volume	Batch Density	Sodium	TOC	Oxalate (C2O4-2)	Adjusted TOC (TOC+Oxalate)
		Gallons	g/cc	kmol	kmol	kmol	kg
							Equation 21
7/11/2025 11:20	67	100279	1.37815	3038.70	4.02E+01	4.53E+00	591.59
7/29/2025 15:52	68	100299	1.37815	3039.30	4.02E+01	4.53E+00	591.71
8/17/2025 5:52	69	100330	1.37815	3040.25	4.02E+01	4.53E+00	591.89
9/6/2025 12:12	70	100162	1.37713	3013.32	3.76E+01	4.42E+00	557.79
9/24/2025 19:40	71	100158	1.37397	2947.14	3.01E+01	4.15E+00	461.07
10/12/2025 21:04	72	100234	1.37365	2942.92	2.94E+01	4.13E+00	452.16
10/31/2025 5:32	73	100243	1.37359	2941.85	2.92E+01	4.13E+00	450.27
11/17/2025 10:28	74	100106	1.37359	2937.77	2.92E+01	4.12E+00	449.60
12/5/2025 20:56	75	100344	1.37358	2944.73	2.93E+01	4.13E+00	450.64
12/23/2025 7:28	76	100019	1.37358	2935.19	2.92E+01	4.12E+00	449.18
1/10/2026 6:56	77	100117	1.37358	2938.09	2.92E+01	4.12E+00	449.62
1/28/2026 13:00	78	100028	1.37358	2935.48	2.92E+01	4.12E+00	449.22
2/14/2026 21:12	79	100078	1.37358	2936.92	2.92E+01	4.12E+00	449.44
3/7/2026 14:44	80	100025	1.37388	2963.89	5.16E+01	4.47E+00	727.67
3/26/2026 21:40	81	100223	1.37442	3028.37	9.76E+01	5.60E+00	1306.88
4/14/2026 7:04	82	100056	1.37444	3026.39	9.98E+01	5.67E+00	1335.27
5/3/2026 10:00	83	100173	1.37445	3030.95	1.01E+02	5.71E+00	1347.03
5/22/2026 7:24	84	100293	1.37445	3034.62	1.01E+02	5.72E+00	1349.07
6/10/2026 22:20	85	100212	1.37445	3032.20	1.01E+02	5.72E+00	1348.12
7/1/2026 1:40	86	100047	1.37445	3027.21	1.01E+02	5.71E+00	1345.91
7/23/2026 9:00	87	100350	1.37445	3036.36	1.01E+02	5.72E+00	1349.98
8/7/2026 22:20	88	100310	1.37445	3035.14	1.01E+02	5.72E+00	1349.44
8/28/2026 1:20	89	100084	1.37445	3028.33	1.01E+02	5.71E+00	1346.41
9/17/2026 22:44	90	100116	1.37176	2977.84	9.17E+01	5.78E+00	1240.42
10/9/2026 18:48	91	100210	1.36297	2812.67	6.24E+01	6.11E+00	896.32
11/3/2026 3:44	92	100306	1.36283	2812.72	6.20E+01	6.12E+00	891.76
11/25/2026 12:24	93	100003	1.36269	2801.38	6.13E+01	6.11E+00	883.29
12/20/2026 13:08	94	100309	1.36268	2809.84	6.15E+01	6.13E+00	885.80
1/13/2027 17:04	95	100116	1.36268	2804.41	6.14E+01	6.11E+00	884.01
2/7/2027 15:16	96	100098	1.36268	2803.89	6.14E+01	6.11E+00	883.85
4/26/2027 20:04	97	100026	1.36268	2801.89	6.13E+01	6.11E+00	883.21
5/21/2027 16:24	98	100061	1.36268	2802.86	6.13E+01	6.11E+00	883.52
6/11/2027 9:56	99	100258	1.35727	2754.20	7.59E+01	5.02E+00	1031.80
6/30/2027 11:28	100	100340	1.35614	2745.17	7.89E+01	4.80E+00	1063.29
7/18/2027 12:44	101	100053	1.35599	2735.83	7.91E+01	4.76E+00	1064.37
8/5/2027 10:28	102	100073	1.35599	2736.37	7.91E+01	4.76E+00	1064.66
8/24/2027 10:40	103	100244	1.35599	2741.00	7.93E+01	4.77E+00	1066.55
9/9/2027 15:44	104	100236	1.35599	2740.79	7.92E+01	4.77E+00	1066.47
9/27/2027 17:52	105	100039	1.35599	2735.42	7.91E+01	4.76E+00	1064.38
10/15/2027 17:36	106	100059	1.35599	2735.96	7.91E+01	4.76E+00	1064.59
11/3/2027 14:04	107	100232	1.35599	2740.69	7.92E+01	4.77E+00	1066.43
11/21/2027 13:40	108	100114	1.35599	2737.46	7.92E+01	4.77E+00	1065.18
12/11/2027 4:16	109	100232	1.37790	2895.17	6.98E+01	4.37E+00	943.22
12/29/2027 12:20	110	100178	1.38465	2941.23	6.68E+01	4.27E+00	905.29
1/15/2028 19:16	111	100233	1.38521	2946.76	6.66E+01	4.27E+00	902.73
2/3/2028 20:16	112	100227	1.38529	2947.15	6.66E+01	4.26E+00	902.25
5/15/2028 3:24	113	100263	1.38530	2948.29	6.66E+01	4.27E+00	902.51
6/1/2028 8:08	114	100017	1.38530	2941.07	6.64E+01	4.26E+00	900.30
6/19/2028 13:24	115	100177	1.38530	2945.76	6.66E+01	4.26E+00	901.73
7/8/2028 4:24	116	100083	1.38530	2943.00	6.65E+01	4.26E+00	900.88
7/27/2028 5:56	117	100008	1.38530	2940.79	6.64E+01	4.25E+00	900.21
8/13/2028 7:52	118	100163	1.38530	2945.35	6.65E+01	4.26E+00	901.60
9/2/2028 21:56	119	100036	1.39903	3014.39	6.41E+01	4.29E+00	873.02
9/21/2028 9:00	120	100052	1.40051	3022.70	6.39E+01	4.29E+00	870.19
10/9/2028 19:24	121	100049	1.40080	3024.15	6.38E+01	4.29E+00	869.59
10/29/2028 17:56	122	100244	1.40082	3030.17	6.39E+01	4.30E+00	871.25
11/15/2028 20:56	123	100100	1.40082	3025.82	6.38E+01	4.30E+00	869.98
12/3/2028 23:48	124	100181	1.40082	3028.28	6.39E+01	4.30E+00	870.69
12/22/2028 22:52	125	100102	1.40082	3025.90	6.38E+01	4.30E+00	870.00
1/11/2029 6:08	126	100282	1.40082	3031.34	6.40E+01	4.30E+00	871.57
1/30/2029 3:32	127	100203	1.40082	3028.94	6.39E+01	4.30E+00	870.88
2/20/2029 14:40	128	100103	1.40033	3022.91	6.35E+01	4.30E+00	866.59
3/10/2029 7:56	129	100231	1.38545	2934.97	5.48E+01	4.39E+00	764.13
3/27/2029 17:24	130	100108	1.38219	2911.25	5.29E+01	4.41E+00	740.72
4/15/2029 13:52	131	100073	1.38186	2908.21	5.26E+01	4.41E+00	738.19
5/3/2029 14:52	132	100117	1.38181	2909.18	5.26E+01	4.41E+00	738.18
5/21/2029 20:52	133	100048	1.38180	2907.12	5.26E+01	4.41E+00	737.62
6/8/2029 13:12	134	100149	1.38180	2910.07	5.27E+01	4.41E+00	738.37
6/26/2029 6:20	135	100098	1.38180	2908.57	5.26E+01	4.41E+00	737.98
7/13/2029 19:36	136	100233	1.38180	2912.46	5.27E+01	4.41E+00	738.99

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Date	Batch #	Batch Volume Gallons	Batch Density g/cc	Sodium kmol	TOC kmol	Oxalate (C2O4-2) kmol	Adjusted TOC (TOC+Oxalate) kg
							Equation 21
8/1/2029 5:00	137	100303	1.38180	2914.54	5.27E+01	4.42E+00	739.50
8/22/2029 4:52	138	100106	1.38178	2919.02	5.17E+01	4.46E+00	728.05
9/8/2029 0:52	139	100104	1.38154	3013.58	4.31E+01	4.90E+00	635.37
9/26/2029 12:44	140	100048	1.38152	3019.76	4.24E+01	4.93E+00	627.42
10/19/2029 20:08	141	100317	1.38152	3029.80	4.23E+01	4.96E+00	627.31
11/7/2029 9:04	142	100058	1.38152	3022.09	4.22E+01	4.94E+00	625.57
11/25/2029 22:48	143	100149	1.38152	3024.89	4.22E+01	4.95E+00	626.11
12/13/2029 23:08	144	100027	1.38152	3021.21	4.22E+01	4.94E+00	625.34
1/1/2030 0:04	145	100180	1.38152	3025.82	4.22E+01	4.95E+00	626.30
1/19/2030 3:04	146	100268	1.38152	3028.47	4.23E+01	4.95E+00	626.85
2/5/2030 15:52	147	100293	1.38152	3029.24	4.23E+01	4.96E+00	627.01
2/26/2030 14:28	148	100328	1.38191	3031.24	4.37E+01	4.96E+00	643.91
3/17/2030 1:28	149	100286	1.38427	3035.47	5.24E+01	5.00E+00	749.11
4/7/2030 7:24	150	100338	1.38468	3037.81	5.40E+01	5.01E+00	768.71
4/24/2030 16:04	151	100146	1.38473	3032.10	5.41E+01	5.01E+00	769.55
5/12/2030 23:48	152	100064	1.38474	3029.63	5.40E+01	5.00E+00	769.14
5/31/2030 15:48	153	100091	1.38474	3030.47	5.41E+01	5.00E+00	769.40
6/19/2030 23:16	154	100099	1.38474	3030.71	5.41E+01	5.00E+00	769.46
7/8/2030 4:32	155	100022	1.38474	3028.37	5.40E+01	5.00E+00	768.87
7/25/2030 19:44	156	100136	1.38474	3031.82	5.41E+01	5.00E+00	769.75
8/13/2030 4:04	157	100331	1.38474	3037.72	5.42E+01	5.01E+00	771.24
9/1/2030 22:36	158	100334	1.38186	3038.46	5.06E+01	5.10E+00	730.02
9/30/2030 11:32	159	100057	1.37166	3032.12	3.77E+01	5.40E+00	582.91
10/17/2030 13:04	160	100073	1.37086	3032.67	3.68E+01	5.43E+00	571.90
11/5/2030 13:08	161	100242	1.37067	3037.81	3.66E+01	5.44E+00	570.12
11/22/2030 11:08	162	100228	1.37066	3037.40	3.66E+01	5.44E+00	569.90
12/10/2030 22:20	163	100019	1.37066	3031.06	3.65E+01	5.43E+00	568.67
12/29/2030 5:20	164	100099	1.37066	3033.47	3.65E+01	5.43E+00	569.12
1/17/2031 5:40	165	100056	1.37066	3032.17	3.65E+01	5.43E+00	568.87
2/3/2031 13:48	166	100116	1.37066	3034.01	3.65E+01	5.43E+00	569.22
2/22/2031 1:52	167	100031	1.37066	3031.43	3.65E+01	5.43E+00	568.73
3/11/2031 16:40	168	100210	1.37007	3000.82	3.87E+01	5.18E+00	589.07
3/29/2031 16:52	169	100310	1.36827	2883.17	4.59E+01	4.37E+00	656.70
4/16/2031 21:44	170	100194	1.36808	2863.34	4.69E+01	4.27E+00	665.83
5/5/2031 21:12	171	100100	1.36805	2858.12	4.70E+01	4.26E+00	666.76
5/22/2031 16:24	172	100136	1.36805	2859.06	4.70E+01	4.26E+00	667.07
6/9/2031 13:04	173	100030	1.36805	2855.98	4.70E+01	4.25E+00	666.38
6/27/2031 12:28	174	100137	1.36805	2859.04	4.70E+01	4.26E+00	667.10
7/15/2031 23:12	175	100070	1.36805	2857.12	4.70E+01	4.25E+00	666.65
8/2/2031 6:36	176	100285	1.36805	2863.26	4.71E+01	4.26E+00	668.08
8/20/2031 13:56	177	100218	1.36805	2861.36	4.71E+01	4.26E+00	667.64
	Average	100153	1.37726	2982.39	69.79	4.94	957.00
	Minimum	100003	1.32225	2735.42	29.16	4.07	449.18
	Maximum	100350	1.40559	3063.63	123.75	7.07	1584.27