

APR 18 2017

Wolfgang Rochert
Rivermaid Trading, Company
PO Box 350
Lodi, CA 95241

RE: Notice of Final Action - Authority to Construct
Facility Number: N-8844
Project Number: N-1160591

Dear Mr. Rochert:

The Air Pollution Control Officer has issued the Authority to Construct permit to Rivermaid Trading, Company for the construction of a new fumigation chamber, at 6011 East Pine Street in Lodi. Enclosed are the Authority to Construct permit and a copy of the notice of final action to be published approximately three days from the date of this letter.

Notice of the District's preliminary decision to issue the Authority to Construct permit was published on November 2, 2016. The District's analysis of the proposal was also sent to CARB on October 27, 2016. All comments received following the District's preliminary decision on this project were considered. The comments and the District's response to each comment are included in the attached application review document.

Comments received by the District during the public notice period resulted in addition of some monitoring and recordkeeping requirements for workers safety purposes. These changes were minor and did not trigger additional public notification requirements, nor did they have any impact upon the Best Available Control Technology determination or on the amount of offsets required for project approval.

Also enclosed is an invoice for the engineering evaluation fees pursuant to District Rule 3010. Please remit the amount owed, along with a copy of the attached invoice, within 60 days.

Seyed Sadredin
Executive Director/Air Pollution Control Officer

Northern Region
4800 Enterprise Way
Modesto, CA 95356-8718
Tel: (209) 557-6400 FAX: (209) 557-6475

Central Region (Main Office)
1990 E. Gettysburg Avenue
Fresno, CA 93726-0244
Tel: (559) 230-6000 FAX: (559) 230-6061

Southern Region
34946 Flyover Court
Bakersfield, CA 93308-9725
Tel: 661-392-5500 FAX: 661-392-5585

Mr. Wolfgang Rochert
Page 2

Thank you for your cooperation in this matter. If you have any questions, please contact Mr. Nick Peirce at (209) 557-6400.

Sincerely,



Arnaud Marjollet
Director of Permit Services

AM:WMS

Enclosures

cc: Tung Le, CARB (w/enclosure) via email
Jake Uhlenkott, Hilbers Inc. via email (jake@hilbersinc.com)
Nick Hilbers, Hilbers Inc. via email (nick@hilbersinc.com)
Elizabeth Forsyth, Earthjustice California Office via email (eforsyth@earthjustice.org)
Dolores Weller, Central Valley Air Quality (CVAQ) Coalition via email
(Dolores@cleanair.org)
Sarah Aird and Mark Weller, Californians for Pesticide Reform via email
(sarah@pesticidereform.org)
Nan Wishner, California Environmental Health Initiative, via email (nan@cal-ehi.org)
Dan Silver, Endangered Habitats League via email (dsilverla@me.com)
Mar Preston, TriCounty Watchdogs via email (marpreston@franzmtn.com)
Tom Frantz, Association of Irrigated Residents via email (Tom.frantz49@gmail.com)
Caroline Cox, Center for Environmental Health via email (caroline@ceh.org)
Tom Helme, Valley Improvement Project via email
(valleyimprovementprojects@gmail.com)
Nayamin Martinez, Central California Environmental Justice Network via email
(Nayamin.martinez@outlook.com)
Anne Katten, California Rural Legal Assistance Foundation via email
(akatten@crlaf.org)



APR 18 2017

Gerardo Rios

U.S. EPA

Via email: SJV_T5_Permits@epamail.epa.gov

**Re: Notice of Issuance of Authority to Construct at a Minor Stationary Source
District Facility # N-8844
Project # N-1160591**

Dear Mr. Rios:

Pursuant to the CAA Section 105 Cooperative Agreement between U.S. EPA Region IX and the San Joaquin Valley Air Pollution Control District concerning EPA notification of issuance of Authority to Construct permits at minor sources that establish emission limits that are at least 80% of the major source threshold, please find the enclosed final Authority to Construct permit.

If you have any questions, please contact Mr. Nick Peirce, Permit Services Manager, at (209) 557-6400.

Sincerely,



Arnaud Marjollet
Director of Permit Services

AM: WMS/ys

Enclosure

Seyed Sadredin
Executive Director/Air Pollution Control Officer

Northern Region
4800 Enterprise Way
Modesto, CA 95356-8718
Tel: (209) 557-6400 FAX: (209) 557-6475

Central Region (Main Office)
1990 E. Gettysburg Avenue
Fresno, CA 93726-0244
Tel: (559) 230-6000 FAX: (559) 230-6061

Southern Region
34946 Flyover Court
Bakersfield, CA 93308-9725
Tel: 661-392-5500 FAX: 661-392-5585



San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT



Facility # N-8844
RIVERMAID TRADING, CO.
PO BOX 350
LODI, CA 95241

AUTHORITY TO CONSTRUCT (ATC)

QUICK START GUIDE

1. **Pay Invoice:** Please pay enclosed invoice before due date.
2. **Fully Understand ATC:** Make sure you understand ALL conditions in the ATC prior to construction, modification and/or operation.
3. **Follow ATC:** You must construct, modify and/or operate your equipment as specified on the ATC. Any unspecified changes may require a new ATC.
4. **Notify District:** You must notify the District's Compliance Department, at the telephone numbers below, upon start-up and/or operation under the ATC. Please record the date construction or modification commenced and the date the equipment began operation under the ATC. You may NOT operate your equipment until you have notified the District's Compliance Department. A startup inspection may be required prior to receiving your Permit to Operate.
5. **Source Test:** Schedule and perform any required source testing. See http://www.valleyair.org/busind/comply/source_testing.htm for source testing resources.
6. **Maintain Records:** Maintain all records required by ATC. Records are reviewed during every inspection (or upon request) and must be retained for at least 5 years. Sample record keeping forms can be found at http://www.valleyair.org/busind/comply/compliance_forms.htm.

By operating in compliance, you are doing your part to improve air quality for all Valley residents.

**For assistance, please contact District Compliance staff at
any of the telephone numbers listed below.**

Seyed Sadredin
Executive Director/Air Pollution Control Officer

Northern Region
4800 Enterprise Way
Merced, CA 95356-6718
Tel: (209) 557-6400 FAX: (209) 557-6475

Central Region (Main Office)
1980 E. Gettysburg Avenue
Fresno, CA 93726-0244
Tel: (559) 230-6000 FAX: (559) 230-6061

Southern Region
34946 Flyover Court
Bakersfield, CA 93308-9725
Tel: 661-392-5500 FAX: 661-392-5585



San Joaquin Valley
AIR POLLUTION CONTROL DISTRICT


HEALTHY AIR LIVING

AUTHORITY TO CONSTRUCT

PERMIT NO: N-8844-2-0

ISSUANCE DATE: 04/12/2017

LEGAL OWNER OR OPERATOR: RIVERMAID TRADING, CO.

MAILING ADDRESS: PO BOX 350
LODI, CA 95241

LOCATION: 6011 EAST PINE
LODI, CA 95241

EQUIPMENT DESCRIPTION:

METHYL BROMIDE FUMIGATION OPERATION CONSISTING OF ONE CHAMBER (APPROXIMATE CAPACITY 40'L X 55'W X 28'6"H)

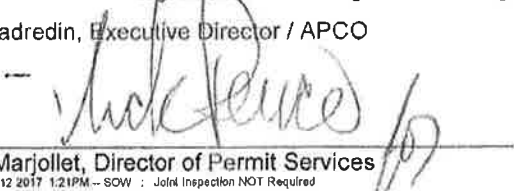
CONDITIONS

1. No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]
2. No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]
3. All fumigation operations must be conducted inside the fumigation chamber, and the fumigation chamber must be maintained in a sealed and air-tight condition when in operation. [District Rule 4102]
4. The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction. [District Rule 4102]
5. The height of the exhaust stack from the ground shall be at least 100 feet. [District Rule 4102]
6. The fumigation chamber shall be aerated only from the period of 11 PM through 5 AM in any rolling 24-hour period. [District Rule 4102]
7. Methyl Bromide (MeBr) shall be the only fumigant used in this fumigation operation. [District Rules 2201 and 4102]
8. VOC emissions from this fumigation operation shall not exceed 300.0 pounds in any one day, equivalent to the use of 300.0 pounds of MeBr in any one day. [District Rule 2201]
9. VOC emissions from this fumigation operation shall not exceed 10,000 pounds in any one calendar year, equivalent to the use of 10,000 pounds of MeBr in any one calendar year. [District Rules 2201 and 4102]

CONDITIONS CONTINUE ON NEXT PAGE

YOU MUST NOTIFY THE DISTRICT COMPLIANCE DIVISION AT (209) 557-6400 WHEN CONSTRUCTION IS COMPLETED AND PRIOR TO OPERATING THE EQUIPMENT OR MODIFICATIONS AUTHORIZED BY THIS AUTHORITY TO CONSTRUCT. This is NOT a PERMIT TO OPERATE. Approval or denial of a PERMIT TO OPERATE will be made after an inspection to verify that the equipment has been constructed in accordance with the approved plans, specifications and conditions of this Authority to Construct, and to determine if the equipment can be operated in compliance with all Rules and Regulations of the San Joaquin Valley Unified Air Pollution Control District. Unless construction has commenced pursuant to Rule 2050, this Authority to Construct shall expire and application shall be cancelled two years from the date of issuance. The applicant is responsible for complying with all laws, ordinances and regulations of all other governmental agencies which may pertain to the above equipment.

Seyed Sadredin, Executive Director / APCO


Arnaud Marjollet, Director of Permit Services

N-8844-2-0: Apr 12 2017 1:21PM - SOW : Jotir Inspection NOT Required

Northern Regional Office • 4800 Enterprise Way • Modesto, CA 95356-8718 • (209) 557-6400 • Fax (209) 557-6475

10. MeBr emissions from this fumigation operation shall not exceed 272.1 pounds in any given rolling hour. The hourly MeBr emissions rate shall be calculated: $\text{MeBr Emissions (lb/hour)} = \text{Quantity of MeBr injected into the chamber (lb/cycle)} \times 0.907 \text{ (cycle/hour)}$. [District Rule 4102]
11. The concentration of methyl bromide in the fumigation chamber shall not exceed 5 ppm at any time that the fumigation chamber doors are open. APHIS-approved thermal conductivity gas analyzer or infrared spectroscopy gas monitoring device shall be used to ensure compliance with this requirement. [District Rule 2201]
12. There shall be no emissions of methyl bromide from valves, flanges, or other connectors, and APHIS-approved leak detection device shall be used to ensure compliance with this requirement. [District Rule 2201]
13. The permittee shall keep records of the data collected from all methyl bromide analyzers and leak detection devices to demonstrate compliance with the emissions limits on this permit. [District Rule 2201]
14. The following records shall be maintained for the fumigation operation: 1) date; 2) chamber aeration start time; 3) chamber aeration end time; 4) daily MeBr usage in pounds; 5) cumulative annual MeBr usage in pounds; and 6) hourly MeBr emissions in pounds. [District Rules 2201 and 4102]
15. The cumulative annual MeBr usage records shall be updated at least once during each week that MeBr is used. [District Rules 1070 and 2201]
16. On a monthly basis, the permittee shall calculate and record the monthly VOC emissions from this unit. [District Rule 2201]
17. On a monthly basis, the permittee shall calculate and record the facility-wide VOC emissions in pounds for the rolling 12-month period. The facility-wide VOC emissions shall be calculated by summing the VOC emissions from the previous 12 months from every permitted unit at this facility. [District Rule 2201]
18. All records shall be maintained and retained on-site for a period of at least 5 years and shall be made available for District inspection upon request. [District Rule 1070]

San Joaquin Valley Air Pollution Control District
Authority to Construct Application Review
Methyl Bromide Fumigation Operation

Facility Name:	Rivermaid Trading, Company	Revised Date:	April 10, 2017
Mailing Address:	P.O. Box 350	Engineer:	Wai-Man So
	Lodi, CA 95241	Lead Engineer:	Nick Peirce
Contact Person:	Wolfgang Rochert	Jake Uhlenkott (Consultant)	
Telephone:	(209) 369 – 3586	(530) 673 – 2947 ext. 144	
Cell:	(209) 327 – 0445	(530) 933 – 8110	
E-Mail:	Wolfgang@rivermaid.com	jake@hilbersinc.com	
Application #(s):	N-8844-2-0		
Project #:	N-1160591		
Deemed Complete:	March 17, 2016		

I. Proposal

Rivermaid Trading Company (hereinafter RTC) is requesting Authority to Construct (ATC) for the construction of a new fumigation chamber that utilize Methyl Bromide (MeBr) as the only fumigant. The draft ATC is included in Appendix A.

II. Applicable Rules

Rule 2201	New and Modified Stationary Source Review Rule (2/18/16)
Rule 2410	Prevention of Significant Deterioration (6/16/11)
Rule 2520	Federally Mandated Operating Permits (6/21/01)
Rule 4001	New Source Performance Standards (4/14/99)
Rule 4002	National Emissions Standards for Hazardous Air Pollutants (5/20/04)
Rule 4101	Visible Emissions (2/17/05)
Rule 4102	Nuisance (12/17/92)
Rule 4201	Particulate Matter Concentration (12/17/92)
Rule 4301	Fuel Burning Equipment (12/17/92)
Rule 4305	Boilers, Steam Generators and Process Heaters – Phase II (8/21/03)
Rule 4306	Boilers, Steam Generators and Process Heaters – Phase III (3/17/05)
Rule 4320	Advanced Emission Reduction Options for Boilers, Steam Generators, and Process Heaters Greater than 5.0 MMBtu/hr (10/16/08)
Rule 4801	Sulfur Compounds (12/17/92)
CH&SC 41700	Health Risk Assessment
CH&SC 42301.6	School Notice
Public Resources Code 21000-21177: California Environmental Quality Act (CEQA)	
California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000-15387: CEQA Guidelines	

III. Project Location

The facility is located at 6011 East Pine Street, Lodi, in California. The equipment is not located within 1,000 feet of the outer boundary of a K-12 school. Therefore, the public notification requirement of California Health and Safety Code 42301.6 is not applicable to this project.

IV. Process Description

The primary business of RTC is processing and packing agricultural commodities. The new fumigation chamber is mainly used for fumigate cherries. The capacity of the new chamber is approximately 62,700 cubic feet (40'L x 55' W x 28'6" H).

Cherries are placed inside the fumigation chamber then MeBr is injected into the chamber for the purpose of killing various bacteria. After a fumigation cycle is complete, the chamber is aerated to the atmosphere until the fumigant concentration inside the chamber is less than 5 ppmv, and cherries are unloaded and packed for shipment.

V. Equipment Listing

N-8844-2-0: METHYL BROMIDE FUMIGATION OPERATION CONSISTING OF ONE CHAMBER (APPROXIMATE CAPACITY (40'L X 55'W X 28'6"H)

VI. Emission Control Technology Evaluation

All used fumigant is vented directly to the atmosphere. No emission control technology is used.

VII. General Calculations

A. Assumptions

- MeBr in gaseous form is 100% VOC.
- All MeBr used is emitted to the atmosphere.
- Other assumptions will be stated as each is made.

B. Emission Factors

Since MeBr is considered 100% VOC, therefore, EF = 1 lb-VOC/lb-fumigant.

C. Calculations

1. Pre-Project Potential to Emit (PE1)

Since this is a new emissions unit, PE1 = 0 for all pollutants.

2. Post Project Potential to Emit (PE2)

The proposed daily and annual MeBr usages are 300 pounds per day and 10,000 pounds per year respectively. The post-project potential to emit for this permit unit is summarized below:

PE2		
Pollutant	Daily Emissions (lb/day)	Annual Emissions (lb/year)
NO _x	0	0
SO _x	0	0
PM ₁₀	0	0
CO	0	0
VOC	300	10,000

3. Pre-Project Stationary Source Potential to Emit (SSPE1)

Pursuant to District Rule 2201, the SSPE1 is the Potential to Emit (PE) from all units with valid Authorities to Construct (ATC) or Permits to Operate (PTO) at the Stationary Source and the quantity of Emission Reduction Credits (ERC) which have been banked since September 19, 1991 for Actual Emissions Reductions (AER) that have occurred at the source, and which have not been used on-site.

SSPE1 (lb/year)					
Permit Unit	NO _x	SO _x	PM ₁₀	CO	VOC
N-8844-1-1	0	0	0	0	9,000
SSPE1	0	0	0	0	9,000

4. Post Project Stationary Source Potential to Emit (SSPE2)

Pursuant to District Rule 2201, the SSPE2 is the PE from all units with valid ATCs or PTOs at the Stationary Source and the quantity of ERCs which have been banked since September 19, 1991 for AER that have occurred at the source, and which have not been used on-site.

SSPE2 (lb/year)					
Permit Unit	NO _x	SO _x	PM ₁₀	CO	VOC
N-8844-1-2	0	0	0	0	9,000
N-8844-2-0	0	0	0	0	10,000
SSPE2	0	0	0	0	19,000

5. Major Source Determination

Rule 2201 Major Source Determination:

Pursuant to District Rule 2201, a Major Source is a stationary source with a SSPE2 equal to or exceeding one or more of the following threshold values. For the purposes of determining major source status the following shall not be included:

- any ERCs associated with the stationary source
- Emissions from non-road IC engines (i.e. IC engines at a particular site at the facility for less than 12 months)
- Fugitive emissions, except for the specific source categories specified in 40 CFR 51.165

Rule 2201 Major Source Determination (lb/year)						
	NO _x	SO _x	PM ₁₀	PM _{2.5}	CO	VOC
SSPE1	0	0	0	0	0	9,000
SSPE2	0	0	0	0	0	19,000
Major Source Threshold	20,000	140,000	140,000	140,000	200,000	20,000
Major Source?	No	No	No	No	No	No

Note: PM2.5 assumed to be equal to PM10

As seen in the table above, the facility is not an existing Major Source and is not becoming a Major Source as a result of this project.

Rule 2410 Major Source Determination:

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(iii). Therefore the PSD Major Source threshold is 250 tpy for any regulated NSR pollutant.

PSD Major Source Determination (tons/year)						
	NO ₂	VOC	SO ₂	CO	PM	PM ₁₀
Estimated Facility PE before Project Increase	0	4.5	0	0	0	0
PSD Major Source Thresholds	250	250	250	250	250	250
PSD Major Source ? (Y/N)	N	N	N	N	N	N

As shown above, the facility is not an existing PSD major source for any regulated NSR pollutant expected to be emitted at this facility.

6. Baseline Emissions (BE)

The BE calculation (in lb/year) is performed pollutant-by-pollutant for each unit within the project to calculate the QNEC, and if applicable, to determine the amount of offsets required.

Pursuant to District Rule 2201, BE = PE1 for:

- Any unit located at a non-Major Source,
- Any Highly-Utilized Emissions Unit, located at a Major Source,
- Any Fully-Offset Emissions Unit, located at a Major Source, or
- Any Clean Emissions Unit, located at a Major Source.

otherwise,

BE = Historic Actual Emissions (HAE), calculated pursuant to District Rule 2201.

As shown in Section VII.C.5 above, the facility is not a Major Source for any pollutant.

Therefore BE = PE1.

N-8844-2-0:

Since this is a new emissions unit, BE = PE1 = 0 for all pollutants.

7. SB 288 Major Modification

SB 288 Major Modification is defined in 40 CFR Part 51.165 as "any physical change in or change in the method of operation of a major stationary source that would result in a significant net emissions increase of any pollutant subject to regulation under the Act."

Since this facility is not a major source for any of the pollutants addressed in this project, this project does not constitute an SB 288 major modification.

8. Federal Major Modification

District Rule 2201 states that a Federal Major Modification is the same as a "Major Modification" as defined in 40 CFR 51.165 and part D of Title I of the CAA.

Since this facility is not a Major Source for any pollutants, this project does not constitute a Federal Major Modification.

9. Rule 2410 – Prevention of Significant Deterioration (PSD) Applicability Determination

Rule 2410 applies to any pollutant regulated under the Clean Air Act, except those for which the District has been classified nonattainment. The pollutants which must be addressed in the PSD applicability determination for sources located in the SJV and which are emitted in this project are: (See 52.21 (b) (23) definition of significant)

The proposed project emit only VOC.

I. Project Emissions Increase - New Major Source Determination

The post-project potentials to emit from all new and modified units are compared to the PSD major source thresholds to determine if the project constitutes a new major source subject to PSD requirements.

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(iii). The PSD Major Source threshold is 250 tpy for any regulated NSR pollutant.

PSD Major Source Determination: Potential to Emit (tons/year)						
	NO₂	VOC	SO₂	CO	PM	PM₁₀
Total PE from New and Modified Units	0	5.0	0	0	0	0
PSD Major Source threshold	250	250	250	250	250	250
New PSD Major Source?	N	N	N	N	N	N

As shown in the table above, the potential to emit for the project, by itself, does not exceed any PSD major source threshold. Therefore Rule 2410 is not applicable and no further analysis is required.

10. Quarterly Net Emissions Change (QNEC)

The QNEC is calculated solely to establish emissions that are used to complete the District's PAS emissions profile screen. Detailed QNEC calculations are included in Appendix E.

VIII. Compliance Determination

Rule 2201 New and Modified Stationary Source Review Rule

A. Best Available Control Technology (BACT)

1. BACT Applicability

BACT requirements are triggered on a pollutant-by-pollutant basis and on an emissions unit-by-emissions unit basis. Unless specifically exempted by Rule 2201, BACT shall be required for the following actions*:

- a. Any new emissions unit with a potential to emit exceeding two pounds per day,
- b. The relocation from one Stationary Source to another of an existing emissions unit with a potential to emit exceeding two pounds per day,
- c. Modifications to an existing emissions unit with a valid Permit to Operate resulting in an AIPE exceeding two pounds per day, and/or
- d. Any new or modified emissions unit, in a stationary source project, which results in an SB 288 Major Modification or a Federal Major Modification, as defined by the rule.

*Except for CO emissions from a new or modified emissions unit at a Stationary Source with an SSPE2 of less than 200,000 pounds per year of CO.

a. New emissions units – PE > 2 lb/day

As seen in Section VII.C.2 above, the applicant is proposing to install a new fumigation chamber with a PE greater than 2 lb/day for VOC. BACT is triggered for VOC.

b. Relocation of emissions units – PE > 2 lb/day

As discussed in Section I above, there are no emissions units being relocated from one stationary source to another; therefore BACT is not triggered.

c. Modification of emissions units – AIPE > 2 lb/day

As discussed in Section I above, there are no modified emissions units associated with this project. Therefore BACT is not triggered.

d. SB 288/Federal Major Modification

As discussed in Sections VII.C.7 and VII.C.8 above, this project does not constitute an SB 288 and/or Federal Major Modification for VOC emissions. Therefore BACT is not triggered for any pollutant.

2. BACT Guideline

BACT Guideline 5.4.12 applies to commodity Methyl Bromide fumigation chamber (See Appendix B).

3. Top-Down BACT Analysis

Per Permit Services Policies and Procedures for BACT, a Top-Down BACT analysis shall be performed as a part of the application review for each application subject to the BACT requirements pursuant to the District's NSR Rule.

Pursuant to the attached Top-Down BACT Analysis (see Appendix C), BACT has been satisfied with the following:

VOC: minimize use of fumigant (i.e. use no more than product specifications recommend), and airtight fumigation

B. Offsets

1. Offset Applicability

Offset requirements shall be triggered on a pollutant by pollutant basis and shall be required if the SSPE2 equals to or exceeds the offset threshold levels in Table 4-1 of Rule 2201.

The SSPE2 is compared to the offset thresholds in the following table.

Offset Determination (lb/year)					
	NO _x	SO _x	PM ₁₀	CO	VOC
SSPE2	0	0	0	0	19,000
Offset Thresholds	20,000	54,750	29,200	200,000	20,000
Offsets triggered?	No	No	No	No	No

2. Quantity of Offsets Required

As seen above, the SSPE2 is not greater than the offset thresholds for all the pollutants; therefore offset calculations are not necessary and offsets will not be required for this project.

C. Public Notification

1. Applicability

Public noticing is required for:

- a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications,
- b. Any new emissions unit with a Potential to Emit greater than 100 pounds during any one day for any one pollutant,
- c. Any project which results in the offset thresholds being surpassed,
- d. Any project with an SSPE of greater than 20,000 lb/year for any pollutant, and/or
- e. Any project which results in a Title V significant permit modification

a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications

New Major Sources are new facilities, which are also Major Sources. Since this is not a new facility, public noticing is not required for this project for New Major Source purposes.

As demonstrated in Sections VII.C.7 and VII.C.8, this project does not constitute an SB 288 or Federal Major Modification; therefore, public noticing for SB 288 or Federal Major Modification purposes is not required.

b. PE > 100 lb/day

The PE2 for the new chamber is compared to the daily PE Public Notice thresholds in the following table:

PE > 100 lb/day Public Notice Thresholds			
Pollutant	PE2 (lb/day)	Public Notice Threshold	Public Notice Triggered?
NO _x	0.0	100 lb/day	No
SO _x	0.0	100 lb/day	No
PM ₁₀	0.0	100 lb/day	No
CO	0.0	100 lb/day	No
VOC	300.0	100 lb/day	Yes

Therefore, public noticing for PE > 100 lb/day purposes is required.

c. Offset Threshold

The SSPE1 and SSPE2 are compared to the offset thresholds in the following table.

Offset Thresholds				
Pollutant	SSPE1 (lb/year)	SSPE2 (lb/year)	Offset Threshold	Public Notice Required?
NO _x	0	0	20,000 lb/year	No
SO _x	0	0	54,750 lb/year	No
PM ₁₀	0	0	29,200 lb/year	No
CO	0	0	200,000 lb/year	No
VOC	9,000	19,000	20,000 lb/year	No

As detailed above, there were no thresholds surpassed with this project; therefore public noticing is not required for offset purposes.

d. SSIP > 20,000 lb/year

Public notification is required for any permitting action that results in a SSIP of more than 20,000 lb/year of any affected pollutant. According to District policy, the SSIP = SSPE2 – SSPE1. The SSIP is compared to the SSIP Public Notice thresholds in the following table.

SSIP Public Notice Thresholds					
Pollutant	SSPE2 (lb/year)	SSPE1 (lb/year)	SSIP (lb/year)	SSIP Public Notice Threshold	Public Notice Required?
NO _x	0	0	0	20,000 lb/year	No
SO _x	0	0	0	20,000 lb/year	No
PM ₁₀	0	0	0	20,000 lb/year	No
CO	0	0	0	20,000 lb/year	No
VOC	19,000	9,000	10,000	20,000 lb/year	No

As demonstrated above, the SSIPs for all pollutants were less than 20,000 lb/year; therefore public noticing for SSIP purposes is not required.

e. Title V Significant Permit Modification

Since this facility does not have a Title V operating permit, this change is not a Title V significant Modification, and therefore public noticing is not required.

2. Public Notice Action

As discussed above, public noticing is required for this project for VOC emissions in excess of 100 lb/day. Therefore, public notice documents will be submitted to the California Air Resources Board (CARB) and a public notice will be published in a local newspaper of general circulation prior to the issuance of the ATC for the equipment.

D. Daily Emission Limits (DELs)

DELs and other enforceable conditions are required by Rule 2201 to restrict a unit's maximum daily emissions, to a level at or below the emissions associated with the maximum design capacity. The DEL must be contained in the latest ATC and contained in or enforced by the latest PTO and enforceable, in a practicable manner, on a daily basis. DELs are also required to enforce the applicability of BACT.

Proposed Rule 2201 (DEL) Conditions:

- VOC emissions from this fumigation operation shall not exceed 300.0 pounds in any one day, equivalent to the use of 300.0 pounds of MeBr in any one day. [District Rules 2201 and 4102]
- VOC emissions from this fumigation operation shall not exceed 10,000 pounds in any calendar year, equivalent to the use of 10,000 pounds of MeBr in any one calendar year. [District Rules 2201 and 4102]
- Methyl Bromide (MeBr) shall be the only fumigant used in this fumigation operation. [District Rules 2201 and 4102]

E. Compliance Assurance

1. Source Testing

Pursuant to District Policy APR 1705, source testing is not required to demonstrate compliance with Rule 2201.

2. Monitoring

No monitoring is required to demonstrate compliance with Rule 2201.

3. Recordkeeping

Recordkeeping is required to demonstrate compliance with the offset, public notification and daily emission limit requirements of Rule 2201. The following condition(s) are listed on the permit to operate:

- The following records shall be maintained for the fumigation operation: 1) date; 2) chamber aeration start time; 3) chamber aeration end time; 4) daily MeBr usage in pounds; 5) cumulative annual MeBr usage in pounds; and 6) hourly MeBr emissions in pounds. [District Rules 2201 and 4102]
- The cumulative annual MeBr usage records shall be updated at least once during each week that MeBr is used. [District Rules 1070 and 2201]

4. Reporting

No reporting is required to demonstrate compliance with Rule 2201.

F. Ambient Air Quality Analysis (AAQA)

An AAQA shall be conducted for the purpose of determining whether a new or modified Stationary Source will cause or make worse a violation of an air quality standard.

This project involves only VOCs for which AAQA does not exist; therefore, AAQA is not performed for this project.

Compliance with the requirements of this Rule is expected.

Rule 2410 Prevention of Significant Deterioration

As shown in Section VII.C.9 above, this project does not result in a new PSD major source or PSD major modification. No further discussion is required.

Rule 2520 Federally Mandated Operating Permits

Since this facility's potential emissions do not exceed any major source thresholds of Rule 2201, this facility is not a major source, and Rule 2520 does not apply.

Rule 4001 New Source Performance Standards (NSPS)

This rule incorporates NSPS from Part 60, Chapter 1, Title 40, Code of Federal Regulations (CFR); and applies to all new sources of air pollution and modifications of existing sources of air pollution listed in 40 CFR Part 60. However, no subparts of 40 CFR Part 60 apply to commodity fumigation operation.

Rule 4002 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

This rule incorporates NESHAPs from Part 61, Chapter I, Subchapter C, Title 40, CFR and the NESHAPs from Part 63, Chapter I, Subchapter C, Title 40, CFR; and applies to all sources of hazardous air pollution listed in 40 CFR Part 61 or 40 CFR Part 63. However, no subparts of 40 CFR Part 61 or 40 CFR Part 63 apply to commodity fumigation operation.

Rule 4101 Visible Emissions

Rule 4101 states that no person shall discharge into the atmosphere emissions of any air contaminant aggregating more than 3 minutes in any hour which is as dark as or darker than Ringelmann 1 (or 20% opacity). MeBr is a colorless gas, so visible emissions are not expected to exceed Ringelmann 1 or 20% opacity. The following condition will be listed on the permit to ensure compliance:

- {15} No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]

Rule 4102 Nuisance

Rule 4102 prohibits discharge of air contaminants which could cause injury, detriment, nuisance or annoyance to the public. Public nuisance conditions are not expected as a result of these operations provided that the equipment is well maintained.

California Health & Safety Code 41700 (Health Risk Assessment)

As part of the application review process, the District performed a Risk Management Review (RMR). Conservative assumptions were utilized to determine the worst-case risk to all possible receptors. Please note that the values used to arrive at the project risk level have many safety factors built in. The purpose of those safety factors is to ensure that the most sensitive receptors (children, elderly, pregnant women and people with weakened immune systems) are protected.

In 2015, the state Office of Environmental Health Hazard Assessment (OEHHA) adopted changes to *Air Toxics Hot Spots Program Guidance Manual for the Preparation of Risk Assessments* (Risk Assessment Guidelines). These revisions were mainly designed to provide enhanced protection of children and other sensitive receptors.

To ensure the greatest health protection, the District's incorporated all of OEHHA's suggested revisions that increased calculated risk, but did not incorporate those changes that decreased calculated risk. The District's revised risk management policies, incorporated the following:

- More health protective 95th percentile breathing rate for both children AND adults, instead of OEHHA's proposed 95th percentile for children only and 80th percentile for adults,
- More health protective 70-year residential exposure instead of OEHHA's proposed 30-year, unless the expected project life is shorter,
- More health protective 40-year worker exposure instead of OEHHA's proposed 25-year, unless the expected project life is shorter,
- More health protective receptor (point-specific) impacts instead of OEHHA's spatial averaging method,
- All of the OEHHA changes that increase calculated risk for children

The District's current thresholds of significance for toxic air contaminant (TAC) emissions are presented in the following table. Evaluated under the new methodologies described above, the proposed project health risk exposure - short-term acute, long-term chronic, and carcinogen are within acceptable limits, and as such, are not expected to pose a significant health risk to any receptor (see Appendix D for further detail).

Maximally Exposed Individual risk Category	Significance Thresholds for Toxic Air Contaminant (TAC) Emissions	Proposed Project	Significant Toxic Air Contaminant Emissions?
*Carcinogens	≥ 20 in one million	N/A	NO
Non-Carcinogen (Acute)	≥ 1	0.68	NO
Non-Carcinogen (Chronic)	≥ 1	0.01	NO

*Carcinogens were not calculated since there are no risk factors associated with any of the Toxic Air Contaminants (TACs) for this project.

Discussion of Toxic Best Available Control Technology (T-BACT)

Although the project is approvable as shown above, risk can be further reduced by applying additional control techniques, on an emission unit-by-emission unit basis, when emissions are above the District's Toxic Best Available Control Technology (T-BACT) threshold of 1 in a million for cancer risk. The cancer risk for the units in this project are shown in the table below:

HRA Summary		
Unit	*Cancer Risk	T-BACT Required?
N-8844-2-0	N/A	NO

*Cancer risk was not calculated since there are no risk factors associated with any of the Toxic Air Contaminants (TACs) for this project.

As shown above, T-BACT is not required for this project because the HRA indicates that the risk is not above the District's thresholds for triggering T-BACT requirements; therefore, compliance with the District's Risk Management Policy is expected.

District policy APR 1905 also specifies that the increase in emissions associated with a proposed new source or modification not have acute or chronic indices, or a cancer risk greater than the District's significance levels (i.e. acute and/or chronic indices greater than 1 and a cancer risk greater than 20 in a million). As outlined by the HRA Summary in Appendix D of this report, the emissions increases for this project was determined to be less than significant.

- The exhaust stack shall be at least 100 feet tall.
- The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap, roof overhang, or any other obstruction.

- The chamber daily and annual methyl bromide usage shall not exceed 300 lb/day or 10,000 lb/yr.
- Total methyl bromide emissions emitted into the atmosphere shall not be greater than 272.1 pounds in any given rolling hour.
- The fumigation chamber may only be exhausted from 11 PM to 5 AM.

Therefore, compliance with the requirements of this rule is expected and the following condition will be listed on the permit:

- {98} No air contaminant shall be released into the atmosphere, which causes a public nuisance. [District Rule 4102]

California Health & Safety Code 42301.6 (School Notice)

The District has verified that this site is not located within 1,000 feet of a school. Therefore, pursuant to California Health and Safety Code 42301.6, a school notice is not required.

California Environmental Quality Act (CEQA)

CEQA requires each public agency to adopt objectives, criteria, and specific procedures consistent with CEQA Statutes and the CEQA Guidelines for administering its responsibilities under CEQA, including the orderly evaluation of projects and preparation of environmental documents. The District adopted its *Environmental Review Guidelines* (ERG) in 2001. The basic purposes of CEQA are to:

- Inform governmental decision-makers and the public about the potential, significant environmental effects of proposed activities;
- Identify the ways that environmental damage can be avoided or significantly reduced;
- Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible; and
- Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

The District is the Lead Agency for this project because there is no other agency with broader statutory authority over this project. The District performed an assessment (this document) to determine whether or not any potential environmental impacts for this project are significant under CEQA. Further details of this analysis are presented below:

Criteria Pollutants - Operational Emissions: Permitted Sources

District implementation of New Source Review (NSR) ensures that there are no net increases in emissions above specified thresholds from New and Modified Stationary Sources for all nonattainment pollutants and their precursors from stationary source emissions which require District-issued permits. The project-related stationary source criteria pollutant emissions are below the District CEQA thresholds of significance for all pollutants (see table below):

Pollutant	CEQA Significance Thresholds for Permitted Equipment and Activities (tpy)	Proposed Project Potential to Emit (tpy)	Significant Criteria Emissions Under CEQA?
CO	100	0	NO
NOx	10	0	NO
VOC	10	5	NO
SOx	27	0	NO
PM10	15	0	NO
PM2.5	15	0	NO

Criteria Pollutants - Operational Emissions: Non-Permitted Sources

The non-permitted operational criteria emissions (i.e., from sources which are not subject to District permitting requirements) for the project, consisting of those emissions generated from new vehicle miles traveled or rail traffic, are below the District's established levels of significance for non-permitted equipment and activities, which are the same thresholds as those identified above for Permitted equipment and activities (e.g. 10 tons of NOx per year). The proposed project is below the District's conservative significance screening threshold of 47 one-way truck trips per day, and is therefore below the significance threshold for all pollutants. In conclusion, operational emissions for non-permitted sources are below the District CEQA thresholds of significance for all pollutants.

Criteria Pollutants - Construction

A project may be subject to further District CEQA analysis if the project involves construction activities such as disturbing soil outside the perimeter of the existing facility. The project does not involve demolition, excavation, and/or grading construction activities that encompass an area exceeding 20,000 SF (inside or outside the perimeter of the existing facility). This project involves the installation of a fumigation chamber inside an existing building. As such, there would be minimal construction activities. Therefore, construction emissions would be considered to be below the District CEQA thresholds of significance.

Toxic Air Contaminants

As part of the application review process, the District performed a Risk Management Review (RMR). Conservative assumptions were utilized to determine the worst-case risk to all possible receptors. Please note that the values used to arrive at the project risk level have many safety factors built in. The purpose of those safety factors is to ensure that the most sensitive receptors (children, elderly, pregnant women and people with weakened immune systems) are protected.

In 2015, the state Office of Environmental Health Hazard Assessment (OEHHA) adopted changes to *Air Toxics Hot Spots Program Guidance Manual for the Preparation of Risk Assessments* (Risk Assessment Guidelines). These revisions were mainly designed to provide enhanced protection of children and other sensitive receptors.

To ensure the greatest health protection, the District's incorporated all of OEHHA's suggested revisions that increased calculated risk, but did not incorporate those changes that decreased calculated risk. The District's revised risk management policies, incorporated the following:

- More health protective 95th percentile breathing rate for both children AND adults, instead of OEHHA's proposed 95th percentile for children only and 80th percentile for adults,
- More health protective 70-year residential exposure instead of OEHHA's proposed 30-year, unless the expected project life is shorter,
- More health protective 40-year worker exposure instead of OEHHA's proposed 25-year, unless the expected project life is shorter,
- More health protective receptor (point-specific) impacts instead of OEHHA's spatial averaging method,
- All of the OEHHA changes that increase calculated risk for children.

The District's current thresholds of significance for toxic air contaminant (TAC) emissions from the operations of both permitted and non-permitted sources are combined and presented in the following table.

Evaluated under these new methodologies, the proposed project health risk values are within acceptable limits (see table below), and as such, are not expected to pose a significant health risk to any receptor.

Maximally Exposed Individual risk Category	CEQA Significance Thresholds for Toxic Air Contaminant (TAC) Emissions	Proposed Project	Significant Toxic Air Contaminant Emissions Under CEQA?
*Carcinogens	≥ 20 in one million	N/A	NO
Non-Carcinogen (Acute)	≥ 1	0.68	NO
Non-Carcinogen (Chronic)	≥ 1	0.01	NO

*Carcinogens were not calculated since there are no risk factors associated with any of the Toxic Air Contaminants (TACs) for this project.

Other Impacts (e.g. Water Quality, Noise, Odor Nuisance, etc.)

The District assessed the other possible environmental impacts of the proposed project as well. The proposed project is below all of the District's established screening levels of significance for non-permitted equipment and activities (*District Policy APR 2010 - CEQA Implementation*). In addition, Rivermaid is a facility that processes and packages agricultural

commodities, which already includes fumigation as an operational activity. The operation is an allowed-use by the County of San Joaquin, and is surrounded by similar industrial operations. As such, the District has concluded that the project will not have any significant adverse effects on the environment due to these other impacts.

Greenhouse Gases (GHGs)

Stationary Source GHGs:

The project involves the use of Methyl Bromide for fumigation. Methyl Bromide is not considered a greenhouse gas. As such the project would not result in an increase in project specific greenhouse gas emissions. Therefore, the project would have a less than cumulatively significant impact on global climate change.

Mobile Source GHGs:

On December 17, 2009, the District's Governing Board adopted a policy, APR 2005, *Addressing GHG Emission Impacts for Stationary Source Projects Under CEQA When Serving as the Lead Agency*, for addressing GHG emission impacts when the District is Lead Agency under CEQA and approved the District's guidance document for use by other agencies when addressing GHG impacts as lead agencies under CEQA. Under this policy, the District's determination of significance of project-specific GHG emissions is founded on the principal that projects with GHG emission reductions consistent with AB 32 emission reduction targets are considered to have a less than significant impact on global climate change. Consistent with District Policy 2005, projects complying with an approved GHG emission reduction plan or GHG mitigation program, which avoids or substantially reduces GHG emissions within the geographic area in which the project is located, would be determined to have a less than significant individual and cumulative impact for GHG emission.

The California Air Resources Board (ARB) adopted a Cap-and-Trade regulation as part of one of the strategies identified for AB 32. This Cap-and-Trade regulation is a statewide plan, supported by a CEQA compliant environmental review document, aimed at reducing or mitigating GHG emissions from targeted industries. Facilities required to comply with the Cap-and-Trade regulation are subject to an industry-wide cap on overall GHG emissions. Any growth in emissions must be accounted for under that cap such that a corresponding and equivalent reduction in emissions must occur to allow any increase. Further, the cap decreases over time, resulting in an overall decrease in GHG emissions.

Under District policy APR 2025, *CEQA Determinations of Significance for Projects Subject to ARB's GHG Cap-and-Trade Regulation*, the District finds that the Cap-and-Trade is a regulation plan approved by ARB, consistent with AB32 emission reduction targets, and supported by a CEQA compliant environmental review document. As such, consistent with District Policy 2005, projects complying with Cap-and-Trade requirements are determined to have a less than significant individual and cumulative impact for GHG emissions.

Industries covered by Cap-and-Trade are identified in the regulation under section 95811, Covered Entities:

1. *Group 1: Large industrial facilities*

These types of facilities are subject to Cap and Trade, and the specific companies covered are listed at <http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm>, Section 95811 (a), under the "Publically Available Market Information" section (list maintained by the California Air Resources Board).

2. *Group 2: Electricity generation facilities located in California, or electricity importers*

These types of facilities are subject to Cap and Trade (section 95811, b).

3. *Group 3: Suppliers of Natural Gas, Suppliers of Reformulated Gasoline Blendstock for Oxygenate Blending and Distillate Fuel Oil, Suppliers of Liquefied Petroleum Gas, and Suppliers of Blended Fuels*

These entities are subject to Cap and Trade compliance obligations which must cover all fuels (except jet fuels) identified in section 95811 (c) through (f) of the Cap-and-Trade regulation delivered to end users in California, less the fuel delivered to covered entities (group 1 above).

Mobile source GHG emissions are subject to the Cap-and-Trade regulation. Therefore, as discussed above, consistent with District Policies APR 2005 and APR 2025, the District concludes that the GHG emissions increases associated with this project would have a less than significant individual and cumulative impact on global climate change.

District CEQA Findings:

As discussed above, the District reviewed and assessed if there would be any potential significant impacts to the environment, and determined that the proposed project will not result in a potentially significant impact to the environment. As such, the project is exempt per the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment (e.g.: general CEQA "common sense" exemption.)

In addition, the size of the proposed project is approximately 2,200 ft². CEQA Guideline for Categorical Exemptions, specifically 15301(e) (Existing Facilities), allows for addition to existing structures that will not result in an increase in size of existing structure (not to exceed 10,000 ft²). The size of the proposed project is less than the 10,000 ft² and is within the scope of the exemption.

In conclusion, the District finds that the project is exempt per the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the

environment (CEQA Guidelines §15061(b)(3)), and is also categorically exempt from the provisions of CEQA pursuant to CEQA Guideline §15301 (Existing Facilities).

IX. Recommendation

Compliance with all applicable rules and regulations is expected. Pending a successful NSR Public Noticing period, issue ATC N-8844-2-0 subject to the permit conditions on the attached draft ATC in Appendix A.

X. Billing Information

Annual Permit Fees			
Permit Number	Fee Schedule	Fee Description	Annual Fee
N-8844-2-0	3020-01-A	7 hp	\$97.00

Appendixes

- A: Draft ATC
- B: BACT Guideline
- C: BACT Analysis
- D: HRA Summary
- E: Quarterly Net Emissions Change
- F: Public Comments
- G: District Responses to Public Comments

APPENDIX A
Draft ATC

San Joaquin Valley
Air Pollution Control District

AUTHORITY TO CONSTRUCT

ISSUANCE DATE: DRAFT

PERMIT NO: N-8844-2-0

LEGAL OWNER OR OPERATOR: RIVERMAID TRADING, CO.

MAILING ADDRESS: PO BOX 350
LODI, CA 95241

LOCATION: 6011 EAST PINE
LODI, CA 95241

EQUIPMENT DESCRIPTION:

METHYL BROMIDE FUMIGATION OPERATION CONSISTING OF ONE CHAMBER (APPROXIMATE CAPACITY 40'L X 55'W X 28'6"H)

CONDITIONS

1. {15} No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]
2. {98} No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]
3. All fumigation operations must be conducted inside the fumigation chamber, and the fumigation chamber must be maintained in a sealed and air-tight condition when in operation. [District Rule 4102]
4. {1898} The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction. [District Rule 4102]
5. The height of the exhaust stack from the ground shall be at least 100 feet. [District Rule 4102]
6. The fumigation chamber shall be aerated only from the period of 11 PM through 5 AM in any rolling 24-hour period. [District Rule 4102]
7. Methyl Bromide (MeBr) shall be the only fumigant used in this fumigation operation. [District Rules 2201 and 4102]
8. VOC emissions from this fumigation operation shall not exceed 300.0 pounds in any one day, equivalent to the use of 300.0 pounds of MeBr in any one day. [District Rule 2201]
9. VOC emissions from this fumigation operation shall not exceed 10,000 pounds in any one calendar year, equivalent to the use of 10,000 pounds of MeBr in any one calendar year. [District Rules 2201 and 4102]

CONDITIONS CONTINUE ON NEXT PAGE

YOU **MUST** NOTIFY THE DISTRICT COMPLIANCE DIVISION AT (209) 557-6400 WHEN CONSTRUCTION IS COMPLETED AND PRIOR TO OPERATING THE EQUIPMENT OR MODIFICATIONS AUTHORIZED BY THIS AUTHORITY TO CONSTRUCT. This is NOT a PERMIT TO OPERATE. Approval or denial of a PERMIT TO OPERATE will be made after an inspection to verify that the equipment has been constructed in accordance with the approved plans, specifications and conditions of this Authority to Construct, and to determine if the equipment can be operated in compliance with all Rules and Regulations of the San Joaquin Valley Unified Air Pollution Control District. Unless construction has commenced pursuant to Rule 2050, this Authority to Construct shall expire and application shall be cancelled two years from the date of issuance. The applicant is responsible for complying with all laws, ordinances and regulations of all other governmental agencies which may pertain to the above equipment.

Seyed Sadredin, Executive Director / APCO

Arnaud Marjollet, Director of Permit Services

N-8844-2-0, Feb 24 2017, 8:40AM - SOW - Joint Inspection NOT Required

10. MeBr emissions from this fumigation operation shall not exceed 272.1 pounds in any given rolling hour. The hourly MeBr emissions rate shall be calculated: $\text{MeBr Emissions (lb/hour)} = \text{Quantity of MeBr injected into the chamber (lb/cycle)} \times 0.907 \text{ (cycle/hour)}$. [District Rule 4102]
11. The concentration of methyl bromide in the fumigation chamber shall not exceed 5 ppm at any time that the fumigation chamber doors are open. APHIS-approved thermal conductivity gas analyzer or infrared spectroscopy gas monitoring device shall be used to ensure compliance with this requirement. [District Rule 2201]
12. There shall be no emissions of methyl bromide from valves, flanges, or other connectors, and APHIS-approved leak detection device shall be used to ensure compliance with this requirement. [District Rule 2201]
13. The permittee shall keep records of the data collected from all methyl bromide analyzers and leak detection devices to demonstrate compliance with the emissions limits on this permit. [District Rule 2201]
14. The following records shall be maintained for the fumigation operation: 1) date; 2) chamber aeration start time; 3) chamber aeration end time; 4) daily MeBr usage in pounds; 5) cumulative annual MeBr usage in pounds; and 6) hourly MeBr emissions in pounds. [District Rules 2201 and 4102]
15. The cumulative annual MeBr usage records shall be updated at least once during each week that MeBr is used. [District Rules 1070 and 2201]
16. {4922} On a monthly basis, the permittee shall calculate and record the monthly VOC emissions from this unit. [District Rule 2201]
17. {4923} On a monthly basis, the permittee shall calculate and record the facility-wide VOC emissions in pounds for the rolling 12-month period. The facility-wide VOC emissions shall be calculated by summing the VOC emissions from the previous 12 months from every permitted unit at this facility. [District Rule 2201]
18. {3246} All records shall be maintained and retained on-site for a period of at least 5 years and shall be made available for District inspection upon request. [District Rule 1070]

DRAFT

APPENDIX B

BACT Guideline

San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.4.12*

Last Update: 06/25/2008

Commodity Methyl Bromide Fumigation Chamber

Pollutant	Achieved in Practice or contained in the SIP	Technologically Feasible	Alternate Basic Equipment
VOC	Minimize use of fumigant (i.e. use no more than product specifications recommend), and airtight fumigation	1. 99% control (chemical scrubbing) 2. 98% control (thermal or catalytic reduction) 3. 95% control (carbon adsorption) 4. 81% control (carbon adsorption with onsite re-activation using chemical scrubber) 5. 80% control (condensation refrigeration system)	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source**

APPENDIX C

BACT Analysis

Top-Down BACT Analysis for VOC Emissions

The following VOC emission control technologies are listed in BACT guideline 5.4.12, 1st quarter, 2016, Commodity Methyl Bromide Fumigation Chamber.

Step 1: Identify All Possible Control Technologies

Achieved in Practice or contained in SIP:

Minimize use of fumigant (i.e. use no more than product specifications recommend), and airtight fumigation

Technologically Feasible:

- 99% control (chemical scrubbing)
- 98% control (thermal or catalytic reduction)
- 95% control (carbon adsorption)
- 81% control (carbon adsorption with onsite re-activation using chemical scrubber)
- 80% control (condensation refrigeration system)

Alternate Basic Equipment:

There is no alternate basic equipment listed in this guideline.

Step 2: Eliminate Technologically Infeasible Options

For option: 98% control (thermal or catalytic reduction)

Thermal incineration of methyl bromide produces toxic gas hydrogen bromide. The incineration process must be followed with a chemical scrubber to treat this toxic gas. Furthermore, installing such an incineration apparatus would result in significant increases in collateral emissions (mainly NO_x).

Catalytic incineration of methyl bromide will foul the catalyst. Furthermore, installing such incineration apparatus would result in significant increases in collateral emissions (mainly NO_x).

Therefore, thermal and catalytic incineration is considered to be technologically infeasible for this operation and is eliminated from further analysis.

For option: 81% control (carbon adsorption with onsite re-activation using chemical scrubber)

The District is in the progress of revising this current BACT guideline for commodity Methyl Bromide fumigation chamber, to split it into two categories; a) smaller scale methyl bromide fumigation operations using less than 100,000 pounds of methyl bromide per year; and b) operations using greater than or equal to 100,000 pounds of methyl bromide per year. Both categories will remove onsite re-activation from the current BACT guideline. For large-scale

commodity fumigation facilities that use large quantities of fumigant, on-site carbon bed re-activation is a cost-saving alternative to shipping saturated carbon canisters offsite for reactivation. On-site re-activation of saturated carbon canisters using a chemical scrubber only controls emissions from the re-activation process; it has no effect on controlling emissions from the fumigation chamber venting process.

Therefore, carbon adsorption with onsite re-activation using chemical scrubber is eliminated from further analysis because it has no effect on controlling emissions from the fumigation chamber venting process.

All other options identified above are considered to be technologically feasible.

Step 3: Rank Remaining Control Technologies by Control Effectiveness

- 1) 99% control – Chemical scrubbing system (Technologically Feasible)
- 2) 95% control – Carbon adsorption (Technologically Feasible)
- 3) 80% control – Condensation using a refrigeration system (Technologically Feasible)
- 4) Use of air-tight fumigation chambers and minimized use of fumigant (i.e. use no more than product specification recommend). (Achieved in Practice)

Step 4: Cost Effectiveness Analysis

A cost-effective analysis will now be performed for the control technologies specified above. As shown in section VII.C.1 of this document, the uncontrolled VOC emissions from the new fumigation operation is calculated to 10,000 lb/yr.

Option 1: Chemical Scrubber with 99% control

No fumigation facility in the District has been permitted to use a chemical scrubber system to control methyl bromide emissions from fumigation operation. Therefore, an actual cost quote for a chemical scrubber system that capable to achieve 99% control efficiency provided under engineering evaluation N-1062096, for a similar MeBr fumigation operation, is used.

Per project N-1062096, the proposed fumigation operation will be conducted inside an airtight atmospheric chamber with minimize use of fumigant. Most methyl bromide fumigation operations permitted in the District are conducted inside of this type of chamber and utilize no more than product specifications recommend amount of fumigant. US Department of Agriculture also requires fumigations be conducted inside airtight chambers. Therefore, using airtight atmospheric chamber with minimize use of fumigant is determined to be "industry standard".

The annual methyl bromide usage for the fumigation operation under project N-1062096 is 19,999 pounds. Based on economics of scales, it is obvious that any control found to not be cost-effective at this level of throughput would be even less cost-effective at lower capacities, such as the annual methyl bromide usage of 10,000 pounds in this application.

This cost quote provided in project N-1062096 includes two elements:

- 1) Two scrubbers should be connected in series for every 100 acfm to obtain 99% control.
- 2) Scrubber cost is \$45,000/unit.

The exhaust airflow rate of the proposed fumigation operation is 12,000 acfm. Therefore, the control system would need 240 scrubbers with a total cost of \$10,800,000 (\$45,000/unit x 240 units).

Adjusting from 2006 dollars to 2016 dollars; (multiply by 1.344, 3% inflation/yr)¹.

The cost of the scrubbers system = \$10,800,000 x 1.344 = \$14,515,200

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

$$\text{Amortization Factor} = \left[\frac{0.1(1.1)^{10}}{(1.1)^{10} - 1} \right] = 0.163 \text{ per District policy, amortizing over 10 years at 10\%}$$

Therefore,

Annualized Capital Investment = \$14,515,200 x 0.163 = \$2,365,978

$$\begin{aligned} \text{Controlled VOC emissions} &= 10,000 \text{ lb-VOC/yr} \times 1 \text{ tons-VOC}/2,000 \text{ lb-VOC} \times 0.99 \\ &= 4.95 \text{ ton-VOC/yr} \end{aligned}$$

Cost of VOC reduction is calculated as follows:

$$\begin{aligned} \text{Cost of VOC reduction} &= \text{cost of system} \div \text{controlled VOC emissions} \\ &= \$2,365,978/\text{yr} \div 4.95 \text{ ton-VOC/yr} \\ &= \$477,975/\text{ton-VOC} \end{aligned}$$

Since the calculated cost of VOC reduction exceeds the VOC cost effective threshold of \$17,500/ton. Therefore, this control technology of utilize a chemical scrubber system is deemed not cost effective and will be removed from consideration at this time.

Option 2: Carbon Adsorption with 95% control

Carbon adsorption occurs when air containing VOC mixture is blown through a carbon canister and the VOC mixture is adsorbed onto the surface of the cracks in the activated carbon particles.

Equipment Cost

Per information provided by Calgon on January 19, 2017, two Protect RO-10 units connected in parallel is recommended for the proposed fumigation operation. Each Protect RO-10 unit holds 10,000 pounds of VPR 4X10 reactivated carbon. The cost of each Protect RO-10 unit filled with VPR 4X10 reactivated carbons is \$89,250. The capital cost of the carbon adsorption system is

¹ Inflation multiplier (IM) = (1 + i)ⁿ, where I is the inflation rate of 3%, and n is the number of year of 10. IM = (1 + 0.03)¹⁰ = 1.344

\$178,500 (\$89,250 x 2). This cost does not include sales tax, freight expenses, operational and maintenance costs, site preparation, etc.

In addition, the spent carbons contain MeBr which is considered a hazardous waste per Resource Conservation and Recovery Act (RCRA)², and Calgon will charge one time RCRA hazardous reactivation testing fee of \$1,000 for the reactivation services.

The total initial capital investment = \$178,500 + \$1,000 = \$179,500

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10} - 1} \right] = 0.163$ per District policy, amortizing over 10 years at 10%

Therefore,

Annualized Capital Investment = \$179,500 x 0.163 = \$29,259

Carbon Exchange Cost

Per information provided by Calgon on January 19, 2017, carbon exchange is required after each aeration period of six hours for the proposed fumigation operation. The cost of exchange these units would be \$4,200 for the service plus \$0.98/lb for VPR 4X10 carbon replacement.

Based on the annual MeBr usage of 10,000 pounds per year and 300.0 lb-MeBr per cycle, the maximum number of fumigation cycle is calculated to 33 cycles per year.

The annual carbon exchange service cost is \$138,600/year (\$4,200/service x 33 services/year). The VPR 4X10 carbon cost is calculated to \$646,800/year (\$0.98/lb-carbon x 10,000 lb-carbon/unit x 2 units/cycle x 33 cycles/year).

Therefore, the total annual carbon exchange cost is calculated to:

Cost = \$138,600/yr + \$646,800/yr = \$785,400/yr

Electricity Cost:

$$\text{Power}_{\text{fan}} = \frac{(1.17 \times 10^{-4}) \times Q \times \Delta P}{\epsilon}$$

Where,

ΔP : Pressure drop across system is assumed to 4 in. H₂O

ϵ : Efficiency for fan and motor is assumed to 0.6

Q: Exhaust flow rate = 12,000 cfm

Power_{fan} = 9.36 kW

² <https://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol27/xml/CFR-2012-title40-vol27-part261.xml>

Per PG&E Electric Schedule AG-1, Rate B with summer season, the electric rate is \$0.23689/kW-hr³.

Thus,

$$\begin{aligned}\text{Electricity cost} &= (\$0.23689/\text{kWh})(9.36 \text{ kW})(6 \text{ hr/day})(33 \text{ days/yr}) \\ &= \$439/\text{yr}\end{aligned}$$

$$\begin{aligned}\text{Total Cost} &= \$29,259/\text{yr} + \$785,400/\text{yr} + \$439/\text{yr} \\ &= \$815,098/\text{yr}\end{aligned}$$

$$\begin{aligned}\text{Controlled VOC emissions} &= 10,000 \text{ lb-VOC/yr} \times 1 \text{ tons-VOC}/2,000 \text{ lb-VOC} \times 0.95 \\ &= 4.75 \text{ ton-VOC/yr}\end{aligned}$$

Cost of VOC reduction is calculated as follow:

$$\begin{aligned}\text{Cost of VOC reduction} &= \text{cost of carbon} \div \text{controlled VOC emissions} \\ &= \$815,098/\text{yr} \div 4.75 \text{ ton-VOC/yr} \\ &= \$171,600/\text{ton-VOC}\end{aligned}$$

Since the calculated cost of VOC reduction exceeds the VOC cost effective threshold of \$17,500/ton. Therefore, this control technology of utilize a carbon adsorption system is deemed not cost effective and will be removed from consideration at this time.

Option 3: Condensation Refrigeration System with 80% control

The cost of the electricity required to operate a refrigerated vapor condenser system alone will be sufficiently to cause this control technology to be not cost effective per District BACT policy. This partial cost estimate does not include the capital equipment costs, or any associated operational and maintenance costs.

This process requires the methyl bromide and exhaust air to be cooled from the typical chamber exhaust temperature of 70°F to the methyl bromide dew point of 35°F and then cooled to a final temperature of 32°F.

An SDUPA study estimated the cost for electricity to run a compressor at \$44,000/cycle, assuming \$0.10/kW-hr and 234,000 cubic foot of air chilled from 70°F to 35°F.

The capacity of the chamber is 62,700 ft³, and the cost to chill the air from 70°F to 35°F for the entire chamber is calculated to:

$$\text{Cost} = \$44,000/\text{cycle} \times (62,700 \text{ ft}^3 \div 234,000 \text{ ft}^3) = \$11,790/\text{cycle}$$

Per PG&E Electric Schedule AG-1, Rate B with summer season, the electric rate is \$0.23614/kW-hr.

³ Per PG&E Electric Schedule AG-1, http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHS_AG-1.pdf
This facility has more than one single-motor installed and the total horsepower rating of the equipment is more than 15 hp, so Rate B is used. In addition, cherries fumigation operation is a seasonal operation which normally operates from 1st to 2nd quarter. Therefore, be conservative summer season rate is used.

Adjusting the cost calculated in the SDUPA study to reflect \$0.23614/kWh-hr results in an electrical compressor cost as follows:

$$\text{Cost} = \$11,790/\text{cycle} \times (\$0.23614/\text{kW-hr} \div \$0.10/\text{kW-hr}) = \$27,841/\text{cycle}$$

Based on the annual MeBr usage of 10,000 pounds per year and 300.0 lb-MeBr per cycle, the maximum fumigation cycle is calculated to 33 cycles per year. Therefore, the annual electricity cost is calculated to:

$$\text{Cost} = \$27,841/\text{cycle} \times 33 \text{ cycle/yr} = \$918,753/\text{yr}$$

$$\begin{aligned} \text{Controlled VOC emissions} &= 10,000 \text{ lb-VOC/yr} \times 1 \text{ tons-VOC}/2,000 \text{ lb-VOC} \times 0.80 \\ &= 4.0 \text{ ton-VOC/yr} \end{aligned}$$

Cost of VOC reduction is calculated as follow:

$$\begin{aligned} \text{Cost of VOC reduction} &= \text{cost of system} \div \text{controlled VOC emissions} \\ &= \$918,753/\text{yr} \div 4.0 \text{ ton-VOC/yr} \\ &= \$229,688/\text{ton-VOC} \end{aligned}$$

Since the calculated cost of VOC reduction exceeds the VOC cost effective threshold of \$17,500/ton. Therefore, this control technology of utilize a condensation refrigeration system is deemed not cost effective and will be removed from consideration at this time.

Step 5: Select BACT

None of the technologically feasible control technologies are cost effective. Therefore, no emissions control equipment is required, and use no more than product specifications recommend and airtight fumigation shall be considered BACT for this operation.

APPENDIX D

HRA Summary

San Joaquin Valley Air Pollution Control District Risk Management Review

To: Wai-Man So – Permit Services
From: Kyle Melching – Permit Services
Date: October 25, 2016
Facility Name: Rivermaid Trading
Location: 6011 Pine St., Lodi
Application #(s): N-8844-2-0
Project #: N-1160591

A. RMR SUMMARY

Categories	Fumigation Operation (Unit 2-0)	Project Totals	Facility Totals
Prioritization Score	105	>1	>1
Acute Hazard Index	0.68	0.68	0.83
Chronic Hazard Index	0.01	0.01	0.4
Maximum Individual Cancer Risk	N/A ¹	0.00	0.00
T-BACT Required?	No		
Special Permit Requirements?	Yes		

¹The Maximum Individual Cancer Risk was not calculated since there are no risk factors associated with any of the Toxic Air contaminants (TACs) under analysis.

Proposed Permit Requirements

To ensure that human health risks will not exceed District allowable levels; the following permit requirements must be included for:

Unit 2-0

1. The exhaust stack shall be at least 100 feet tall.
2. {1898} The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction.
[District Rule 4102] N
3. The chambers daily and annual methyl bromide usage shall not exceed 300 lb/day or 10,000 lb/yr;
4. Total Methyl bromide emissions emitted into the atmosphere shall not be greater than 272.1 pounds in any given rolling hour.
5. The fumigation chamber may only be exhausted from 11 PM to 5 AM.

B. RMR REPORT

I. Project Description

Technical Services received a request on March 17, 2016 to perform a Risk Management Review for the installation of a new methyl bromide fumigation chamber.

II. Analysis

Toxic emissions from the project were calculated after reviewing process rates for Methyl Bromide provided by the engineer and input into the San Joaquin Valley APCD's Hazard Assessment and Reporting Program (SHARP). In accordance with the District's Risk Management Policy for Permitting New and Modified Sources (APR 1905, May 28, 2015), risks from the proposed unit's toxic emissions were prioritized using the procedure in the 1990 CAPCOA Facility Prioritization Guidelines. The prioritization score for the facility is greater than 1.0 (see RMR Summary Table). Therefore, a refined health risk assessment was required. The AERMOD model was used, with the parameters outlined below and meteorological data for 2010-2014 from Stockton to determine the dispersion factors (i.e., the predicted concentration or X divided by the normalized source strength or Q) for a receptor grid. These dispersion factors were input into the SHARP Program, which then used the Air Dispersion Modeling and Risk Tool (ADMRT) of the Hot Spots Analysis and Reporting Program Version 2 (HARP 2) to calculate the chronic and acute hazard indices and the carcinogenic risk for the project.

The following parameters were used for the review:

Analysis Parameters (Unit 2-0)			
Source Type	Point	Closest Receptor (m)	125
Stack Height (m)	30.48	Type of Receptor	Residence
Stack Diameter (m)	0.92	Location Type	Rural
Stack Gas Temperature (K)	294	Stack Gas Velocity (m/sec)	8.57
Methyl Bromide Increase in Emissions (lb/hr)	272.1	Methyl Bromide Emissions (lb/yr)	10,000

III. Conclusions

There is no Cancer Risk associated with Methyl Bromide; and the Acute and Chronic Hazard Index is below 1.0. In accordance with the District's Risk Management Policy, the unit is approved **without** Toxic Best Available Control Technology (T-BACT).

To ensure that human health risks will not exceed District allowable levels; the permit requirements listed on Page 1 of this report must be included for this permit unit.

These conclusions are based on the data provided by the applicant and the project engineer. Therefore, this analysis is valid only as long as the proposed data and parameters do not change.

IV. Attachments

- A. RMR request from the project engineer
- B. Prioritization score
- C. HARP Risk Report
- D. Facility Summary

APPENDIX E
Quarterly Net Emissions Change (QNEC)

Quarterly Net Emissions Change (QNEC)

The Quarterly Net Emissions Change is used to complete the emission profile screen for the District's PAS database. The QNEC shall be calculated as follows:

$QNEC = PE2 - PE1$, where:

- QNEC = Quarterly Net Emissions Change for each emissions unit, lb/qtr.
- PE2 = Post Project Potential to Emit for each emissions unit, lb/qtr.
- PE1 = Pre-Project Potential to Emit for each emissions unit, lb/qtr.

Using the values in Sections VII.C.2 and VII.C.1 in the evaluation above, quarterly PE2 and quarterly PE1 can be calculated as follows:

$$\begin{aligned} PE2_{\text{quarterly}} &= PE2_{\text{annual}} \div 4 \text{ quarters/year} \\ &= 10,000 \text{ lb/year} \div 4 \text{ qtr/year} \\ &= 2,500 \text{ lb VOC/qtr} \end{aligned}$$

$$\begin{aligned} PE1_{\text{quarterly}} &= PE1_{\text{annual}} \div 4 \text{ quarters/year} \\ &= 0 \text{ lb/year} \div 4 \text{ qtr/year} \\ &= 0 \text{ lb VOC/qtr} \end{aligned}$$

Quarterly NEC [QNEC]			
Pollutant	PE2 (lb/qtr)	PE1 (lb/qtr)	QNEC (lb/qtr)
NO _x	0	0	0
SO _x	0	0	0
PM ₁₀	0	0	0
CO	0	0	0
VOC	2,500	0	2,500

APPENDIX F

Public Comments



December 2, 2016

Via Email and US Mail

Arnaud Marjollet
Director of Permit Services
San Joaquin Valley Unified Air Pollution Control District
4800 Enterprise Way
Modesto, CA, 95356
Arnaud.Marjollet@valleyair.org

Re: Comments on Rivermaid Trading's Proposal to Vent 10,000 pounds per year of Methyl Bromide with No Pollution Controls (Project N-1160591)

Dear Mr. Marjollet:

On behalf of Central Valley Air Quality Coalition, Californians for Pesticide Reform, California Environmental Health Initiative, Endangered Habitats League, TriCounty Watchdogs, Association of Irrigated Residents, Central California Environmental Justice Network, Valley Improvement Project, Center for Environmental Health, and California Rural Legal Assistance Foundation, we submit the following comments on Project N-1160591—Rivermaid Trading Company's application for an Authority to Construct a new methyl bromide fumigation chamber in Lodi, California. Methyl bromide is a highly toxic, ozone depleting substance that the U.S. Environmental Protection Agency (EPA) is in the process of phasing out. This project would vent 10,000 pounds a year of methyl bromide directly to the atmosphere, even though pollution controls would be cost effective. The Air District must conduct a full California Environmental Quality Act (CEQA) review for this project, including an analysis of alternatives to the use of methyl bromide, and must require incorporation of all feasible mitigation measures, including requiring the use of carbon absorption as Best Available Control Technology (BACT).

I. The Air District Must Conduct CEQA Review.

CEQA requires the preparation of an Environmental Impact Report (EIR) whenever a public agency proposes to approve a project that may have a significant effect on the environment. (Pub. Resources Code § 21151.) The Air District claims that this project is categorically exempt under CEQA's "common sense exemption" for projects that have insignificant environmental impacts (14 Cal. Code Regs. (CEQA Guidelines) § 15061, subd. (b)(3)), as well as under CEQA Guideline § 15301, which exempts minor alterations at existing facilities from CEQA review. Because neither exemption applies to this project, which releases 10,000 pounds a year of a highly and ozone-depleting toxic chemical into the community, the Air District must conduct CEQA review before approving this project.

CALIFORNIA OFFICE 50 CALIFORNIA STREET, SUITE 500 SAN FRANCISCO, CA 94111

T: 415.217.2000 F: 415.217.2040 CAOFFICE@EARTHJUSTICE.ORG WWW.EARTHJUSTICE.ORG

A. CEQA's Common Sense Exemption Does Not Apply.

CEQA's common sense exemption provides that projects are exempt from CEQA when "it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment." (CEQA Guidelines, § 15061, subd. (b)(3); *Muzzy Ranch*, 41 Cal.4th at pp. 386-87.) The Air District bears the burden in showing that this exemption is appropriate. (*Muzzy Ranch Co. v. Solano County Airport Land Use Com'n* (2007) 41 Cal.4th 372, 387; *Rominger v. County of Colusa* (2014) 229 Cal.App.4th 690, 704; Kostka & Zischke, Practice Under the Cal. Environmental Quality Act (2016) § 5.129, p. 5-120 [noting that the showing that must be made by the agency "is a stringent one"].)

Here, the District concluded, without analysis, that "the activity will not have a significant effect on the environment." (Authority to Construct Application Review at 15.) But the Air District has failed to show with "certainty" that there is no possibility of a significant environmental effect. Given the large quantities of a highly toxic and ozone depleting substance emitted without control by the project, it cannot be said with certainty that this project will not have a significant effect on the environment.

Methyl bromide is a highly toxic gas. Exposure to methyl bromide can cause convulsions, coma, and long-term neuromuscular and cognitive deficits.¹ It is an odorless, colorless gas, which means that it lacks adequate warning properties, and significant exposures can occur before symptoms are evident.² It has caused serious and sometimes fatal poisonings, including to workers using methyl bromide during fumigation.³ The project's use and venting of methyl bromide without control therefore has the obvious potential to "create a significant hazard to the public . . . through the routine . . . use . . . of hazardous materials," and the Air District must conduct environmental review under CEQA. (CEQA Checklist, § VIII(a).)

The Authority to Construct Application Review provides no evidence that this project will not present a significant public health and safety hazard. It fails entirely to evaluate the risks to workers at the fumigation site. And while the Review includes a risk management report for offsite-receptors, as discussed in more detail in section IV, *infra*, the risk management report's conclusions are not supported because (1) it inaccurately calculates the distance to the closest receptor; (2) does not support its assumption that methyl bromide releases would be limited to

¹ Agency for Toxic Substances and Disease Registry, Medical Management Guidelines for Methyl Bromide 5, available at <https://www.atsdr.cdc.gov/mmg/mmg.asp?id=818&tid=160>, Exhibit A; see also Budnik, et al., Prostate Cancer and Toxicity from Critical Use Exemptions of Methyl Bromide: Environmental Protection Helps Protect against Human Health Risks, 2012 Environmental Health 11:5, available at

<https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-11-5>, Exhibit B.

² *Ibid.*

³ W.M.N. Hustinx, Systematic Effects of Inhalational Methyl Bromide Poisoning: A Study of Nine Cases Occupationally Exposed Due to Inadvertent Spread During Fumigation (1993), 50 British Journal of Industrial Medicine 155-159, available at <http://oem.bmj.com/content/50/2/155.full.pdf+html>, Exhibit C.

272.1 lbs./hour; and (3) its conclusions regarding the hazard risk at the facility are in conflict with earlier calculations at the same facility.

Not only is methyl bromide highly toxic, it is a potent ozone-depleting substance.⁴ Under the Montreal Protocol, EPA must phase out most uses of methyl bromide entirely, and as of 2014, only 158 tons of methyl bromide remained for use in the United States.⁵ Although EPA's phase-out does not include quarantine and preshipment uses, these quarantine and preshipment uses are themselves limited, and should only be applications to meet "official requirements" and not "informal or purely contractual or commercial arrangements not required under official regulations." (Protection of Stratospheric Ozone: Process for Exempting Quarantine and Preshipment Applications of Methyl Bromide, 68 Fed. Reg. 238-01, 241 (Jan. 2, 2003).)

There is no evidence in the Authority to Construct Application Review that the use of methyl bromide in this project complies with the narrow exception for quarantine and preshipment uses of methyl bromide and is therefore consistent with the Montreal Protocol and domestic policy and regulations implementing the Protocol. Because the project has the potential to conflict with federal and international regulations and policy concerning ozone depletion, the Air District must conduct environmental review under CEQA. (See, e.g., CEQA Checklist, § III(a) [lead agencies must evaluate conflicts with air quality plans].) The common sense exemption to CEQA does not apply.

B. CEQA's Existing Facilities Exemption Does Not Apply.

The project is also not exempt from CEQA under the existing facilities exemption. The Section 15301 categorical exemption applies to the "operation, repair, maintenance . . . or minor alteration of existing public or private structures, facilities . . . involving *negligible or no expansion of use beyond that existing at the time of the lead agency's determination.*" (CEQA Guidelines § 15301, emphasis added.) Section 15301 plainly states that "[t]he key consideration is whether the project involves negligible or no expansion of an existing use." (*Ibid.*) Section 15301 lists sixteen types of minor activities that may avail themselves of the exemption from environmental review. They include, but are not limited to: interior or exterior alterations "involving such things as interior partitions, plumbing, and electrical conveyances"; maintenance of existing highways and streets; and the "restoration or rehabilitation of deteriorated or damaged structures, facilities, or mechanical equipment to meet current standards of public health and safety." (*Ibid.*)

Fumigation chambers resulting in the release of 10,000 pounds per year of methyl bromide are not listed on the enumerated categories of projects exempt under Guideline § 15301 and the Air District, therefore, may not completely forego environmental review. (CEQA

⁴ See United States Environmental Protection Agency, Methyl Bromide, *available at* <https://www.epa.gov/ods-phaseout/methyl-bromide>, Exhibit D. See also Ozone Secretariat, Montreal Protocol on Substances that Deplete the Ozone Layer, Article 2H: Methyl Bromide, *available at* <http://ozone.unep.org/en/handbook-montreal-protocol-substances-deplete-ozone-layer/16>, Exhibit E.

⁵ *Ibid.*

December 2, 2016

Guidelines § 15301; *see also Azusa Land Reclamation Co. v. Main San Gabriel Basin Watermaster* (1997) 52 Cal.App.4th 1165, 1194-95 [landfill expansion did not fall within the categories enumerated by Guidelines].)

Further, the fumigation chamber proposed here does not otherwise qualify for the Section 15301 exemption, which only applies to projects with “negligible or no expansion of an existing use.” (CEQA Guidelines §15301.) This project will construct a new 2,200 square foot fumigation chamber, resulting in the release of 10,000 pounds per year of methyl bromide, and will more than double the VOC emissions of the facility. This is not a “negligible” expansion of an existing use. Moreover, the “rationale for the existing facilities exemption is that the environmental effects of the operation of such facilities must already have been considered.” (*Azusa Land*, 52 Cal.App.4th at 1194.) Here, there does not appear to be prior environmental review for the facility, making use of the existing facilities exemption particularly inappropriate.⁶ Accordingly, construction of the new fumigation chamber does not fit within the types of activities covered by the exemption – i.e., those involving *negligible* or *no* expansion.

Decisions interpreting the Section 15301 exemption confirm that it was meant to be limited to minor activities which, unlike the planned construction of the fumigation chamber, do not expand uses beyond those existing at the time an agency approves a particular project. For example, in *County of Amador v. El Dorado County Water Agency* (1999) 76 Cal. App.4th 931, 967, the court found that the transfer of ownership of a hydroelectric project and approval to use an additional 17,000 acre-feet of water was a “major change in focus” of the project, and did not fall within the Section 15301 exemption. The court recited the language of the Guidelines which states that “[t]he key consideration is whether the project involves negligible or no expansion of an existing use,” and found that because the project would enable additional water consumption, it did not constitute a “negligible expansion of current use.” (*Ibid.* at p. 967.) Similarly, in *Azusa Land*, the court concluded that a permit allowing reopening of a landfill for disposal of municipal solid waste did not qualify for the Section 15301 exemption. (52 Cal.App.4th at pp. 1194-95.) The permit would have allowed dumping of additional quantities of waste, thereby placing the activity outside the type of “minor alteration” allowed by the Guidelines. (*Ibid.* at p. 1194; *c.f.*, *Santa Monica Chamber of Commerce v. City of Santa Monica* (2002) 101 Cal.App.4th 786, 793 [exemption applied because “no additional parking spaces or structures are being added to the parking stock in the relevant area”].)

Just like in *County of Amador* and *Azusa Land*, construction of the fumigation chamber would provide the Rivermaid Trading with entirely new capacity to fumigate products, and would more than double the facility’s existing VOC emissions. Adding a new fumigation chamber and more than doubling emissions amounts to considerably more than a “negligible expansion of current use,” and the exemption cannot apply here. (*County of Amador*, 76 Cal.App.4th at p. 967.) Thus, to comply with CEQA, the Air District must conduct at least an

⁶ See Authority to Construct Application Review for Application N-8844-1-1 at 15 (noting that no environmental review was conducted on prior fumigation because the District found pollution levels to be less than significance thresholds); Authority to Construct Application Review for Application N-8844-1-0 at 13 (same), Exhibits F and G.

initial study. (See CEQA Guidelines §15063, subd. (a); *Save Our Carmel River*, 141 Cal.App.4th at p. 688.)

Even if the existing facilities exemption applied—which it does not—a CEQA categorical exemption may not be invoked to forego environmental review where “there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances.” (CEQA Guidelines §15300.2, subd. (c).) This exception requiring CEQA review trumps an otherwise lawful categorical exemption from review where: (1) a fair argument can be made that there is a “reasonable possibility that the activity will have a significant effect on the environment,” and (2) this effect is due to “unusual circumstances.” (CEQA Guidelines 15300.2, subd. (c); *Berkeley Hillside Preservation v. City of Berkeley* (2015) 60 Cal.4th 1086, 1097-98.)

An unusual circumstance exists when the “project has some feature that distinguishes it from others in the exempt class, such as its size or location.” (*Berkeley Hillside Preservation*, 60 Cal.4th at 1105.) The existing facilities exemption typically covers ongoing operation, repair, or minor alterations of existing facilities. The construction of a new project to vent 10,000 pounds of a toxic chemical distinguishes this project from those typical of the existing facilities exemption, providing an unusual circumstance. (See *McQueen v. Bd. of Directors* (1988) 202 Cal.App.3d 1136, 1148-49 [“known existence of PCB and other hazardous wastes on property to be acquired is an unusual circumstance threatening the environment”], *disapproved on other grounds*, *W. States Petroleum Assn. v. Superior Court* (1995) 9 Cal.4th 559; see also, *Azusa Land*, 52 Cal.App.4th at p.1207 [risk of landfill contaminating groundwater constituted unusual circumstance].)

Once an “unusual circumstance” has been established, the party invoking the exception “need only show a reasonable possibility of a significant effect due to that unusual circumstance.” (*Berkeley Hillside*, 60 Cal.4th at p. 1105.) As explained above, this Project has a reasonable possibility of a significant environmental impact because it will expose workers and offsite receptors to a highly toxic chemical, and because use of methyl bromide may conflict with national and international law encouraging the phase out of this potent ozone-depleting gas. The Air District must conduct CEQA review.

C. The Air District’s CEQA Review Must Evaluate Project Alternatives and Mitigation Measures.

As discussed above, the Air District must conduct CEQA review on the potentially significant impacts of the project, which proposes to vent 10,000 pounds of methyl bromide into the surrounding community with no pollution controls. The Air District’s review of significant impacts must include an analysis of alternatives to the project, as well as mitigation measures. (Public Resources Code §§ 21002, 21002.1(a), 21100(b)(4), 21150; Public Resources Code §§ 21002.1(a), 21100(b)(3); CEQA Guidelines § 15126.4.)

The Air District must review alternatives to fumigation with methyl bromide, including a “no-project” alternative. Several alternatives to methyl bromide exist as quarantine treatments for

cherries, including control atmospheric heat treatments,⁷ introduction of carbon dioxide into storage chambers, generation of low oxygen atmospheres by burning oxygen,⁸ as well as other fumigant replacements.⁹ The Air District should also evaluate whether lower quantities of methyl bromide would still meet project objectives, and whether there are alternative sites for the fumigation chamber located away from businesses and residences.

The Air District must also review and describe potential mitigation measures. At a minimum, the Air District must disclose and evaluate mitigation measures to restrict the amount of methyl bromide released into the atmosphere, as well as measures to ensure worker and community safety.

II. Carbon Absorption With 95% Control is Cost Effective and Must Be Adopted.

The Air District asserts that installation of a carbon absorption system, which would remove 95% of the methyl bromide from the atmosphere, is not cost effective, because the Air District's calculated cost of \$21,053/ton slightly exceeds the District's cost effectiveness threshold of \$17,500/ton. However, the Air District's assumptions regarding cost per pound of carbon is inflated, and its assumption of carbon absorption rate is overly conservative and conflicts with the Air District's own prior assumptions, leading to an overinflation of costs. Using more accurate cost assumptions and the Air District's prior prediction of carbon absorption rate, carbon absorption is cost effective. It must be adopted as BACT.

First, the Air District assumed the carbon would capture only 20% of its weight in VOCs, citing "verbal communication" with an unidentified "process engineer and vendor" in 2002.¹⁰ But in a prior application review for a methyl bromide fumigation chamber at the same facility, the Air District assumed a 30% adsorption ratio for methyl bromide per a "SDUPA study."¹¹ Second, the Air District calculated the cost assuming that carbon is needed to capture 100% of

⁷ Lisa Neven, et al., Comparison of Alternative Postharvest Quarantine Treatments for Sweet Cherries (2000) 20 *Postharvest Biology and Technology* 107, available at <http://ucce.ucdavis.edu/files/datastore/234-1772.pdf>, Exhibit H.

⁸ Patricia Lindsey, et al., Methyl Bromide on Dried Fruits and Nuts: Issues and Alternatives (1989) 41-50, available at <http://ucce.ucdavis.edu/files/datastore/234-1098.pdf>, Exhibit I.

⁹ Paul Fields, et al., Alternatives to Methyl Bromide Treatments for Stored-Product and Quarantine Insects (2002), 47 *Annual Review of Entomology* 331, available at <http://www.annualreviews.org/doi/pdf/10.1146/annurev.ento.47.091201.145217>, Exhibit J.

¹⁰ Earthjustice requested documentation from the Air District supporting this assumption. The Air District responded that this information came from "verbal communication between the process engineer and vendor on September 10, 2002" but that "no phone log correspondence could be located." Exhibit K.

¹¹ Authority to Construct Application Review for Application N-8844-1-1, Exhibit F. Other scientific literature has shown that carbon absorption of methyl bromide can be 22.6% depending on the carbon used. See, James Leesch, Methyl Bromide Absorption on Activated Carbon to Control Emissions From Commodity Fumigations (2000), 36 *Journal of Stored Products Research* 65, available at <http://www.sciencedirect.com/science/article/pii/S0022474X99000284>, Exhibit L.

December 2, 2016

the methyl bromide released, even while acknowledging that 5% of emissions go uncontrolled. Finally, the Air District assumed a relatively high cost per pound of carbon, citing a “verbal communication” to Calgon Carbon in 2009 (\$2.00/lb.).¹² In contrast, EPA’s official guidance for assuming costs of carbon filtration of VOCs states that a conservative median price for carbon is \$1.50 per pound¹³, and our own recent inquiry to Calgon Carbon provided an written cost estimate of \$1.87 per pound.¹⁴

Using these inputs, a carbon adsorption system would be cost effective.

Annual carbon requirement, assuming Air District’s prior assumption that carbon can capture 30% of its weight and 5 % is uncaptured = $(.95*10,000)/(.3) = 31,667$

The cost of carbon using EPA cost estimates = $31,667*1.5 = \$47,500$

The cost of carbon using Calgon cost estimates = $31,667*1.87 = \$59,217$

Cost of VOC reduction using EPA and Air District estimates = $\$47,500/4.75 \text{ tons} = \$10,000/\text{ton}$

Cost of VOC reduction using Calgon and Scientific literature estimates = $\$59,217/4.75 \text{ tons} = \$12,467/\text{ton}$

Accordingly, installation of a carbon absorption system is less than \$17,500/ton and therefore cost effective. It must be adopted as BACT.

III. The Air District should Analyze Carbon Absorption With Onsite Re-Activation Using Chemical Scrubbers.

The use of reactivated carbon is a cost-effective alternative to the use of virgin carbon.¹⁵ The Air District refused to analyze this option, on the basis that the District is in the process of removing the option from the District’s BACT guidance and because “the use of onsite carbon bed re-activation is not directly related to the amount of fumigant used during the fumigation operation.” (Authority to Construct Application Review Top-Down BACT Analysis at 2.) The Air District, however, has not explained why the technology is not technologically feasible, and has not attempted to show that it would not be cost-effective. The Air District should analyze this option.

¹² Earthjustice requested documentation from the Air District supporting this assumption. The Air District responded that this information came from “verbal communication between the process engineer and vendor on April 2, 2009” but that “no phone log correspondence could be located.” Exhibit K.

¹³ United States Environmental Protection Agency, Cost Reports and Guidance for Air Pollution Regulations, Section 3 – VOC Controls (1999), *available at* <https://www3.epa.gov/ttn/ecas/docs/cs3-1ch1.pdf>, Exhibit M.

¹⁴ Exhibit N.

¹⁵ See, Calgon Carbon, White Paper: Carbon Adsorption & Reactivation, *available at* <http://www.calgoncarbon.com/wp-content/uploads/case-studies/WP-AdsorpReactIndust15-ZOLT-E1.pdf>, Exhibit O.

IV. The Risk Management Report is Flawed.

The Air District conducted a risk management report, concluding that the health risks would not exceed allowable levels and therefore Toxic Best Available Control Technology was not required. But this risk management report looked only at the risk to offsite receptors, and did not analyze the risk to workers at the facility from exposure to methyl bromide. Moreover, the analysis parameters the report used were inaccurate.

First, the risk management report assumed that the closest residence was 125 meters from the site, but there appears to be no basis for this conclusion. According to Google Maps, there is a gift shop adjoining the site of the fumigation chamber, and there are homes immediately adjacent to and across the street from the facility, or about 17 meters (56 feet) from the site.¹⁶ The application itself stated that the closest residence was 250 feet, and closest business 360 feet—76 meters and 110 meters respectively. Even a prior risk management report for a prior methyl bromide fumigation chamber at the precise location assumed that the closest receptor was 82 meters away.¹⁷ The risk management report should be revised to adopt the most conservative assumption of the closest offsite receptor.

Second, the risk management report assumed that methyl bromide increases would be limited to 272.1 lbs./hour. But the permit allows for 300 pounds of methyl bromide to be used per day, and assumes that “all MeBr used is emitted to the atmosphere.” (Authority to Construct Application Review at 2.) Although the permit assumes that not all 300 pounds would be emitted in one hour, this assumption is not supported. Accordingly, the risk management report should have used more conservative assumption all 300 pounds would be emitted in an hour, when analyzing risk to offsite receptors.

Finally, the risk management report’s conclusions regarding the acute and chronic hazard index are inconsistent with the prior risk management report for the facility. The prior report was for an earlier methyl bromide fumigation chamber at the same address, predicted to emit 9,000 lbs. of methyl bromide each year (as opposed to 10,000 lbs. for this project).¹⁸ The prior risk management report predicted a chronic hazard index of .39 and an acute hazard index of .15. The current larger project, in contrast, predicts a chronic hazard index of only .01, and an acute hazard index of .68. Given that these are nearly identical projects in the same location, the stark differences in hazard calculations are suspect and unexplained. The District should ensure the calculations have been performed correctly and provide an explanation for the disparity.

¹⁶ Google Maps (2016), available at <https://www.google.com/maps/dir/6011+East+Pine+Street,+Lodi,+CA/38.1337317,-121.2408175/@38.1348249,-121.2422369,17z/data=!4m9!4m8!1m5!1m1!1s0x809a9fe795c913f7:0x404106db1ee35378!2m2!1d-121.241025!2d38.13497!1m0!3e2> [showing distance to home as 56 feet], Exhibit P.

¹⁷ Authority to Construct Application Review for Application N-8844-1-1 at 31. Exhibit F.

¹⁸ *Ibid* at 33.

December 2, 2016

V. Conclusion

For the foregoing reasons, we urge the District to conduct CEQA review, revise its BACT and risk management analysis, and to require pollution controls to prevent the unmitigated risks of methyl bromide release.

Sincerely,



Elizabeth Forsyth
Earthjustice California Office
800 Wilshire Blvd, Suite 1000
Los Angeles, CA 90017
eforsyth@earthjustice.org

Dolores Weller
Central Valley Air Quality (CVAQ) Coalition
Dolores@cleanair.org

Sarah Aird and Mark Weller
Californians for Pesticide Reform
sarah@pesticidereform.org

Nan Wishner
California Environmental Health Initiative
nan@cal-ehi.org

Dan Silver
Endangered Habitats League
dsilverla@me.com

Mar Preston
TriCounty Watchdogs
marpreston@franzmtn.com

Tom Frantz
Association of Irrigated Residents
Tom.frantz49@gmail.com

Caroline Cox
Center for Environmental Health
caroline@ceh.org

December 2, 2016

Tom Helme
Valley Improvement Projects
valleyimprovementprojects@gmail.com

Nayamin Martinez
Central California Environmental Justice Network
Nayamin.martinez@outlook.com

Anne Katten
California Rural Legal Assistance Foundation
akatten@crlaf.org

EXHIBIT A

Methyl Bromide (CH₃Br)
CAS 74-83-9; UN 1062

Synonyms include bromomethane, monobromomethane, isobrome, and methyl fume.

- **Persons exposed only to methyl bromide gas do not pose substantial risks of secondary contamination; however, some methyl bromide may permeate clothing. Persons whose clothing or skin is contaminated with liquid methyl bromide (temperatures less than 38.5 °F) can secondarily contaminate others by direct contact or through off-gassing vapor.**
- **A gas at room temperature, methyl bromide readily penetrates skin, cloth, and other protective materials such as rubber and leather. It is nonflammable and toxic at low concentrations.**
- **Methyl bromide is odorless and odor provides no warning of hazardous concentrations. However, because methyl bromide is odorless and nonirritating, a lacrimator (an agent that irritates the eyes and causes tearing), most commonly chloropicrin, is often added as a warning agent.**
- **Methyl bromide is absorbed well by the lungs and to some degree through intact skin. Oral exposure is rare because methyl bromide is a gas at room temperature, but it may be absorbed by the gastrointestinal tract. Exposure by any route can cause systemic effects.**

Description

Methyl bromide is a colorless gas at room temperature and a liquid below 38.5 °F (3.6 °C) or when compressed. It is usually shipped as a liquefied, compressed gas. It is odorless and nonirritating at low concentrations and has a musty or fruity odor at high concentrations (greater than 1,000 ppm). Because methyl bromide lacks adequate physiologic warning properties, up to 2% chloropicrin, a lacrimator, is often added to prevent significant exposure.

Routes of Exposure

Inhalation

Most exposures occur by inhalation and by absorption through the skin. **Odor is not an adequate indicator of the presence of pure methyl bromide and does not provide reliable warning of hazardous concentrations.** Because pure methyl bromide lacks adequate warning properties, significant exposure can occur before symptoms are evident.

Methyl bromide is 3 times heavier than air and can accumulate in poorly ventilated or low-lying areas. Under adverse conditions, it can remain in the air for days after application as

a fumigant. Fatalities have occurred among pesticide applicators and building occupants who were exposed during the application process or who prematurely reentered fumigated buildings.

Children exposed to the same levels of methyl bromide as adults may receive larger doses because they have greater lung surface area:body weight ratios and increased minute volumes:weight ratios. In addition, they may be exposed to higher levels than adults in the same location because of their short stature and the higher levels of methyl bromide found nearer to the ground.

Skin/Eye Contact

Methyl bromide gas easily penetrates most protective clothing (e.g., cloth, rubber, and leather) and skin. Prolonged retention in clothing and rubber boots may lead to chemical dermatitis and severe burns. Skin absorption may contribute to systemic toxicity

Children are more vulnerable to toxicants absorbed through the skin because of their relatively larger surface area:body weight ratio.

Ingestion

Ingestion of methyl bromide is unlikely because it is a gas at room temperature.

Sources/Uses

Methyl bromide is produced by adding sulfuric acid to a mixture of sodium bromide and methyl alcohol. Methyl bromide is used primarily as a pesticide to fumigate soil, spaces, structures, and commodities. It is also used as a methylating agent, low-boiling solvent, and oil extractant in chemical syntheses. Less toxic chemicals have replaced it as a refrigerant and fire-extinguisher constituent.

Standards and Guidelines

OSHA ceiling limit = 20 ppm (skin)

NIOSH IDLH (immediately dangerous to life or health) = 250 ppm

AIHA ERPG-2 (the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action) = 50 ppm

Physical Properties

Description: Colorless; gas at room temperature and liquid below 38.5 °F (3.6 °C)

Warning properties: **Inadequate**; musty or fruity odor at greater than 1,000 ppm; eye and throat irritation at greater than 500 ppm.

Molecular weight: 95.0 daltons

Boiling point (760 mm Hg): 38.5 °F (3.6 °C)

Freezing point: -137 °F (-94 °C)

Vapor pressure: 1420 mm Hg at 68 °F (20 °C)

Gas density: 3.4 (air = 1)

Water solubility: Water soluble (0.09% at 68 °F) (20 °C)

Flammability: Flammable, but only in the presence of a high-energy ignition source.

Flammable range: 13.5% to 14.5% (concentration in air)

Incompatibilities

Methyl bromide reacts with strong oxidizers, magnesium, aluminum, tin, zinc, and alloys. It attacks aluminum to form aluminum trimethyl, which is spontaneously flammable.

Health Effects

- Methyl bromide is a neurotoxic gas that can cause convulsions, coma, and long-term neuromuscular and cognitive deficits.
- Exposure to high concentrations of pure methyl bromide may cause inflammation of the bronchi or lungs, an accumulation of fluid in the lung, and irritation of the eyes and nose. Tearing agents added to methyl bromide to provide warning of its presence can also cause these symptoms, even at very low concentrations.
- Skin contact with high vapor concentrations or with liquid methyl bromide can cause systemic toxicity and may cause stinging pain and blisters.

Acute Exposure

Methyl bromide methylates the sulfhydryl groups of enzymes, causing cellular disruption and reduced glutathione levels. Cellular disruption, primarily in the CNS, results in progressive dysfunction. In sublethal poisoning, a latency period of 2 to 48 hours can occur between exposure and onset of symptoms. Methanol, a metabolite of methyl bromide, may also contribute to the neurologic and visual effects, but this is only likely to be significant at high levels of exposure.

Children do not always respond to chemicals in the same way that adults do. Different protocols for managing their care may be needed.

CNS

The most serious effects of acute inhalation exposure involve the CNS. Depending on the concentration and duration of exposure, initial neurologic effects may be delayed for 2 or more hours after exposure and may include headache, nausea, vomiting, dizziness, malaise, and visual disturbances. Examination may reveal involuntary movements of the eyes, dilated pupils, slurred speech, trembling of the extremities during movement, impaired gait, impaired sensation of touch, brain damage (i.e., cerebellar abnormalities), motor deficits, and decreased reflexes.

Neuropsychiatric abnormalities often occur after acute exposure, although onset may be delayed for days to weeks. In some cases, mental disturbances may predominate with only mild neurologic signs and no seizures; in others, severe and prolonged seizures may occur. Motor and cognitive deficits may persist indefinitely.

Peripheral Neurologic

Peripheral neuropathy may develop after acute exposure to methyl bromide and may persist indefinitely.

Respiratory

Respiratory symptoms are the most likely nonneurologic effects of acute methyl bromide inhalation. Throat irritation, chest pain, and shortness of breath are common. Severe exposures may cause inflammation of the bronchi or lungs and an accumulation of fluid in the lungs, which may be delayed 24 hours or longer after exposure. Death may result from respiratory or cardiovascular failure.

Exposure to certain chemicals can lead to Reactive Airway Dysfunction Syndrome (RADS), a chemically- or irritant-induced type of asthma.

Children may be more vulnerable because of relatively increased minute ventilation per kg and failure to evacuate an area promptly when exposed.

Cardiovascular

Acute inhalation of high concentrations can cause rapid, ineffective beating of the heart.

Renal

Protein and blood in the urine, scant urine production, absence of urine production, and accumulation of urea and other nitrogen wastes in the blood due to death of kidney cells have been described. Complete recovery is usual.

Hepatic

Elevated liver enzymes in serum and jaundice occur occasionally after acute exposure.

Ocular

Eye exposure to liquid methyl bromide or to high concentrations of vapor may cause corneal irritation and burns.

Dermal

Contact with either liquid or high vapor concentrations can cause stinging pain, redness of the skin, and blisters characteristic of second-degree burns.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin.

Potential Sequelae

Peripheral nerve damage, speech difficulty, and neuropsychiatric sequelae such as impaired gait, involuntary movements of the eyes, tremors, involuntary muscle jerks, seizures, decline in mental abilities, and severe mental disorders (i.e., psychoses) may develop weeks after exposure.

Chronic Exposure

Repeated exposures have been associated with peripheral neuropathies, especially sensory neuropathy, impaired gait, behavioral changes, and mild liver and kidney dysfunction. Visual impairment secondary to atrophy of the optic nerve has been reported. Chronic exposure may be more serious for children because of their potential longer latency period.

Carcinogenicity

The International Agency for Research on Cancer has determined that methyl bromide is not classifiable as to its carcinogenicity to humans.

*Reproductive and
Developmental Effects*

Methyl bromide is not considered a reproductive or developmental toxicant. No human data are available; one study of experimental animals (rats and rabbits) did not find teratogenic effects at levels below those causing maternal death. Methyl bromide is not included in *Reproductive and Developmental Toxicants*, a 1991 report published by the U.S. General Accounting Office (GAO) that lists 30 chemicals of concern because of widely acknowledged reproductive and developmental consequences.

Prehospital Management

- Victims exposed only to methyl bromide gas do not pose substantial risks of secondary contamination to personnel outside the Hot Zone; however, some methyl bromide may permeate clothing. Victims whose clothing or skin is contaminated with liquid methyl bromide (i.e., ambient temperature less than 38.5 °F) can secondarily contaminate response personnel by direct contact or through off-gassing vapor.
- Methyl bromide is a neurotoxic gas that may cause headaches, dizziness, visual disturbances, ventricular fibrillation, pulmonary edema, ataxia, convulsions, coma, and death.
- Exposures to high concentrations of methyl bromide can cause eye, skin, and respiratory tract irritation, as well as chemical pneumonitis. Dermal absorption may contribute to systemic toxicity.
- There is no antidote for methyl bromide. Treatment consists of support of respiratory and cardiovascular functions.

Hot Zone

Rescuers should be trained and appropriately attired before entering the Hot Zone. If the proper equipment is not available, or if rescuers have not been trained in its use, assistance should be obtained from a local or regional HAZMAT team or other properly equipped response organization.

Rescuer Protection

Methyl bromide is a highly toxic systemic poison that is absorbed well by inhalation and through the skin.

Respiratory Protection: Positive-pressure, self-contained breathing apparatus (SCBA) with a full facepiece is recommended in response situations that involve exposure to potentially unsafe levels of methyl bromide vapor.

Skin Protection: Chemical-protective clothing (including boots and gloves) is recommended because methyl bromide vapor or liquid can be absorbed through the skin and may contribute to systemic toxicity. Contact with liquid methyl bromide can cause skin irritation and burns.

ABC Reminders

Quickly access for a patent airway, ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible.

Victim Removal

If victims can walk, lead them out of the Hot Zone to the Decontamination Zone. Victims who are unable to walk may be removed on backboards or gurneys; if these are not available, carefully carry or drag victims to safety.

Consider appropriate management of chemically contaminated children, such as measures to reduce separation anxiety if a child is separated from a parent or other adult.

Decontamination Zone

Remove clothing, including footwear, from all victims because methyl bromide gas persists in cloth, leather, and rubber. After clothing has been removed, patients exposed only to the gas who have no skin or eye irritation may be transferred immediately to the Support Zone. All others require decontamination (see *Basic Decontamination* below).

Rescuer Protection

If exposure levels are determined to be safe, decontamination may be conducted by personnel wearing a lower level of protection than that worn in the Hot Zone (see *Rescuer Protection*, above).

ABC Reminders

Quickly access for a patent airway, ensure adequate respiration and pulse. Stabilize the cervical spine with a collar and a backboard if trauma is suspected. Administer supplemental oxygen as required. Assist ventilation with a bag-valve-mask device if necessary.

Basic Decontamination

Victims who are able may assist with their own decontamination. Remove all contaminated clothing including footwear. Methyl bromide can persist in cloth, leather, and rubber, and these materials may contribute to severe chemical burns after prolonged skin contact. Double-bag contaminated clothing and personal belongings. **Leave these items in the Hot Zone.**

Flush exposed skin and hair with water for at least 15 minutes, then wash twice with mild soap. Rinse thoroughly with water. Use caution to avoid hypothermia when decontaminating children or the elderly. Use blankets or warmers when appropriate.

Irrigate exposed or irritated eyes with plain water or saline for 15 to 20 minutes. Remove contact lenses if easily removable without additional trauma to the eye. If pain or injury is evident, continue irrigation while transferring the victim to the Support Zone.

Oral exposure to methyl bromide is rare (it is a gas at temperatures above 38.5 °F); however, if ingestion occurs, **do not induce emesis**. If the victim is alert and able to swallow, administer a slurry of activated charcoal at 1 gm/kg (usual adult dose 60–90 g, child dose 25–50 g). A soda can and straw may be of assistance when offering charcoal to a child.

Consider appropriate management of chemically contaminated children at the exposure site. Also, provide reassurance to the child during decontamination, especially if separation from a parent occurs. If possible, seek assistance from a child separation expert.

Transfer to Support Zone

As soon as basic decontamination is complete, move the victim to the Support Zone.

Support Zone

Be certain that victims have been decontaminated properly (see *Decontamination Zone* above). Persons who have undergone decontamination pose no serious risks of secondary contamination. Support Zone personnel require no specialized protective gear in such cases.

ABC Reminders

Quickly access for a patent airway. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Ensure adequate respiration and pulse. Administer supplemental oxygen as required and establish intravenous access if necessary. Place on a cardiac monitor.

Additional Decontamination

Continue irrigating exposed skin and eyes, as appropriate.

Advanced Treatment

In cases of respiratory compromise secure airway and respiration via endotracheal intubation. If not possible, perform cricothyroidotomy if equipped and trained to do so.

Treat patients who have bronchospasm with aerosolized bronchodilators. The use of bronchial sensitizing agents in situations of multiple chemical exposures may pose additional risks. Consider the health of the myocardium before choosing which type of bronchodilator should be administered. Cardiac sensitizing agents may be appropriate; however, the use of cardiac sensitizing agents after exposure to certain chemicals may pose enhanced risk of cardiac arrhythmias (especially in the elderly).

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine

solution in 2.5 cc water, repeat every 20 minutes as needed, cautioning for myocardial variability.

Patients who are comatose, hypotensive, or are having seizures or cardiac arrhythmias should be treated according to advanced life support (ALS) protocols.

If evidence of shock or hypotension is observed begin fluid administration. For adults, bolus 1,000 mL/hour intravenous saline or lactated Ringer's solution if blood pressure is under 80 mm Hg; if systolic pressure is over 90 mm Hg, an infusion rate of 150 to 200 mL/hour is sufficient. For children with compromised perfusion administer a 20 mL/kg bolus of normal saline over 10 to 20 minutes, then infuse at 2 to 3 mL/kg/hour.

Transport to Medical Facility

Only decontaminated patients or patients not requiring decontamination should be transported to a medical facility. "Body bags" are not recommended.

Report to the base station and the receiving medical facility the condition of the patient, treatment given, and estimated time of arrival at the medical facility.

If the patient has ingested methyl bromide, prepare the ambulance in case the patient vomits toxic material or has diarrhea. Have ready several towels and open plastic bags to quickly clean up and isolate vomitus.

Multi-Casualty Triage

Consult with the base station physician or the regional poison control center for advice regarding triage of multiple victims. Because systemic symptoms may be delayed for several hours after exposure, all exposed patients should be transported to a medical facility for evaluation. Symptomatic patients should receive priority in transport.

Emergency Department Management

- Hospital personnel away from the scene are not at significant risk of secondary contamination from patients exposed to methyl bromide gas or to liquid methyl bromide at ambient temperatures greater than 38.5 °F; however, some methyl bromide may have permeated clothing.
- Methyl bromide is a neurotoxic gas that may cause headaches, dizziness, visual disturbances, ventricular fibrillation, pulmonary edema, ataxia, convulsions, coma, and death.
- Exposures to high concentrations of methyl bromide can cause eye, skin, and respiratory tract irritation, as well as chemical pneumonitis. Dermal absorption can contribute to systemic toxicity.
- There is no antidote for methyl bromide. Treatment consists of support of respiratory and cardiovascular functions.

Decontamination Area

Patients who have been decontaminated previously may be transferred immediately to the Critical Care Area. Other patients require decontamination as described below.

Be aware that use of protective equipment by the provider may cause fear in children, resulting in decreased compliance with further management efforts.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants absorbed through the skin. Also, emergency room personnel should examine children's mouths because of the frequency of hand-to-mouth activity among children.

ABC Reminders

Evaluate and support airway, breathing, and circulation. Intubate the trachea in cases of respiratory compromise. In cases of respiratory compromise secure airway and respiration via endotracheal intubation. If not possible, surgically create an airway.

Treat patients who have bronchospasm with aerosolized bronchodilators. The use of bronchial sensitizing agents in situations of multiple chemical exposures may pose additional risks. Consider the health of the myocardium before choosing which type of bronchodilator should be administered. Cardiac sensitizing agents may be appropriate; however, the use of

cardiac sensitizing agents after exposure to certain chemicals may pose enhanced risk of cardiac arrhythmias (especially in the elderly).

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution in 2.5 cc water, repeat every 20 minutes as needed, cautioning for myocardial variability.

Patients who are comatose, hypotensive, or have seizures or ventricular arrhythmias should be treated in the conventional manner.

Basic Decontamination

Patients who are able may assist with their own decontamination. Remove and double-bag all clothing, including footwear, because methyl bromide penetrates many materials and can remain trapped in them. If clothing is to be reused, it must undergo thorough decontamination. Some contaminated clothing may not be safe for reuse (e.g., leather articles).

Flush exposed skin and hair with water for at least 15 minutes, then wash **twice** with mild soap. Rinse thoroughly with water. Use caution to avoid hypothermia when decontaminating children or the elderly. Use blankets or warmers when appropriate.

Irrigate exposed or irritated eyes with plain water or saline for 15 to 20 minutes. Remove contact lenses if easily removable without additional trauma to the eye. If pain or injury is evident, continue irrigation while transferring the victim to the Critical Care Area. An ophthalmic anesthetic, such as 0.5% tetracaine, may be necessary to alleviate blepharospasm, and lid retractors may be required to allow adequate irrigation under the eyelids.

Oral exposure to methyl bromide is rare (it is a gas at temperatures above 38.5 °F); however, if ingestion occurs, **do not induce emesis**. If the victim is alert and able to swallow, and if not already done, administer a slurry of activated charcoal (at 1 gm/kg, usual adult dose 60–90 g, child dose 25–50 g). A soda can and straw may be of assistance when offering charcoal to a child.

Critical Care Area

Be certain that appropriate decontamination has been carried out (see *Decontamination Area*, above).

ABC Reminders

Evaluate and support airway, breathing, and circulation as in *ABC Reminders* above. Establish intravenous access in seriously ill patients. Continuously monitor cardiac rhythm.

Patients who are comatose, hypotensive, or have seizures or cardiac arrhythmias should be treated in the conventional manner.

Inhalation Exposure

Administer supplemental oxygen by mask to patients who have respiratory complaints. Treat patients who have bronchospasm with aerosolized bronchodilators. The use of bronchial sensitizing agents in situations of multiple chemical exposures may pose additional risks. Consider the health of the myocardium before choosing which type of bronchodilator should be administered. Cardiac sensitizing agents may be appropriate; however, the use of cardiac sensitizing agents after exposure to certain chemicals may pose enhanced risk of cardiac arrhythmias (especially in the elderly).

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution in 2.5 cc water, repeat every 20 minutes as needed, cautioning for myocardial variability.

Observe these patients for 24 hours using repeated chest examinations and other appropriate tests. Follow-up as clinically indicated.

Skin Exposure

If the skin was in contact with concentrated methyl bromide vapor or liquid, chemical burns may result; treat as thermal burns. Burns may be delayed in onset.

Eye Exposure

Continue irrigation for at least 15 minutes. Test visual acuity. Examine the eyes for corneal damage and treat appropriately. Immediately consult an ophthalmologist for patients who have corneal injuries.

Ingestion

Oral exposure to methyl bromide is rare (it is a gas at temperatures above 38.5 °F); however, if ingestion occurs, **do not induce emesis**. If the victim is alert and able to swallow, and if not already done, administer a slurry of activated charcoal (at 1 gm/kg, usual adult dose 60–90 g, child dose 25–50 g). A soda can and straw may be of assistance when offering charcoal to a child.

*Antidotes and
Other Treatments*

There is no proven antidote for methyl bromide poisoning. Dimercaprol (BAL) or acetylcysteine (Mucomyst) have been

suggested as antidotes based on the postulated mechanism of methyl bromide's toxicity. However, no adequate studies have tested the efficacy of these therapies, and they are not recommended for routine use.

Laboratory Tests

Serum bromide levels can be used to document that exposure did occur. However, bromide levels do not accurately predict the clinical course. Routine laboratory studies include CBC, glucose, and electrolyte determinations. Additional studies for patients exposed to methyl bromide include liver-function tests and renal-function tests. In cases of inhalation exposure, chest radiography and pulse oximetry (or ABG measurements) may be helpful.

**Disposition and
Follow-up**

Decisions to admit or discharge a patient should be based on exposure history, physical examination, and test results. The probable delay in onset of serious effects from methyl bromide exposure should be considered.

Delayed Effects

Because the onset of pulmonary edema may be delayed for up to several days, patients who have severe exposure should be monitored with serial examinations before absence of toxic effects can be assured. If pulmonary edema is suspected, admit patients to an intensive care unit. Neurological symptoms also may not develop for several days or weeks.

Patient Release

Patients who have no evidence of neuropsychiatric or pulmonary effects 24 hours after exposure may be discharged with instructions to return to the ED if symptoms develop or recur (see the *Methyl Bromide—Patient Information Sheet*).

Follow-up

Obtain the name of the patient's primary care physician so that the hospital can send a copy of the ED visit to the patient's doctor.

Patients exposed to methyl bromide should be monitored for late neuropsychiatric sequelae.

Patients who have corneal injuries should be reexamined within 24 hours.

Reporting

Methyl bromide is a pesticide. If a pesticide or work-related incident has occurred, you may be legally required to file a report; contact your state or local health department.

Other persons may still be at risk in the setting where this incident occurred. If the incident occurred in the workplace, discussing it with company personnel may prevent future

incidents. If a public health risk exists, notify your state or local health department or other responsible public agency. When appropriate, inform patients that they may request an evaluation of their workplace from OSHA or NIOSH. See Appendices III and IV for a list of agencies that may be of assistance.

Methyl Bromide Patient Information Sheet

This handout provides information and follow-up instructions for persons who have been exposed to methyl bromide.

What is methyl bromide?

Methyl bromide is a colorless gas or liquid that is odorless at low concentrations. At very high concentrations, it has a sweet, fruity odor. Tear gas is often mixed with it so that a person exposed to methyl bromide will be warned of its presence. Methyl bromide is used to kill insects in the soil and to rid soils and buildings of termites. Typically, the field or home is covered ("tented") by a large tarp and the methyl bromide is pumped in. Methyl bromide is also used in industry to make other chemicals.

What immediate health effects can be caused by exposure to methyl bromide?

Breathing methyl bromide can cause injury to the brain, nerves, lungs, and throat. High doses can also injure the kidneys and liver. Contact with the skin and eyes can lead to irritation and burns. Generally, the more serious the exposure, the more severe the symptoms.

Can methyl bromide poisoning be treated?

There is no antidote for methyl bromide poisoning, but its effects can be treated and most persons recover. Persons who have experienced serious symptoms may need to be hospitalized and may need follow-up examinations or treatment later on.

Are any future health effects likely to occur?

A single small exposure from which a person recovers quickly is not likely to cause delayed or long-term effects. After a serious exposure that causes lung or nervous system-related problems, permanent brain or nerve damage can result.

What tests can be done if a person has been exposed to methyl bromide?

Specific tests for the presence of bromide in blood may provide some useful information to the doctor. If a severe exposure has occurred, blood and urine analyses and other tests may show whether the lungs, brain, nerves, liver, or kidneys have been damaged. Testing is not needed in every case.

Where can more information about methyl bromide be found?

More information about methyl bromide can be obtained from your regional poison control center; your state, county, or local health department; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in occupational and environmental health. If the exposure happened at work, you may wish to discuss it with your employer, the Occupational Safety and Health Administration (OSHA), or the National Institute for Occupational Safety and Health (NIOSH). Ask the person who gave you this form for help in locating these telephone numbers.

Follow-up Instructions

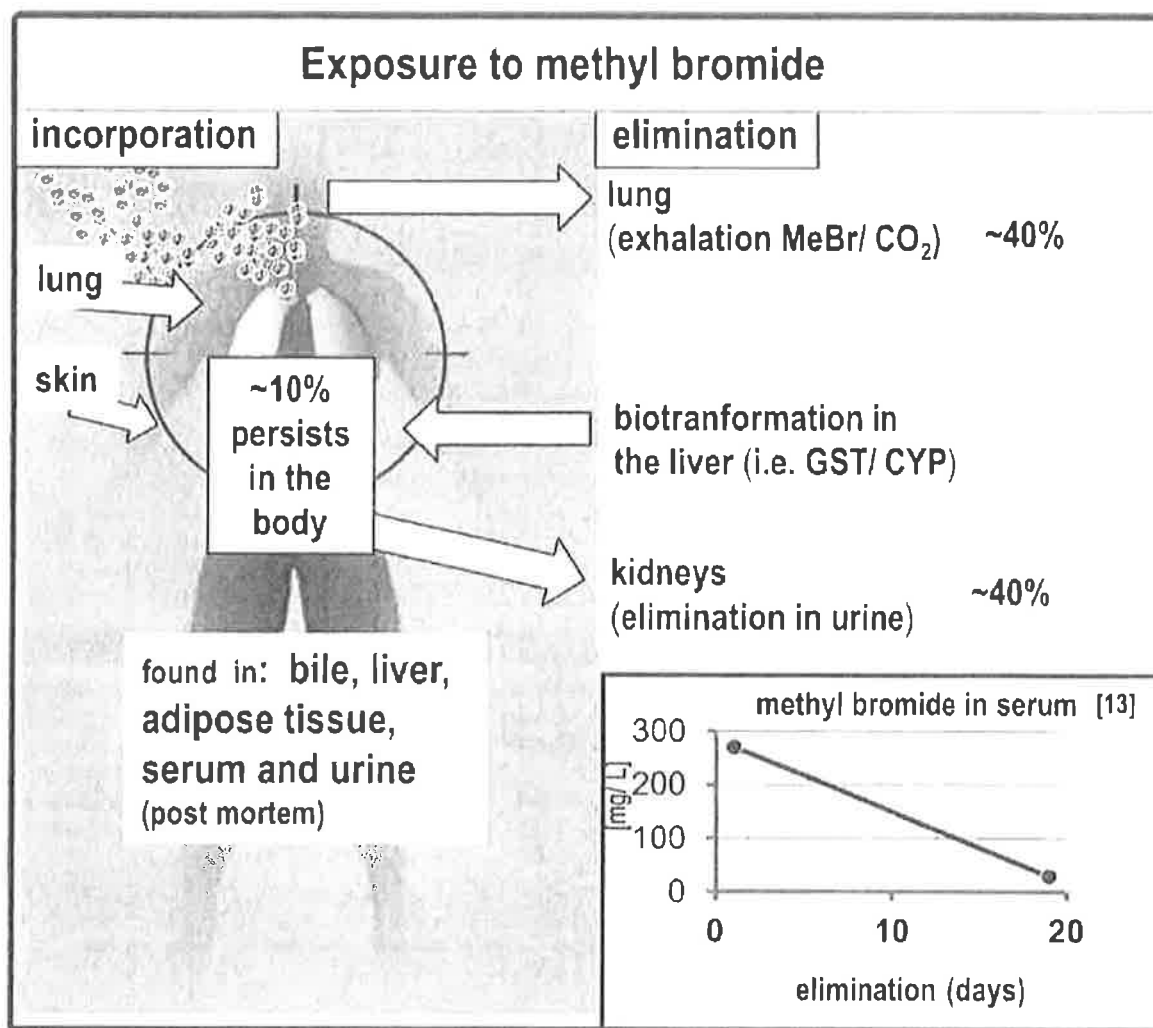
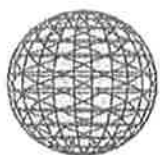
Keep this page and take it with you to your next appointment. Follow *only* the instructions checked below.

- ☐ Call your doctor or the Emergency Department if you develop any unusual signs or symptoms within the next 24 hours, especially:
- coughing or wheezing
 - difficulty in breathing, shortness of breath, or chest pain
 - difficulty in walking
 - numbness of hands or feet
 - confusion, dizziness, or fainting
 - increased pain or a discharge from exposed eyes
 - increased redness or pain or a pus-like discharge in the area of a skin burn
- ☐ No follow-up appointment is necessary unless you develop any of the symptoms listed above.
- ☐ Call for an appointment with Dr. _____ in the practice of _____.
When you call for your appointment, please say that you were treated in the Emergency Department at _____ Hospital by _____ and were advised to be seen again in _____ days.
- ☐ Return to the Emergency Department/ _____ Clinic on (date) _____ at _____ AM/PM for a follow-up examination.
- ☐ Do not perform vigorous physical activities for 1 to 2 days.
- ☐ You may resume everyday activities including driving and operating machinery.
- ☐ Do not return to work for _____ days.
- ☐ You may return to work on a limited basis. See instructions below.
- ☐ Avoid exposure to cigarette smoke for 72 hours; smoke may worsen the condition of your lungs.
- ☐ Avoid drinking alcoholic beverages for at least 24 hours; alcohol may worsen injury to your stomach or have other effects.
- ☐ Avoid taking the following medications: _____
- ☐ You may continue taking the following medication(s) that your doctor(s) prescribed for you: _____
- _____
- ☐ Other instructions: _____
- _____
- _____
- Provide the Emergency Department with the name and the number of your primary care physician so that the ED can send him or her a record of your emergency department visit.
 - You or your physician can get more information on the chemical by contacting: _____ or _____, or by checking out the following Internet Web sites: _____.

Signature of patient _____ Date _____

Signature of physician _____ Date _____

EXHIBIT B



Prostate cancer and toxicity from critical use exemptions of methyl bromide: Environmental protection helps protect against human health risks

Budnik *et al.*



REVIEW

Open Access

Prostate cancer and toxicity from critical use exemptions of methyl bromide: Environmental protection helps protect against human health risks

Lygia T Budnik^{1*}, Stefan Kloth¹, Marcial Velasco-Garrido² and Xaver Baur³

Abstract

Background: Although ozone-depleting methyl bromide was destined for phase-out by 2005, it is still widely applied as a consequence of various critical-use-exemptions and mandatory international regulations aiming to restrict the spread of pests and alien species (e.g. in globalized transport and storage). The withdrawal of methyl bromide because of its environmental risk could fortuitously help in the containment of its human toxicity.

Methods: We performed a systematic review of the literature, including in vitro toxicological and epidemiological studies of occupational and community exposure to the halogenated hydrocarbon pesticide methyl bromide. We focused on toxic (especially chronic) or carcinogenic effects from the use of methyl bromide, on biomonitoring data and reference values. Eligible epidemiological studies were subjected to meta-analysis.

Results: Out of the 542 peer reviewed publications between 1990-2011, we found only 91 referring to toxicity of methyl bromide and 29 using the term "carcinogenic", "neoplastic" or "mutagenic". Several studies provide new additional data pertaining to the mechanistic aspects of methyl bromide toxicity. Few studies have performed a detailed exposure assessment including biomonitoring. Three evaluated epidemiological studies assessed a possible association between cancer and methyl bromide. Overall, exposure to methyl bromide is associated with an increased risk of prostate cancer OR, 1.21; 95% CI (0.98-1.49), $P = 0.076$. Two epidemiological studies have analyzed environmental, non-occupational exposure to methyl bromide providing evidence for its health risk to the general public. None of the epidemiological studies addressed its use as a fumigant in freight containers, although recent field and case reports do refer to its toxic effects associated with its use in shipping and storage.

Conclusions: Both the epidemiological evidence and toxicological data suggest a possible link between methyl bromide exposure and serious health problems, including prostate cancer risk from occupational and community exposure. The environmental risks of methyl bromide are not in doubt, but also its health risks, especially for genetically predisposed subjects, should not be underestimated.

Keywords: methyl bromide, bromomethane, fumigant, halomethane, pesticide, toxic effect, carcinogenic risk, critical use exemptions

Background

Fumigation with pesticides is a widely used defensive measure against the multitude of pests responsible for destroying foodstuffs and other natural commodities during storage and transport. Necessarily, pesticide chemicals are highly toxic to pests, but present also a substantial risk to both human health and the environment [1-5]. The methyl and ethyl halides, in particular methyl

bromide (IUPAC name: bromomethane), are highly effective fumigants and are often used as pesticides, both during and after the harvest. Methyl bromide is a broad spectrum pesticide with a long history of use as a fumigant in farming (stripping the soil of pathogens) and for disinfecting furniture, wood, barges, warehouses, buildings and cargo ships [1-3,5]. Its use has accelerated more recently because of increased globalization and the perceived threat of invasion by alien species. Recent regulations requiring fumigation with methyl bromide (or

* Correspondence: L.Budnik@uke.uni-hamburg.de
Full list of author information is available at the end of the article



heat treatment) of wooden packaging, flooring and wooden goods in imported freight containers [6] have resulted in an epidemic of freight container fumigation.

To be set against the desirable characteristics of this almost perfect fumigant is its remarkable potency as a depleter of atmospheric ozone. Methyl bromide and related ozone-depleting compounds were banned in the 1987 Montreal and 1997 Kyoto Protocols [4] and methyl bromide was destined for a phase-out of production within the current decade (2005 by industrial nations and 2015 by developing nations). The ocean is a net sink for atmospheric methyl bromide, where it is slowly degraded by chemical and biological processes [7].

Although more than 15 industrialized nations have claimed not to fumigate with methyl bromide anymore, most continue to do so under the auspices of a critical use exemptions (CUE) clause. The CUE allows continued use of methyl bromide where no adequate alternative is available, thus assuring its unremitting popularity and widespread use as a fumigant. In 2003, methyl bromide was the most commonly used pesticide among California growers [8,9] and since 2001 it is required for fumigation of grapes in the US [10]. This pesticide is still being used in agriculture [11], in urban pest control [12-14], and for processing onboard ship [15,16]. Also in major ports worldwide, several hundred tons of methyl bromide continue to be used annually for the fumigation of containers destined for export, representing a substantial environmental and human health risk [17-19]. Fumigation of freight containers with methyl bromide is a standard procedure, particularly in Asia [17,18], though adequate alternatives like heat treatment are known. The imported containers and the fumigated products are shipped deep within an importing country before being opened, unloaded, distributed and used by workers and the general public. The primary routes for methyl bromide exposure are by inhalation and by dermal absorption from direct skin contact [20,21]. Exposure due to off gassing is likely since methyl bromide persists on clothes, leather, and rubber brought home or when entering storage facilities where highly fumigated products are stored [3,11,21]. The most common consequences of a transient exposure to methyl bromide are nervous system symptoms, including headache, nausea, vomiting, dizziness, blurred vision, impairment of coordination and twitching. Acute massive or prolonged exposure ultimately leads to permanent debilitation or death [22]. A link between methyl bromide exposure and cancer has been demonstrated experimentally and is also documented clinically, which is not surprising considering its recognized genotoxic effects [23,24]. From animal studies, the National Institute for Occupational Safety and Health (NIOSH) lists methyl bromide as a potential occupational carcinogen [1,4]. However, the

interpretation of toxicological data is often limited by various shortcomings in the available studies. First, the hazard data from animal experiments may not always be immediately relevant to human beings because of the acknowledged physiological and catabolic differences in methyl bromide activity [24]. In addition, several epidemiological studies are vague about the actual pesticide(s) under investigation. Furthermore, inadequate exposure assessment precludes the efficient identification of any causal inferences between a given pesticide and subsequent cancer [25].

For the current study, we performed a systematic review of the literature addressing the risks associated with the exposure to methyl bromide, including the available in-vitro toxicology assessments, in-vivo animal experiments and population-based epidemiological studies. We provide evidence that this pesticide should be phased out not only because of environmental concerns but also because of its human health risks.

Methods

A Pubmed search for peer-reviewed studies on methyl bromide was performed for the period 1990-2011 [26]. Several combinations of the following MeSH terms were utilized in the search: "methyl bromide", "bromomethane", "halogenated hydrocarbon pesticide", "fumigant", "poisoning", "toxicity", "cancer", "neoplasm", "mutagenic" and "tumour". We selected studies according to the following inclusion criteria:

- original studies published in English or German between June 1990 and July 2011
- in-vivo and in-vitro studies on the toxicity of methyl bromide
- papers analyzing molecular mechanisms underlying possible links between methyl bromide exposure and toxic or cancer risk
- cohort or case-control studies analyzing the association between exposure to halogenated hydrocarbon methyl bromide used as fumigant and the incidence of cancer (any site of cancer)
- studies providing data on exposure assessment and bioavailability.

The results from in vitro and in vivo toxicity studies are summarized in an evidence table and discussed further. The results from the included epidemiological studies were summarized quantitatively. Summary odds ratio (OR), with its corresponding 95% confidence interval, was calculated using both fixed and random effects models [26,27]. We calculated I^2 to assess the degree of heterogeneity across studies. Values of I^2 under 25% indicate low, up to 60% medium, and over 75% considerable heterogeneity [27]. Meta-analysis results are presented as a

forest plot. All calculations were performed with the software Comprehensive Meta-Analysis 2.0. (Biostat™, Englewood, USA).

Results

The initial electronic database search yielded 543 publications on methyl bromide. 442 were considered not relevant for the review (because they considered the chemical synthesis of methyl bromide, its bacterial or chemical degradation, pest control issues and regulations or did not contribute new information). Among the included studies, 91 matched the terms toxic, toxicological effects or poisoning and 30 matched the terms cancer or DNA damage. We identified only 5 publications reporting epidemiological studies addressing an association between methyl bromide exposure and cancer or toxicity. Two publications reported data from the same study [28,29], three studies addressed the risk of prostate cancer [28,30,31] and were included in the meta-analysis. One additional epidemiological study analyzed the toxic effects of methyl bromide only, but did not report on possible carcinogenic effects [32] and a further one only considered safety issues [33].

Toxicity of methyl bromide

Methyl bromide, like other methyl halides (i.e. methyl chloride, methyl iodide), has pronounced acute and chronic toxicity (EPA toxicity class I) [4]. It is known as a developmental, neurologic and respiratory toxin [34-36]. Other known target organs are the heart, adrenal glands, liver, kidneys and testis [24]. Chronic low exposure to methyl bromide causes depression of the central nervous system and injury to the kidney. Methyl bromide is a dangerous cumulative poison with the initial symptoms from damage of the nervous system often delayed by 48 hours to several months. The symptoms of acute poisoning vary depending on the concentration and duration of exposure. In sublethal poisoning, the most serious effects involve the central nervous system (with first symptoms including headache, nausea, vomiting, dizziness, malaise and visual disturbances, followed by peripheral neuropathies or neuropsychiatric abnormalities (Table 1). Throat irritation, chest pain and shortness of breath are the most likely first respiratory symptoms with inflammation of the bronchi or lung edema after severe acute exposure. Death may result from respiratory and cardiovascular failure [13,22].

Chronic and acute exposure to methyl bromide may cause respiratory problems, and irritate the skin and eyes. Central nervous system toxicity and early peripheral neuropathy following dermal exposure to methyl bromide [36] confirm the earlier data (see below). Central neurological disorders and chronic toxic encephalopathy were documented in Korean workers after

exposure to methyl bromide [37]. Other studies describe motor neuron disease [16], cerebro-vestibular and pyramidal neuropathy, and paresthesia (see Table 1 for details). One clinical case report implicates erectile dysfunction in humans [38].

Structurally similar ethyl halides (i.e. ethylene dichloride, ethyl chloride, ethyl bromide) show less acute toxicities than their methyl counterparts, but more pronounced chronic toxicity [24].

The effects of methyl bromide on regional brain glutathione-S-transferase has been well documented [39]. Human data from accidental poisoning show that the conjugator status plays an important role in the expression of toxicity in humans, with non-conjugators being apparently relieved of the acute neurotoxic effects (see below for more details). They may not be subjectively aware of the toxic exposure, which may lead them into a false sense of security, especially as silent genotoxic effects may only become clinically manifest years after exposure [40-43].

Genotoxic and carcinogenic effects of methyl bromide

Methyl bromide is genotoxic in vitro, as shown in bacteria [23], animals [44] and human cell culture tests [54] (Table 1). The strong alkylating potency of methyl bromide is primarily responsible for its cytotoxic effect, causing this pesticide to be classified as a potent stimulator of cell growth and, therefore, a potential tumor promoter. Distinguishing alkylation from metabolic incorporation provides proof for the direct genotoxic effect of methyl bromide, methyl iodide and other methyl halides [46-48]. Based on in-vivo and in-vitro studies, methyl bromide induces gene mutations in bacteria, mice and humans. No systemic genotoxic effect was seen with methyl chloride [46,47] in animal experiments. Effects such as DNA single strand breaks after methyl halide intoxication can, however, point to both genotoxic as well as non-genotoxic mechanisms [24]. Methyl bromide causes DNA methylation in rats and mice with concomitant decreases in the activity of O⁶-alkylguanine-DNA-alkyltransferase [48]. Interestingly more recent data show that O⁶-alkylguanine-DNA-alkyltransferase has opposing effects in modulating the genotoxicity of dibromomethane, suggesting a pathway which is alternative to the well-recognized pathway that involves activation by GSTs [49]. Conversely, deficiencies in nucleotide excision repair have been shown to strongly potentiate the mutagenic effects of methyl bromide [44]. A clear DNA-alkylating potential of methyl bromide can be demonstrated directly with [¹⁴C]-methyl bromide binding to DNA in various animal studies [24]. Three additional methylated bases (3-methyl-adenine, 7-methyl-guanine, O⁶-methyl guanine) were also recognized along with further unidentified DNA adducts found in liver, lung and stomach [46].

Table 1 Toxic effects of methyl bromide (data 1990-2011)

Effect observed	Ref.
In vitro	
chromosomal aberration (mammalian cells exposed to gaseous methyl bromide)	[54]
Sister chromatid exchange and chromosome aberrations in lymphocytes	
O-6-alkylguanine-DNA-alkyltransferase	[49]
genotoxic in bacteria (Ames test)	[23]
Genotoxicity in workers exposed to methyl bromide	[88]
In vivo	
toxic encephalopathies (animal experiments)	[65]
Immunoreactive HSP 70 in rat olfactory receptor neurone	[64]
DNA methylation (rat, mice)	[48]
reduction in the white blood cells (rat)	[89]
Increase in SCOT, SGPT activities (mice)	[89]
hepatic and glomerular injuries (mice)	[89]
MMP-9, matrix-metalloproteinase -9 and -2, MMP-2 expression in olfactory bulb following methyl bromide gas exposure (mice)	[66]
human	
irritation of eyes, skin, respiratory system; muscle weakness, coordination loss, visual disturbance, dizziness; nausea, vomiting, headache; malaise (vague feeling of discomfort); hand tremor; convulsions; dyspnea (breathing difficulty); skin vesiculation; liquor frostbite; (potential occupational carcinogen)	[11,34]
acute poisoning: ataxia, behavioral changes, seizures, coma chronic low level exposure: peripheral neuropathy, electroencephalogram abnormalities, deficits on the Wechsler memory scale (on 2-point discrimination at the Index scale)	[90]
headache, dizziness, nausea	[11,34]
chronic exposure: central and peripheral system disorders, cerebro-vestibular and pyramidal neuropathy of lower limbs, paresthesia	
cerebro-vestibular and pyramidal neuropathy of lower limbs, paresthesia	
motor neuron disease	[16]
acute exposure (high concentration): refractory seizures, intermittent fever, multiorgan system failure, death	[13]
liver degenerative changes	[1]
reduction of lung function, chest pain, shortness of breath, inflammation of the lung	[1]
erectile dysfunction	[38]
central nervous system toxicity and early peripheral neuropathy following dermal exposure	[36]
diffuse lesions in the spleen of the corpus callosum	[91]

DNA single strand breaks, liberation of reactive oxygen species and enhanced cell proliferation were detected both in vivo (animal studies) and in vitro using cell-based assays [24,50]. Older studies reported that methyl bromide induces squamous cell papillomas and carcinomas in the forestomach of the rat [4,46]. No carcinogenic effect was observed in further studies applying methyl bromide orally with gavages [51]. A technical report from the US National Toxicology Program showed no evidence of carcinogenic activity in mice exposed to methyl bromide by inhalation [52]. Bolt and Gansewendt [24] explained the negative results in animal experiments by the different or deficient catabolic conjugation pathways for methyl bromide in different species. They also considered that the conclusions from these animal experiments could not be extrapolated to human non-conjugators, since these particular individuals are unable to

metabolize methyl bromide as quickly as a rodent can [24]. Other studies report pre-carcinogenic sister chromatid exchange and the induction of chromosome aberrations after exposure to methyl bromide [53,54].

Recent data from Koutros et al. has highlighted the association between the single nucleotide polymorphisms (SNP) in genes coding for xenobiotic-metabolizing enzyme (enzymes of oxidative stress and phase I/II enzymes) and the risk of prostate cancer after exposure to pesticides [55]. The authors could link the enhanced prostate cancer risk after methyl bromide exposure with a SNP in rs93322959 gene coding for the microsomal GST1 enzyme (OR, 3.1; 95% CI (1.3-7.5) and SNP in rs5764318 of cytosolic sulfotransferase, SULT4A1 (OR, 2.2; 95% CI (1.0-4.5). Such polymorphisms may lead to an imbalance in the oxidative stress/antioxidant status, resulting in DNA/chromosome damage and/or induction

of possible epigenetic or tumor suppressor gene alterations [55].

Possible molecular mechanisms

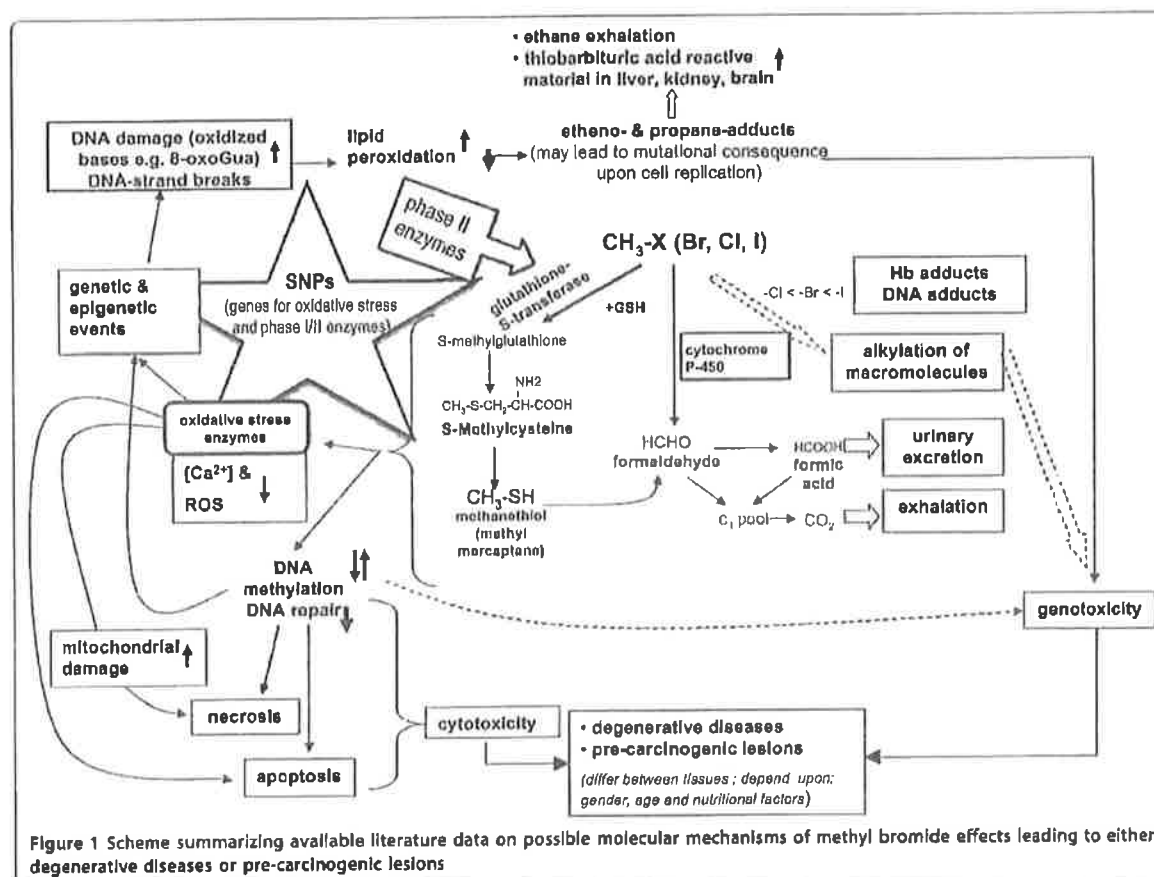
According to the alkylation hypothesis, the methylating activity of methyl bromide should play an important role in the molecular mechanism of toxicity for methyl bromide. Besides this, epigenetic damage [57] may be the most important fundamental cause of degenerative diseases and it can induce carcinogenic lesions (see Figure 1 for a simple model summarizing the current knowledge on non-linear response relationships between the exposure to halomethane methyl bromide, oxidative stress status, DNA damage and pre-carcinogenic lesions).

The conjugation with glutathione, is regarded as the main initiation pathway of methyl bromide: upon inhalation of [^{14}C]-methyl bromide, some radioactivity was covalently attached to haemoglobin [56]. The presence of S-methyl-cysteine in the haemoglobin of workers exposed to methyl bromide has been demonstrated [42].

Humans accidentally exposed to either methyl bromide, methyl iodide, methyl chloride in Japan, The Netherlands or in the US showed similar S-methyl-cysteine levels after exposure suggesting similar metabolism of methyl halides in older literature.

Although metabolism of methyl bromide, methyl chloride and methyl iodide has been studied in different systems and to different extents, it has been suggested that the general metabolic scheme is valid for all methyl halides. The tissue specificity and the degree of toxicity of the organic halides are manifested either by the parent compound or their metabolic or catabolic products. The genotoxic effects of methyl bromide appear to be caused by the direct alkylation of macromolecules, producing adducts [40] and sister chromatid exchange [41]. Conversely, the neurotoxic effects appear to arise after the alkylation of methyl bromide by conjugation with glutathione, producing acutely toxic catabolites that preferentially target the nervous system [42].

Data collected within the last five years point to an intriguing association between the alkylation activity of



methyl bromide (which is modulated by the expression of various isoforms of GST) and the development of prostate cancer. Two gene products seem to be involved in the epigenetic changes caused by methyl bromide. Pi-class glutathione S-transferases (GSTP1) protect the cell from cytotoxic and carcinogenic agents and have been found to be hypermethylated and silenced in prostate cancer tissue [57,58]. The glutathione S-transferase *theta* (GSTT1) gene, whose activity can be influenced by methyl bromide in human erythrocytes, was reported to be positively associated with the risk of prostate cancer [59-61], although other studies have not found these associations [62,63]. It must be pointed out that glutathione S-transferases may also undergo complex epigenetic changes, such as hyper/hypomethylation, depending on the stage of the carcinogenic progression of the prostate cancer.

The molecular mechanisms responsible for the neurotoxic effects of methyl bromide (either alone or with other halo-methanes or halo-ethanes) have been elucidated to great extent [50]. Methyl halides (and probably also ethyl halides) readily react with GST causing its

depletion in several cerebellum cell types and lowering the antioxidant status of these cells [50]. There is a marked cooperation between neurones and astrocytes with regard to maintenance of GSH. GSH is toxic to isolated cerebellar granule cells in culture and to astrocytes. The mechanism of neuronal cell loss with methyl halides appears to involve DNA damage, methylation and inhibition of DNA repair, plus depletion of the intracellular antioxidant GSH and oxidative stress; the apoptotic pathways and neuronal cell death may be switched on [50].

Additionally, recent data provide evidence for the mechanistic aspects of methyl bromide neurotoxicity and point to its ability to alter epithelial density and expansion of bulbar projections [64], to inhibit creatine kinase in rat brain [65] or its effects on matrix metalloproteinase-9 and -2 in the olfactory bulb following methyl bromide gas exposure [66].

Epidemiological studies addressing methyl bromide exposure

No epidemiological studies analysing the potential carcinogenic effects from the exposure to methyl bromide

Table 2 Overview of epidemiological studies on methyl bromide effects (1990-2011)

Reference	Study design	Magnitude of study	Specified measure 1		Exposure to methyl bromide	cases			p value high vs. low	
study	year			sample size	location		cancer (prostate)	Odds Ratio adjusted	95% CI	
[28]	2003	cohort study	occupational agriculture, farmers	55, 332	USA, IA, NC	exposed/controls *84/482	84	1.10	0.77, 1.36	0.004
						low exposure	6	2.73	1.18, 6.33	
						high exposure	5	3.47	1.37, 8.76	
[29]	2010	data analysis	occupational agriculture, farmers	55, 332	USA, IA, NC		5	3.47	1.37, 8.76	0.004
[30]	2003	case-control study	occupational agriculture, Hispanic farm workers	1, 332	USA, CA	exposed/controls 121/1110	64	1.17	0.77, 1.75	0.25
						low exposure	37	1.20	0.66, 2.18	
						high exposure	32	1.59	0.77, 3.30	
[31]	2011	case-control study	population, near intensive agricult. areas		USA, CA	exposed/controls 173/162	87	1.62	1.02, 2.59	0.1
						low exposure	45	1.81	1.03, 3.18	
						high exposure	42	1.45	0.82, 2.57	
[29]	2010	data analysis	occupational agriculture, farmers	55, 332	USA, IA, NC		5	3.47	1.37, 8.76	0.004
							toxic effects			
[32]	2006	cohort study	population, farmers' wives		USA, CA	exposed/controls *145/797		1.82	1.02-3.24	

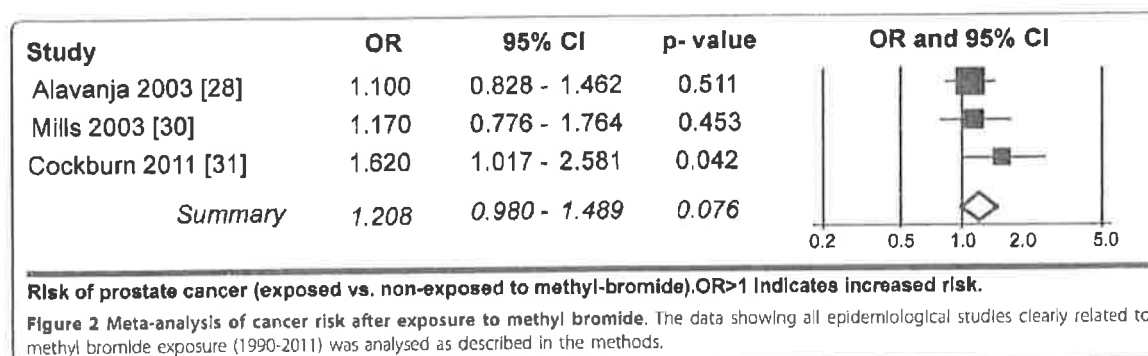
contaminants (or any other pesticide) due to its use in shipping and storage (i.e. in the atmosphere of containers) have been published to date. Most of the epidemiological studies analysing the causal link between methyl bromide exposure and the development of cancer have focused on the agricultural use of pesticides. However, the first clue implicating methyl bromide in a carcinogenic effect was from a study of chemical industry workers who were exposed to methyl halides. In this cohort study, an increased mortality from testicular cancer was reported in association with long-term occupational exposure to methyl bromide in a chemical plant [3]. There were only 3 more recent studies analysing the association between exposure to methyl bromide and cancer or toxicity. Two were cohort studies and one a case-control study. The main characteristics and results of the included studies are summarized in Table 2. All of them addressed exposure in relation to the use of methyl bromide in agriculture, either as occupational or environmental. One of the studies, the Agricultural Health Study (AHS), is a long-term cohort study of pesticide applicators and their spouses [28]. A report from the US National Cancer Institute [35] stated that a few of the 45 evaluated pesticides showed evidence of a possible association with prostate cancer in the pesticide applicators. While methyl bromide was linked with the risk of prostate cancer in the entire group, exposure to six other pesticides was only associated with an increased risk of prostate cancer among those men with a family history of the disease [35]. Alavanja et al. reported a slightly increased relative risk among farmers occupationally exposed to methyl bromide [28]. This study demonstrated a gradient for the risk of prostate cancer with increasing level of exposure to methyl bromide, with the greatest risks among the two highest exposure categories (OR 3.47 95%-CI 1.37-8.76 for the highest exposure category) [28]. The risk was two to four times higher than for men who were never exposed to methyl bromide [28,35]. Among the 45 specific pesticides evaluated, only methyl bromide was associated with a statistically significant

exposure-response trend. This effect was not seen among those without a family history of prostate cancer [35]. Mills and Yung also showed an association between methyl bromide exposure and prostate cancer with OR, 1.17; 95% CI (0.77-1.75), $P = 0.45$ although statistically non-significant [30]. Control subjects were age and location-matched farm workers without prostate cancer. The risk was associated with relatively high levels of exposure to methyl bromide. In a first study on prostate cancer and non-occupational exposure to pesticides, Cockburn et al. [31] confirmed the data from Alavanja et al. and provided evidence for an association between prostate cancer and the environmental exposure to methyl bromide in and around homes in highly agricultural areas [31]. Our meta-analysis shows a slight increase in prostate cancer risk after exposure to methyl bromide with OR, 1.21; 95% CI (0.98-1.49), $P = 0.07$. The results of the included studies are homogeneous ($I^2 = 0\%$, thus we report results from the fixed effects model (see Figure 2, Table 2)). The model choice did not affect the results.

A further epidemiological study [32] of intoxication cases showed an association with chronic low-dose methyl bromide pollution and chronic bronchitis with OR, 1.82; 95% CI (1.02-3.24), $P = 0.04$, due to non-occupational exposure.

Related population-based epidemiological studies

Studies evaluating exposure to pesticides in general (i.e. without differentiating between compounds) have reported rather contradictory results, with some indicating an increase in cancer risk with risk increases ranging from 1.1 to 2.73 [9,67-70] and others showing rather lower cancer risks after pesticide exposure, ranging from 0.7 to 0.93 [67] for both workers and the community. Based on cohorts exposed to pesticides, 8 studies explored a possible association with increased cancer risk. Some reports identified an insignificant slightly decreased risk and others a significantly increased risk of cancer from pesticide exposure [9,68-70]. Yet, a declaration on carcinogenicity was not always available; similarly, retrospective personal or



apocryphal reporting of product use (or misclassification of the degree of exposure or constitution of the chemical mixtures) is notoriously inadequate for risk association and assessments. Marusek et al. [39] concluded that this might also lead to misestimating of exposure level for control groups, especially when family members, generally considered as bystanders in farming activities, were used as controls. It has been reported that farmers tend to be at higher risk for cancers of the lip, brain, prostate, stomach, connective tissue melanoma and for carcinogenic changes in lymphatic and hematopoietic systems than the general population [71,72]. Several case-control studies have reported elevated relative risks of prostate cancer in agricultural workers [73]. Both in Italy and the USA [74-76], case control studies (though very inhomogeneous in nature) do report a slight increase in prostate cancer risk after pesticide exposure (with RR of 1.69 and RR 2.13). One US study reported a significantly increased risk of cancer in association with farming activities RR, 2.17; 95% CI (1.18-3.98), although the authors suggest a possible association with methyl bromide exposure, they acknowledged that another, as yet unidentified, factor may be involved [77]. More recent studies focused on cancer risk associated with pesticide use including methyl bromide: Issa et al. analysed two differently exposed groups of pesticide users in a retrospective study (1998-2006) [33]. To estimate prevalence differences between the two populations, directly exposed (farmers) and bystanders (farmers' wives), the authors focused mainly on the change of habits, such as the use of the protective equipment or the applied dosage, concluding that there were some positive changes in the handling of pesticides amongst participants. The authors listed methyl bromide as one of the fumigant used but its possible carcinogenic effects were not addressed. A review by Weichenthal et al. [29] provided a comprehensive summary for most of the pesticides evaluated in the AHS.

The authors concluded that the data outside the study was still limited, but that the animal toxicity findings support the biological plausibility of a cancer risk. In addressing the issue of the link between the methyl bromide use and the incidence of the prostate cancer risk, the authors referred to the AHS study included in our meta-analysis and highlighted the increased risk of prostate cancer in methyl bromide applicators in the highest category of intensity-weighted exposure-days (Table 2).

Bioavailability

The routes of absorption of methyl bromide are the lungs and skin with elimination routes via the lung, urine and faeces. The available animal biotransformation data *in vivo* show that seventy two hours after exposure to [^{14} C]-methyl bromide, 43% was found in urine, ~40% was exhaled and 14-17% remained in the body (not only

in fat tissue, but mainly in liver and kidneys). Notably, the animal data may not be directly extrapolated to humans (the serum half-life of bromide in humans is 12-16 days but only 1.5-3.5 days in the rat). Rats and mice metabolize methyl halides more rapidly than humans, so that the information on exposure concentration/duration and the association between the exposure concentration and symptoms cannot be directly extrapolated to humans. Fatal cases resulting from home fumigation exposure to humans were reported early [21]. One reported fatal case [13] provided both biomonitoring (exposure biomonitoring) and bioavailability data that showed initial serum methyl bromide levels on day 1 of 270 mg/L and of 29 mg/L on day 19 after exposure (at post mortem); the urine bromide concentration was 62 mg/L (normal <16 mg/L) one day after the exposure. Post-mortem (19 days after exposure) bromide levels were 17 mg/L in the bile, 24 μ g/g in the liver and 28 μ g/g in adipose tissue; urine formic acid was 58 μ g/L (normal 50-360 μ g/L). It needs to be noted that, as a consequence of the unrecognized first intoxication symptoms, the patient was presumed to have the flu and took bromide-containing flu medication. While this could have influenced the elimination kinetics, this data is important in highlighting differences between human and animal bioavailability.

Exposure assessment and biomonitoring

On a short time scale, the assessment of possible methyl bromide intoxication can be performed by air (ambient) monitoring or exposure biomonitoring [78]. Ambient monitoring data, associated with intoxication incidents, revealed values of 2-10 ppm methyl bromide in storage units (measured in cold-storage facilities, where off-gassing grapes were stored) [10]. We have measured over 4000 import freight container units in Hamburg and Rotterdam (2007-2010) and found the following range of methyl bromide concentrations in air samples from containers arriving at the harbor customs for inspection: 0.005-50 ppm (11.5% incidence in 2006-2008) and 0.005-7.1 ppm (4.8% in 2009/2010) [18,19]. In 2006, 3 individual container atmospheres had methyl bromide levels exceeding 800 ppm [17]. It has to be noted that the container air samples had multiple contaminations with fumigants and/or toxic industrial chemicals (like benzene) [17-19,79].

If supported by toxicological validation, exposure assessment based on biomarkers [78,80] provides the most valuable information about possible methyl bromide intoxication (for the individual incorporation through the lungs and skin), with the parent methyl bromide, or its metabolite bromide, being used for the biomonitoring of methyl bromide exposure. In a 17-year follow-up study, urinary bromide concentrations in

factory workers (using protective equipment) exposed to methyl bromide were 25.2 ± 18.7 mg/g creatinine (3.0-125 mg/g creatinine) [20]. The measured urine values of 32.4-68.7 mg bromide/mg creatinine and serum levels of 36.2-52.1 mg bromide/L (normal reference levels are <5 mg/L) were associated with technical incidents and could be correlated with reported episodes of dizziness [20]. Blood samples from greenhouse workers analyzed 11 days after the application of methyl bromide revealed 3.4-20.6 mg/L of serum bromide. The increased bromide values, observed in most applicators, were associated with reported symptoms of irritation to the eyes, coughing, neurological, psychiatric, respiratory and gastrointestinal symptoms [11]. Biological effect biomonitoring [78,80] provides useful information about prior intoxication and has implied an association between an increase in proximate pre-carcinogenic lesions after pesticide exposure and the cancer risk [81-83]. A prospective analysis of blood samples from more than 6700 agricultural and greenhouse workers revealed an elevation of cytogenetic biomarkers and enhanced cancer risk after pesticide exposure [81]; Several other studies using micronuclei (and other functional cytogenetic biological markers) revealed both an increase in cytogenetic damage after exposure to pesticide mixtures and their correlation with an increased cancer risk in several European populations [74,82,83].

Reference values, community exposure limits

The calculated reference concentration values (RfC) for non-carcinogenic effects of methyl bromide in humans [84] can be regarded as community exposure limits. The RfC is a reference point to gauge potential effects, the incidence of which increases for an exposure greater than RfC [45]. An RfC limit value of 0.210 ppm (0.210 mL/m³) was recently estimated for acute inhaled exposure of methyl bromide [84]. Also, for a subchronic exposure to methyl bromide for 1 week, the RfC was estimated to be 0.129 ppm and 0.079 ppm for adults and children, respectively; while the chronic 6 week RfCs were estimated to be 0.002 ppm and 0.001 ppm for adults and children, respectively. The California Office of Environmental Health has also settled non-cancer reference dose (RfD) values for acute air exposure to methyl bromide at 0.05 ppm (neurologic targeted toxicity) and for chronic RfD for the respiratory tract target (based on degenerative and proliferative lesions of the olfactory epithelium of the nasal cavity) to be 0.005 mg/m³ (0.0012 ppm) [9]. Additionally, community exposure data, which showed air values of 0.005 ppm [9,69,85] due to pollution from farming activities, provides the basis for the estimation of hazard quotients (HQ) (defining non-cancer risk) [84,85]. These risk quotients were characterized for populations within a few

miles of the air monitoring stations [9]. The HQ is defined as a ratio between the estimated intake of methyl bromide (in mg/kg/day) and the reference dose (RfD); the acute HQ was estimated to be 0.7 mg/kg/day (95% CI), the subchronic as 13.9 mg/kg/day (95% CI) and the HQ for chronic intake as 2.0 mg/kg/day [84].

Discussion

The halogenated hydrocarbon pesticide methyl bromide, which was designed for phase-out in 2005, remains in frequent use because of various critical use exemptions and new regulations. The exposure assessment data and epidemiological analysis indicate health risk concerns for both workers and the general public [31,32]. Recent case reports continue to demonstrate episodes of illness (with disabling neurological symptoms, memory difficulties and dizziness) in association with elevated levels of serum bromide [10,15].

Methyl bromide is at least as poisonous to humans as it is to the pests with genetic susceptibility (i.e. the conjugator status) or acquired single point mutations playing an essential role in humans. The conjugator status varies phenotypically between species and individuals and may help to explain the variation in toxicity observed (with data showing no immediate, otherwise expected, effects). In human non-conjugators, the absence of the glutathione S-transferase (GST) pathway pushes methyl bromide into alternative oxidation pathways [43], effectively reducing its acute neurotoxicity but concomitantly and insidiously exacerbating its chronic genotoxic effects [40-42].

The exposure to pesticides in agriculture is almost always additive in nature [35]. The possible additive or subadditive effects might be different for cases of exposure to fumigated container and contaminated goods however. We found not only methyl bromide but also high levels of contamination with ethylene dichloride, methylene chloride, ethylene dibromide or tetrachlorethanes in import containers (all halo-methanes or halo-ethanes that share signalling pathway disruption mechanisms). Many epidemiological studies refer to pesticide exposure but without discriminating between the different chemical entities nor their formulations, which differ not only chemically but also in their toxicity, patho-physiological mode of action, target organ, symptoms and possible carcinogenic status (with many not listed as carcinogenic nor even evaluated [35]. Retrospective personal or apocryphal reporting of product use, or misclassification of the degree of exposure or constitution of the chemical mixtures, all fail to contribute adequately to risk associations and assessments. Occupational circumstances associated with farming alone (as confounder) do not appear to provide a risk factor for prostate cancer; rather there is a perceived decrease in overall cancer incidence among unexposed farmers [87].

On the other hand, the community exposure risks to air-borne agricultural pesticides have been documented [9] and the study from Cockburn et al. demonstrated an association between prostate cancer and the ambient non-occupational exposure to methyl bromide [31].

Our meta-analysis indicates an increased prostate cancer risk after exposure to methyl bromide. The International Agency for Research on Cancer (IARC) continues to classify methyl bromide in the carcinogenic category 3 (defined as unclassifiable as to its carcinogenicity to humans because of inadequate evidence in humans and limited evidence in experimental animals) [86]. Yet many studies provide evidence that application of this pesticide may not only elicit a number of toxic effects but also is associated with an increased risk of cancer [28-31]. However, the carcinogenicity of methyl bromide cannot be easily explained as a function of the concentration levels and the exposure period, especially with the limitations and disputed relevance of animal experimentation. More recent data delineate the role of single point mutations in enhanced prostate cancer risk after pesticide exposure, affecting genes which code for phase I/II and oxidative stress enzymes, [55].

The complicated and complex biotransformation pathways of methyl bromide in humans have only been partially elucidated. Human studies are rare and any extrapolation from animal data is difficult to justify. Further investigations are needed to explore the molecular mechanisms of the toxicological and carcinogenic effects of methyl bromide in more detail.

The exposure misclassification in many epidemiological studies may have caused an underestimation of the effects (especially when the control groups, such as family members, are also exposed). It has also to be emphasized that many available studies concern average risks and, therefore, do not represent the actual risks in genetically predisposed human subjects. We recommend further studies to redress this deficiency.

Conclusions

Both the epidemiological evidence and toxicological data suggest a link between methyl bromide exposure and serious health problems, including cancer risk (prostate cancer), from occupational and community exposure. The carcinogenic classification of methyl bromide should be reevaluated.

List of abbreviations

AHS: Agriculture Health Study; CUE: critical use exemptions; DNA: Deoxyribonucleic acid; EPA: Environmental Protective Agency; GSH: glutathione ((2S)-2-amino-4-[[[(1R)-1-[(carboxymethyl)carbamoyl]-2-sulfanylethyl]carbamoyl]butanol acid); GST: Glutathione S-transferase; GSTT1: Glutathione S-transferase theta1; HQ: hazard quotient; IUPAC: International Union of Pure and Applied Chemistry; NTP: National toxicology program OD:

odds ratio; ppm: parts per million (= mL/m³); RfC: Reference concentration values; SNP: single nucleotide polymorphism

Acknowledgements

We would like to thank Dr. Hul Zhang for supportive data extraction and Dr. Kevan Wiley for critical appraisal of the manuscript. Part of the study was supported by the Federal Ministry of Labour, Germany (XB), the State Ministry for Health and Consumer Protection, Hamburg (XB, LTB) and is also part of a WHO GPA (global plan of action) project "New chemical health risks hazards in transportation and warehousing of marine cargo due to the process of globalization" (LTB).

Author details

¹Division of Occupational Toxicology and Immunology, Institute for Occupational and Maritime Medicine (ZfAM), Medical Faculty, University of Hamburg, University Medical Center, Hamburg, Germany, ²Division of Clinical Occupational Medicine, Institute for Occupational and Maritime Medicine (ZfAM), University Medical Center Hamburg-Eppendorf, Hamburg, Germany, ³Chair for Occupational Medicine, Medical Faculty, University of Hamburg, University Medical Center, Hamburg, Germany.

Authors' contributions

XB and LTB made substantial contributions in the conception, design of the study and the interpretation of data. SK did the detailed literature search and building up the molecular model. LTB analyzed the toxicological data and MVG performed the analysis of epidemiological data and performed the meta-analysis. LTB wrote the manuscript. All authors approved the final version for submission.

Competing interests

The authors declare that they have no competing interests

Received: 22 September 2011 Accepted: 27 January 2012

Published: 27 January 2012

References

1. IPCS: The WHO recommended classification of pesticides by hazard. 2006 [http://www.who.int/entity/ipcs/pesticides_hazard/en/index.html].
2. IMO: International Maritime Organization, Recommendations on the safe use of pesticides in ships. London: IMO, SOLAS. Consolidated Edition Consolidated Text of the International Convention for the Safety of Life at Sea, London 2004.
3. FAO: Food and Agriculture Organization of the United Nations, International standards for phytosanitary measures. Manual on Pesticides. 2003 [http://www.fao.org/ag/AGP/L/qualitycontrol05.pdf].
4. EPA, Environmental Protective Agency: The phase out of methyl bromide. 2011 [http://www.epa.gov/ozone/mbr].
5. DHS: Hazard evaluation and Information system: Methyl bromide Fact sheet. 2008 [http://www.dhs.gov/ohb/HESIS/mebr.html].
6. FAO: Food and Agriculture Organization of the United Nations, International standards for phytosanitary measures, Guidelines for regulating wood packaging material in international trade. ISPM Pub., ISPM No. 15, N° 6, FAO, Rome 2007.
7. Goodwin KD, Tokarczyk R, Stephens FC, Saltzman ES: Description of toluene inhibition of methyl bromide biodegradation in seawater and Isolation of a marine toluene oxidizer that degrades methyl bromide. *Appl Environ Microbiol* 2005, **71**:3495-3503.
8. McCook A: The banned pesticide in our soil. *The Scientist* 2006, **20**:40-47.
9. Lee S, McLaughlin R, Harnly M, Gunier R, Kreutzer R: Community exposures to airborne agricultural pesticides in California: ranking of inhalation risks. *Environ Health Perspect* 2002, **110**:1175-1184.
10. CDC: Illness associated with exposure to methyl bromide-fumigated produce in California. *MMWR Morb Mortal Wkly Rep* 2011, **60**:923-926.
11. Akca ET, Serpil S, Sezer U, Ozlem E, Ayse G, Canan C, Hakan B, Ozgur K, Banu O, Hulya G: Health profiles of methyl bromide applicators in greenhouses in Turkey. *Ann Acad Med Singapore* 2009, **38**:707-713.
12. MacFarlane E, Benke G, Goddard D, Sim M: Urban pest control operators in Australia. *Occup Environ Med* 2007, **64**:422-427.
13. Horowitz BZ, Albertson IT, O'Malley M, Swenson EJ: An unusual exposure to methyl bromide leading to fatality. *J Toxicol Clin Toxicol* 1998, **36**:353-357.

14. Breeman W: Methylbromide intoxication: a clinical case study. *Adv Emerg Nurs J* 2009, **31**:153-160.
15. Preisser AM, Budnik LT, Hampel E, Baur X: Surprises perilous: Toxic health hazards for employees unloading fumigated shipping containers. *Sci Total Environ* 2011, **409**:3106-3113.
16. Shaw I: Motor neurone disease - a methyl bromide exposure cluster points to a causal mechanism. *Hum Exp Toxicol* 2010, **29**:241-242.
17. Baur X, Poschadel B, Budnik LT: High frequency of fumigants and other toxic gases in imported freight containers—an underestimated occupational and community health risk. *Occup Environ Med* 2010, **67**:207-212.
18. Budnik LT, Fahrenholtz S, Kloth S, Baur X: Halogenated hydrocarbon pesticides and other volatile organic contaminants provide analytical challenges in global trading. *J Environ Monit* 2010, **12**:936-942.
19. Fahrenholtz S, Hühnerfuss H, Baur X, Budnik LT: Determination of phosphine and other fumigants in air samples by thermal desorption and 2D heart cutting gas chromatography with synchronous SIM/Scan mass spectrometry and flame photometric detection. *Journal of Chromatography A* 2010, **1217**:8298-8307.
20. Yamano Y, Tokutake T, Ishizu S, Nakadate T: Occupational exposure in methyl bromide manufacturing workers: 17-year follow-up study of urinary bromide ion concentration for biological monitoring. *Ind Health* 2011, **49**:133-138.
21. CDC, NIOSH, Centers for Disease Control and Prevention: Methyl Bromide. 2011 (http://www.cdc.gov/niosh/npg/npgd0400.html/methyl_bromide).
22. Langard S, Hognum T, Flotterød O, Skaug V: Fatal accident resulting from methyl bromide poisoning after fumigation of a neighbouring house; leakage through sewage pipes. *J Appl Toxicol* 1996, **16**:445-448.
23. Ames BN, Gold LS: Animal cancer tests and cancer prevention. *J Natl Cancer Inst Monogr* 1992, **125**:1-132.
24. Bolt HM, Gansewendt B: Mechanisms of carcinogenicity of methyl halides. *Crit Rev Toxicol* 1993, **23**:237-253.
25. Maroni M, Fanetti AC, Metruccio F: Risk assessment and management of occupational exposure to pesticides in agriculture. *Med Lav* 2005, **97**:430-437.
26. Cochrane.org: The Cochrane Collaboration Handbook for Systematic Reviews of Interventions (<http://www.cochrane.org/resources/handbook/>).
27. Huedo-Medina TB, Sanchez-Meca J, Marin-Martinez F, Botella J: Assessing heterogeneity in meta-analysis: Q statistic or I² Index? *Psychol Methods* 2006, **11**:193-206.
28. Alavanja MC, Samanic C, Dosemeci M, Lubin J, Tarone R, Lynch CF, Knott C, Thomas K, Hopplin JA, Barker J, et al: Use of agricultural pesticides and prostate cancer risk in the Agricultural Health Study cohort. *Am J Epidemiol* 2003, **157**:800-814.
29. Weichenhan S, Moase C, Chan P: A review of pesticide exposure and cancer incidence in the Agricultural Health Study cohort. *Environ Health Perspect* 2010, **118**:1117-1125.
30. Mills PK, Yang R: Prostate cancer risk in California farm workers. *J Occup Environ Med* 2003, **45**:249-258.
31. Cockburn M, Mills P, Zhang X, Zadnick J, Goldberg D, Ritz B: Prostate cancer and ambient pesticide exposure in agriculturally intensive areas in California. *Am J Epidemiol* 2011, **173**:1280-1288.
32. Hopplin JA, Valcin M, Henneberger PK, Kullman GJ, Umbach DM, London SJ, Alavanja MC, Sandler DP: Pesticide use and chronic bronchitis among farmers in the Agricultural Health Study. *Am J Ind Med* 2007, **50**:969-979.
33. Issa Y, Sham'a FA, Nijem K, Bjertness E, Kristensen P: Pesticide use and opportunities of exposure among farmers and their families: cross-sectional studies 1998-2006 from Hebron governorate, occupied Palestinian territory. *Environ Health* 2010, **9**:63.
34. Agency for Toxic Substances & Disease Registry: Medical Management Guidelines for Bromomethane. 2011 (<http://www.watsdr.cdc.gov/substances/toxsubstance.asp?toxid=160>).
35. National Cancer Institute: Agricultural Pesticide Use May Be Associated With Increased Risk of Prostate Cancer. 2010 (<http://www.waghealith.org>).
36. Lifshitz M, Gavrilov V: Central nervous system toxicity and early peripheral neuropathy following dermal exposure to methyl bromide. *J Toxicol Clin Toxicol* 2000, **38**:799-801.
37. Kim EA, Kang SK: Occupational neurological disorders in Korea. *J Korean Med Sci* 2010, **25**:526-535.
38. Park HJ, Lee KM, Nam JK, Park NC: A case of erectile dysfunction associated with chronic methyl bromide intoxication. *Int J Impot Res* 2005, **17**:207-208.
39. Davenport CJ, Ali SF, Miller FJ, Lipe GW, Morgan KT, Bonnefoi MS: Effect of methyl bromide on regional brain glutathione, glutathione-S-transferases, monoamines, and amino acids in F344 rats. *Toxicol Appl Pharmacol* 1992, **112**:120-127.
40. Garnier R, Rambourg-Schepens MO, Muller A, Hallier E: Glutathione transferase activity and formation of macromolecular adducts in two cases of acute methyl bromide poisoning. *Occup Environ Med* 1996, **53**:211-215.
41. Hallier E, Langhof T, Dannappel D, Leutbecher M, Schröder K, Goergens HW, Müller A, Bolt HM: Polymorphism of glutathione conjugation of methyl bromide, ethylene oxide and dichloromethane in human blood: influence on the induction of sister chromatid exchanges (SCE) in lymphocytes. *Arch Toxicol* 1993, **67**:173-178.
42. Hallier E, Schröder KR, Asmuth K, Dommermuth A, Aust B, Goergens HW: Metabolism of dichloromethane (methylene chloride) to formaldehyde in human erythrocytes: influence of polymorphism of glutathione transferase theta (GST T1-1). *Arch Toxicol* 1994, **68**:423-427.
43. Müller M, Bunge J, Voss M, Westphal G, Ruhnau P, Hallier E: Phenotyping of human glutathione S-transferase hGSTT1-1: a comparison of two ex vivo routine procedures. *Arch Toxicol* 2002, **76**:634-642.
44. Ballering LA, Nivard MJ, Vogel EW: A deficiency for nucleotide excision repair strongly potentiates the mutagenic effectiveness of methyl bromide in *Drosophila*. *Mutagenesis* 1994, **9**:387-389.
45. U.S. Environmental Protection Agency: Integrated Risk Information System (IRIS) on Bromomethane. National Center for Environmental Assessment. Office of Research and Development. Washington, DC; 1999.
46. Gansewendt B, Foest U, Xu D, Hallier E, Bolt HM, Peter H: Formation of DNA adducts in F-344 rats after oral administration or inhalation of [14C]methyl bromide. *Food Chem Toxicol* 1991, **29**:557-563.
47. Gansewendt B, Xu D, Foest U, Hallier E, Bolt HM, Peter H: DNA binding of methyl iodide in male and female F344 rats. *Carcinogenesis* 1991, **12**:463-467.
48. Pletsa V, Steenwinkel MJ, van Delft JH, Baan RA, Kypourou SA: Methyl bromide causes DNA methylation in rats and mice but fails to induce somatic mutations in lambda lacZ transgenic mice. *Cancer Lett* 1999, **135**:21-27.
49. Liu L, Williams KM, Guengerich FP, Pegg AE: O⁶-alkylguanine-DNA alkyltransferase has opposing effects in modulating the genotoxicity of dibromomethane and bromomethyl acetate. *Chem Res Toxicol* 2004, **17**:742-752.
50. Fonnum F, Lock EA: The contributions of excitotoxicity, glutathione depletion and DNA repair in chemically induced injury to neurons: exemplified with toxic effects on cerebellar granule cells. *J Neurochem* 2004, **88**:513-531.
51. Mitsumori K, Maeda K, Kosaka T, Miyazaki T, Shirasu Y: Two-year oral chronic toxicity and carcinogenicity study in rats of diets fumigated with methyl bromide. *Food Chem Toxicol* 1990, **28**:109-119.
52. National Toxicology Program N: Toxicology and carcinogenesis studies of methyl bromide. *National Toxicology Program Tech Rep Ser* 2002, **385**:1-212.
53. Garry VF, Nelson RL, Griffith J, Harkins M: Preparation for human study of pesticide applicators: sister chromatid exchanges and chromosome aberrations in cultured human lymphocytes exposed to selected fumigants. *Teratog Carcinog Mutagen* 1990, **10**:21-29.
54. Asakura M, Sasaki T, Sugiyama T, Arito H, Fukushima S, Matsushima T: An improved system for exposure of cultured mammalian cells to gaseous compounds in the chromosomal aberration assay. *Mutat Res* 2008, **652**:122-130.
55. Koutros S, Andreotti G, Berndt SI, Hughes Barry K, Lubin JH, Hopplin JA, Kamel F, Sandler DP, Burdette LA, Yuenger J, et al: Xenobiotic-metabolizing gene variants, pesticide use, and the risk of prostate cancer. *Pharmacogenet Genomics* 2011, **21**:615-623.
56. Strzaker C, Song JZ, Davidson B, Clark SJ: Transcriptional gene silencing promotes DNA hypermethylation through a sequential change in chromatin modifications in cancer cells. *Cancer Res* 2004, **64**:3871-3877.
57. Xu DG, Peter H, Hallier E, Bolt HM: Hemoglobin adducts of monohalomethanes. *Ind Health* 1990, **28**:121-123.

58. Lin X, Asgari K, Putzi MJ, Gage WR, Yu X, Cornblatt BS, Kumar A, Plantadosi S, DeWeese TL, De Marzo AM, Nelson WG: Reversal of GSTP1 CpG island hypermethylation and reactivation of pi-class glutathione S-transferase (GSTP1) expression in human prostate cancer cells by treatment with procainamide. *Cancer Res* 2001, **61**:8611-8616.
59. Mallick S, Romana M, Blanchet P, Multigner L: GSTM1 and GSTT1 polymorphisms and the risk of prostate cancer in a Caribbean population of African descent. *Urology* 2007, **69**:1165-1169.
60. Kote-Jarai Z, Easton D, Edwards SM, Jefferies S, Durocher F, Jackson RA, Singh R, Arden-Jones A, Murkin A, Dearnaley DP, et al: Relationship between glutathione S-transferase M1, P1 and T1 polymorphisms and early onset prostate cancer. *Pharmacogenetics* 2001, **11**:325-330.
61. Rebbeck TR, Walker AH, Jaffe JM, White DL, Wein AJ, Malkowicz SB: Glutathione S-transferase-mu (GSTM1) and -theta (GSTT1) genotypes in the etiology of prostate cancer. *Cancer Epidemiol Biomarkers Prev* 1999, **8**:283-287.
62. Agalliu I, Lin DW, Salinas CA, Feng Z, Stanford JL: Polymorphisms in the glutathione S-transferase M1, T1, and P1 genes and prostate cancer prognosis. *Prostate* 2006, **66**:1535-1541.
63. Mo Z, Gao Y, Cao Y, Gao F, Jian L: An updating meta-analysis of the GSTM1, GSTT1, and GSTP1 polymorphisms and prostate cancer: a HuGE review. *Prostate* 2009, **69**:662-688.
64. McMillan Carr V, Ring G, Youngentob SL, Schwob JE, Farbman AI: Altered epithelial density and expansion of bulbar projections of a discrete HSP70 immunoreactive subpopulation of rat olfactory receptor neurons in reconstituting olfactory epithelium following exposure to methyl bromide. *J Comp Neurol* 2004, **469**:475-493.
65. Igisu H, Kinoshita Y: Magnetic resonance for evaluation of toxic encephalopathies: implications from animal experiments. *Neurotoxicology* 2007, **28**:252-256.
66. Bakos SR, Schwob JE, Costanzo RM: Matrix metalloproteinase-9 and -2 expression in the olfactory bulb following methyl bromide gas exposure. *Chem Senses* 2010, **35**:655-661.
67. Zhong Y, Rafnsson V: Cancer incidence among Icelandic pesticide users. *Int J Epidemiol* 1996, **25**:1117-1124.
68. Parker AS, Cerhan JR, Putnam SD, Cantor KP, Lynch CF: A cohort study of farming and risk of prostate cancer in Iowa. *Epidemiology* 1999, **10**:452-455.
69. Reynolds P, Von Behren J, Gunier RB, Goldberg DE, Hertz A, Hainly ME: Childhood cancer and agricultural pesticide use: an ecologic study in California. *Environ Health Perspect* 2002, **110**:319-324.
70. Kilstensen P, Andersen A, Irgens LM, Laake P, Bye AS: Incidence and risk factors of cancer among men and women in Norwegian agriculture. *Scand J Work Environ Health* 1996, **22**:14-26.
71. Blair A, Zahm SH, Pearce NE, Heineman EF, Fraumeni JF Jr: Clues to cancer etiology from studies of farmers. *Scand J Work Environ Health* 1992, **18**:209-215.
72. Pearce N, Reif JS: Epidemiologic studies of cancer in agricultural workers. *Am J Ind Med* 1990, **18**:133-148.
73. Deschamps FJ, Turpin JC: Methyl bromide intoxication during grain store fumigation. *Occup Med (Lond)* 1996, **46**:89-90.
74. Forastiere F, Quercia A, Miceli M, Settimi L, Terenzoni B, Rapiti E, Faustini A, Borgia P, Cavarani F, Perucci CA: Cancer among farmers in central Italy. *Scand J Work Environ Health* 1993, **19**:382-389.
75. Settimi L, Cornba P, Bosia S, Ciapini C, Desideri E, Fedi A, Perazzo PL, Axelsson O: Cancer risk among male farmers: a multi-site case-control study. *Int J Occup Med Environ Health* 2001, **14**:339-347.
76. van der Gulden JW, Kolk JJ, Verbeek AL: Work environment and prostate cancer risk. *Prostate* 1995, **27**:250-257.
77. Kristev S, Baris D, Stewart P, Dosemeci M, Swanson GM, Greenberg RS, Schoenberg JB, Schwartz AG, Liff JM, Hayes RB: Occupational risk factors and prostate cancer in U.S. blacks and whites. *Am J Ind Med* 1998, **34**:421-430.
78. Budnik LT, Baur X: The assessment of environmental and occupational exposure to hazardous substances by biomonitoring. *Dtsch Arztebl Int* 2009, **106**:91-97.
79. Baur X, Budnik LT, Preisser AM: Health risks from fumigant residues in import containers. *Dtsch Med Wochenschr* 2010, **135**:516-521.
80. Budnik LT, Baur X: Biomonitoring of toxic substances in the work environment. A complex diagnostic scheme with many players. *The Praeger Handbook of Environmental Health*.
81. Bonassi S, Znaor A, Ceppl M, Lando C, Chang WP, Holland N, Kirsch-Volders M, Zeiger E, Ban S, Barale R, et al: An increased micronucleus frequency in peripheral blood lymphocytes predicts the risk of cancer in humans. *Carcinogenesis* 2007, **28**:625-631.
82. Lucero L, Pastor S, Suarez S, Durban R, Gomez C, Parron T, Creus A, Marcos R: Cytogenetic biomonitoring of Spanish greenhouse workers exposed to pesticides: micronuclei analysis in peripheral blood lymphocytes and buccal epithelial cells. *Mutat Res* 2000, **464**:255-262.
83. Pastor S, Creus A, Parron T, Cebulski-Wasilewska A, Siffel C, Piperakis S, Marcos R: Biomonitoring of four European populations occupationally exposed to pesticides: use of micronuclei as biomarkers. *Mutagenesis* 2003, **18**:249-258.
84. Wedge RM, Abt EN, Hobbs CH: Methyl bromide risk characterization in California. *J Toxicol Environ Health B Crit Rev* 2001, **43**:333-339.
85. Nuckols JR, Gunier RB, Riggs P, Miller R, Reynolds P, Ward MH: Linkage of the California Pesticide Use Reporting Database with spatial land use data for exposure assessment. *Environ Health Perspect* 2007, **115**:684-689.
86. Parent ME, Siemiatycki J: Occupation and prostate cancer. *Epidemiol Rev* 2001, **23**:138-143.
87. IRAC: Evaluation of Carcinogenic risk to human. *Monographs from the International Agency for Research on Cancer* 1999, **71**:721-735.
88. Calvert GM, Talaska G, Mueller CA, Ammenheuser MM, Au WW, Fajen JM, Fleming LE, Briggie T, Ward E: Genotoxicity in workers exposed to methyl bromide. *Mutat Res* 1998, **417**:115-128.
89. Mostafa IY, Zayed SM, Hazzaa NI, Hegazi B: Bioavailability to rats and toxicity of bound residues in bean seeds fumigated with ¹⁴C-methyl bromide. *J Environ Sci Health B* 1992, **27**:407-417.
90. Calvert GM, Mueller CA, Fajen JM, Chrislip DW, Russo J, Briggie T, Fleming LE, Suruda AJ, Steenland K: Health effects associated with sulfuryl fluoride and methyl bromide exposure among structural fumigation workers. *Am J Public Health* 1998, **88**:1774-1780.
91. Kang K, Song YM, Jo KD, Roh JK: Diffuse lesion in the splenium of the corpus callosum in patients with methyl bromide poisoning. *J Neurol Neurosurg Psychiatry* 2006, **77**:703-704.

doi:10.1186/1476-069X-11-5

Cite this article as: Budnik et al: Prostate cancer and toxicity from critical use exemptions of methyl bromide: Environmental protection helps protect against human health risks. *Environmental Health* 2012 **11**:5.

Submit your next manuscript to BioMed Central and take full advantage of:

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit



EXHIBIT C

Systemic effects of inhalational methyl bromide poisoning: a study of nine cases occupationally exposed due to inadvertent spread during fumigation

W N M Hustinx, R T H van de Laar, A C van Huffelen, J C Verwey, J Meulenbelt, T J F Savelkoul

Abstract

Systemic methyl bromide (CH_3Br) poisoning with signs and symptoms of varying severity developed in nine greenhouse workers after acute inhalational exposure on two consecutive days. Measurements of CH_3Br , carried out at the site within hours after the accident, suggest that exposure on the second day may have been in excess of 200 ppm (800 mg/m^3) CH_3Br . All workers were admitted for observation. Seven of them were discharged after an uneventful overnight observation and residual symptoms, if any, subsided within three weeks of the accident. Two patients needed intensive care for several weeks because of severe reactive myoclonus and tonic-clonic generalised convulsions. These conditions were unresponsive to repeated doses of diazepam, clonazepam, and diphenylhydantoin but could be suppressed effectively by induction of a thiopental coma that had to be continued for three weeks. In some of the patients prior subchronic exposure to CH_3Br , as shown by their occupational histories and high serum bromide (Br^-) concentrations, is likely to have been a factor contributing to the severity of their symptoms. A direct association between serum Br^- concentrations and the severity of neurological symptoms, however, seemed to

be absent. An on site investigation into the circumstances leading to the accident showed the presence of an empty and out of use drainage system that covered both sections of the greenhouse. This was probably the most important factor contributing to the rapid and inadvertent spread of CH_3Br .

(British Journal of Industrial Medicine 1993;50:155-159)

In the past methyl bromide (CH_3Br) was mainly used as a fire extinguisher. In 1932 it was introduced as an insecticide. Nowadays the compound is primarily used as a fumigant for the control of nematodes, fungi, and weeds in greenhouses, warehouses, and mills. It is a colourless, non-inflammable, and highly volatile substance and exists in the gaseous phase at normal pressures and temperatures. It has a density of more than three times that of air, which may explain its easy penetration in soil. Furthermore, it has poor warning properties because it is odourless at concentrations of up to 100 times the Dutch maximum allowable concentration (MAC) of 5 ppm.¹ This may explain why CH_3Br has so often caused serious and sometimes fatal poisoning.²⁻⁴ Alexeeff and Kilgore have extensively summarised and reviewed the reported poisoning incidents from CH_3Br .⁵ They are not infrequently fatal. Legislative measures have considerably restricted the use of the compound in The Netherlands since 1981. The present report of occupational poisoning with CH_3Br underscores the need for continuous monitoring in and around fumigation sites as an integral part of good fumigation practice. It also shows the difficulties that may be encountered in the clinical management of the neurological manifestations of serious systemic CH_3Br poisoning. Generalised seizures after poisoning with CH_3Br may be resistant to treatment with drugs like diazepam, clonazepam, and diphenylhydantoin. We describe treatment with thiopental as an effective alternative.

Department of Intensive Care and Clinical Toxicology

W N M Hustinx, J Meulenbelt, T J F Savelkoul

Department of Clinical Neurophysiology

A C van Huffelen

Department of Neurology, Utrecht State University Hospital

J C Verwey

National Poison Control Centre, National Institute of Public Health and Environmental Protection

W N M Hustinx, R T H van de Laar, J Meulenbelt, T J F Savelkoul

Materials and methods

The accident came to the attention of the National Poison Control Centre (NVIC) through requests for information about CH_3Br poisoning by general practitioners and physicians in neighbouring hospitals where two greenhouse workers, with serious neurological signs of CH_3Br poisoning, had been admitted. From interviews with their relatives and the greenhouse owner it became clear that another seven people had probably been exposed to CH_3Br as well. They were all traced within hours and admitted to the intensive care and clinical toxicology department of Utrecht State University Hospital for clinical observation, the department being an integrated unit with the NVIC. The two serious cases were also transferred to that same intensive care unit. All patients were examined by an internist and a neurologist. Further investigations included (1) blood sampling for routine haematology, biochemical tests, and measurement of serum Br^- and blood CH_3Br concentrations. This was repeated six and 12 hours after admission and again six and 19 days later; (2) urinalysis, including a semi-quantitative check on the presence of glucose, protein and traces of blood; (3) chest radiography; (4) blood gas analysis; (5) electrocardiography (ECG); (6) daily monitoring of seizure activity with 20-channel electroencephalography together with ECG and movement recording, when indicated by abnormal findings on neurological examination. Measurement of blood CH_3Br concentrations was performed by gas chromatographic analysis of air samples from head space tubes (detection limit $0.005 \mu\text{g}/\text{ml}$) and serum bromide (Br^-) measurements by induction coupled plasma mass spectrometry (detection limit $3 \mu\text{g}/\text{l}$) (Laboratory for Inorganic Chemistry, National Institute of Public Health and Environmental Protection). Data regarding the circumstances of the accident were collected by the NVIC occupational hygienist through interviews with patients, the greenhouse owner, and employees of the firm that contracted the fumigation job. He also visited the site of the accident. Repeated CH_3Br measurements were carried out for 19 days after the accident with a Dräger gas detector (tubes 3/a and 5/a with detection limits of 3 ppm and 5 ppm respectively). Measurements were done in ambient air at 10–100 cm above ground level. Whenever it was considered relevant in describing the sequelae of the accident, patients are identified in the text by numbers in parentheses.

Results

CIRCUMSTANCES OF THE ACCIDENT

The accident occurred in a greenhouse consisting of two sections with a surface area of almost 8500 m^2 each, separated by a glass partition wall. A door in this wall was sealed with weather stripping. The

partition wall had its foundations 30–35 cm below ground level. At a height of around 2 m above ground level several heating pipes passed the partition through poorly sealed openings. The water drainage system, running at a depth of 100 cm and covering both sections, had been closed before fumigation started. After the accident, an empty and out of use set of drainage pipes was found at a depth of 120 cm, 80 cm above ground water level. These pipes also crossed the partition and covered the entire length of the greenhouse. Both sections were heated at the time of the accident. The recorded temperatures ranged from 15°C in the fumigated section to 17°C near the glass partition and 21°C at the far end of the non-fumigated section. Soil temperature was $<21^\circ\text{C}$ in both sections. Of the non-fumigated section only the part nearest to the partition wall was slightly ventilated. The soil consisted of clay and was prepared for fumigation by rooting to 60 cm below ground level. The sections were fumigated separately with an interval of three weeks. The section where the exposure occurred had been fumigated three weeks earlier. Fumigation was carried out from a pressurised vapouriser, stationed outside the greenhouse, by application of hot vapour through perforated tubing under gas tight plastic sheeting. The sheeting was removed 10 days after fumigation. The dose used ($200 \text{ g}/\text{m}^3$) was five times the legally allowed dose. During fumigation, a CH_3Br concentration of 25 ppm ($100 \text{ mg}/\text{m}^3$) was measured near the glass partition in the non-fumigated section. Away from the partition wall, concentrations rapidly declined to below the detection limit. An employee working near the partition was advised to keep away from it. Unfortunately no repeat measurements were done until after the accident. Five hours after all the workers were forced to leave the greenhouse on the second day, CH_3Br concentrations ranged from 200 ppm near the partition-wall to 150 ppm at the far end of the non-fumigated section. No CH_3Br was detectable at the outside perimeter of the greenhouse. Sixteen days after the accident the CH_3Br concentration in the fumigated section had fallen to below the Dutch MAC of 5 ppm and it took 20 days for CH_3Br to become undetectable. In the non-fumigated section CH_3Br concentrations had dropped to MAC and zero after five and 15 days respectively.

PATIENTS

The accident involved nine greenhouse workers (two women, seven men; age 21–40 years). Three weeks before the accident five of them (2, 3, 5, 8, 9), including the two patients (8 and 9) with serious neurological signs of poisoning, had been working in the section of the greenhouse later to be fumigated, while fumigation was in process in the other section. Already at that time, two workers (3 and 6) had experienced symptoms (nausea, vomiting, and dizzi-

ness) that might retrospectively be attributable to CH_3Br poisoning. Another worker (9) had been involved in a car crash two weeks before the poisoning accident. The man had a complete amnesia for the car accident despite no evidence of skull or brain damage. His relatives reported a striking absent mindedness that had become apparent already before the accident. Apart from these data, the medical histories of all workers were unremarkable. All patients had been working in the non-fumigated section of the greenhouse on the day before the accident for an average of six hours (range four to eight hours). Most of them had already experienced some degree of nausea and headache in the course of that day. This caused two of them (1 and 6) to stay at home the next day. Two hours after the remaining seven workers had resumed their work on the next day, all except one (7) (who only reported a slight burning sensation in the throat) quite suddenly and almost simultaneously experienced extreme nausea, repeated vomiting, and dizziness. This forced all of them to leave the greenhouse and go home. Two hours later while at home two workers (8 and 9), developed twitching of all limbs followed by generalised seizures. On admission these two patients showed a uniform picture characterised by coma (Glasgow coma scale $\text{E}_1\text{M}_3\text{V}_1$) and myoclonic contractions of all limbs but predominantly of the arms that could be provoked or aggravated by touching the body. This myoclonic activity precluded a correct assessment of muscle power and sensory functions. In addition generalised seizures occurred at regular intervals. Apart from absent peristalsis physical examination showed no other abnormalities at that time. Repeated intravenous doses of clonazepam, diazepam, and a diphenylhydantoin loading dose did not arrest the seizures. A thiopental coma was then induced and mechanical ventilation started. Electroencephalograms in conjunction with measurements of serum thiopental concentrations were performed at regular intervals to evaluate the efficacy of the thiopental dosing regimen. Recordings with a suppression-burst pattern showing suppression-periods of 5–10 seconds were considered to represent adequate suppression of convulsive activity. This effect was achieved immediately and could be maintained by blood thiopental concentrations ranging from 40 to 70 $\mu\text{g/l}$. Both patients were receiving diphenylhydantoin as comedication. Three days after admission their chest x ray films showed unilateral infiltrative changes with some pleural effusion that gradually disappeared within the next 10–14 days. Persisting intermittent fever and varying degrees of leucocytosis with or without left shift existed in both of them for more than three weeks despite several courses of broad spectrum antimicrobial treatment. Repeated cultures of blood, sputum, and urine remained negative or grew

microorganisms considered to be contaminants. For some time both patients had to be ventilated with 0.4–0.5 fractional inspired oxygen but application of positive end expiratory pressure was never considered necessary. It took three weeks before thiopental administration could be withdrawn after electroencephalograms had shown epileptiform patterns to return only sporadically in its absence. More than two months after admission one patient could be transferred to a physical rehabilitation centre, still suffering from debilitating proximal action and distal intention myoclonus unresponsive to experimental treatment with 5-hydroxytryptophan. Muscle power, sensory function, and reflexes were all normal. Four months after the accident the proximal action myoclonus had completely disappeared, although the distal intention myoclonus had remained unchanged. The second serious case could be transferred to a physical rehabilitation centre three months after admission. As well as a similar distal action myoclonus, he showed a slight distal muscular weakness of the legs and a painful plantar dysaesthesia, and tendon reflexes were brisk except for a diminished ankle jerk reflex. These signs of axonal neuropathy improved only slightly over the six months after the accident. Intellectually both patients, who regained consciousness soon after withdrawal of thiopental rapidly improved to near normal. In both of them a similar rise in ALAT-ASAT, and LDH activities occurred that started three days after admission with peak values of roughly 130, 170, and 520 U/l respectively on the sixth day of admission and a return to normal values soon afterwards. High initial CK activities returned to normal soon after adequate suppression of seizure activity was established.

Signs and symptoms in the other seven patients were remarkably uniform and included headache, nausea, and a sensation described as "floating." One patient (3) complained of unsteady gait. Neurological examination confirmed mild ataxia (that persisted for a fortnight) whereas in another man (2) a slurred speech had developed that disappeared 16 hours later. Physical examination was otherwise unremarkable in these patients, who were all discharged after an uneventful overnight observation. Routine laboratory tests, chest x ray films, ECG, and urinalysis showed no gross abnormalities except for raised serum chloride concentrations in some patients. The likely reason for this is discussed later. Most of the patients were seen again for a check up and blood sampling (to monitor serum Br^- concentrations) on days 6 and 19 after the accident. By then all residual complaints (mostly mild headache, nausea, and loss of appetite) had disappeared. Electroencephalography was performed in four patients. They proved normal in two patients who had developed slurring of speech (2) and mild ataxia (3). In the two serious cases the recordings showed a remarkable

Table Concentrations of methyl bromide in blood and of bromide ion in serum of nine patients exposed to methyl bromide

Patient no	CH ₃ Br T _{24h}	Br ⁻ (mg/l)				
		T _{12h}	T _{18h}	T _{24h}	T _{6d}	T _{1w}
1	ND	54	56	51	42	22
2	ND	273	—	269	227	119
3	ND	72	69	69	55	30
4	ND	59	56	57	44	22
5	ND	186	185	188	127	—
6	ND	—	75	74	48	14
7	ND	51	56	55	36	—
8	ND	363*	—	—	189	66
9	ND	267*	238	225	25	5

T = Time elapsed, expressed as hours (h) or days (d) after exposure; ND = not detectable (detection limit 0.005 µg/ml); *bromide concentrations in serum of patients (8 and 9) as measured in the referring hospital at T₀ were 460 and 320 mg/l respectively; Br⁻ = bromide ion (detection limit 3 µg/l; normal value for the Dutch population 3.5–5.5 mg/l¹³).

pattern. There were runs of very sharp spikes of short duration followed by a short wave. Myoclonic jerks coincided with these polyspike and wave complexes. These spikes were of such a short duration that they resembled muscle artefacts but apparently were not of such origin because they persisted after the administration of muscle relaxants.

ANALYTICAL TOXICOLOGY

Table 1 presents results of blood CH₃Br and serum Br⁻ measurements. No CH₃Br was detectable in any of the samples (detection limit 0.005 µg/l). Serum Br⁻ concentrations (detection limit 3 µg/l) were considerably increased in all patients, most notably in four (2, 5, 8, and 9) of five patients whose histories suggested the possibility of repeated subchronic exposure to CH₃Br in the weeks preceding the accident. Among them were the two transferred serious cases (8 and 9) and the patient with transient slurring of his speech (2).

Discussion

A dry and out of use set of drainage pipes, crossing both greenhouse sections over their entire length, was identified as the most likely major cause of considerable and rapid spread of CH₃Br to the non-fumigated section. Other contributing factors were the dose of CH₃Br used for fumigation (five times the accepted dose of 40 g/m²), the higher temperature in the non-fumigated section, and the fact that the glass partition wall separating the sections had its foundation at only 30–35 cm below ground level, and showed some poorly sealed openings. This may explain why CH₃Br concentrations close to it were higher compared with the more remote parts of the section. In as much as CH₃Br concentrations, measured five hours after the accident (200 ppm), can

be taken to reflect the actual CH₃Br concentrations at the time of the accident, they clearly illustrate the poor warning properties of CH₃Br at concentrations below 500 ppm where CH₃Br reportedly gets a faintly acrid smell. On the day of the actual fumigation, a single CH₃Br measurement near the partition wall in the non-fumigated section indicated a CH₃Br concentration of 25 ppm or five times the MAC value. Despite this, no ongoing monitoring was carried out on that same day or the next day. This accident therefore shows the need for continuous monitoring and supervision in and around the fumigated site as an integral part of good practice in fumigation-activities of this kind, as has already been suggested by various authors.^{1,7,8}

Blood sampling (with the specific purpose of detection of CH₃Br) was not carried out until 24 hours after the accident. A likely explanation for the absence of detectable CH₃Br in those samples is a short half life for CH₃Br in humans. Experimental studies in rats^{9,10} support this explanation. The biological half life of the bromide ion is 10–12 days.^{11,12} Normal values of serum Br⁻ concentrations in the Dutch population are between 3.5 and 5.5 mg/l.¹³ Its distribution and behaviour in the human body is like that of the chloride ion. In the everyday laboratory practice of most hospitals the measured chloride ion concentrations actually represent the total concentration of halogens.¹³ This may explain the high chloride concentrations in patients with very high Br⁻ concentrations (2, 5, 8, and 9). Serum Br⁻ concentrations are considered by some authors^{14,15} (but not all¹⁷) to correlate poorly with clinical symptoms and outcome. The considerable difference in signs and symptoms between patients 2, transient slurring of speech; 5, transient burning sensation in the throat; and 8 and 9, reactive myoclonus and generalised convulsions, who had comparably high serum Br⁻ concentrations illustrate this.

Cases of fatal CH₃Br poisoning have reportedly occurred in association with serum Br⁻ concentrations of only 30 mg/l whereas concentrations of more than 200 mg/l were found in professional fumigators without any accompanying symptoms.¹⁶ Those data are in line with the commonly held view that the strong alkylating (methylating) properties of intact CH₃Br and not the Br⁻ residues are responsible for the toxicity of that compound. In some of our patients (2, 5, 8 and 9) intermittent (sub)chronic occupational exposure is likely to have occurred in the weeks preceding the accident although pre-accident values of serum Br⁻ concentrations would have been needed to validate this hypothesis. Acute exposure superimposed on subchronic or intermittent acute and low level exposure might help to explain the much more severe symptoms in those workers that were likely to have been pre-exposed. If correct this assumption would confirm similar find-

ings in earlier reports as reviewed by Alexeeff and Kilgore.⁵

None of our patients showed evidence of CH₃Br related lung damage. Signs of systemic CH₃Br poisoning may follow both inhalational and dermal exposure.^{6,18} Lung damage usually occurs after high level inhalational exposure. At lower levels of inhalational exposure, signs of systemic poisoning may develop in the absence of lung damage.^{2,7} Increased serum glutamic oxaloacetic transaminase and glutamic pyruvic transaminase activities were found only in the two serious cases. As these rapidly become normal while high dosed sodium thiopental treatment continued, they probably were the result of true CH₃Br related hepatotoxicity and not induced by sodium thiopental. Although previous reports have noted the possible renal toxicity of CH₃Br, none of our patients showed any evidence of this.

Persisting fever (> 39°C for more than three weeks), despite several courses of antimicrobial treatment and in the absence of infection proved by culture has to our knowledge not been reported before and its direct relation with CH₃Br poisoning remains unclear. The fever did not have a pattern consistent with a possible central origin.

Symptoms of the central nervous system such as headache, nausea, vomiting, a sense of drunkenness, ataxia, slurred speech, and confusion are the more common and early manifestations of systemic CH₃Br poisoning and may be preceded by a symptom free interval of two hours^{2,7} as was the case in our patients. Progression to the more severe stage with coma, generalised seizures, myoclonus, and a distal axonopathy may follow within hours to days. Treatment with diphenylhydantoin, diazepam, paraldehyde, or clonazepam is often not sufficient to suppress convulsive activity. In these cases it may be necessary to resort to anaesthesia (for example with thiopental). Convalescence may take months and not infrequently shows psychiatric disturbances, seizures, action myoclonus and ataxia as residual and sometimes permanent manifestations.¹⁹ The drug resistant status epilepticus, by some authors also described as status myoclonicus, is associated with a high mortality.^{7,19,20} The myoclonus is usually asymmetrical, distally located, and may occur spontaneously or in response to somatosensory stimuli. Electroencephalograms in these patients showed polyspike and wave complexes with frontal predominance. Also giant somatosensory evoked potentials may be recorded. By using a back averaging technique, Uncini *et al* were able to show that the status myoclonicus, as seen in some cases of serious CH₃Br poisoning, may represent a form of cortical reflex myoclonus.²¹

There is no established causal therapy for CH₃Br poisoning. In the past haemoperfusion, chelating agents (for example, dimercaprol), and N-acetylcysteine have been used. None of these drugs were used in the context of controlled prospective trials, however, and their reported effectiveness concerned

only less severely poisoned patients. To date treatment can only be supportive and symptomatic. High dose thiopental anaesthesia seems effective in the treatment of CH₃Br induced generalised seizures that have proved to be unresponsive to regular treatment with antiepileptic drugs.

Requests for reprints to: W N M Hustinx, Utrecht State University Hospital (AZU), Heidelberglaan 100, PO Box 85500, 3508GA Utrecht, The Netherlands.

- 1 Van den Oever R, Roosels D, Lahaye D. Actual hazard of methyl bromide fumigation in soil disinfection. *Br J Ind Med* 1982; 39:140-4.
- 2 Marraccini JV, Thomas GE, Ongley JP, Pfaffenberger CD, Davis JH, Bednarczyk LR. Death and injury caused by methyl bromide, an insecticide fumigant. *J Forensic Sci* 1983;3:601-7.
- 3 Behrens RH, Dukes DC. Fatal methyl bromide poisoning. *Br J Ind Med* 1986;43:561-2.
- 4 Dutch expert committee for occupational standards. *Health-based recommended occupational exposure limits for methyl bromide*. Voorburg, The Netherlands: Directorate-General of Labour and the Ministry of Social Affairs and Employment, 1990.
- 5 Alexeeff BV, Kilgore WW. Methyl bromide. *Residue reviews* 1983;88:101-53.
- 6 Zwaveling JH, de Kort WJAM, Meulenbelt J, Hezemans-Boer M, Vloten WA van, Sangster B. Exposure of the skin to methyl bromide: a study of six cases occupationally exposed to high concentrations during fumigation. *Human Toxicology* 1987;6: 491-5.
- 7 Hine CH. Methyl bromide poisoning. *J Occup Med* 1969;11: 1-10.
- 8 Herzstein J, Cullen MR. Methyl bromide intoxication in four field-workers during removal of soil fumigation sheets. *Am J Ind Med* 1990;17:321-6.
- 9 Sato M, Hasegawa H, Homma T, Miyagawa M, Suda M, Sudo A. Studies on intoxication due to methyl bromide (2)-distribution of methyl bromide and bromine in the living body. *Sangyo Igaku Sogo-Kenkyusho Nempo* 1980a;22 (Cited in *Pest Abstracts* 1980;81:3225).
- 10 Homma T, Miyagawa M, Sato M, Hasegawa H. Neurotoxicity of methyl bromide in rats. *Toxicol Appl Pharmacol* 1985;81: 183-91.
- 11 Sangster B, Blom JL, Sekhuis VM, Loeber JG *et al*. The influence of sodium bromide in man: a study in human volunteers with special emphasis on the endocrine and nervous system. *Food Chem Toxicol* 1983;21:409-19.
- 12 Soremark R. Distribution and kinetics of bromide ions in the mammalian body. Some experimental investigations using Br 80M and Br 82. *Acta Radiol Suppl* 1960;190:1.
- 13 Leeuwen FKR van, Sangster B. The toxicology of bromide ion. *Critical Reviews in Toxicology* 1987;18:189-213.
- 14 Verberk MM, Rooyackers-Beemster T, Vliet M de, Vliet AGM van. Bromine in blood, EEG and transaminases in methyl bromide workers. *Br J Ind Med* 1979;36:159-64.
- 15 Bradford JC. Methyl bromide and related compounds. In: Haddad LM and Winchester JP, eds. *Clinical management of poisoning and drug overdose*. 2nd ed. Philadelphia: W B Saunders Company, 1990.
- 16 Hessing JGM. *Biologische monitoring van blootstelling aan methyl bromide bij grondontsmetters*. MBL 1980-1, TNO, Medisch Biologisch Laboratorium.
- 17 Rathus EM, Landy PJ. Methyl bromide poisoning. *Br J Ind Med* 1961;18:53.
- 18 Bruhin J. *Perkutane Vergiftungen mit Methylbromid bei der Schädlingsbekämpfung*. Thesis Universität Zürich: Mettler and Saltz AG, Bern 1942.
- 19 Shield LK, Coleman TL, Markesbery WR. Methyl bromide intoxication: neurologic features, including simulation of Reye syndrome. *Neurology* 1977;27:959-62.
- 20 Mellerio F, Levy-Ancover MA. Myoclonus d'origine toxique. *Rev EEG Neurophysiol Clin* 1982;12:210-18.
- 21 Uncini A, Basciani M, DiMuzio A, Antonini D, Onofri M. Methyl bromide myoclonus: an electrophysiological study. *Acta Neurol Scand* 1990;81:159-64.

EXHIBIT D



Methyl Bromide

Methyl bromide is a fumigant used to control pests in agriculture and shipping. Along with other countries, EPA has agreed to restrict the use of methyl bromide and reduce the amount used each year because it depletes the ozone layer. Learn more about protecting the ozone layer.

Exemptions for Methyl Bromide
Allowed Uses
Users and Suppliers

What Is Methyl Bromide?

Methyl bromide is an odorless, colorless gas used to control a wide variety of pests in agriculture and shipping, including fungi, weeds, insects, nematodes (or roundworms), and rodents.

Agricultural growers inject methyl bromide about two feet into the ground to sterilize the soil before crops are planted. Although the soil is covered with plastic tarps immediately after a treatment, 50 to 95 percent of the methyl bromide eventually enters the atmosphere. More information on soil fumigants can be found [here](#).

Methyl bromide is also used to treat commodities such as grapes, asparagus, logs, and other imported goods to prevent introducing pests to the United States. Treatments often fulfill official quarantine requirements for international shipments.

Methyl bromide is a toxic substance. Because it dissipates rapidly to the atmosphere, it is most dangerous at the fumigation site. Human exposure to high concentrations of methyl bromide can cause central nervous system and respiratory system failures and can harm the lungs, eyes, and skin.

Methyl bromide damages the ozone layer

In the atmosphere, methyl bromide depletes the ozone layer and allows increased ultraviolet radiation to reach the earth's surface. Methyl bromide is a Class I ozone-depleting substance (ODS), as defined by the Montreal Protocol on Substances that Deplete the Ozone Layer.

Find more information on methyl bromide:

Methyl Bromide and the United Nations Environment Programme [Exii](#)
The National Oceanic and Atmospheric Administration Scientific Assessment of Ozone Depletion: 2014 [Exii](#)
2014 Methyl Bromide Technical Options Committee Assessment Report [Exii](#)

Health Effects:

- EPA's Office of Air Quality Planning & Standards Air Toxics Website: Methyl Bromide (Bromomethane)
- EPA Integrated Risk Assessment of Methyl Bromide

Key Resource

Learn more about the Montreal Protocol [Exit](#)

The Phaseout of Methyl Bromide

The amount of methyl bromide produced or imported was reduced incrementally until it was phased out on January 1, 2005. Certain uses of methyl bromide are exempt from this phaseout. These include:

- Critical uses
- Quarantine and preshipment uses

Methyl Bromide Alternatives

Both chemical and non-chemical alternatives to methyl bromide exist. In most cases, these alternatives can manage the pests previously controlled with methyl bromide. For example, steam sterilization of soil is a viable alternative to using chemical fumigants for certain pests and soil types. Also, harvesters can use integrated pest management techniques, as well as pheromone, electrocution, and light traps, to manage or monitor pest populations.

Alternatives research is ongoing, and EPA continues to prioritize the registration of alternatives to methyl bromide.

Learn more:

- Proceedings from the Annual Methyl Bromide Alternatives Outreach Conference [Exit](#)
- U.S. Department of Agriculture, Agricultural Research Service (Crop Protection & Quarantine Research)
- U.S. Department of Agriculture, Agricultural Research Service (Plant Disease Research)
- Alternatives for Specific Commodities

Methyl Bromide Inventory

EPA annually tracks the remaining quantity of methyl bromide produced prior to 2005 in the United States.

Year Amount of Inventory at the End of the Year (Metric Tons)

2003	16,422
2004	12,994
2005	9,974
2006	7,941
2007	6,458
2008	4,271
2009	3,064
2010	1,803
2011	1,249
2012	627
2013	357
2014	158

Last updated on March 18, 2016

EXHIBIT E

Article 2H: Methyl bromide

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1995, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, its calculated level of consumption in 1991. Each Party producing the substance shall, for the same period, ensure that its calculated level of production of the substance does not exceed, annually, its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.
2. Each Party shall ensure that for the twelve-month period commencing on 1 January 1999, and in the twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, seventy-five per cent of its calculated level of consumption in 1991. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, seventy-five per cent of its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.
3. Each Party shall ensure that for the twelve-month period commencing on 1 January 2001, and in the twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, fifty per cent of its calculated level of consumption in 1991. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, fifty per cent of its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.
4. Each Party shall ensure that for the twelve-month period commencing on 1 January 2003, and in the twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, thirty per cent of its calculated level of consumption in 1991. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, thirty per cent of its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.
5. Each Party shall ensure that for the twelve-month period commencing on 1 January 2005, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed zero. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may, until 1 January 2002 exceed that limit by up to fifteen per cent of its calculated level of production in 1991; thereafter, it may exceed that limit by a quantity equal to the annual average of its production of the controlled substance in Annex E for basic domestic needs for the period 1995 to 1998 inclusive. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be critical uses.

5 *bis*. Each Party shall ensure that for the twelve-month period commencing on 1 January 2005 and in each twelve-month period thereafter, its calculated level of production of the controlled substance in Annex E for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed eighty per cent of the annual average of its production of the substance for basic domestic needs for the period 1995 to 1998 inclusive.

5 *ter*. Each Party shall ensure that for the twelve-month period commencing on 1 January



Article 2H: Methyl bromide

Published on OZONE SECRETARIAT (<http://ozone.unep.org>)

2015 and in each twelve-month period thereafter, its calculated level of production of the controlled substance in Annex E for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed zero.

6. The calculated levels of consumption and production under this Article shall not include the amounts used by the Party for quarantine and pre-shipment applications.

- [Add your Tribute](#) [1]

Links

[1] <http://ozone.unep.org/en/comment/reply/25427#comment-form>

EXHIBIT F

San Joaquin Valley Air Pollution Control District

Authority to Construct Application Review

Increase Limits for Methyl Bromide Fumigation

Facility Name:	Rivermaid Trading Co.	Date:	April 12, 2014
Mailing Address:	P.O. Box 350	Engineer:	G. Heinen
	Lodi, CA 95241	Lead Engineer:	Brian Clements
Contact Person:	Wolfgang Rochert		
Telephone:	209-810-8594		
Fax:	209-369-5465		
E-Mail:	Wolfgang@rivermaid.com		
Application #(s):	N-8844-1-1		
Project #:	N-1141279		
Deemed Complete:	April 11, 2014		

I. Proposal

Rivermaid Trading Co. has requested an Authority to Construct (ATC) permit for the increasing the daily and annual fumigant limits of their fumigation chamber using methyl bromide (CH₃Br) to fumigate cherries. Due to the opportunity for processing special orders, the operator is requesting to increase to their existing fumigation limit from 112 lb/day and 5,040 lb/year to 300 lb/day and 9,000 lb/year. Production and use of CH₃Br was phased out under the *Montreal Protocol on Substances that Deplete the Ozone Layer*. An allowable exception to the Protocol is the use of CH₃Br for Quarantine and Pre-shipment fumigation. This facility is preparing fruit for shipment and falls under this exemption. The draft ATC is included in Appendix A.

II. Applicable Rules

Rule 2201	New and Modified Stationary Source Review Rule (4/21/11)
Rule 2520	Federally Mandated Operating Permits (6/21/01)
Rule 4001	New Source Performance Standards (4/14/99)
Rule 4002	National Emissions Standards for Hazardous Air Pollutants (5/20/04)
Rule 4101	Visible Emissions (2/17/05)
Rule 4102	Nuisance (12/17/92)
CH&SC 41700	Health Risk Assessment
CH&SC 42301.6	School Notice
Public Resources Code 21000-21177:	California Environmental Quality Act (CEQA)
California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000-15387:	CEQA Guidelines

III. Project Location

The facility is located at 6011 E Pine St in Lodi, CA. The equipment is not located within 1,000 feet of the outer boundary of a K-12 school. Therefore, the public notification requirement of California Health and Safety Code 42301.6 is not applicable to this project.

IV. Process Description

The primary business is processing and packing agricultural commodities. The facility receives cherries and stores them onsite until they can be processed. During the storage process, the cherries are fumigated to control pests. The cherries will be fumigated with gaseous CH_3Br .

The fumigation chamber is 40' L X 25' W X 30' H. The cherries are placed inside the chamber, the doors are sealed, and the fumigant is introduced. After fumigation, the chambers are vented directly to atmosphere until fumigant levels are low enough to safely allow workers to remove the product.

Fumigation takes place primarily in the first and second quarters, depending on the harvest.

V. Equipment Listing

Pre-project Equipment Description:

N-8844-1-0: METHYL BROMIDE FUMIGATION OPERATION WITH ONE CHAMBER

Proposed Modification:

N-8844-1-1: MODIFICATION OF METHYL BROMIDE FUMIGATION OPERATION WITH ONE CHAMBER: INCREASE FUMIGANT USAGE LIMITS

Post Project Equipment Description:

N-8844-1-1: METHYL BROMIDE FUMIGATION OPERATION WITH ONE CHAMBER

VI. Emission Control Technology Evaluation

The fumigation chamber is vented directly to the atmosphere with no add-on control technology. 100% of the fumigant is assumed to be emitted.

VII. General Calculations

A. Assumptions

Methyl Bromide (CH_3Br)

- All methyl bromide is vented to the atmosphere; no fumigant is absorbed by the fruit.
- Pre-Project CH_3Br usage = 112 lb/day and 5,040 lb/year (current permit limits)

- Post-Project CH₃Br usage = 300 lb/day and 9,000 lb/year (per applicant)

B. Emission Factors

Methyl Bromide (CH₃Br) is considered a VOC

- 1 lb of CH₃Br = 1 lb-VOC

C. Calculations

1. Pre-Project Potential to Emit (PE1)

Pre-project emissions were calculated using the currently permitted limits:

Daily:

VOC (lb/day) = CH₃Br (lb/day)

VOC lb/day = 112.0 lb/day

Annual:

VOC (lb/yr) = CH₃Br (lb/yr)

VOC lb/yr = 5,040 lb/yr

2. Post Project Potential to Emit (PE2)

Post-project emissions were calculated using the proposed limits:

Daily:

VOC (lb/day) = CH₃Br (lb/day)

VOC lb/day = 300.0 lb/day

Annual:

VOC (lb/yr) = CH₃Br (lb/yr)

VOC lb/yr = 9,000 lb/yr

3. Pre-Project Stationary Source Potential to Emit (SSPE1)

Pursuant to District Rule 2201, the SSPE1 is the Potential to Emit (PE) from all units with valid Authorities to Construct (ATC) or Permits to Operate (PTO) at the Stationary Source and the quantity of Emission Reduction Credits (ERC) which have been banked since September 19, 1991 for Actual Emissions Reductions (AER) that have occurred at the source, and which have not been used on-site.

SSPE1 (lb/year)					
Permit Unit	NO _x	SO _x	PM ₁₀	CO	VOC
N-8844-1-0	0	0	0	0	5,040
SSPE1	0	0	0	0	5,040

4. Post Project Stationary Source Potential to Emit (SSPE2)

Pursuant to District Rule 2201, the SSPE2 is the PE from all units with valid ATCs or PTOs at the Stationary Source and the quantity of ERCs which have been banked since September 19, 1991 for AER that have occurred at the source, and which have not been used on-site.

SSPE2 (lb/year)					
Permit Unit	NO _x	SO _x	PM ₁₀	CO	VOC
N-8844-1-1	0	0	0	0	9,000
SSPE2	0	0	0	0	9,000

5. Major Source Determination

Rule 2201 Major Source Determination:

Pursuant to District Rule 2201, a Major Source is a stationary source with a SSPE2 equal to or exceeding one or more of the following threshold values. For the purposes of determining Major Source status the following shall not be included:

- any ERCs associated with the stationary source
- Emissions from non-road IC engines (i.e. IC engines at a particular site at the facility for less than 12 months)
- Fugitive emissions, except for the specific source categories specified in 40 CFR 51.165

Rule 2201 Major Source Determination (lb/year)					
	NO _x	SO _x	PM ₁₀	CO	VOC
Facility emissions pre-project	0	0	0	0	5,040
Facility emissions post project	0	0	0	0	9,000
Major Source Threshold	20,000	140,000	140,000	200,000	20,000
Major Source?	No	No	No	No	No

As seen in the table above, the facility is not an existing Major Source and is not becoming a Major Source as a result of this project.

Rule 2410 Major Source Determination:

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(i). Therefore the following PSD Major Source thresholds are applicable.

PSD Major Source Determination (tons/year)							
	NO2	VOC	SO2	CO	PM	PM10	CO2e
Estimated Facility PE before Project Increase	0	2.5	0	0	0	0	0
PSD Major Source Thresholds	250	250	250	250	250	250	100,000
PSD Major Source ? (Y/N)	No	No	No	No	No	No	No

As shown above, the facility is not an existing Major Source for PSD for at least one pollutant. Therefore the facility is not an existing Major Source for PSD.

6. Baseline Emissions (BE)

The BE calculation (in lb/year) is performed pollutant-by-pollutant for each unit within the project to calculate the QNEC, and if applicable, to determine the amount of offsets required.

Pursuant to District Rule 2201, BE = PE1 for:

- Any unit located at a non-Major Source,
- Any Highly-Utilized Emissions Unit, located at a Major Source,
- Any Fully-Offset Emissions Unit, located at a Major Source, or
- Any Clean Emissions Unit, located at a Major Source.

otherwise,

BE = Historic Actual Emissions (HAE), calculated pursuant to District Rule 2201.

As shown in Section VII.C.5 above, the facility is not a Major Source for any pollutant.

Since this is a unit located at a non-Major Source, BE = PE1 for all pollutants.

7. SB 288 Major Modification

SB 288 Major Modification is defined in 40 CFR Part 51.165 as "any physical change in or change in the method of operation of a major stationary source that would result in a significant net emissions increase of any pollutant subject to regulation under the Act."

Since this facility is not a Major Source for any of the pollutants addressed in this project, this project does not constitute an SB 288 major modification.

8. Federal Major Modification

District Rule 2201 states that a Federal Major Modification is the same as a "Major Modification" as defined in 40 CFR 51.165 and part D of Title I of the CAA.

Since this source is not included in the 28 specific source categories specified in 40 CFR 51.165, the increases in fugitive emissions are not included in the Federal Major Modification determination.

Since this facility is not a Major Source for any pollutants, this project does not constitute a Federal Major Modification. Additionally, since the facility is not a Major Source for PM₁₀ (140,000 lb/year), it is not a Major Source for PM_{2.5} (200,000 lb/year).

9. Rule 2410 – Prevention of Significant Deterioration (PSD) Applicability Determination

Rule 2410 applies to pollutants for which the District is in attainment or for unclassified, pollutants. The pollutants addressed in the PSD applicability determination are listed as follows:

- NO₂ (as a primary pollutant)
- SO₂ (as a primary pollutant)
- CO
- PM
- PM₁₀
- Greenhouse gases (GHG): CO₂, N₂O, CH₄, HFCs, PFCs, and SF₆

The first step of this PSD evaluation consists of determining whether the facility is an existing PSD Major Source or not (See Section VII.C.5 of this document).

In the case the facility is new source, the second step of the PSD evaluation is to determine if this new facility will become a new PSD Major Source as a result of the project and if so, to determine which pollutant will result in a PSD significant increase.

I. Potential to Emit for New or Modified Emission Units vs PSD Major Source Thresholds

As a screening tool, the project potential to emit from all new and modified units is compared to the PSD Major Source threshold, and if total project potential to emit from all new and modified units is below this threshold, no further analysis will be needed.

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(i). Therefore the following PSD Major Source thresholds are applicable.

PSD Major Source Determination: Potential to Emit (tons/year)							
	NO2	VOC	SO2	CO	PM	PM10	CO2e
Total PE from New and Modified Units	0	4.5	0	0	0	0	0
PSD Major Source threshold	250	250	250	250	250	250	100,000
New PSD Major Source?	No	No	No	No	No	No	No

As shown in the table above, the project potential to emit, by itself, does not exceed any of the PSD Major Source thresholds. Therefore Rule 2410 is not applicable and no further discussion is required.

10. Quarterly Net Emissions Change (QNEC)

The QNEC is calculated solely to establish emissions that are used to complete the District's PAS emissions profile screen. Detailed QNEC calculations are included in Appendix B.

VIII. Compliance

Rule 2201 New and Modified Stationary Source Review Rule

A. Best Available Control Technology (BACT)

1. BACT Applicability

BACT requirements are triggered on a pollutant-by-pollutant basis and on an emissions unit-by-emissions unit basis. Unless specifically exempted by Rule 2201, BACT shall be required for the following actions*:

- Any new emissions unit with a potential to emit exceeding two pounds per day,
- The relocation from one Stationary Source to another of an existing emissions unit with a potential to emit exceeding two pounds per day,
- Modifications to an existing emissions unit with a valid Permit to Operate resulting in an AIPE exceeding two pounds per day, and/or
- Any new or modified emissions unit, in a stationary source project, which results in an SB 288 Major Modification or a Federal Major Modification, as defined by the rule.

*Except for CO emissions from a new or modified emissions unit at a Stationary Source with an SSPE2 of less than 200,000 pounds per year of CO.

a. New emissions units – PE > 2 lb/day

As discussed in Section I above, there are no new emissions units associated with this project. Therefore BACT for new units with PE > 2 lb/day purposes is not triggered

b. Relocation of emissions units – PE > 2 lb/day

As discussed in Section I above, there are no emissions units being relocated from one stationary source to another; therefore BACT is not triggered.

c. Modification of emissions units – AIPE > 2 lb/day

As seen in Section VII.C.2 above, the applicant is proposing to modify the fumigation chamber fumigant limits, therefore, an AIPE must be calculated:

$$\text{AIPE} = \text{PE2} - \text{HAPE}$$

Where,

AIPE = Adjusted Increase in Permitted Emissions, (lb/day)

PE2 = Post-Project Potential to Emit, (lb/day)

HAPE = Historically Adjusted Potential to Emit, (lb/day)

$$\text{HAPE} = \text{PE1} \times (\text{EF2}/\text{EF1})$$

Where,

PE1 = The emissions unit's PE prior to modification or relocation, (lb/day)

EF2 = The emissions unit's permitted emission factor for the pollutant after modification or relocation. If EF2 is greater than EF1 then EF2/EF1 shall be set to 1

EF1 = The emissions unit's permitted emission factor for the pollutant before the modification or relocation

$$\text{AIPE} = \text{PE2} - (\text{PE1} \times (\text{EF2} / \text{EF1}))$$

$$\text{AIPE} = 300.0 - (112.0 \times (1/1))$$

$$= 300.0 - (112.0 \times 1)$$

$$= 188.0 \text{ lb/day}$$

As demonstrated above, the AIPE is greater than 2.0 lb/day for VOC emissions. Therefore BACT is triggered for AIPE > 2.0 lb/day.

d. SB 288/Federal Major Modification

As discussed in Section VII.C.7 above, this project does not constitute an SB 288 and/or Federal Major Modification for NO_x emissions; therefore BACT is not triggered for major modification purposes.

2. BACT Guideline

BACT Guideline 5.4.12, (Appendix C), applies to operation involving a "Commodity Methyl Bromide Fumigation Chamber".

3. Top-Down BACT Analysis

Per District Policy APR 1305, Section IX, "A top-down BACT analysis shall be performed as a part of the Application Review for each application subject to the BACT requirements pursuant to the District's NSR Rule for source categories or classes covered in the BACT Clearinghouse, relevant information under each of the following steps may be simply cited from the Clearinghouse without further analysis."

Pursuant to the attached Top-Down BACT Analysis, (Appendix C), BACT is satisfied, with:

VOC: Minimize use of fumigant (i.e. use no more than product specifications recommend); and air-tight fumigation chamber

The following permit condition must be included:

The fumigation chambers shall be sealed air-tight during the fumigation process. [District Rule 2201] N

The amount of methyl bromide used per fumigation cycle shall not exceed recommendation of the product specifications. [District Rule 2201] N

The amount of methyl bromide used per fumigation cycle shall not exceed manufacturer recommendation. [District Rule 2201] N

B. Offsets

1. Offset Applicability

Offset requirements shall be triggered on a pollutant by pollutant basis and shall be required if the SSPE2 equals to or exceeds the offset threshold levels in Table 4-1 of Rule 2201.

The SSPE2 is compared to the offset thresholds in the following table.

Offset Determination (lb/year)					
	NO _x	SO _x	PM ₁₀	CO	VOC
SSPE2	0	0	0	0	9,000
Offset Thresholds	20,000	54,750	29,200	200,000	20,000
Offsets triggered?	No	No	No	No	No

2. Quantity of Offsets Required

As seen above, the SSPE2 is not greater than the offset thresholds for all the pollutants; therefore offset calculations are not necessary and offsets will not be required for this project.

C. Public Notification

1. Applicability

Public noticing is required for:

- New Major Sources, Federal Major Modifications, and SB 288 Major Modifications,
- Any new emissions unit with a Potential to Emit greater than 100 pounds during any one day for any one pollutant,
- Any project which results in the offset thresholds being surpassed, and/or
- Any project with an SSPE of greater than 20,000 lb/year for any pollutant.

a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications

New Major Sources are new facilities, which are also Major Sources. As shown in Section VII.C.5 above, the SSPE2 is not greater than the Major Source threshold for any pollutant. Therefore, public noticing is not required for this project for new Major Source purposes.

b. PE > 100 lb/day

Applications which include a new emissions unit with a PE greater than 100 pounds during any one day for any pollutant will trigger public noticing requirements. This project does not include any new emissions units so public notice is not required under this provision.

c. Offset Threshold

The SSPE1 and SSPE2 are compared to the offset thresholds in the following table.

Offset Thresholds				
Pollutant	SSPE1 (lb/year)	SSPE2 (lb/year)	Offset Threshold	Public Notice Required?
NO _x	0	0	20,000 lb/year	No
SO _x	0	0	54,750 lb/year	No
PM ₁₀	0	0	29,200 lb/year	No
CO	0	0	200,000 lb/year	No
VOC	5,040	9,000	20,000 lb/year	No

As detailed above, there were no thresholds surpassed with this project; therefore public noticing is not required for offset purposes.

d. SSIPE > 20,000 lb/year

Public notification is required for any permitting action that results in a SSIPE of more than 20,000 lb/year of any affected pollutant. According to District policy, the $SSIPE = SSPE2 - SSPE1$. The SSIPE is compared to the SSIPE Public Notice thresholds in the following table.

SSIPE Public Notice Thresholds					
Pollutant	SSPE2 (lb/year)	SSPE1 (lb/year)	SSIPE (lb/year)	SSIPE Public Notice Threshold	Public Notice Required?
NO _x	0	0	0	20,000 lb/year	No
SO _x	0	0	0	20,000 lb/year	No
PM ₁₀	0	0	0	20,000 lb/year	No
CO	0	0	0	20,000 lb/year	No
VOC	9,000	5,040	3,960	20,000 lb/year	No

As demonstrated above, the SSIPEs for all pollutants were less than 20,000 lb/year; therefore public noticing for SSIPE purposes is not required.

2. Public Notice Action

As discussed above, public noticing is not required for this project.

D. Daily Emission Limits (DELs)

DELs and other enforceable conditions are required by Rule 2201 to restrict a unit's maximum daily emissions, to a level at or below the emissions associated with the maximum design capacity. The DEL must be contained in the latest ATC and contained in or enforced by the latest PTO and enforceable, in a practicable manner, on a daily basis. DELs are also required to enforce the applicability of BACT. The following conditions will appear on the permit:

- Only methyl bromide shall be used as a fumigant. [District Rule 2201]
- Daily emissions of VOC shall not exceed 300 lb, equivalent to the use of 300 lb methyl bromide per day. [District Rule 2201]
- Annual emissions of VOC shall not exceed 9,000 lb, equivalent to the use of 9,000 lb methyl bromide per year. [District Rule 2201]

E. Compliance Assurance

1. Source Testing

Pursuant to District Policy APR 1705, source testing is not required to demonstrate compliance with Rule 2201.

2. Monitoring

No monitoring is required to demonstrate compliance with Rule 2201.

3. Recordkeeping

Recordkeeping is required to demonstrate compliance with the offset, public notification and daily emission limit requirements of Rule 2201. The following conditions will appear on the permit:

- Permittee shall maintain daily and annual records of the amount of methyl bromide used (in pounds). [District Rule 2201]
- Records shall be maintained, retained on-site for a period of at least five years and made available for District inspection upon request. [District Rule 4305]

4. Reporting

No reporting is required to demonstrate compliance with Rule 2201.

Rule 2520 Federally Mandated Operating Permits

Since this facility's potential emissions do not exceed any Major Source thresholds of Rule 2201, this facility is not a Major Source, and Rule 2520 does not apply.

Rule 4001 New Source Performance Standards (NSPS)

This rule incorporates NSPS from Part 60, Chapter 1, Title 40, Code of Federal Regulations (CFR); and applies to all new sources of air pollution and modifications of existing sources of air pollution listed in 40 CFR Part 60. However, no subparts of 40 CFR Part 60 apply to commodity fumigation operations.

Rule 4002 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

This rule incorporates NESHAPs from Part 61, Chapter I, Subchapter C, Title 40, CFR and the NESHAPs from Part 63, Chapter I, Subchapter C, Title 40, CFR; and applies to all sources of hazardous air pollution listed in 40 CFR Part 61 or 40 CFR Part 63. However, no subparts of 40 CFR Part 61 or 40 CFR Part 63 apply to commodity fumigation operations.

Rule 4101 Visible Emissions

Per Section 5.0, no person shall discharge into the atmosphere emissions of any air contaminant aggregating more than 3 minutes in any hour which is as dark as or darker than Ringelmann 1 (or 20% opacity). Based on past inspections of similar operations, compliance is expected. The following condition will be added to the permit to assure compliance with this rule.

- {15} No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]

Rule 4102 Nuisance

Rule 4102 prohibits discharge of air contaminants which could cause injury, detriment, nuisance or annoyance to the public. Public nuisance conditions are not expected as a result of these operations, provided the equipment is well maintained. The following condition will be added to the permit to further assure compliance with this rule.

- {98} No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]

California Health & Safety Code 41700 (Health Risk Assessment)

District Policy APR 1905 – *Risk Management Policy for Permitting New and Modified Sources* specifies that for an increase in emissions associated with a proposed new source or modification, the District perform an analysis to determine the possible impact to the nearest resident or worksite.

An HRA is not required for a project with a total facility prioritization score of less than one. According to the Technical Services Memo for this project (**Appendix D**), the total facility prioritization score including this project was greater than one. Therefore, an HRA was required to determine the short-term acute and long-term chronic exposure from this project. The results of the HRA are summarized below:

Categories	Fumigation Operation (Unit 1-1)	Project Totals	Facility Totals
Prioritization Score	19.2	19.2	>1
Acute Hazard Index	0	0	0.15
Chronic Hazard Index	0.29	0.29	0.39
Maximum Individual Cancer Risk	N/A ¹	0.00	0.00
T-BACT Required?	No		
Special Permit Conditions?	Yes		

¹The Maximum Individual Cancer Risk was not calculated since there are no risk factors associated with any of the Toxic Air contaminants (TACs) under analysis.

To ensure that human health risks will not exceed District allowable levels; the following permit condition must be included:

- {1898} The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction.
[District Rule 4102] N

Discussion of T-BACT

BACT for toxic emission control (T-BACT) is required if the cancer risk exceeds one in one million. As demonstrated above, T-BACT is not required for this project because the HRA indicates that the risk is not above the District's thresholds for triggering T-BACT requirements; therefore, compliance with the District's Risk Management Policy is expected.

California Health & Safety Code 42301.6 (School Notice)

The District has verified that this site is not located within 1,000 feet of a school. Therefore, pursuant to California Health and Safety Code 42301.6, a school notice is not required.

California Environmental Quality Act (CEQA)

CEQA requires each public agency to adopt objectives, criteria, and specific procedures consistent with CEQA Statutes and the CEQA Guidelines for administering its responsibilities under CEQA, including the orderly evaluation of projects and preparation of environmental documents. The District adopted its *Environmental Review Guidelines* (ERG) in 2001. The basic purposes of CEQA are to:

- Inform governmental decision-makers and the public about the potential, significant environmental effects of proposed activities;
- Identify the ways that environmental damage can be avoided or significantly reduced;
- Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible; and
- Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

Greenhouse Gas (GHG) Significance Determination

Methyl Bromide is not a GHG. The District's engineering evaluation (this document) demonstrates that the project would not result in an increase in project specific greenhouse gas emissions. The District therefore concludes that the project would have a less than cumulatively significant impact on global climate change.

District CEQA Findings

The District is a Lead Agency for the project because of its discretionary approval power over the project via its Permits Rule (Rule 2010) and New Source Review Rule (Rule 2201), (CEQA Guidelines §15381). The District's engineering evaluation of the project (this document) demonstrates that compliance with District rules and permit conditions would reduce Stationary Source emissions from the project to levels below the District's significance thresholds for criteria pollutants. The District has determined that no additional findings are required (CEQA Guidelines §15096(h)).

IX. Recommendation

Compliance with all applicable rules and regulations is expected. Issue ATC N-8844-1-0 subject to the permit conditions on the attached draft ATC in **Appendix A**.

X. Billing Information

Annual Permit Fees			
Permit Number	Fee Schedule	Fee Description	Annual Fee
N-8844-1-1	3020-06	Miscellaneous	\$105.00

Appendixes

- A: Draft ATC
- B: Quarterly Net Emissions Change
- C: BACT Analysis
- D: Risk Management Review Summary
- E: Emissions Profile

Appendix A
Draft ATC

San Joaquin Valley
Air Pollution Control District

AUTHORITY TO CONSTRUCT

ISSUANCE DATE: DRAFT

PERMIT NO: N-8844-1-1

LEGAL OWNER OR OPERATOR: RIVERMAID TRADING, CO.

MAILING ADDRESS: PO BOX 350
LODI, CA 95241

LOCATION: 6011 EAST PINE
LODI, CA 95241

EQUIPMENT DESCRIPTION:

MODIFICATION OF METHYL BROMIDE FUMIGATION OPERATION WITH ONE CHAMBER: INCREASE FUMIGANT USAGE LIMITS

CONDITIONS

1. {98} No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]
2. {15} No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]
3. Only methyl bromide shall be used as a fumigant. [District Rules 2201 and 4102]
4. The fumigation chamber shall be sealed air-tight during the fumigation process. [District Rule 2201]
5. The amount of methyl bromide used per fumigation cycle shall not exceed recommendation of the product specifications. [District Rule 2201]
6. The amount of methyl bromide used per fumigation cycle shall not exceed manufacturer recommendation. [District Rule 2201]
7. Daily emissions of VOC shall not exceed 300 lb, equivalent to the use of 300 lb methyl bromide per day. [District Rule 2201]
8. Annual emissions of VOC shall not exceed 9,000 lb, equivalent to the use of 9,000 lb methyl bromide per year. [District Rule 2201]
9. {1898} The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction. [District Rule 4102]

CONDITIONS CONTINUE ON NEXT PAGE

YOU MUST NOTIFY THE DISTRICT COMPLIANCE DIVISION AT (209) 557-6400 WHEN CONSTRUCTION IS COMPLETED AND PRIOR TO OPERATING THE EQUIPMENT OR MODIFICATIONS AUTHORIZED BY THIS AUTHORITY TO CONSTRUCT. This is NOT a PERMIT TO OPERATE. Approval or denial of a PERMIT TO OPERATE will be made after an inspection to verify that the equipment has been constructed in accordance with the approved plans, specifications and conditions of this Authority to Construct, and to determine if the equipment can be operated in compliance with all Rules and Regulations of the San Joaquin Valley Unified Air Pollution Control District. Unless construction has commenced pursuant to Rule 2050, this Authority to Construct shall expire and application shall be cancelled two years from the date of issuance. The applicant is responsible for complying with all laws, ordinances and regulations of all other governmental agencies which may pertain to the above equipment.

Seyed Sadredin, Executive Director LAPCO

Arnaud Marjolle, Director of Permit Services

N-8844-1-1, Apr 17 2014 8:53AM - HEIWEING Joint Inspection NOT Required

Northern Regional Office • 4800 Enterprise Way • Modesto, CA 95356-8718 • (209) 557-6400 • Fax (209) 557-6475

10. Permittee shall maintain daily and annual records of the amount of methyl bromide used (in pounds). [District Rule 2201]
11. {3246} All records shall be maintained and retained on-site for a period of at least 5 years and shall be made available for District inspection upon request. [District Rule 1070]

DRAFT

Appendix B
Quarterly Net Emissions Change (QNEC)

Quarterly Net Emissions Change (QNEC)

The Quarterly Net Emissions Change is used to complete the emission profile screen for the District's PAS database. This is a seasonal source with the majority of the emissions occurring in the first and second quarter, therefore the QNEC shall be calculated as follows:

$QNEC = (PE2 - PE1)/2$, where:

QNEC = Quarterly Net Emissions Change for each emissions unit, lb/qtr.

PE2 = Post Project Potential to Emit for each emissions unit, lb/year.

PE1 = BE, since this is not a major source

Quarterly NEC [QNEC]			
	PE2 (lb/year)	PE1 (lb/year)	QNEC (lb/qtr)
NO _x	0	0	0
SO _x	0	0	0
PM ₁₀	9,000	5,040	1,980*
CO	0	0	0
VOC	0	0	0

* First and Second Quarter only

Appendix C

BACT Analysis

Best Available Control Technology (BACT) Guideline 5.4.12
Last Update: 6/25/2008

Commodity Methyl Bromide Fumigation Chamber

Pollutant	Achieved In Practice or in the SIP	Technologically Feasible	Alternate Basic Equipment
VOC	Minimize use of fumigant (i.e. use no more than product specifications recommend); and air-tight fumigation chamber	1. 99% control (chemical scrubbing) 2. 98% control (thermal or catalytic reduction) 3. 95% control (carbon adsorption) 4. 80% control (condensation refrigeration system)	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

This is a Summary Page for this Class of Source.

BACT Analysis for VOC Emissions:

BACT Analysis for VOC Emissions

Step 1 - Identify all control technologies

The SJVUAPCD BACT Clearinghouse guideline 5.4.12, identifies achieved in practice and technologically feasible BACT for Commodity Methyl Bromide Fumigation Chambers as follows

- 1) Chemical scrubbing system – 99% (Technologically Feasible)
- 2) Thermal and catalytic reduction – 98% (Technologically Feasible)
- 3) Carbon adsorption – 95% (Technologically Feasible)
- 4) Condensation using a refrigeration system – 80% (Technologically Feasible)
- 5) Use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend). (Achieved in Practice)

Step 2 - Eliminate technologically infeasible options

Thermal and catalytic reduction

Thermal and catalytic reduction uses heat and a catalyst to chemically breakdown a VOC into a less reactive compound such as water and elemental nitrogen. When methyl bromide is reduced, however, the process results in the generation of hydrogen bromide. Hydrogen bromide is listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA), requiring the use of additional control system(s) to prevent these secondary emissions.

Thus, thermal and catalytic reduction is considered to be technologically infeasible for this operation and is eliminated from further consideration.

All other options identified above are considered to be technologically feasible.

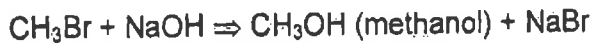
Step 3 - Rank remaining options by control effectiveness

- 1) Chemical scrubbing system – 99% (Technologically Feasible)
- 2) Carbon adsorption – 95% (Technologically Feasible)
- 3) Condensation using a refrigeration system – 80% (Technologically Feasible)
- 4) Use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend). (Achieved in Practice)

Step 4 - Cost Effectiveness Analysis

1) Chemical scrubbing system

Chemical scrubbing of methyl bromide (CH_3Br) involves using a packed tower with sodium hydroxide (NaOH). The reaction that occurs in the packed tower with 10 pH NaOH is given by the following formula:



Stoichiometrically, one mole of NaOH (MW = 40) is required to react with one mole of methyl bromide (MW = 95) or 0.42 lb NaOH per lb of CH₃Br. The NaOH is an aqueous solution, which is mostly water. The concentration of NaOH is found in the following manner:

The pH value is defined as:

$$\begin{aligned}\text{pH} &= -\log[\text{H}^+] = 10 \\ [\text{H}^+] &= 1.0 \text{ E-}10\end{aligned}$$

The concentration of NaOH is equal to the concentration of OH ions in a scrubber solution of water and NaOH:

$$[\text{OH}] = \{K_w \times [\text{H}_2\text{O}]\} + [\text{H}^+]$$

where $K_w = 1.0\text{E-}14$ and $[\text{H}_2\text{O}] = 1.0$ for a very dilute solution, thus:

$$\begin{aligned}[\text{OH}] &= \{1.0\text{E-}14 \times 1\} + 1.0 \text{ E-}10 \\ &= 1.0 \text{ E-}4 \text{ moles/liter}\end{aligned}$$

NaOH has a molecular weight of 40 grams/liter so the concentration at a pH value of 10 is:

$$\begin{aligned}\text{NaOH} &= 40 \text{ gram/mol} \times 1\text{E-}4 \text{ mol/l} \times 1 \text{ lb/453.6 gram} \times 3.7854 \text{ l/gal} \\ &= 3.3\text{E-}5 \text{ lb-NaOH/gal}\end{aligned}$$

Based on the stoichiometric formula, the minimum amount of aqueous solution needed for the calculated amount of CH₃Br emissions per year is:

$$\begin{aligned}\text{Aqueous solution} &= 9,000 \text{ lb-CH}_3\text{Br/yr} \times 0.42 \text{ lb-NaOH/lb-CH}_3\text{Br} \\ &= 3,780 \text{ lb-NaOH/yr}\end{aligned}$$

$$\begin{aligned}\text{Gallons of NaOH/yr} &= 3,780 \text{ lb-NaOH/yr} + 3.3\text{E-}5 \text{ lb-NaOH/gal} \\ &= 114,545,454 \text{ gal-NaOH/yr}\end{aligned}$$

The depleted solution must be disposed of as a hazardous material. A 2010 estimate from Van Waters and Rogers indicated the disposal cost for bulk quantities of this liquid to be \$3.75/gallon plus freight charges. For the amount of solution required:

$$\begin{aligned}\text{Annual disposal cost} &= 114,545,454 \text{ gal-NaOH/yr} \times 3.75/\text{gallon} \\ &= \$430,000,000 \text{ dollars per year.}\end{aligned}$$

Controlled Cost per ton of emissions:

As shown above, the amount of reduction from a chemical scrubbing system is expected to be:

$$\begin{aligned}\text{VOCs controlled} &= 9,000 \text{ lb-VOC/yr} \times 0.99 \times 1 \text{ ton}/2,000 \text{ lb} \\ &= 4.5 \text{ ton-VOC/yr}\end{aligned}$$

$$\begin{aligned}\text{Cost/ton of emissions (\$/ton)} &= \$430,000,000 \text{ \$/yr} \div 4.5 \text{ ton-VOC/yr} \\ &= \$107,500,000\end{aligned}$$

The VOC cost effectiveness threshold is \$17,500 per ton (per BACT Policy addendum dated 8/14/2008). Since the calculated controlled cost exceeds the cost effective value of \$17,500/ton for VOC, a chemical scrubbing system is deemed not cost effective for this project.

2) Carbon adsorption

An SDUPA study indicated that CH₃Br to carbon adsorption ratio is about 0.3 at 70 °F and 1.0 psia. The study used a three-bed, parallel system, which rotates between beds as the concentration changed. A single bed would become saturated and begin to emit CH₃Br during the later stages of the chamber venting period when the CH₃Br exhaust concentrations drop. The size of a three-bed system to control one ton of CH₃Br is:

$$\begin{aligned}\text{System size} &= 9,000 \text{ lb CH}_3\text{Br/yr} \times (1 \text{ lb C} + 0.3 \text{ lb CH}_3\text{Br}) \\ &= 30,000 \text{ lb-C required/year}\end{aligned}$$

Based on a 2010 phone conversation with a supplier of activated carbon, 4' x 8' mesh activated carbon is \$1.46/lb plus tax and shipping. Using this price, the cost of carbon for this system would be:

$$\begin{aligned}\text{Carbon cost} &= \$1.46/\text{lb-carbon} \times 30,000 \text{ lb carbon/ton of CH}_3\text{Br controlled} \\ &= \$43,800/\text{year}\end{aligned}$$

The cost of a carbon adsorption system sized for a typical 14,000 scfm enclosed automotive spray booth is estimated using the calculations from Chapter 12 of Air Pollution Control - A Design Approach by C. David Cooper and F.C. Alley.

Capital Cost:

The purchase price for a carbon-steel package adsorber, complete with fan, instrumentation and piping can be estimated from the following relationship equation:

$$\text{PEC (\$)} = 50,000 + 0.277M_c^{1.200}$$

Where PEC = Purchase price in 1977 dollars
M_c = mass of carbon in the system

$$\text{PEC} = 50,000 + (0.277)(100,000^{1.200})$$

$$\begin{aligned} &= 50,000 + (0.277)(1,000,000) \\ &= 50,000 + (277,000) \end{aligned}$$

$$\text{PEC} = \$327,000$$

Total Capital Investment:

The total capital investment is equal to 1.25 times the purchase cost. The sales tax and freight charges total 8% of the base equipment cost. Finally, adjusting from 1977 dollars to 2014 dollars, multiply by 2.75% inflation/yr = 2.69.

Therefore,

$$\text{TCI (2013 dollars)} = (\$327,000) \times (1.25) \times (1.08) \times 2.69 = \$1,187,500$$

According to the six-tenths rule, the ratio between the increase in equipment cost (C) and the increase in capacity (V) given by $C_1/C_2 = (V_1/V_2)^{0.6}$. This rule will be used to scale the equipment cost from a typical 14,000 scfm to the proposed 5,300 scfm fumigation chamber:

$$\begin{aligned} \text{TCI}(5,300 \text{ scf}) &= \text{TCI}(14,000 \text{ scf}) \times (5,300/14,000)^{0.6} \\ &= \$1,187,500 \times 0.558 \\ &= \$662,625 \end{aligned}$$

Pursuant to the District's BACT Policy section X, (Revised 11/9/99), the annual cost of installing and maintaining the thermal oxidizer will be calculated as follows. The installed cost will be spread over the expected life of the carbon adsorption system which is estimated at 10 years and using the capital recovery equation (Equation 1). A 10% interest rate is assumed in this equation and the assumption will be made that the equipment has no salvage value at the end of the ten-year cycle.

A = Annualized total capital investment cost

where

P = present value of capital

CRF = capital recovery factor = $i(i+1)^n / (i+1)^n - 1$

i = interest rate = 10%

n = useful lifetime of equipment in years = 10

$$\text{CRF} = 0.1(0.1 + 1)^{10} / (1 + 0.1)^{10} - 1 = 0.1627$$

$$A = P \times \text{CRF}$$

$$\begin{aligned} \text{So: } A &= \$662,625 \times 0.1627 \\ &= \$107,810/\text{yr} \end{aligned}$$

Operating Cost (Annualized Equipment Cost and Carbon Replacement Cost):

Cost of carbon = \$43,800/yr

Annualized cost of equipment = \$107,810/yr

Total annual cost = \$43,800/yr + \$107,810/yr = **\$151,610/yr**

This is the cost of purchasing carbon for the carbon adsorption system and the capital cost of the equipment itself. Additional energy costs for instrumentation and process equipment and labor costs exist but will not be evaluated.

Controlled Cost per ton of emissions:

As shown above, the amount of reduction from a carbon adsorption system is expected to be:

$$\begin{aligned}\text{VOCs controlled} &= 9,000 \text{ lb-VOC/yr} \times 0.95 \times 1 \text{ ton}/2,000 \text{ lb} \\ &= \mathbf{4.5 \text{ ton-VOC/yr}}\end{aligned}$$

$$\begin{aligned}\text{Cost/ton of emissions (\$/ton)} &= \$151,610/\text{yr} + 4.5 \text{ ton-VOC/yr} \\ &= \mathbf{\$33,691}\end{aligned}$$

The VOC cost effectiveness threshold is \$17,500 per ton (per BACT Policy addendum dated 8/14/2008). Since the calculated controlled cost exceeds the cost effective value of \$17,500/ton for VOC, a carbon adsorption system is deemed not cost effective for this project.

3) Condensation using a refrigeration system

This process requires the CH₃Br and exhaust air to be cooled from the typical chamber exhaust temperature of 70° F to the CH₃Br dew point of 35° F and then cooled to a final temperature of 32 °F (491.7°R).

An SDUPA study estimated the cost for electricity to run a compressor at \$44,000/cycle, assuming \$0.10/kwh and 3 x 78,000 ft² (234,000 ft²) of air chilled from 70 °F to 35 °F.

The chamber has a fan rated at 3.0 hp, with a total exhaust rating of 5,300 cfm, which is equivalent to 159,000 ft² in 30 minutes.

Adjusting the cost calculated in the SDUPA study to reflect the smaller chamber:

$$\begin{aligned}\text{Total cost} &= \$44,000/\text{cycle} \times (159,000 \text{ ft}^2 + 234,000 \text{ ft}^2) \\ \text{Total cost} &= \mathbf{\$29,897/\text{cycle}}\end{aligned}$$

Adjusting the cost calculated in the SDUPA study to reflect \$0.12/kWhr results in an electrical compressor cost as follows:

$$\begin{aligned}\text{Total cost} &= \$29,897/\text{cycle} \times (\$0.12/\text{kwh} + \$0.10/\text{kwh}) \\ \text{Total cost} &= \mathbf{\$35,876/\text{cycle}}\end{aligned}$$

For worse case scenario there is two cycles run per day with the maximum daily fumigant usage of 300 lb-CH₃Br. Assuming that the compressor is run for the first 30 minutes of the exhaust cycle to recover 80% of the 300 lb CH₃Br exhausted, the control captures 240 lb/cycle. The cost per ton of the electricity to run the compressor is therefore:

$$\begin{aligned}\text{Electrical cost} &= \$35,876/\text{cycle} \times 2 \text{ cycles}/240 \text{ lb} \times 2,000 \text{ lb/ton} \\ &= \$597,930/\text{ton}\end{aligned}$$

The VOC cost effectiveness threshold is \$17,500 per ton (per BACT Policy addendum dated 8/14/2008). Since the calculated controlled cost exceeds the cost effective value of \$17,500/ton for VOC, a condensation using a refrigeration system is deemed not cost effective for this project.

Step 5 - Select BACT

The only remaining control method is achieved in practice BACT which is the use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend). The facility has proposed to use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend); therefore, BACT is satisfied.

Appendix D:
Risk Management Review Summary

San Joaquin Valley Air Pollution Control District Risk Management Review

To: George Heinen – Permit Services
From: Trevor Joy – Compliance
Date: April 15, 2014
Facility Name: Rivermaid Trading
Location: 6011 Pine St., Lodi
Application #(s): N-8844-1-1
Project #: N-1130200

A. RMR SUMMARY

Categories	Fumigation Operation (Unit 1-1)	Project Totals	Facility Totals
Prioritization Score	19.2	19.2	>1
Acute Hazard Index	0	0	0.15
Chronic Hazard Index	0.29	0.29	0.39
Maximum Individual Cancer Risk	N/A ¹	0.00	0.00
T-BACT Required?	No		
Special Permit Conditions?	Yes		

¹The Maximum Individual Cancer Risk was not calculated since there are no risk factors associated with any of the Toxic Air contaminants (TACs) under analysis.

Proposed Permit Conditions

To ensure that human health risks will not exceed District allowable levels; the following permit conditions must be included for:

Unit 1-1

1. {1898} The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction.
[District Rule 4102] N

B. RMR REPORT

I. Project Description

Technical Services received a request on April 8, 2014 to perform a Risk Management Review for the modification of a methyl bromide fumigation chamber, increasing the methyl bromide usage.

II. Analysis

Toxic emissions from the project were calculated after reviewing process rates for Methyl Bromide provided by the engineer. In accordance with the District's *Risk Management Policy for Permitting New and Modified Sources* (APR 1905-1, March 2, 2001), risks from the proposed project were prioritized using the procedures in the 1990 CAPCOA Facility Prioritization Guidelines and incorporated in the District's HEART's database. The prioritization score for the proposed project was greater than 1.0 (see RMR Summary Table). Therefore, a refined Health Risk Assessment was required and performed for the project. AERMOD was used with point source parameters outlined below and concatenated 5-year meteorological data from Stockton to determine maximum dispersion factors at the nearest residential and business receptors. The dispersion factors were input into the HARP model to calculate the Chronic and Acute Hazard Indices and the Carcinogenic Risk.

The following parameters were used for the review:

Analysis Parameters (Unit 1-1)			
Source Type	Point	Closest Receptor (m)	82
Stack Height (m)	12.8	Type of Receptor	Business
Stack Diameter (m)	0.61	Location Type	Rural
Stack Gas Temperature	Ambient	Stack Gas Velocity (m/sec)	8.57
Methyl Bromide Increase in Emissions (lb/hr)	0	Methyl Bromide Emissions (lb/yr)	5600

III. Conclusions

There is no Cancer Risk associated with Methyl Bromide; and the Acute and Chronic Hazard Index is below 1.0. In accordance with the District's Risk Management Policy, the unit is approved without Toxic Best Available Control Technology (T-BACT).

To ensure that human health risks will not exceed District allowable levels; the permit conditions listed on Page 1 of this report must be included for this permit unit.

These conclusions are based on the data provided by the applicant and the project engineer. Therefore, this analysis is valid only as long as the proposed data and parameters do not change.

IV. Attachments

- A. RMR request from the project engineer
- B. Prioritization score
- C. HARP Risk Report
- D. Facility Summary

**Appendix E:
Emission Profile**

SJVUAPCD
NORTHERN

Application Emissions

4/12/14
9:08 am

Permit #: N-8844-1-1	Last Updated
Facility: RIVERMAID TRADING, CO.	04/12/2014 HEINENG

Equipment Pre-Baselined: NO

	<u>NOX</u>	<u>SOX</u>	<u>PM10</u>	<u>CO</u>	<u>VOC</u>
Potential to Emit (lb/Yr):	0.0	0.0	0.0	0.0	9000.0
Daily Emis. Limit (lb/Day)	0.0	0.0	0.0	0.0	300.0
Quarterly Net Emissions Change (lb/Qtr)					
Q1:	0.0	0.0	0.0	0.0	1980.0
Q2:	0.0	0.0	0.0	0.0	1980.0
Q3:	0.0	0.0	0.0	0.0	0.0
Q4:	0.0	0.0	0.0	0.0	0.0
Check if offsets are triggered but exemption applies	N	N	N	N	N
Offset Ratio					
Quarterly Offset Amounts (lb/Qtr)					
Q1:					
Q2:					
Q3:					
Q4:					

EXHIBIT G

San Joaquin Valley Air Pollution Control District
Authority to Construct Application Review
New Methyl Bromide Fumigation Chamber

Facility Name: Rivermaid Trading Co.	Date: February 12, 2013
Mailing Address: P.O. Box 350	Engineer: G. Heinen
Lodi, CA 95241	Lead Engineer: Chay Thao
Contact Person: Wolfgang Rochert	
Telephone: 209-810-8594	
Fax: 209-369-5465	
E-Mail: Wolfgang@rivermaid.com	
Application #(s): N-8844-1-0	
Project #: N-1130200	
Deemed Complete: February 11, 2013	

I. Proposal

Rivermaid Trading Co. has requested an Authority to Construct (ATC) permit for the installation of a new fumigation chamber using methyl bromide (CH₃Br) to fumigate cherries. The draft ATC is included in Appendix A.

II. Applicable Rules

Rule 2201	New and Modified Stationary Source Review Rule (4/21/11)
Rule 2520	Federally Mandated Operating Permits (6/21/01)
Rule 4001	New Source Performance Standards (4/14/99)
Rule 4002	National Emissions Standards for Hazardous Air Pollutants (5/20/04)
Rule 4101	Visible Emissions (2/17/05)
Rule 4102	Nuisance (12/17/92)
CH&SC 41700	Health Risk Assessment
CH&SC 42301.6	School Notice
Public Resources Code 21000-21177: California Environmental Quality Act (CEQA)	
California Code of Regulations, Title 14, Division 6, Chapter 3, Sections 15000-15387: CEQA Guidelines	

III. Project Location

The facility is located at 6011 E Pine St in Lodi, CA. The equipment is not located within 1,000 feet of the outer boundary of a K-12 school. Therefore, the public notification requirement of California Health and Safety Code 42301.6 is not applicable to this project.

IV. Process Description

The primary business is processing and packing agricultural commodities. The facility receives cherries and stores them onsite until they can be processed. During the storage process, the cherries are fumigated to control pests. The cherries will be fumigated with gaseous CH_3Br .

The fumigation chamber is 40'L X 25' W X 30' H. The cherries are placed inside the chamber, the doors are sealed, and the fumigant is introduced. After fumigation, the chambers are vented directly to atmosphere until fumigant levels are low enough to safely allow workers to remove the product.

Fumigation takes place primarily in the first and second quarters, depending on the harvest time.

V. Equipment Listing

N-8844-1-0: METHYL BROMIDE FUMIGATION OPERATION WITH ONE CHAMBER

VI. Emission Control Technology Evaluation

The fumigation chamber is vented directly to the atmosphere with no add-on control technology. 100% of the fumigant is assumed to be emitted.

VII. General Calculations

A. Assumptions

Methyl Bromide (CH_3Br)

- All methyl bromide is vented to the atmosphere; no fumigant is absorbed by the fruit.
- Maximum methyl bromide usage = 112 lb/day and 5,040 lb/year (per applicant)

B. Emission Factors

Methyl Bromide (CH_3Br) is considered a VOC

- 1 lb of CH_3Br = 1 lb-VOC

C. Calculations

1. Pre-Project Potential to Emit (PE1)

Since this is a new emissions unit, $\text{PE1} = 0$ for all pollutants.

2. Post Project Potential to Emit (PE2)

Daily:

VOC (lb/day) = CH₃Br (lb/day)

VOC lb/day = 112.0 lb/day

Annual:

VOC (lb/yr) = CH₃Br (lb/yr)

VOC lb/yr = 5,040 lb/yr

3. Pre-Project Stationary Source Potential to Emit (SSPE1)

Since this is a new facility, there are no valid ATCs, PTOs, or ERCs at the Stationary Source; therefore, the SSPE1 is equal to zero.

4. Post Project Stationary Source Potential to Emit (SSPE2)

Pursuant to District Rule 2201, the SSPE2 is the PE from all units with valid ATCs or PTOs at the Stationary Source and the quantity of ERCs which have been banked since September 19, 1991 for AER that have occurred at the source, and which have not been used on-site.

SSPE2 (lb/year)					
Permit Unit	NO _x	SO _x	PM ₁₀	CO	VOC
N-8844-1-0	0	0	0	0	5,040
SSPE2	0	0	0	0	5,040

5. Major Source Determination

Rule 2201 Major Source Determination:

Pursuant to District Rule 2201, a Major Source is a stationary source with a SSPE2 equal to or exceeding one or more of the following threshold values. For the purposes of determining Major Source status the following shall not be included:

- any ERCs associated with the stationary source
- Emissions from non-road IC engines (i.e. IC engines at a particular site at the facility for less than 12 months)
- Fugitive emissions, except for the specific source categories specified in 40 CFR 51.165

Rule 2201 Major Source Determination (lb/year)					
	NO _x	SO _x	PM ₁₀	CO	VOC
Facility emissions pre-project	0	0	0	0	0
Facility emissions post project	0	0	0	0	5,040
Major Source Threshold	20,000	140,000	140,000	200,000	20,000
Major Source?	No	No	No	No	No

As seen in the table above, the facility is not an existing Major Source and is not becoming a Major Source as a result of this project.

Rule 2410 Major Source Determination:

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(i). Therefore the following PSD Major Source thresholds are applicable.

PSD Major Source Determination (tons/year)							
	NO ₂	VOC	SO ₂	CO	PM	PM ₁₀	CO _{2e}
Estimated Facility PE before Project Increase	0	0	0	0	0	0	0
PSD Major Source Thresholds	250	250	250	250	250	250	100,000
PSD Major Source ? (Y/N)	No	No	No	No	No	No	No

As shown above, the facility is not an existing Major Source for PSD for at least one pollutant. Therefore the facility is not an existing Major Source for PSD.

6. Baseline Emissions (BE)

The BE calculation (in lbs/year) is performed pollutant-by-pollutant for each unit within the project to calculate the QNEC, and if applicable, to determine the amount of offsets required.

Pursuant to District Rule 2201, BE = PE1 for:

- Any unit located at a non-Major Source,
- Any Highly-Utilized Emissions Unit, located at a Major Source,
- Any Fully-Offset Emissions Unit, located at a Major Source, or
- Any Clean Emissions Unit, located at a Major Source.

otherwise,

BE = Historic Actual Emissions (HAE), calculated pursuant to District Rule 2201.

As shown in Section VII.C.5 above, the facility is not a Major Source for any pollutant.

Since this is a new emissions unit, BE = PE1 = 0 for all pollutants.

7. SB 288 Major Modification

SB 288 Major Modification is defined in 40 CFR Part 51.165 as "any physical change in or change in the method of operation of a major stationary source that would result in a significant net emissions increase of any pollutant subject to regulation under the Act."

Since this facility is not a Major Source for any of the pollutants addressed in this project, this project does not constitute an SB 288 major modification.

8. Federal Major Modification

District Rule 2201 states that a Federal Major Modification is the same as a "Major Modification" as defined in 40 CFR 51.165 and part D of Title I of the CAA.

Since this source is not included in the 28 specific source categories specified in 40 CFR 51.165, the increases in fugitive emissions are not included in the Federal Major Modification determination.

Since this facility is not a Major Source for any pollutants, this project does not constitute a Federal Major Modification. Additionally, since the facility is not a Major Source for PM₁₀ (140,000 lb/year), it is not a Major Source for PM_{2.5} (200,000 lb/year).

9. Rule 2410 – Prevention of Significant Deterioration (PSD) Applicability Determination

Rule 2410 applies to pollutants for which the District is in attainment or for unclassified, pollutants. The pollutants addressed in the PSD applicability determination are listed as follows:

- NO₂ (as a primary pollutant)
- SO₂ (as a primary pollutant)
- CO
- PM
- PM₁₀
- Greenhouse gases (GHG): CO₂, N₂O, CH₄, HFCs, PFCs, and SF₆

The first step of this PSD evaluation consists of determining whether the facility is an existing PSD Major Source or not (See Section VII.C.5 of this document).

In the case the facility is new source, the second step of the PSD evaluation is to determine if this new facility will become a new PSD Major Source as a result of the project and if so, to determine which pollutant will result in a PSD significant increase.

I. Potential to Emit for New or Modified Emission Units vs PSD Major Source Thresholds

As a screening tool, the project potential to emit from all new and modified units is compared to the PSD Major Source threshold, and if total project potential to emit from all new and modified units is below this threshold, no further analysis will be needed.

The facility or the equipment evaluated under this project is not listed as one of the categories specified in 40 CFR 52.21 (b)(1)(i). Therefore the following PSD Major Source thresholds are applicable.

PSD Major Source Determination: Potential to Emit (tons/year)							
	NO2	VOC	SO2	CO	PM	PM10	CO2e
Total PE from New and Modified Units	0	2.5	0	0	0	0	0
PSD Major Source threshold	250	250	250	250	250	250	100,000
New PSD Major Source?	No	No	No	No	No	No	No

As shown in the table above, the project potential to emit, by itself, does not exceed any of the PSD Major Source thresholds. Therefore Rule 2410 is not applicable and no further discussion is required.

10. Quarterly Net Emissions Change (QNEC)

The QNEC is calculated solely to establish emissions that are used to complete the District's PAS emissions profile screen. Detailed QNEC calculations are included in Appendix B.

VIII. Compliance

Rule 2201 New and Modified Stationary Source Review Rule

A. Best Available Control Technology (BACT)

1. BACT Applicability

BACT requirements are triggered on a pollutant-by-pollutant basis and on an emissions unit-by-emissions unit basis. Unless specifically exempted by Rule 2201, BACT shall be required for the following actions*:

- a. Any new emissions unit with a potential to emit exceeding two pounds per day,
- b. The relocation from one Stationary Source to another of an existing emissions unit with a potential to emit exceeding two pounds per day,
- c. Modifications to an existing emissions unit with a valid Permit to Operate resulting in an AIPE exceeding two pounds per day, and/or
- d. Any new or modified emissions unit, in a stationary source project, which results in an SB 288 Major Modification or a Federal Major Modification, as defined by the rule.

*Except for CO emissions from a new or modified emissions unit at a Stationary Source with an SSPE2 of less than 200,000 pounds per year of CO.

a. New emissions units – PE > 2 lb/day

As seen in Section VII.C.2 above, the applicant is proposing to install a fumigation chamber with a PE greater than 2 lb/day for VOC; therefore BACT is triggered for VOC.

b. Relocation of emissions units – PE > 2 lb/day

As discussed in Section I above, there are no emissions units being relocated from one stationary source to another; therefore BACT is not triggered.

c. Modification of emissions units – AIPE > 2 lb/day

As discussed in Section I above, there are no modified emissions units associated with this project; therefore BACT is not triggered.

d. SB 288/Federal Major Modification

As discussed in Section VII.C.7 above, this project does not constitute an SB 288 and/or Federal Major Modification for NO_x emissions; therefore BACT is not triggered for major modification purposes.

2. BACT Guideline

BACT Guideline 5.4.12, (Appendix C), applies to operation involving a "Commodity Methyl Bromide Fumigation Chamber".

3. Top-Down BACT Analysis

Per District Policy APR 1305, Section IX, "A top-down BACT analysis shall be performed as a part of the Application Review for each application subject to the BACT requirements pursuant to the District's NSR Rule for source categories or classes covered in the BACT Clearinghouse, relevant information under each of the following steps may be simply cited from the Clearinghouse without further analysis."

Pursuant to the attached Top-Down BACT Analysis, (Appendix C), BACT is satisfied, with:

VOC: Minimize use of fumigant (i.e. use no more than product specifications recommend); and air-tight fumigation chamber

The following permit condition must be included:

- The fumigation chamber must be maintained in a sealed and air-tight condition when in operation and fumigation shall be minimized (i.e. no more than the product specification recommends). [District Rule 2201] N

B. Offsets

1. Offset Applicability

Offset requirements shall be triggered on a pollutant by pollutant basis and shall be required if the SSPE2 equals to or exceeds the offset threshold levels in Table 4-1 of Rule 2201.

The SSPE2 is compared to the offset thresholds in the following table.

Offset Determination (lb/year)					
	NO_x	SO_x	PM₁₀	CO	VOC
SSPE2	0	0	0	0	5,040
Offset Thresholds	20,000	54,750	29,200	200,000	20,000
Offsets triggered?	No	No	No	No	No

2. Quantity of Offsets Required

As seen above, the SSPE2 is not greater than the offset thresholds for all the pollutants; therefore offset calculations are not necessary and offsets will not be required for this project.

C. Public Notification

1. Applicability

Public noticing is required for:

- a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications,
- b. Any new emissions unit with a Potential to Emit greater than 100 pounds during any one day for any one pollutant,
- c. Any project which results in the offset thresholds being surpassed, and/or
- d. Any project with an SSPE of greater than 20,000 lb/year for any pollutant.

a. New Major Sources, Federal Major Modifications, and SB 288 Major Modifications

New Major Sources are new facilities, which are also Major Sources. As shown in Section VII.C.5 above, the SSPE2 is not greater than the Major Source threshold for any pollutant. Therefore, public noticing is not required for this project for new Major Source purposes.

b. PE > 100 lb/day

Applications which include a new emissions unit with a PE greater than 100 pounds during any one day for any pollutant will trigger public noticing requirements.

The PE2 for this new unit is compared to the daily PE Public Notice thresholds in the following table:

PE > 100 lb/day Public Notice Thresholds			
Pollutant	PE2 (lb/day)	Public Notice Threshold	Public Notice Triggered?
NO _x	0	100 lb/day	No
SO _x	0	100 lb/day	No
PM ₁₀	0	100 lb/day	No
CO	0	100 lb/day	No
VOC	112	100 lb/day	Yes

Therefore, public noticing **is** required for PE > 100 lb/day purposes.

c. Offset Threshold

The SSPE1 and SSPE2 are compared to the offset thresholds in the following table.

Offset Thresholds				
Pollutant	SSPE1 (lb/year)	SSPE2 (lb/year)	Offset Threshold	Public Notice Required?
NO _x	0	0	20,000 lb/year	No
SO _x	0	0	54,750 lb/year	No
PM ₁₀	0	0	29,200 lb/year	No
CO	0	0	200,000 lb/year	No
VOC	0	5,040	20,000 lb/year	No

As detailed above, there were no thresholds surpassed with this project; therefore public noticing is not required for offset purposes.

d. SSIPE > 20,000 lb/year

Public notification is required for any permitting action that results in a SSIPE of more than 20,000 lb/year of any affected pollutant. According to District policy, the $SSIPE = SSPE2 - SSPE1$. The SSIPE is compared to the SSIPE Public Notice thresholds in the following table.

SSIPE Public Notice Thresholds					
Pollutant	SSPE2 (lb/year)	SSPE1 (lb/year)	SSIPE (lb/year)	SSIPE Public Notice Threshold	Public Notice Required?
NO _x	0	0	0	20,000 lb/year	No
SO _x	0	0	0	20,000 lb/year	No
PM ₁₀	0	0	0	20,000 lb/year	No
CO	0	0	0	20,000 lb/year	No
VOC	5,040	0	5,040	20,000 lb/year	No

As demonstrated above, the SSIPEs for all pollutants were less than 20,000 lb/year; therefore public noticing for SSIPE purposes is not required.

2. Public Notice Action

As discussed above, public noticing is required for this project for VOC emissions in excess of 100 lb/day. Therefore, public notice documents will be submitted to the California Air Resources Board (CARB) and a public notice will be published in a local newspaper of general circulation prior to the issuance of the ATC for this equipment.

D. Daily Emission Limits (DELs)

DELs and other enforceable conditions are required by Rule 2201 to restrict a unit's maximum daily emissions, to a level at or below the emissions associated with the maximum design capacity. The DEL must be contained in the latest ATC and contained in or enforced by the latest PTO and enforceable, in a practicable manner, on a daily basis. DELs are also required to enforce the applicability of BACT. The following conditions will appear on the permit:

- Only methyl bromide shall be used as a fumigant. [District Rule 2201]
- Daily emissions of VOC shall not exceed 112 lb, equivalent to the use of 112 lb methyl bromide per day. [District Rule 2201]
- Annual emissions of VOC shall not exceed 5,040 lb, equivalent to the use of 5,040 lb methyl bromide per year. [District Rule 2201]

E. Compliance Assurance

1. Source Testing

Pursuant to District Policy APR 1705, source testing is not required to demonstrate compliance with Rule 2201.

2. Monitoring

No monitoring is required to demonstrate compliance with Rule 2201.

3. Recordkeeping

Recordkeeping is required to demonstrate compliance with the offset, public notification and daily emission limit requirements of Rule 2201. The following conditions will appear on the permit:

- Permittee shall maintain daily and annual records of the amount of methyl bromide used (in pounds). [District Rule 2201]
- Records shall be maintained, retained on-site for a period of at least five years and made available for District inspection upon request. [District Rule 4305]

4. Reporting

No reporting is required to demonstrate compliance with Rule 2201.

Rule 2520 Federally Mandated Operating Permits

Since this facility's potential emissions do not exceed any Major Source thresholds of Rule 2201, this facility is not a Major Source, and Rule 2520 does not apply.

Rule 4001 New Source Performance Standards (NSPS)

This rule incorporates NSPS from Part 60, Chapter 1, Title 40, Code of Federal Regulations (CFR); and applies to all new sources of air pollution and modifications of existing sources of air pollution listed in 40 CFR Part 60. However, no subparts of 40 CFR Part 60 apply to commodity fumigation operations.

Rule 4002 National Emission Standards for Hazardous Air Pollutants (NESHAPs)

This rule incorporates NESHAPs from Part 61, Chapter I, Subchapter C, Title 40, CFR and the NESHAPs from Part 63, Chapter I, Subchapter C, Title 40, CFR; and applies to all sources of hazardous air pollution listed in 40 CFR Part 61 or 40 CFR Part 63. However, no subparts of 40 CFR Part 61 or 40 CFR Part 63 apply to commodity fumigation operations.

Rule 4101 Visible Emissions

Per Section 5.0, no person shall discharge into the atmosphere emissions of any air contaminant aggregating more than 3 minutes in any hour which is as dark as or darker than Ringelmann 1 (or 20% opacity). Based on past inspections of similar operations, compliance is expected. The following condition will be added to the permit to assure compliance with this rule.

- {15} No air contaminant shall be discharged into the atmosphere for a period or periods aggregating more than three minutes in any one hour which is as dark as, or darker than, Ringelmann 1 or 20% opacity. [District Rule 4101]

Rule 4102 Nuisance

Rule 4102 prohibits discharge of air contaminants which could cause injury, detriment, nuisance or annoyance to the public. Public nuisance conditions are not expected as a result of these operations, provided the equipment is well maintained. The following condition will be added to the permit to further assure compliance with this rule.

- {98} No air contaminant shall be released into the atmosphere which causes a public nuisance. [District Rule 4102]

California Health & Safety Code 41700 (Health Risk Assessment)

District Policy APR 1905 – *Risk Management Policy for Permitting New and Modified Sources* specifies that for an increase in emissions associated with a proposed new source or modification, the District perform an analysis to determine the possible impact to the nearest resident or worksite.

An HRA is not required for a project with a total facility prioritization score of less than one. According to the Technical Services Memo for this project (**Appendix D**), the total facility prioritization score including this project was greater than one. Therefore, an HRA was required to determine the short-term acute and long-term chronic exposure from this project.

The cancer risk for this project is shown below:

HRA Summary		
Unit	Cancer Risk	T-BACT Required
N-8844-1-0	N/A per million	No

To ensure that human health risks will not exceed District allowable levels; the following permit condition must be included:

- {1898} The exhaust stack shall vent vertically upward. The vertical exhaust flow shall not be impeded by a rain cap (flapper ok), roof overhang, or any other obstruction. [District Rule 4102] N

Discussion of T-BACT

BACT for toxic emission control (T-BACT) is required if the cancer risk exceeds one in one million. As demonstrated above, T-BACT is not required for this project because the HRA indicates that the risk is not above the District's thresholds for triggering T-BACT requirements; therefore, compliance with the District's Risk Management Policy is expected.

California Health & Safety Code 42301.6 (School Notice)

The District has verified that this site is not located within 1,000 feet of a school. Therefore, pursuant to California Health and Safety Code 42301.6, a school notice is not required.

California Environmental Quality Act (CEQA)

CEQA requires each public agency to adopt objectives, criteria, and specific procedures consistent with CEQA Statutes and the CEQA Guidelines for administering its responsibilities under CEQA, including the orderly evaluation of projects and preparation of environmental documents. The District adopted its *Environmental Review Guidelines* (ERG) in 2001. The basic purposes of CEQA are to:

- Inform governmental decision-makers and the public about the potential, significant environmental effects of proposed activities;
- Identify the ways that environmental damage can be avoided or significantly reduced;
- Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible; and
- Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

Greenhouse Gas (GHG) Significance Determination

Methyl Bromide is not a GHG. The District's engineering evaluation (this document) demonstrates that the project would not result in an increase in project specific greenhouse gas emissions. The District therefore concludes that the project would have a less than cumulatively significant impact on global climate change.

District CEQA Findings

The District is a Lead Agency for the project because of its discretionary approval power over the project via its Permits Rule (Rule 2010) and New Source Review Rule (Rule 2201), (CEQA Guidelines §15381). The District's engineering evaluation of the project (this document) demonstrates that compliance with District rules and permit conditions would reduce Stationary Source emissions from the project to levels below the District's significance thresholds for criteria pollutants. The District has determined that no additional findings are required (CEQA Guidelines §15096(h)).

IX. Recommendation

Compliance with all applicable rules and regulations is expected. Pending a successful NSR Public Noticing period, issue ATC N-8844-1-0 subject to the permit conditions on the attached draft ATC in **Appendix A**.

X. Billing Information

Annual Permit Fees			
Permit Number	Fee Schedule	Fee Description	Annual Fee
N-8844-1-0	3020-10	Miscellaneous	\$105.00

Appendixes

- A: Draft ATC
- B: Quarterly Net Emissions Change
- C: BACT Analysis
- D: Risk Management Review Summary

Appendix A
Draft ATC

Appendix B
Quarterly Net Emissions Change (QNEC)

Quarterly Net Emissions Change (QNEC)

The Quarterly Net Emissions Change is used to complete the emission profile screen for the District's PAS database. This is a seasonal source with the majority of the emissions occurring in the first and second quarter, therefore the QNEC shall be calculated as follows:

$QNEC = (PE2 - PE1)/2$, where:

QNEC = Quarterly Net Emissions Change for each emissions unit, lb/qtr.

PE2 = Post Project Potential to Emit for each emissions unit, lb/year.

PE1 = 0 lb/year, since this is a new source

Quarterly NEC [QNEC]		
	PE2 (lb/year)	QNEC (lb/qtr)
NO _x	0	0
SO _x	0	0
PM ₁₀	5,040	2,520
CO	0	0
VOC	0	0

Appendix C

BACT Analysis

Best Available Control Technology (BACT) Guideline 5.4.12
Last Update: 6/25/2008

Commodity Methyl Bromide Fumigation Chamber

Pollutant	Achieved in Practice or in the SIP	Technologically Feasible	Alternate Basic Equipment
VOC	Minimize use of fumigant (i.e. use no more than product specifications recommend); and air-tight fumigation chamber	1. 99% control (chemical scrubbing) 2. 98% control (thermal or catalytic reduction) 3. 95% control (carbon adsorption) 4. 80% control (condensation refrigeration system)	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

This is a Summary Page for this Class of Source.

BACT Analysis for VOC Emissions:

BACT Analysis for VOC Emissions

Step 1 - Identify all control technologies

The SJVUAPCD BACT Clearinghouse guideline 5.4.12, identifies achieved in practice and technologically feasible BACT for Commodity Methyl Bromide Fumigation Chambers as follows

- 1) Chemical scrubbing system – 99% (Technologically Feasible)
- 2) Thermal and catalytic reduction – 98% (Technologically Feasible)
- 3) Carbon adsorption – 95% (Technologically Feasible)
- 4) Condensation using a refrigeration system – 80% (Technologically Feasible)
- 5) Use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend). (Achieved in Practice)

Step 2 - Eliminate technologically infeasible options

Thermal and catalytic reduction

Thermal and catalytic reduction uses heat and a catalyst to chemically breakdown a VOC into a less reactive compound such as water and elemental nitrogen. When methyl bromide is reduced, however, the process results in the generation of hydrogen bromide. Hydrogen bromide is listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA), requiring the use of additional control system(s) to prevent these secondary emissions.

Thus, thermal and catalytic reduction is considered to be technologically infeasible for this operation and is eliminated from further consideration.

All other options identified above are considered to be technologically feasible.

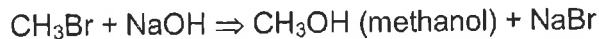
Step 3 - Rank remaining options by control effectiveness

- 1) Chemical scrubbing system – 99% (Technologically Feasible)
- 2) Carbon adsorption – 95% (Technologically Feasible)
- 3) Condensation using a refrigeration system – 80% (Technologically Feasible)
- 4) Use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend). (Achieved in Practice)

Step 4 - Cost Effectiveness Analysis

1) Chemical scrubbing system

Chemical scrubbing of methyl bromide (CH_3Br) involves using a packed tower with sodium hydroxide (NaOH). The reaction that occurs in the packed tower with 10 pH NaOH is given by the following formula:



Stoichiometrically, one mole of NaOH (MW = 40) is required to react with one mole of methyl bromide (MW = 95) or 0.42 lb NaOH per lb of CH₃Br. The NaOH is an aqueous solution, which is mostly water. The concentration of NaOH is found in the following manner:

The pH value is defined as:

$$\begin{aligned}\text{pH} &= -\log[\text{H}^+] = 10 \\ [\text{H}^+] &= 1.0 \text{ E-}10\end{aligned}$$

The concentration of NaOH is equal to the concentration of OH ions in a scrubber solution of water and NaOH:

$$[\text{OH}] = \{K_w \times [\text{H}_2\text{O}]\} \div [\text{H}^+]$$

where $K_w = 1.0\text{E-}14$ and $[\text{H}_2\text{O}] = 1.0$ for a very dilute solution, thus:

$$\begin{aligned}[\text{OH}] &= \{1.0\text{E-}14 \times 1\} \div 1.0 \text{ E-}10 \\ &= 1.0 \text{ E-}4 \text{ moles/liter}\end{aligned}$$

NaOH has a molecular weight of 40 grams/liter so the concentration at a pH value of 10 is:

$$\begin{aligned}\text{NaOH} &= 40 \text{ gram/mol} \times 1\text{E-}4 \text{ mol/l} \times 1 \text{ lb/453.6 gram} \times 3.7854 \text{ l/gal} \\ &= 3.3\text{E-}5 \text{ lb-NaOH/gal}\end{aligned}$$

Based on the stoichiometric formula, the minimum amount of aqueous solution needed for the calculated amount of CH₃Br emissions per year is:

$$\begin{aligned}\text{Aqueous solution} &= 5,040 \text{ lb-CH}_3\text{Br/yr} \times 0.42 \text{ lb-NaOH/lb-CH}_3\text{Br} \\ &= 2,117 \text{ lb-NaOH/yr}\end{aligned}$$

$$\begin{aligned}\text{Gallons of NaOH/yr} &= 2,117 \text{ lb-NaOH/yr} \div 3.3\text{E-}5 \text{ lb-NaOH/gal} \\ &= 64,150,000 \text{ gal-NaOH/yr}\end{aligned}$$

The depleted solution must be disposed of as a hazardous material. A 2010 estimate from Van Waters and Rogers indicated the disposal cost for bulk quantities of this liquid to be \$3.75/gallon plus freight charges. For the amount of solution required:

$$\begin{aligned}\text{Annual disposal cost} &= 64,150,000 \text{ gal-NaOH/yr} \times 3.75/\text{gallon} \\ &= \$241,000,000 \text{ dollars per year.}\end{aligned}$$

Controlled Cost per ton of emissions:

As shown above, the amount of reduction from a chemical scrubbing system is expected to be:

$$\begin{aligned}\text{VOCs controlled} &= 5,040 \text{ lb-VOC/yr} \times 0.99 \times 1 \text{ ton}/2,000 \text{ lb} \\ &= \mathbf{2.5 \text{ ton-VOC/yr}}\end{aligned}$$

$$\begin{aligned}\text{Cost/ton of emissions (\$/ton)} &= \$241,000,000 \text{ \$/yr} \div 2.5 \text{ ton-VOC/yr} \\ &= \$96,400,000\end{aligned}$$

$$\text{Cost/ton of emission} = \$96,400,000/\text{ton-VOC}$$

The VOC cost effectiveness threshold is \$17,500 per ton (per BACT Policy addendum dated 8/14/2008). Since the calculated controlled cost exceeds the cost effective value of \$17,500/ton for VOC, a chemical scrubbing system is deemed not cost effective for this project.

2) Carbon adsorption

An SDUPA study indicated that CH₃Br to carbon adsorption ratio is about 0.3 at 70 °F and 1.0 psia. The study used a three-bed, parallel system, which rotates between beds as the concentration changed. A single bed would become saturated and begin to emit CH₃Br during the later stages of the chamber venting period when the CH₃Br exhaust concentrations drop. The size of a three-bed system to control one ton of CH₃Br is:

$$\begin{aligned}\text{System size} &= 5,040 \text{ lb CH}_3\text{Br/yr} \times (1 \text{ lb C} + 0.3 \text{ lb CH}_3\text{Br}) \\ &= 16,800 \text{ lb-C required/year}\end{aligned}$$

Based on a 2010 phone conversation with a supplier of activated carbon, 4' x 8' mesh activated carbon is \$1.46/lb plus tax and shipping. Using this price, the cost of carbon for this system would be:

$$\begin{aligned}\text{Carbon cost} &= \$1.46/\text{lb-carbon} \times 16,800 \text{ lb carbon/ton of CH}_3\text{Br controlled} \\ &= \$24,528/\text{year}\end{aligned}$$

The cost of a carbon adsorption system sized for a typical 14,000 scfm enclosed automotive spray booth is estimated using the calculations from Chapter 12 of Air Pollution Control - A Design Approach by C. David Cooper and F.C. Alley.

Capital Cost:

The purchase price for a carbon-steel package adsorber, complete with fan, instrumentation and piping can be estimated from the following relationship equation:

$$\text{PEC (\$)} = 50,000 + 0.277M_c^{1.200}$$

Where PEC = Purchase price in 1977 dollars
M_c = mass of carbon in the system

$$\begin{aligned} \text{PEC} &= 50,000 + (0.277)(100,000^{1.200}) \\ &= 50,000 + (0.277)(1,000,000) \\ &= 50,000 + (277,000) \end{aligned}$$

$$\text{PEC} = \$327,000$$

Total Capital Investment:

The total capital investment is equal to 1.25 times the purchase cost. The sales tax and freight charges total 8% of the base equipment cost. Finally, adjusting from 1977 dollars to 2013 dollars, multiply by 2.75% inflation/yr = 2.66.

Therefore,

$$\text{TCI (2013 dollars)} = (\$327,000) \times (1.25) \times (1.08) \times 2.66 = \$1,174,257$$

According to the six-tenths rule, the ratio between the increase in equipment cost (C) and the increase in capacity (V) given by $C_1/C_2 = (V_1/V_2)^{0.6}$. This rule will be used to scale the equipment cost from a typical 14,000 scfm to the proposed 5,300 scfm fumigation chamber:

$$\begin{aligned} \text{TCI}(5,300 \text{ scf}) &= \text{TCI}(14,000 \text{ scf}) \times (5,300/14,000)^{0.6} \\ &= \$1,174,257 \times 0.558 \\ &= \$655,235 \end{aligned}$$

Pursuant to the District's BACT Policy section X, (Revised 11/9/99), the annual cost of installing and maintaining the thermal oxidizer will be calculated as follows. The installed cost will be spread over the expected life of the carbon adsorption system which is estimated at 10 years and using the capital recovery equation (Equation 1). A 10% interest rate is assumed in this equation and the assumption will be made that the equipment has no salvage value at the end of the ten-year cycle.

A = Annualized total capital investment cost

where

P = present value of capital

CRF = capital recovery factor = $i(i+1)^n / (i+1)^n - 1$

i = interest rate = 10%

n = useful lifetime of equipment in years = 10

$$\text{CRF} = 0.1(0.1 + 1)^{10} / (1 + 0.1)^{10} - 1 = 0.1627$$

$$A = P \times \text{CRF}$$

$$\begin{aligned} \text{So: } A &= \$665,235 \times 0.1627 \\ &= \$108,233/\text{yr} \end{aligned}$$

Operating Cost (Annualized Equipment Cost and Carbon Replacement Cost):

Cost of carbon = \$24,528/yr

Annualized cost of equipment = \$108,233/yr

Total annual cost = \$24,528/yr + \$108,233/yr = **\$132,761/yr**

This is the cost of purchasing carbon for the carbon adsorption system and the capital cost of the equipment itself. Additional energy costs for instrumentation and process equipment and labor costs exist but will not be evaluated.

Controlled Cost per ton of emissions:

As shown above, the amount of reduction from a carbon adsorption system is expected to be:

$$\begin{aligned}\text{VOCs controlled} &= 5,040 \text{ lb-VOC/yr} \times 0.95 \times 1 \text{ ton}/2,000 \text{ lb} \\ &= \mathbf{2.4 \text{ ton-VOC/yr}}\end{aligned}$$

$$\begin{aligned}\text{Cost/ton of emissions (\$/ton)} &= \$132,761/\text{yr} \div 2.4 \text{ ton-VOC/yr} \\ &= \mathbf{\$55,317}\end{aligned}$$

Cost/ton of emission = \$55,317/ton-VOC

The VOC cost effectiveness threshold is \$17,500 per ton (per BACT Policy addendum dated 8/14/2008). Since the calculated controlled cost exceeds the cost effective value of \$17,500/ton for VOC, a carbon adsorption system is deemed not cost effective for this project.

3) Condensation using a refrigeration system

This process requires the CH₃Br and exhaust air to be cooled from the typical chamber exhaust temperature of 70° F to the CH₃Br dew point of 35° F and then cooled to a final temperature of 32 °F (491.7°R).

An SDUPA study estimated the cost for electricity to run a compressor at \$44,000/cycle, assuming \$0.10/kwh and 3 x 78,000 ft² (234,000 ft²) of air chilled from 70 °F to 35 °F.

The chamber has a fan rated at 3.0 hp, with a total exhaust rating of 5,300 cfm, which is equivalent to 159,000 ft² in 30 minutes.

Adjusting the cost calculated in the SDUPA study to reflect the smaller chamber:

$$\begin{aligned}\text{Total cost} &= \$44,000/\text{cycle} \times (159,000 \text{ ft}^2 \div 234,000 \text{ ft}^2) \\ \text{Total cost} &= \mathbf{\$29,897/\text{cycle}}\end{aligned}$$

Adjusting the cost calculated in the SDUPA study to reflect \$0.12/kWhr results in an electrical compressor cost as follows:

$$\begin{aligned}\text{Total cost} &= \$29,897/\text{cycle} \times (\$0.12/\text{kwh} \div \$0.10/\text{kwh}) \\ \text{Total cost} &= \mathbf{\$35,876/\text{cycle}}\end{aligned}$$

For worse case scenario there is one cycle run per day with the maximum daily fumigant usage of 112 lb-CH₃Br. Assuming that the compressor is run for the first 30 minutes of the exhaust cycle to recover 80% of the 112 lb CH₃Br exhausted, the control captures 89.6 lb/cycle. The cost per ton of the electricity to run the compressor is therefore:

$$\begin{aligned}\text{Electrical cost} &= \$35,876/\text{cycle} \times 1 \text{ cycle}/89.6 \text{ lb} \times 2,000 \text{ lb/ton} \\ &= \$800,804/\text{ton}\end{aligned}$$

The VOC cost effectiveness threshold is \$17,500 per ton (per BACT Policy addendum dated 8/14/2008). Since the calculated controlled cost exceeds the cost effective value of \$17,500/ton for VOC, a condensation using a refrigeration system is deemed not cost effective for this project.

Step 5 - Select BACT

The only remaining control method is achieved in practice BACT which is the use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend). The facility has proposed to use of air-tight fumigation chambers and minimized use of fumigant (i. e. use no more than product specification recommend); therefore, BACT is satisfied.

Appendix D:
Risk Management Review Summary

Appendix E: Emission Profile

EXHIBIT H

Comparison of alternative postharvest quarantine treatments for sweet cherries

Lisa G. Neven^{a,*}, Stephen R. Drake^b

^a Yakima Agricultural Research Laboratory, USDA-ARS, 5230 Konnowac Pass Road, Wapato, WA 98951, USA

^b Tree Fruit Research Laboratory, USDA-ARS, 1104 N. Western Ave., Wenatchee, WA 98801, USA

Received 20 August 1999; accepted 23 April 2000

Abstract

The effects of controlled atmosphere heat treatments (CATTS) and irradiation on sweet cherry fruit quality were compared to fumigation with methyl bromide. 'Bing' and 'Rainier' sweet cherry varieties were tested from the Yakima and Wenatchee, WA growing areas. Irradiated cherries had overall quality better than methyl bromide-treated cherries. CATTS-treated 'Rainier' cherries, but not 'Bing', had more pitting and bruising after 14 days of storage than fruit from other treatments. Both cultivars treated with methyl bromide had poorer stem quality than controls. CATTS-treated 'Bing' fruits had poorer stem quality after 7 and 14 days of storage than the controls. This research demonstrated that both irradiation and CATTS have potential for alternative quarantine treatments for sweet cherries. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Sweet cherry; Quarantine; Irradiation; Controlled atmosphere/temperature treatment system

1. Introduction

Sweet cherries, *Prunus avium* L., produced in the U.S. must be fumigated with methyl bromide (MeBr), to meet quarantine restrictions imposed by some importing countries (FAO, 1983; Moffitt et al., 1992). Sweet cherries are exported to Japan following a fumigation treatment to kill any potential codling moth (*Cydia pomonella* L.) larvae, an insect Japan has identified as a quarantine pest. The Pacific Northwest produces 87% of the

sweet cherries in the U.S., and exports approximately 30% of its crop to Japan. Due to the identification of MeBr as an ozone depleter (Anon., 1992), the U.S. Environmental Protection Agency (EPA), in accordance with the Clean Air Act of 1990 (Federal Clean Air Act, 1990), required that the production and sale of this fumigant cease after January 1, 2001. In October of 1998, the U.S. Congress amended the Clean Air Act to agree with the Montreal Protocol on both the phase-out dates and on the exemption for MeBr uses for postharvest and phytosanitary purposes. However, since the major use of MeBr is for soil sterilization, there is no guarantee that this chemical will be available for postharvest

* Corresponding author. Tel.: +1-509-4546556; fax: +1-509-4545646.

E-mail address: neven@yarl.ars.usda.gov (L.G. Neven).

uses. Therefore, two viable alternatives to MeBr fumigation, irradiation and combination controlled atmosphere with hot forced air, were developed in our laboratories.

Irradiation is not a new technology, having been used for decades to sterilize medical supplies and pharmaceuticals. Spices that are ingredients in processed foods are irradiated. Irradiation does not cause the food to become radioactive, nor has there been any evidence that irradiation causes the formation of free radicals above those levels produced in conventionally cooked foods (Urbain, 1986). The U.S. Food and Drug Administration (FDA), has limited the maximum absorbed dose of radiation to <1000 Gy for fresh fruits and vegetables. At these doses, immediate mortality of infesting insect pests is not always achieved. The USDA-APHIS has established guidelines for confirming that a commodity has received the proper dose to render the target pest potentially infesting the commodity biologically 'neutralized' (APHIS, 1996). These guidelines include extensive documentation, dosimetry, and issuance of treatment certification. In fact, USDA-APHIS has already approved irradiation as a quarantine treatment for selected fruits from the state of Hawaii destined to the U.S. mainland (APHIS, 1998). This makes the U.S. the first country to approve phytosanitary irradiation of fruits. We would like to emphasize, however, that although this approval is in the Federal Register, it is not currently used on commercially marketed Hawaiian fruit. This initial approval by the U.S., along with the availability of relatively inexpensive box dosimeters, will likely facilitate the acceptance of irradiation as a quarantine treatment world-wide.

Irradiation has been shown to be effective on the two major insect pests that pose quarantine concerns in U.S.-produced sweet cherries: codling moth (*Cydia pomonella* L.) (Burditt and Hungate, 1989; Toba and Burditt, 1992; Toba and Moffitt, 1996) and western cherry fruit fly (*Rhagoletis indifferens* L.) (Burditt and Hungate, 1988). It was found that 233 Gy was required to prevent pupation of fifth instar codling moth (Toba and Moffitt, 1996) and that 97 Gy was a

sufficient dose to control western cherry fruit fly (Burditt and Hungate, 1988).

Hot forced air has been used to disinfest tropical and subtropical fruits (Armstrong, 1994; Hallman and Armstrong, 1994; Mangan et al., 1998). However, the application to temperate fruits is not as commonplace. Typically, most temperate fruits are stored at cold temperatures as quickly after harvest as possible. (High temperatures are believed to compromise fruit quality.) For pome fruits, cold storage is often accompanied by controlled atmosphere (CA) storage (low O₂ and elevated CO₂), to reduce metabolism and preserve quality (Carpenter and Potter, 1994; Hallman, 1994). Effects of controlled atmosphere storage on pests infesting stored fruit are not effective due to the low temperature of the storage regime. Low temperature reduces the insects' metabolism and thus demand for oxygen. In turn, high temperatures kill infesting insect pests more effectively, but usually at the price of fruit injury due to the duration of exposure necessary to kill the pest. When heat is applied in a controlled atmosphere, the duration of the treatment can be greatly reduced, potentially reducing loss of fruit quality (Neven and Mitcham, 1996; Shellie et al., 1997). CA reduces an insects' ability to acclimate to elevated temperatures and results in suffocation because oxygen availability is lower than the increased metabolic demand of the insect. Knowledge of this effect on insect physiology has led to the development of a Controlled Atmosphere/Temperature Treatment System (CATTS) (Neven and Mitcham, 1996). Using CATTS, we have shown that the total duration of a heat treatment can be greatly reduced in time by 25–50% with the addition of controlled atmospheres. This is a great advantage over traditional hot air and hot water dips, because the reduced treatment times help preserve fruit quality.

In the summer of 1997 we performed a comparison study of irradiation and CATTS treatments against MeBr fumigation to determine whether these treatments were viable alternatives. The results of this study are detailed in this paper.

2. Materials and methods

2.1. Fruit treatments

We assessed quality in 'Bing' and 'Rainier' cherries subjected to the following postharvest quarantine treatments: MeBr fumigation (6°C, 1.13 kg m⁻³), CATTS 1 (45°C, 1% O₂, 15% CO₂, 45 min), CATTS 2 (47°C, 1% O₂, 15% CO₂, 25 min), and irradiation (300 Gy). Fruit were stored at 1°C for 0, 7, and 14 days following treatment. Freshly harvested, unprocessed 'Bing' and 'Rainier' sweet cherries (55 kg each) were obtained from six commercial sources on the day of harvest in 1997. Cherries were divided into four treatment groups.

2.2. Methyl bromide fumigation

Cherries were hydrocooled (2–5°C) in water containing 100 ppm chlorine for 5 min then air dried in a chamber set at 2°C under a fan (2 m s⁻¹). Cherries were placed into wire mesh boxes (25.4 cm × 25.4 cm × 25.4 cm) and equilibrated to 6°C overnight. Fumigation with 1.13 kg m⁻³ of MeBr for 2 h was conducted at 6°C. Cherries were aerated for 2 h prior to removal from the chamber. They were packed into fiberboard boxes (24 cm × 18.8 cm × 16 cm) lined with 1-mm polyliners and held at 2–4°C overnight prior to the 2-h shipment by van to the ARS Tree Fruit Research Laboratory (TFRL) in Wenatchee, WA in ice coolers. The cherries were stored at 1°C until analyzed for quality.

2.3. Irradiation treatments

All irradiations were carried out in a GammaBeam 650 facility located in Richland, WA at Pacific Northwest National Laboratory (PNNL).

Cherries were hydrocooled (2–5°C) in water containing 100 ppm chlorine for 5 min then air dried in a chamber set at 2°C under a fan (2 m s⁻¹). They were packed into lined boxes and packed into ice coolers with ice packs prior to shipment by van to the irradiation facility. The fruit were irradiated at a rate of 61.29 Gy min⁻¹

to a dose of 300 Gy. Following treatment, they were held at 2–4°C overnight prior to shipment by van to the Tree Fruit Research Laboratory (TFRL) in Wenatchee, WA in ice coolers. The cherries were held at 1°C until quality analysis.

2.4. CATTS

Cherries were placed directly into a vented bottom fruit lug (38.1 × 53.35 × 15.24 cm, OnoPac, Hilo, HI) with a vented rubber liner placed on the bottom. CATTS chambers were pre-equilibrated at treatment conditions (CATTS 1: 45°C, 1% O₂, 15% CO₂, 2 m s⁻¹ air speed, >90% RH and CATTS 2: 47°C, 1% O₂, 15% CO₂, 2 m s⁻¹ air speed, >90% RH). Cherries were placed into the lug changer, attached to the CATTS chamber, flushed for 2 min with N₂, and placed into the CATTS chamber. At the end of the treatment (45 min for the 45°C treatment and 25 min for the 47°C treatment) cherries were removed from the CATTS chamber and immersed for 5 min in cold (2–5°C) water containing 100 ppm chlorine. Cherries were air dried prior to packing into fiberboard boxes (24 cm × 18.8 cm × 16 cm) lined with 1-mm polyliners. Packed boxes were stored at 1°C until transported by van to TFRC for analysis.

2.5. Quality evaluation

Quality evaluation consisted of objective and subjective color, firmness, soluble solids content (SSC), titratable acidity (TA), and evaluation for defects such as pitting, bruising, and stem browning. Objective color of fruit and stems was determined with The Color Machine (Pacific Science, Silver Spring, MD) using the Hunter L, a, b system and hue colors were calculated (Hunter and Harold, 1987). Subjective color was determined using two laboratory personnel familiar with cherry color grades. Fruit and stems were rated individually for overall appearance on a scale of 1 to 3 (1 = best; 3 = worst) and the mean value reported. Firmness was determined using the Universal TA-XT2 texture analyzer equipped with a 3-mm probe set at 10 mm s⁻¹ and a penetration distance after contact of 7 mm and

the values were expressed in Newtons (N). SSC of the cherries was determined with an Abbe-type refractometer with a sucrose scale calibrated at 20°C. Acids were titrated to pH 8.2 with 0.1 N NaOH and expressed as percentage of malic acid. Defects (pitting and bruising) present on each cherry were graded by two laboratory personnel as present or absent.

2.6. Statistics

SAS ANOVA and ProcGLM (SAS Institute, 1985) were used to separate the means of each treatment and storage period using General Least Squares and Duncan's Multiple Range Test. Also, SAS contrasts were used to determine differences between MeBr- and CATTS-treated fruit.

3. Results and discussion

3.1. 'Bing' quality

Fruit and stem color was influenced by quaran-

time treatments at all storage intervals (Table 1). At 0 day external fruit L^* (ExL) values were similar between all treatments except for fruit from CATTS 2, which had lower L^* values. The lower L^* indicated a darker fruit for the CATTS 2 treatment. There were no significant differences in external fruit hue (ExHue) values (Table 1) at day 0. After 7 days of storage, external fruit L^* values for CATTS 1 and irradiated fruit were higher than the control fruit. The external fruit L^* values for the other treatments were similar. External fruit hue values between treatments at 7 days were distinctly different with fruit from CATTS 1 and 2 and irradiation displaying reduced values when compared to hue values for control and MeBr-treated fruit. After 14 days of storage, external fruit L^* and hue values were similar between the CATTS 2 and irradiation treatments.

'Bing' visual fruit scores (Table 1) were higher for CATTS 1 and 2, indicating lower visual quality, for 0 and 14 days of storage. Only CATTS 1 treatment was higher than the other treatments at 21 days of storage. Irradiation and MeBr treat-

Table 1
External fruit and stem color and visual assessment of 'Bing' cherries*

Treatment	Store	ExL	ExHue	StL	StHue	VisF	VisS
Control	0	36.9 ± 1.7 _{AB}	7.76 ± 1.5 _A	50.4 ± 3.0 _A	121.9 ± 9.4 _A	1.3 ± 0.1 _B	1.1 ± 0.1 _C
CATTS 1	0	35.3 ± 1.5 _{AB} ^a	9.4 ± 1.3 _A	39.9 ± 2.7 _C ^a	129.5 ± 8.4 _A ^{a,b}	1.9 ± 0.1 _A ^b	1.7 ± 0.1 _A ^b
CATTS 2	0	33.20 ± 1.7 _B ^{a,b}	8.5 ± 1.5 _A	41.3 ± 3.0 _{BC}	113.4 ± 9.2 _A	1.6 ± 0.1 _{AB}	1.3 ± 0.1 _{BC}
IR	0	38.4 ± 1.7 _{AB}	10.0 ± 1.5 _A	43.1 ± 3.0 _{ABC}	119.4 ± 9.2 _A	1.4 ± 0.1 _B	1.2 ± 0.1 _C
MB	0	40.6 ± 1.7 _A	10.5 ± 1.5 _A	49.1 ± 3.0 _{AB}	120.7 ± 9.2 _A	1.4 ± 0.1 _D	1.5 ± 0.1 _{AB}
Control	7	25.9 ± 0.7 _B	12.7 ± 0.8 _{AB}	35.5 ± 3.1 _A	100.4 ± 2.1 _A	1.9 ± 0.1 _B	1.4 ± 0.1 _C
CATTS 1	7	29.4 ± 0.8 _A ^a	10.1 ± 0.8 _C	41.6 ± 3.2 _A ^a	94.7 ± 2.2 _A	2.3 ± 0.1 _A ^{a,b}	2.1 ± 0.1 _A ^b
CATTS 2	7	27.8 ± 0.8 _{AB}	11.8 ± 0.8 _{ABC}	34.8 ± 3.2 _A	94.1 ± 2.2 _A	2.3 ± 0.1 _A ^{a,b}	1.9 ± 0.1 _A ^b
IR	7	28.7 ± 0.8 _A	10.4 ± 0.8 _{BC}	36.2 ± 3.2 _A	95.8 ± 2.2 _A	1.7 ± 0.1 _B	1.4 ± 0.1 _{BC}
MB	7	27.9 ± 0.8 _{AB}	13.3 ± 0.8 _A	29.9 ± 3.2 _A	97.9 ± 2.2 _A	1.8 ± 0.1 _B	1.8 ± 0.1 _{AB}
Control	14	28.8 ± 0.8 _C	12.8 ± 1.0 _{AB}	28.9 ± 0.9 _A	90.5 ± 1.8 _B	1.7 ± 0.1 _{AB}	1.7 ± 0.1 _B
CATTS 1	14	27.4 ± 0.9 _C ^{a,b}	14.6 ± 1.1 _A ^b	31.6 ± 1.1 _A	95.1 ± 1.9 _{AB}	1.9 ± 0.1 _A	1.5 ± 0.1 _B
CATTS 2	14	29.6 ± 0.8 _{BC} ^a	10.4 ± 1.0 _B	27.5 ± 0.9 _A	84.2 ± 1.8 _C	2.0 ± 0.1 _A	2.3 ± 0.1 _A
IR	14	31.6 ± 0.7 _{AB}	10.4 ± 0.8 _B	30.1 ± 0.8 _A	91.1 ± 1.5 _B	1.4 ± 0.1 _B	1.4 ± 0.1 _B
MB	14	32.6 ± 0.80 _A	12.1 ± 1.0 _{AB}	30.8 ± 0.9 _A	96.8 ± 1.8 _A	1.5 ± 0.1 _B	1.7 ± 0.1 _B

* External fruit L^* (ExL), external fruit hue (ExHue), stem L (StL), stem hue (StHue), subjective visual fruit score (VisF), and visual stem score (VisS) are given for treatments of control, CATTS 1, CATTS 2, irradiation (IR), and methyl bromide fumigation (MB) over cold storage periods (Store) of 0, 7, and 14 days. Means followed by the same capital subscript are not significantly different from one another (Duncan's Multiple Range Test).

^a Significantly different from MB ($P < 0.05$).

^b Significantly differently from IR ($P < 0.05$).

Table 2
Quality assessment parameters of 'Bing' cherries*

Treatment	Store	Pitting	Bruise	Firm (N)	SS (%)	TA (%)
Control	0	8.9 ± 1.2 _A	5.9 ± 2.3 _{BC}	5.4 ± 0.1 _A	18.4 ± 0.3 _A	0.72 ± 0.02 _C
CATTS 1	0	6.4 ± 1.0 _A ^a	13.3 ± 2.0 _{AB}	4.2 ± 0.1 _C ^{a,b}	17.8 ± 0.2 _A ^a	0.77 ± 0.02 _{BC} ^{a,b}
CATTS 2	0	9.7 ± 1.2 _A	14.2 ± 2.3 _{AB}	4.7 ± 0.1 _B	18.1 ± 0.3 _A ^b	0.81 ± 0.02 _{AB}
IR	0	7.1 ± 1.2 _A	9.2 ± 2.3 _{BC}	4.9 ± 0.1 _B	18.2 ± 0.3 _A	0.85 ± 0.02 _A
MB	0	9.6 ± 1.2 _A	17.7 ± 2.3 _A	5.1 ± 0.1 _{AB}	16.9 ± 0.3 _B	0.86 ± 0.02 _A
Control	7	7.0 ± 1.3 _C	27.0 ± 1.6 _A	5.3 ± 0.1 _A	18.1 ± 0.2 _A	0.83 ± 0.01 _A
CATTS 1	7	17.2 ± 1.3 _A ^{a,b}	30.4 ± 1.7 _A ^{a,b}	4.1 ± 0.1 _C ^{a,b}	17.8 ± 0.2 _A	0.74 ± 0.01 _C ^{a,b}
CATTS 2	7	18.2 ± 1.3 _A ^{a,b}	30.4 ± 1.7 _A ^{a,b}	4.8 ± 0.1 _B	17.7 ± 0.2 _A	0.77 ± 0.01 _{BC} ^a
IR	7	11.7 ± 1.3 _B	26.0 ± 1.7 _A	4.9 ± 0.1 _B	18.1 ± 0.2 _A	0.80 ± 0.01 _{AB}
MB	7	9.1 ± 1.3 _{BC}	18.5 ± 1.7 _A	4.8 ± 0.1 _B	17.6 ± 0.2 _A	0.83 ± 0.01 _A
Control	14	11.6 ± 2.5 _B	25.9 ± 1.9 _A	5.6 ± 0.2 _A	17.8 ± 0.2 _A	0.79 ± 0.02 _A
CATTS1	14	19.9 ± 2.7 _A	30.0 ± 2.1 _A	4.6 ± 0.2 _C ^b	18.1 ± 0.2 _A ^a	0.73 ± 0.02 _B ^a
CATTS2	14	20.7 ± 2.5 _A	28.3 ± 1.9 _A	4.6 ± 0.2 _C ^b	17.8 ± 0.2 _A ^a	0.78 ± 0.01 _A
IR	14	15.9 ± 2.1 _{AB}	28.1 ± 1.6 _A	5.3 ± 0.2 _{AB}	17.8 ± 0.2 _A	0.78 ± 0.01 _{AB}
MB	14	19.8 ± 2.5 _A	27.6 ± 1.9 _A	5.0 ± 0.2 _{BC}	16.7 ± 0.2 _B	0.83 ± 0.02 _A

* Number of fruit pitted (Pitting), number of fruits bruised (Bruise), percent soluble solids (SS), and percent titratable acidity (TA) are given for treatments of control, CATTS 1, CATTS 2, irradiation (IR), and methyl bromide fumigation (MB) over cold storage periods (Store) of 0, 7, and 14 days. Means followed by the same capital subscript are not significantly different from one another (Duncan's Multiple Range Test).

^a Significantly different from MB ($P < 0.05$).

^b Significantly different from IR ($P < 0.05$).

ments had visual scores similar to control fruit for all storage periods.

'Bing' stem L^* (StL) values (Table 1) were distinctly different between quarantine treatments at the 0 days storage period, but no difference was evident at 7 and 14 days of storage for either L^* or hue (StHue) values. At the initial evaluation period, stem L^* values were reduced for the stems from the different treatments compared to the control stems. Visual assessment of the stems (VisS) (Table 1) from the CATTS 1 and 2 treatments were given higher visual assessment scores when compared to control, irradiated, treated stems indicating lower stem quality for all three storage periods. However, visual stem values were not significantly different from MeBr-treated fruit for all three storage periods.

Enhanced pitting of 'Bing' cherries was very evident for CATTS, irradiated, and MeBr-treated fruit after 7 days of storage (Table 2). However, there were no significant differences between

treated fruit in the number of fruit pitted at the 0- and 14-day storage periods. Bruising was a problem for all treated fruit at the 0-day storage period (Table 2), but not for the remaining storage periods.

'Bing' fruit firmness was reduced with all quarantine treatments (Table 2). At 0 days storage, fruit firmness was reduced with all treatments except for MeBr, which was intermediate between the controls and the other treatments. After 7 days of storage, CATTS 1 firmness was less than all other treatments and after 14 days of storage the firmness of both CATTS 1 and 2 was much less than control and irradiated fruit. MeBr-treated fruit firmness was between the controls and the CATTS-treated fruit.

There was no difference in the percent of soluble solids (SSC) (Table 2) among the treatments and the controls for all the storage periods except for the MeBr treatment at 0 and 14 days of cold storage, where the % SSC was significantly lower (Table 2). Titratable acidity (TA) (Table 2), how-

ever, did show some differences. For all storage periods, CATTS 1 had a lower TA than all other treatments and controls, except for 0-day controls. There were no differences in TA between irradiated and CATTS 2-treated cherries. Interestingly though, TA was higher in all treatments compared to controls directly after treatment (0 Day).

3.2. 'Rainier' quality

'Rainier' fruit and stem color (L^* and hue values) were not significantly influenced by any of the quarantine treatments used in this study, regardless of storage (Table 3), except for MeBr-treated fruit external L^* values at 0 days storage. Visual fruit scores (VisF) (Table 3) were the highest for MeBr-treated fruit at 0 days storage, while CATTS 1 and 2 were higher at 7 and 14 days storage. Irradiation treatments were not significantly different from controls on visual fruit scores.

Stem L^* and stem hue values (Table 3) were significantly different for MeBr-treated fruit at 0

and 7 days storage. The stem L^* and stem hue values of irradiation and CATTS treatments compared favorably with those of control fruits. Visual assessment score of 'Rainier' stems (VisS) (Table 3) was increased by all quarantine treatments at the 14-day evaluation, except the irradiation treatment which was not significantly different from the control fruit. MeBr-treated fruit had the highest visual stem scores (lowest quality) for all storage periods. The increased visual assessment score for the stems from the CATTS treatments was present at only the 14-day storage period.

Fruit pitting and bruising (Table 4) increased for the CATTS treatments compared to the control fruit or fruit from the other two treatments. This increase in pitting and bruising for the CATTS-treated fruit was evident for all storage periods, except for pitting at 0 days storage. Due to the color of the 'Rainier' cherries, it is much easier to discern pitting and bruising problems. Bruising in both cultivars may have been due to increased handling of the fruit that were exposed to the CATTS treatments. Pitting may have been

Table 3
External fruit and stem color and visual assessment of 'Rainier' cherries*

Treatment	Store	ExL	ExHue	StL	StHue	VisF	VisS
Control	0	45.7 ± 1.4 _A	26.9 ± 1.0 _A	29.2 ± 0.6 _{AB}	106.5 ± 1.1 _A	1.0 ± 0.0 _D	1.1 ± 0.0 _B
CATTS 1	0	46.0 ± 1.4 _A	25.8 ± 1.0 _A	30.9 ± 0.6 _A ^a	107.3 ± 1.1 _A ^a	1.3 ± 0.0 _B ^a	1.1 ± 0.0 _B ^a
CATTS 2	0	47.2 ± 1.4 _A	26.8 ± 1.0 _A	30.1 ± 0.6 _{AB}	105.1 ± 1.1 _A ^a	1.1 ± 0.0 _C ^{a,b}	1.1 ± 0.0 _B ^a
IR	0	47.2 ± 1.4 _A	24.3 ± 1.0 _A	30.4 ± 0.6 _A	107.2 ± 1.1 _A	1.0 ± 0.0 _D	1.1 ± 0.0 _B
MB	0	31.7 ± 1.5 _B	25.1 ± 1.0 _A	28.4 ± 0.6 _B	101.1 ± 1.2 _B	1.5 ± 0.0 _A	1.6 ± 0.0 _A
Control	7	39.4 ± 1.1 _A	25.7 ± 2.1 _A	30.6 ± 0.5 _A	107.3 ± 1.0 _A	1.5 ± 0.0 _C	1.5 ± 0.0 _B
CATTS 1	7	39.6 ± 1.1 _A	26.5 ± 2.1 _A	30.1 ± 0.5 _A	106.2 ± 1.0 _A ^a	1.8 ± 0.0 _A ^{a,b}	1.5 ± 0.0 _{AB}
CATTS 2	7	39.6 ± 1.1 _A	33.1 ± 2.1 _A	30.3 ± 0.5 _A ^a	106.6 ± 1.0 _A ^a	1.7 ± 0.0 _B ^{a,b}	1.6 ± 0.0 _{AB}
IR	7	40.2 ± 1.1 _A	24.7 ± 2.1 _A	30.7 ± 0.5 _A	105.7 ± 1.0 _A	1.5 ± 0.0 _{BC}	1.5 ± 0.0 _B
MB	7	40.7 ± 1.1 _A	26.2 ± 2.1 _A	28.7 ± 0.5 _A	97.6 ± 1.0 _B	1.5 ± 0.0 _{BC}	1.6 ± 0.0 _A
Control	14	42.2 ± 1.1 _A	26.6 ± 0.8 _A	26.6 ± 0.6 _B	101.9 ± 1.6 _A	1.2 ± 0.1 _D	1.3 ± 0.0 _B
CATTS 1	14	41.8 ± 1.1 _A	27.1 ± 0.8 _A	27.6 ± 0.6 _{AB} ^{a,b}	101.8 ± 1.6 _A ^a	2.2 ± 0.1 _A ^{a,b}	1.6 ± 0.0 _A ^b
CATTS 2	14	43.1 ± 1.1 _A	26.9 ± 0.8 _A	26.6 ± 0.6 _B ^a	100.8 ± 1.6 _A ^a	1.9 ± 0.1 _B ^{a,b}	1.6 ± 0.0 _A ^b
IR	14	43.0 ± 1.1 _A	25.0 ± 0.8 _A	28.4 ± 0.6 _A	101.6 ± 1.6 _A	1.3 ± 0.1 _D	1.4 ± 0.0 _B
MB	14	43.1 ± 1.1 _A	26.1 ± 0.8 _A	23.4 ± 0.6 _C	92.2 ± 1.6 _B	1.5 ± 0.1 _C	1.7 ± 0.0 _A

* External fruit L^* (ExL), external fruit hue (ExHue), stem L^* (StL), stem hue (StHue), subjective visual fruit score (VisF), and visual stem score (VisS) are given for treatments of control, CATTS 1, CATTS 2, irradiation (IR), and methyl bromide fumigation (MB) over cold storage periods (Store) of 0, 7, and 14 days. Means followed by the same capital subscript are not significantly different from one another (Duncan's Multiple Range Test).

^a Significantly different from MB ($P < 0.05$).

^b Significantly different from IR ($P < 0.05$).

Table 4
Quality assessment parameters of 'Rainier' cherries*

Treatment	Store	Pitting	Bruise	Firm (N)	SS (%)	TA (%)
Control	0	3.6 ± 0.6 _A	2.0 ± 0.7 _B	5.0 ± 0.1 _{AB}	18.5 ± 0.1 _A	0.68 ± 0.01 _A
CATTS 1	0	4.2 ± 0.6 _A	6.5 ± 0.7 _A ^{a,b}	4.6 ± 0.1 _{BC} ^a	18.7 ± 0.1 _A	0.65 ± 0.01 _A
CATTS 2	0	3.6 ± 0.6 _A	6.1 ± 0.7 _A ^{a,b}	4.2 ± 0.1 _C ^a	18.6 ± 0.1 _A	0.67 ± 0.01 _A
IR	0	3.0 ± 0.6 _A	2.6 ± 0.7 _B	4.6 ± 0.1 _{BC}	18.9 ± 0.1 _A	0.68 ± 0.01 _A
MB	0	3.8 ± 0.6 _A	2.1 ± 0.7 _B	5.2 ± 0.2 _A	18.8 ± 0.1 _A	0.66 ± 0.01 _A
Control	7	5.2 ± 1.1 _{BC}	1.7 ± 1.4 _B	5.0 ± 0.1 _A	18.5 ± 0.1 _A	0.63 ± 0.01 _{BC}
CATTS 1	7	9.5 ± 1.0 _A ^{a,b}	15.3 ± 1.4 _A ^{a,b}	4.6 ± 0.1 _A	18.6 ± 0.1 _A	0.60 ± 0.01 _C ^a
CATTS 2	7	8.3 ± 1.1 _{AB} ^{a,b}	14.7 ± 1.4 _A ^{a,b}	4.7 ± 0.1 _A	18.5 ± 0.1 _A	0.62 ± 0.01 _{BC} ^{a,b}
IR	7	3.4 ± 1.1 _C	3.0 ± 1.4 _B	4.9 ± 0.1 _A	18.8 ± 0.1 _A	0.65 ± 0.01 _B
MB	7	3.7 ± 1.1 _C	2.1 ± 1.4 _B	4.8 ± 0.1 _A	18.6 ± 0.1 _A	0.72 ± 0.01 _A
Control	14	3.0 ± 1.0 _B	2.7 ± 1.3 _B	5.1 ± 0.1 _A	18.5 ± 0.2 _A	0.59 ± 0.02 _{AB}
CATTS 1	14	19.7 ± 1.0 _A ^{a,b}	25.1 ± 1.3 _A ^{a,b}	4.8 ± 0.1 _A	18.4 ± 0.2 _A	0.56 ± 0.02 _{AB} ^a
CATTS 2	14	19.1 ± 1.0 _A ^{a,b}	25.2 ± 1.3 _A ^{a,b}	4.9 ± 0.1 _A	18.3 ± 0.2 _A	0.58 ± 0.02 _B ^{a,b}
IR	14	3.8 ± 1.0 _B	3.2 ± 1.3 _B	5.0 ± 0.1 _A	18.6 ± 0.2 _A	0.63 ± 0.02 _A
MB	14	3.1 ± 1.0 _B	2.3 ± 1.3 _B	5.1 ± 0.1 _A	18.8 ± 0.2 _A	0.63 ± 0.02 _A

* Number of fruit pitted (Pitting), number of fruits bruised (Bruise) fruit firmness in Newtons (Firm), percent soluble solids (SS), and percent titratable acidity (TA) are given for treatments of control, CATTS 1, CATTS 2, irradiation (IR), and methyl bromide fumigation (MB) over cold storage periods (Store) of 0, 7, and 14 days. Means followed by the same capital subscript are not significantly different from one another (Duncan's Multiple Range Test).

^a Significantly different from MB ($P < 0.05$).

^b Significantly different from IR ($P < 0.05$).

the result of the formation of carbonic acid during CATTS treatment or prolonged exposure of hot cherries to water containing 100 ppm chlorine during hydrocooling.

Some difference in 'Rainier' fruit firmness (Table 4) was present immediately after treatment, but after 7 and 14 days of storage, no differences in firmness were evident between treated and control fruit. There were no differences in soluble solids in the treatments from those of the control fruit for all storage periods. Titratable acidity in the treatments varied only after 7 and 14 days of storage. For both 7 and 14 days of storage, MeBr-treated cherries had a higher TA than all other treatments and controls. There were no differences between CATTS 1 and 2, irradiated, and controls for storage periods of 7 and 14 days.

These results indicate that both irradiation and CATTS treatments are viable alternative quarantine treatments against both codling moth and western cherry fruit fly in sweet cherries. Comparisons of fruit quality against traditional MeBr fumigation shows that irradiation provides better

overall quality than MeBr fumigation. This is in agreement with previous research (Drake et al., 1994; Drake and Neven, 1997). CATTS treatments slightly reduced fruit quality, particularly increasing fruit pitting and bruising. The commercial significance of this reduced quality has not been assessed. Further research is needed to address both extension of shelf life to achieve the standard 21 days and pitting and bruising problems with the CATTS treatments.

Acknowledgements

The authors thank Michael Brown and David Eakin of New Horizons Technologies of Richland, WA for performing the irradiation treatments. We also thank Fred Scarlett of Northwest Fruit Exporters for securing the fruit used in this study. This project would not have been possible without the technical assistance of Traci Wurtz, Amber Bangs, Linda Rehfield, Linda Olsen, Millie Heidt, Julie Schlaman, Mac Morford, Dennis

Albano, Misty Weishaar, Ruth Barnhardt, and Dr Jim Hansen of the USDA-ARS laboratory in Wapato, WA and Kevin Hansen and Shari Snodgrass of the USDA-ARS laboratory in Wenatchee, WA. This research was supported by the Washington Tree Fruit Research Commission.

References

- Anon., 1992. Methyl Bromide: Atmospheric Science, Technology and Economics. United Nations Environmental Programme. Ozone Secretariat, UN Headquarters, Nairobi, Kenya.
- Animal and Plant Health Inspection Service (APHIS), 1996. The application of irradiation to phytosanitary problems. Fed. Reg. 16, 24433–24439.
- Animal and Plant Health Inspection Service (APHIS), 1998. Use of irradiation as a quarantine treatment for fresh fruits of papaya from Hawaii. Fed. Reg. 63(229) 65645–65649.
- Armstrong, J.W., 1994. Heat and cold treatments. In: Paull, R.E., Armstrong, J.W. (Eds.), *Insect Pests and Fresh Horticultural Products: Treatments and Responses*. CAB International, Wallingford, UK, pp. 103–119.
- Burditt, A.K., Hungate, F.P., 1988. Gamma irradiation as a quarantine treatment for cherries infested by western cherry fruit fly (Diptera: Tephritidae). *J. Econ. Entomol.* 81, 859–862.
- Burditt, A.K., Hungate, F.P., 1989. Gamma irradiation as a quarantine treatment for apples infested by codling moth (Lepidoptera: Tortricidae). *J. Econ. Entomol.* 82, 1386–1390.
- Carpenter, A., Potter, M., 1994. Controlled atmospheres. In: Sharp, J.L., Hallman, G.J. (Eds.), *Quarantine Treatments for Pests of Food Plants*. Westview Press, Boulder, CO, pp. 171–198.
- Drake, S.R., Neven, L.G., 1997. Quality response of 'Bing' and 'Rainier' sweet cherries to low dose electron beam irradiation. *J. Food Proc. Pres.* 21, 345–351.
- Drake, S.R., Moffitt, H.R., Eakin, D.E., 1994. Low dose irradiation of 'Rainier' sweet cherries as a quarantine treatment. *J. Food Proc. Pres.* 18, 473–481.
- FAO, 1983. *International Plant Quarantine Treatment Manual*. FAO Plant Production and Protection Paper 50. Food and Agriculture Organization of the United Nations, Rome, Italy.
- Federal Clean Air Act, 1990. Public Law 101-549, enacted November 15, 1990. Washington, DC.
- Hallman, G.J., 1994. Controlled atmospheres. In: Paull, R.E., Armstrong, J.W. (Eds.), *Insect Pests and Fresh Horticultural Products: Treatments and Responses*. CAB International, Wallingford, UK, pp. 121–138.
- Hallman, G.J., Armstrong, J.W., 1994. Heated air treatments. In: Sharp, J.L., Hallman, G.J. (Eds.), *Quarantine Treatments for Pests of Food Plants*. Westview Press, Boulder, CO, pp. 149–163.
- Hunter, R.S., Harold, R.W., 1987. *The Measurement of Appearance*, 2nd edn. Wiley, New York, pp. 1–411.
- Mangan, R.L., Shellie, K.C., Ingle, S.J., Firko, M.J., 1998. High temperature forced-air treatments with fixed time and temperature for 'Dancy' tangerines, 'Valencia' oranges, and 'Rio Star' grapefruit. *J. Econ. Entomol.* 91, 933–939.
- Moffitt, H.R., Drake, S.R., Toba, H.H., Hartsell, P.L., 1992. Comparative efficacy of methyl bromide against codling moth (Lepidoptera: Tortricidae) larvae in 'Bing' and 'Rainier' cherries and confirmation of efficacy of a quarantine treatment for 'Rainier' cherries. *J. Econ. Entomol.* 85, 1855–1858.
- Neven, L.G., Mitcham, E.J., 1996. CATTs: Controlled atmosphere temperature treatment system. A novel tool for the development of quarantine treatments. *Am. Entomol.* 42, 56–59.
- SAS Institute, 1985. *SAS Users Guide: Statistics*. SAS Institute, Cary, NC.
- Shellie, K.C., Mangan, R.L., Ingle, S.J., 1997. Tolerance of grapefruit and Mexican fruit fly larvae to heated controlled atmosphere. *Postharv. Biol. Technol.* 10, 179–186.
- Toba, H.H., Burditt, A.K., 1992. Gamma irradiation of codling moth (Lepidoptera: Tortricidae) eggs as a quarantine treatment. *J. Econ. Entomol.* 85, 464–467.
- Toba, H.H., Moffitt, H.R., 1996. Posttreatment development and fertility of nondiapausing codling moth (Lepidoptera: Tortricidae) larvae and their progeny following gamma irradiation. *J. Econ. Entomol.* 89, 56–62.
- Urbain, W.M., 1986. Radiation chemistry of food components and of foods. In: Schweigert, B.S. (Ed.), *Food Irradiation*. Academic Press, Orlando, FL, pp. 37–82.

EXHIBIT I

p. 41-50, in: Chemical use in food processing and postharvest handling: issues and alternatives, Agricultural Issues Center, University of California, Davis.

METHYL BROMIDE ON DRIED FRUITS AND NUTS: ISSUES AND ALTERNATIVES

Authors

Patricia J. Lindsey.
Susie S. Briggs
Adel A. Kader
Kirby Moulton

Study Group Members

Adel Kader (Group Leader)
Susie S. Briggs
D. Ken Giles
Patricia J. Lindsey
Sheldon Margen
Kirby Moulton

Study group members contributed data and reviewed early drafts

Acknowledgements

We greatly appreciate the efforts of the following individuals who reviewed drafts of this manuscript or otherwise provided valuable assistance:

Sam Cunningham, Director, Blue Diamond Almond Research Center; Paul D. LaVine, Research Director, Almond Board of California; Gary Obenauf, California Raisin Advisory Board; Edward D. Steffen, Director, Dried Fruit Association of California; Dorothy Thurber, Home Economist, Sacramento County UC Cooperative Extension; Pat Vail, Laboratory Director, U.S. Department of Agriculture, Agricultural Research Service.

Except where noted, the views expressed and conclusions are those of the authors, who are also responsible for any errors or omissions.

METHYL BROMIDE ON DRIED FRUITS AND NUTS: ISSUES AND ALTERNATIVES

Introduction

Storage is a critical component in the marketing of dried fruit and nuts since it allows coordination of the peaks of agricultural production with the requirements of consumer demand. However, if products deteriorate during storage, economic losses can arise. Insect infestation is one of the main factors adversely affecting the quality of dried fruits and nuts during storage.

Currently, the industry controls stored product insects on dried fruits and nuts through periodic fumigation with methyl bromide (bromomethane) or phosphine (hydrogen phosphide). The need for insect control during storage is not in question, but there is a reason to explore alternatives to these chemical treatments. In the case of methyl bromide, consumer safety is an issue; for phosphine, resistance by targeted insect species is an emerging problem.

This study looks at current treatment practices, possible alternatives to these practices, and the economic impact of changes in costs or conditions within the dried fruit and nut industries.

Current Industry Practices

There are several different species of insects which feed on the products in storage, and the infestation can occur at any step of the harvest-processing-storage chain. Some of the major pests are navel orangeworm (*Ameylois transitella*), Indianmeal moth (*Plodia interpunctella*), driedfruit beetle (including *Carpophilus hemipterus*), sawtooth grain beetle (*Oryzaephilus surinamensis* (L.)), merchant grain beetle (*O. mercator*), raisin moth (*Cadra figulilella*), and fruit fly (*Drosophila melanogaster*). In addition, codling moth (*Cydia pomonella*), which originates in the orchards, must be controlled to meet quarantine requirements of some importing countries. Some of these pests, like the navel orangeworm, infest the crop in the field and are carried into storage; others, like the Indianmeal moth, may infest the product at any time and thrive in storage conditions. The pests cause direct damage by feeding on the fruits or nuts, and they make the food unsaleable for sanitary and aesthetic reasons. Large scale control measures are necessary

to protect product quality and to satisfy the Food and Drug Administration's (FDA) sanitary regulations for processing plants. The measures used must not be harmful to the commodity, workers, or consumers (Mitchell and Kader, 1985).

Current practice is to fumigate after harvest with either methyl bromide or phosphine at least once, and possibly at regular intervals during storage, depending on the nature of the insect problem. In some cases the product may be kept under fumigation until it is processed. Three functions of such fumigation are: to control insect populations, to prevent feeding damage, and to meet sanitary requirements through reduction or elimination of live insects (Rhodes, 1986). These fumigants are widely used because they: (1) quickly kill all targeted insects when applied correctly; (2) are easy to use; (3) are efficient, treating up to 4-5,000 tons at once; and (4) are inexpensive and don't necessitate large capital expenditures.

Under proper conditions, methyl bromide fumigation usually induces mortality within 24 hours. Phosphine's effectiveness is more temperature dependent, and the average time to mortality is about 48-72 hours (Mitchell and Kader, 1985), although when temperatures drop to 15°C (about 60°F) or below, the required fumigation time with phosphine may be as long as 96 hours.

Both fumigation treatments are applied under sealed storage conditions. The dried fruits or nuts may be in bins which are stacked and sealed with paper to make them airtight, or held in sealed concrete storage rooms and silos. Tablets or pellets containing aluminum phosphide and ammonium carbamate are put into the fumigation stack or chamber (at a rate of about 30 tablets/1000 cubic feet of storage space for raisins) where exposure to the atmosphere causes decomposition of the tablets to form phosphine, ammonia, carbon dioxide and aluminum hydroxide. Methyl bromide gas is blown into the fumigation chamber at a concentration of 1.5 pounds per 1000 cubic feet of storage space for raisins. With either fumigant, the storage chamber is aerated after the desired exposure period to remove the remaining fumigant (Gardner et al., 1982).

Methyl Bromide on Dried Fruits and Nuts:

According to a raisin industry survey (Soderstrom et al., 1984), methyl bromide is typically used in concrete storage chambers and phosphine in laminated paper covered stacks of storage bins.

Dried prunes are sometimes treated with nightly fogging with pyrethrin and piperonyl butoxide in lieu of periodic refumigation. This controls flying insects which infiltrate the storage chamber before they can reproduce, without penetrating commodity packs, but doesn't control immature stages already infesting the commodity. The chemicals break down quickly and don't leave residues on the product (Rhodes, 1986).

Methyl bromide, phosphine, and piperonyl butoxide are toxic to humans, and workers need to follow safety precautions during and after fumigation. In fact, methyl bromide is a "restricted use" pesticide which can only be used under limited conditions and by certified applicators (Gardner et al., 1982). In addition to its use as a stored product fumigant, methyl bromide is also extensively used as a soil fumigant.

Problems Associated with Current Practices

Methyl bromide use as an insecticide is currently under scrutiny, based upon recent reports that it may be carcinogenic in laboratory animals (Mitchell and Kader, 1985). Other laboratory studies have demonstrated mutagenicity (Rounds, 1980) and mitotic recombinations (Mortelmans and Shepherd, 1980) from methyl bromide. Unlike phosphine, which does not leave "appreciable" residues, methyl bromide fumigation produces residues of inorganic bromine which build up and remain on the product (Gardner et al., 1982). The current FDA tolerance limits for residues of inorganic bromine on dried fruits and nuts are 200 and 125 ppm (parts per million), respectively. These standards are currently under review and may be lowered. The industry routinely meets tougher standards for the portion of production which is exported. The residue tolerance limits for some countries importing California dried fruits and nuts are more stringent: 100 ppm in most European countries and 50 ppm in West Germany and Japan. Those using methyl bromide frequently employ techniques such as vacuum extraction or other accelerated airflow methods to speed aeration of the storage chambers and lower residues. Elevated temperatures during fumigation also result in lower residues by allowing the use of less methyl bromide to achieve the same degree of effectiveness.

Packing and storage facility workers are particularly at risk from excessive or repeated exposure to methyl bromide, although when using

correct precautions it is theoretically safe to apply. Methyl bromide is odorless at low concentrations and non-irritating, so if safety precautions fail, workers may unknowingly be exposed. Acute effects range from headaches, dizziness and nausea, to lung edema (swelling) which may result in death. Repeated exposure above safe limits can cause "blurred vision, staggering gait, mental imbalance, and psychosis" (Rowe, 1957, p. 1). These symptoms may or may not disappear over time, depending on the degree of overexposure. Direct exposure to the skin can also cause burns.

Phosphine, the most widely used chemical alternative to methyl bromide is not considered to pose any health risks for consumers since it doesn't leave residues on the fruit. It is toxic to workers if exposed during fumigation, so safety precautions are required, and there is evidence to suggest that one insect species has developed resistance to it (Price, 1980). This resistance problem and the possibility that methyl bromide use could be further restricted or prohibited has stimulated the dried fruit and nut industry to search for nonchemical alternatives as a means for protecting product storability and quality (Mitchell and Kader, 1985; Rhodes, 1986).

Importance of Dried Fruits and Nuts to California Agriculture

Nuts and dried fruits together comprise an important segment of California's agricultural economy and contribute to the state's trade balance. Here we present an economic profile of the industry in California.

California is the major producing state for several types of nuts and dried fruit products including almonds, walnuts, pistachios, raisins, prunes, dried apricots, figs, dates, peaches and pears. Dried fruits and nuts together accounted for over \$1 billion farm level sales, on 864 thousand acres, representing 7 percent of California farm marketings in 1986. Comparisons of farm level with export values suggests that initial processing and storage adds approximately another 80 percent to the per pound value at the time of shipment (California Crop and Livestock Reporting Service, CCLRS, 1987, and USDA, FATUS, 1987).

In 1986, there were 634.4 thousand bearing acres of tree nuts in the state, with an output valued at \$767.6 million (farm level). Almonds represent two-thirds of the tree nut acreage and just over two-thirds of the value (68.9 percent), followed by walnuts with 28.6 percent of the acreage and pistachios with 5 percent.

Dried fruits are also an important California agricultural product class, with roughly 229 thousand acres¹ yielding a value of about \$300 million (farm level) in 1986. By far the largest dried fruit category is raisins which accounts for 57 percent of dried fruit acreage and 61 percent of the farm value, followed by prunes, with 31 percent of the acreage. Other dried fruit products include apricots, figs, dates, peaches, and pears. Most fruits which are dried have other possible market outlets (fresh, canning, crush for wine and juice), so the amount of acreage devoted to the dried use fluctuates annually.

One hundred percent of all U.S. exports of each of these dried fruit and nut products is from California, and in total they represented 25.2 percent of the value of California agricultural exports in 1986. Total dried fruit and nut export sales of \$716.7 million in 1986 were led by almonds (\$420.3 million), followed by raisins (\$109.3 million), walnuts (\$94.9 million) and prunes (\$72.9 million). The majority of California almonds (71.5 percent in 1986) and prunes (60.4 percent) are exported. The export market is a less important, though still major, outlet for California walnuts (32.2 percent exported in 1986), pistachios (23.1 percent), raisins (14.8 percent) and other dried fruits. The leading export destinations vary among products, but overall, countries within the European Economic Community, Japan, Scandinavia, and Canada figure prominently.

California dried fruits and nuts also face some import competition in the U.S. market. The U.S. was a net importer of pistachios, dried apricots and dried figs in 1986, with smaller proportions of dates and raisins also imported.

After a lull during the 1970s, U.S. per capita consumption of dried fruits recovered to 1960s levels during the first half of the 1980s. In particular, raisin consumption increased to 2.1 pounds per capita by 1984; meanwhile consumption of dried figs and prunes declined. U.S. per capita consumption of tree nuts also expanded during the 1980s to 2.3 lbs. in 1985. More than half (54.4 percent) of the expansion between 1965-70 and 1980-85 was due to increased consumption of almonds, with another 32.8 percent attributable to higher walnut consumption (Bunch, 1987).

Farmers responded to increased demand by expanding almond acreage by 38 percent over the 1978-1986 period. Pistachio acreage has risen tenfold (1978-1986) as domestic nuts replaced

imports for consumption. Despite consumption increases, walnut acreage has not expanded. It is difficult to determine acreage response to changes in dried fruit demand because of multiple outlets for these products. For example, some of the increase in raisin grape acreage in the early 1980s is due to increased demand for fresh market Thompson seedless.

Organization and Structure of the Industry

All of these fruits and nuts are perennial crops which must be planted some years before they begin producing on a commercial scale. Once they begin bearing fruit, their total output is spread over decades, so orchards and vineyards represent a major capital investment for the farmer. Switching to an alternate crop is very expensive, and such decisions are presumably based on expectations of long run conditions. This aspect makes producers of tree and vine crops vulnerable to short run fluctuations in market conditions. Growers of tree nuts have few market options. They can sell domestically or on the export market. Within these markets, nuts can be sold for processing or for final consumption. Dried fruit producers have some latitude to switch to the fresh or processed (canned, frozen or crush) markets. On the other hand, fruit driers and nut processing firms have no immediate alternatives.

While some product is sold immediately, the majority of each season's dried fruit and nut output is stored for part of the year. This provides a steady flow onto the market, minimizing the seasonality problems faced in the fresh produce markets and allowing for processing throughout the year. Output can also be carried over to the next marketing year, so stocks can be drawn down in years with poor harvests. This is particularly important for almonds and pistachios, whose output tends to fluctuate due to high and low yields in alternate years.

The structure of the dried fruit and nut industry in California has the hourglass shape typical in agriculture: There are thousands of farmers whose product funnels into a few processing/storage facilities, from which it is eventually distributed to many thousands of intermediate and final market destinations. Much of the capacity at the processor/storage level is accounted for by grower cooperatives such as the Blue Diamond Growers (formerly the California Almond Growers Exchange) and Sun-Diamond Growers of California (raisins, prunes, walnuts, figs and specialty fruits).

¹Using CCLRS *Fruit and Nut Acreage* and *Fruit and Nut Statistics*, the proportion of the respective crops that was dried in 1986 was multiplied by the acreage in that crop and the results were totaled.

Methyl Bromide on Dried Fruits and Nuts:

Despite concentration at the processor level, which in nonagricultural industries would suggest a high degree of market control, demand and supply uncertainties have led to the establishment of formal organizations of industry members under the auspices of federal or state marketing orders for each of the major products. Within this framework, research, advertising, quality control and sometimes supply control can be pursued. This includes cost sharing for research into and development of solutions to industrywide problems such as the one under investigation here—reliance on chemical fumigants.

Alternatives to Chemical Fumigation

There may well be chemical (pesticide) alternatives to methyl bromide or phosphine fumigation for control of insect infestations during the processing and storage of dried fruits and nuts. However, the difficulty and costs of gaining regulatory approval for new pesticides, the increasing scrutiny of chemical additives for their effects on health and the environment, and the risk of increased insect resistance to chemicals argue for nonchemical means of controlling stored product pests. These considerations have directed much of the recent research effort towards nonchemical alternatives to methyl bromide and/or phosphine. The two currently plausible alternative treatments are controlled atmospheres and irradiation.

Use of Controlled Atmospheres for Insect Disinfestation

Controlled atmosphere disinfestation of stored products is simple in concept: It works by asphyxiating stored product pests. It is appealing on environmental and public health grounds since it does not add any foreign substances to a food product, relying instead on altering concentrations of oxygen, carbon dioxide, and nitrogen, which are already significant components of the earth's atmosphere (Bailey and Banks, 1980). The controlled atmospheres used for insect disinfestation usually involve reducing the oxygen concentration to less than 1 percent and/or increasing the carbon dioxide to well above 10 percent.

Biological and other factors which are crucial to the success of low-oxygen atmospheres for insect control include the following:

- The atmosphere must be easily obtained in sufficient volume to displace the existing atmosphere in bulk storage;
- It must be lethal to storage pests within a reasonable amount of time;

- It must not harm the quality (including taste and odor) or storage life of the treated product; and

- The storage structure must have an adequate gas holding capacity and must be sealable (Storey, 1979; Soderstrom and Brandl, 1985).

Temperature and humidity are also important determinants of the effectiveness of low-oxygen atmosphere (and other) insect control treatments. Other considerations include the equipment required and cost.

Several successful approaches have been identified including:

- Introduction of carbon dioxide into storage chambers;
- Purging the storage chamber with nitrogen from vaporized liquid nitrogen or separated from compressed air using molecular sieve or membrane systems; and
- Generation of low oxygen atmospheres by burning oxygen (Gardner et al., 1982).

To qualify for commercial adoption, a method must be shown to be effective against targeted insect populations, be safe to apply, leave no harmful or distasteful residues, have no adverse effect on storage life, and be cost effective. The choice of a particular controlled atmospheric mixture is dependent on many variables including: type of storage facility; commodity to be treated; volume, weight, moisture content and temperature of the product; the pest species to be controlled including the life stages (i.e. egg, larva, pupa, adult) and/or age distribution; the availability of gases or generators; and the time interval required and available to achieve insect control (Davis and Jay, 1977).

Because the processing and storage facilities for nuts and grains in California are not located near sources of inexpensive liquid nitrogen or carbon dioxide, most of the research on controlled atmospheric disinfestation of nuts and dried fruits has focused on the effectiveness and feasibility of on-site low oxygen atmospheric generators.

How on-site low oxygen atmospheric generators work

Portable atmospheric generators burn natural gas or propane in air at specific ratios to produce atmospheres with desired gas composition. Undesirable nitrogen oxide is avoided through water cooling. The low oxygen atmosphere passes

through a heat exchanger and is further cooled through refrigeration, which extracts moisture to achieve the desired relative humidity. Finally it is filtered through activated charcoal to eliminate oil, unburned hydrocarbons and odors before piping into the storage chamber (Soderstrom et al., 1984).

The amount of time required to achieve the desired atmospheric mixture is dependent on the capacity of the chamber or stack and the purge rate, but can generally be accomplished in one to two days. Once the atmosphere is achieved, it must be maintained through continued generation for a specified number of hours, depending on a host of conditions. Since maintenance requires less generated atmosphere than the initial purging, the process can be set up sequentially, with a new stack or chamber beginning the purging process when the previous stack/chamber reaches the maintenance stage. At the end of the maintenance control period, the storage area is either "purged" or is gradually allowed to return to a normal atmospheric mix. Soderstrom et al. (1984, p. 459) found that "within a month's time, 25 stacks [of raisin bins] could be sequentially purged and maintained with a single 283 m³/h generator."

To make efficient use of the heat generated through this energy-intensive process, it is possible to employ co-generation techniques whereby heat or hot water is captured for use elsewhere in the plant using a heat (or steam) recovery system. The Pacific Gas and Electric company estimates steam generation recovery efficiency at more than 80 percent (Soderstrom et al., 1984).

Their Cost

Estimated costs at 1984 prices for six months worth of insect control for raisins varied from 0.44¢/pound with 90 percent heat recovery to 0.48¢/pound without heat recovery. A doubling of natural gas prices made little difference to the per pound cost in the 90 percent heat recovery case, but raised the cost in the no recovery case to 0.54¢/pound (Soderstrom et al., 1984:460-1). The 1980 cost comparisons for three controlled atmosphere systems for raisins and two chemical treatments are (Gardner et al., 1982):

0.38¢/lb.	Methyl bromide
0.49¢/lb.	Phosphine
0.44-0.48¢/lb.	Low oxygen atmospheric generators
0.81¢/lb.	Trucked liquid nitrogen, controlled atmosphere
0.74¢/lb.	On site liquid nitrogen, controlled atmosphere

Recently new technologies for on-site nitrogen production from compressed air using molecular sieve or membrane systems have been developed. These systems are competitive with other controlled atmosphere systems in terms of capital costs, but their operation and maintenance costs are lower.

Effectiveness

Storey (1980) reports that the atmosphere generated by the on-site combustion method is lethal to the insects which commonly infest stored products at all life stages, although the time-temperature-atmospheric composition combinations vary among different insects and at various stages in their life cycles. Soderstrom and Brandl (1985) discovered differences in response to relative humidity and low oxygen levels between a pest which infests commodities in the field (humidity sensitive) and a storage infesting pest (low oxygen sensitive). Soderstrom and Brandl (1984) report times ranging from 48 to 120 hours for 100 percent mortality of different insects at 27° C (80.6° F), and from three days to more than 14 days at 16°C (60.8° F). At 27°, nearly all species tested were killed (100 percent mortality) after 60 hours, whereas at 16°C all but one were killed after five days. The exception is *D. melanogaster*, a type of fruit fly which exhibits significantly longer kill times at both temperatures studied. In general, Storey (1980) showed that even with sublethal exposures to a controlled atmosphere environment, surviving insects often suffer abnormalities in form or structure and other physiological damage which interfere with normal development.

Safety and Product Quality

Controlled atmosphere treatments have several safety advantages over chemical treatments: They leave no potentially toxic residues on the product; they are nonpolluting; and when used correctly they are theoretically safer to apply since they don't involve handling of toxic substances (Gardner et al., 1982). They also have been shown to be effective in maintaining product quality as long as the controlled atmosphere conditions are continued during storage. A study of raisins stored in a low oxygen controlled atmosphere for one year found them to be "equal or superior in flavor quality and acceptability to similar samples stored in normal atmosphere for the same length of time" (Guadagni, Storey and Soderstrom, 1978). Bulk almonds and other dried products may deteriorate more slowly under controlled atmosphere conditions (low oxygen and/or high carbon dioxide) than under conventional conditions (Mitchell and Kader, 1985).

Disadvantages

Under some conditions the longer exposure time required for controlled atmosphere treatments than for chemical fumigation can be disadvantageous (Brandl, Soderstrom, and Schreiber, 1983). For commodities such as early season walnuts and almonds which are intended for shipment without storage, controlled atmosphere treatment increases the time they must be held at the processing facility. In general, longer duration of treatment for insect disinfestation implies a need for increased capacity of suitable treatment and/or storage chambers.

There is also a potential risk of increased tolerance over time to low oxygen and/or high carbon dioxide atmospheres by stored product pests, although the risk is considered to be less significant than for chemical treatments (Bailey and Banks, 1980).

Irradiation Disinfestation of Nuts and Dried Fruits

Irradiation of nuts and dried fruits has been investigated in a comprehensive study sponsored by the U.S. Department of Energy, California dried fruit and nut marketing orders and the USDA Agricultural Research Service (Rhodes, 1986). The FDA approved irradiation levels up to 1 kilogray (100 kilorads) on food in 1986. Some key factors in the potential for commercial use of irradiation to disinfest dried fruits and nuts are:

- (1) Exposure to radiation at allowable levels must be effective against the problem pest species.
- (2) The exposure level needed to kill the insect pests must not harm the fruit or nut product's quality (appearance, flavor, nutritive value) or storage life.
- (3) The procedure must be safe to workers, consumers and the environment.
- (4) Irradiation disinfestation must be cost effective, including any adverse demand effects from consumer concern about the process.

Each of these aspects is considered in turn following a brief description of how the method works.²

How it works

When living organisms such as insects are exposed to ionizing radiation (from gamma rays or electrons), chemical changes are induced at the molecular level. Sufficient exposure impairs metabolic reactions. Insects are less sensitive to radiation

exposure than humans, but more sensitive than fungi, molds, bacteria or viruses.

The key to successful disinfestation is to subject the commodity to a dose sufficiently high to kill insects without causing unwanted changes in its texture, color or flavor (organoleptic changes). For food products, conveyor belts typically move the items to be treated through the irradiator. Depending on the energy levels of the radiation source, the product density and the desired dose, the configuration (including conveyor speed) can be designed to control total absorbed radiation.

Effectiveness

Tests using a cesium-137 irradiator to treat almonds, raisins and walnuts infested with one or more of three common pests (Indianmeal moth, navel orangeworm and dried fruit beetle) at relevant life stages were conducted to determine the doses needed to effect insect control. The researchers found the most "practical" dose for a "sufficient" level of insect control to be 0.30 kilogray (kGy) [30 kilorad (KR)], indicating an applied dose between 0.45 and 0.60 kGy (45 to 60 KR). For some insects (in some developmental stages) this dose caused sterility rather than death; complete mortality of irradiated navel orangeworm and Indianmeal moth larvae can take as long as two months. Nonetheless, it was stated that the insect control of these pests would be "comparable" to conventional methyl bromide fumigation.

Separate tests on codling moth disinfestation of walnuts using a cobalt-60 irradiator suggest that 0.188 kGy (18.8 KR) is sufficient to completely halt infestations (99.9968 percent mortality), with somewhat lower doses preventing emergence of normal adult moths.

Product quality

Unlike fresh produce items which are easily damaged by irradiation treatments, direct product damage (physiological changes) from irradiation of dried fruits and tree nuts (with a moisture content of less than 10 percent) is unlikely to occur. However, "free radical oxidation reactions" due to irradiation may speed rancidity, especially in tree nuts with high levels of unsaturated fatty acids.

Three nut products (almonds, walnuts and pistachios) and two dried fruit products (raisins and prunes) were tested for immediate and delayed eating quality effects following irradiation with 0.15 to 0.90 kGy (15 to 90 KR) from cesium-137. In each

²Unless stated otherwise, all information in this section is from Rhodes (1986).

case, taste tests included untreated control samples. One conclusion was that there were no "immediate significant differences" in quality following irradiation in any of the products. After storage, different effects were observed for the various items: The quality of walnuts did suffer, particularly at the higher dosages, while almond quality scores were unaffected; quality deterioration was observed in some raisin samples for some radiation levels (0.15 kGy and 0.69 kGy = 15 and 69 KR) but not for others (0.30 and 0.90 kGy = 30 and 90 KR); all pistachio samples remained acceptable, although flavor scores dropped for some samples receiving high (0.60 kGy = 60 KR) doses; the flavor of irradiated prunes was unaffected.

The overall recommendation based on these findings is that dried fruits and nuts be irradiated at < 0.60 kGy (60 KR) for insect disinfestation, with 0.30 to 0.45 kGy (30 to 45 KR) the preferred level.

Safety

At the levels suggested for stored product pest disinfestation of dried fruits and tree nuts, it has been established to the satisfaction of the FDA that irradiated foods are safe for the consumer (Mitchell and Kader, 1985). Using approved methods, it is impossible to make the foods radioactive (Rhodes, 1986).

There are a number of different configurations for food irradiators, and all are designed to shield workers from exposure to radiation. The use of conveyor belts means that humans do not enter the irradiator while it is in operation, so worker safety should not be a problem.

Irradiators utilizing radioisotopes (cesium-137 or cobalt-60) do involve movement of radioactive materials, and these materials maintain their radioactivity even when the machines are not in use. Machine generated electron beam or x-ray machines, however, do not involve transportation of radioactive materials, so when properly constructed, should not be considered an environmental hazard, and may not require as much shielding as radioisotope irradiators.

Food irradiators are fundamentally different from nuclear power plants or nuclear weapons and do not pose significant environmental or public safety risks during operation if they are constructed and operated properly. Flaws in design, construction, or operation introduce a risk of exposure to workers, in addition to any transportation/handling problems for the radioactive materials used in some of the irradiators.

Cost effectiveness

Because of several factors including volume of product to be treated and seasonality (which implies unused capacity much of the year), the unit cost of irradiation disinfestation of dried fruits and tree nuts was found to significantly exceed those of alternative treatments (chemical fumigants and controlled atmosphere)—even under the most favorable conditions of operation. For example, researchers found that "... even at half of the ... estimated cost, irradiation disinfestation of newly harvested almonds and walnuts still costs five to 10 times as much as current fumigation practice for even the largest processors" (Rhodes, 1986, p. 213).

Further, the capital investment in an irradiation facility is so high that it may be prohibitive for smaller operators, and would lock in those who made the investment to the particular technology for an extended period of time. With a 20 year amortization, the fixed costs of owning and operating an irradiator were estimated to be in the \$500,000/yr range (Vail et al., 1987).

Surveys have found some consumer resistance in the United States to the idea of irradiated food (Morrison and Roberts, 1985). The process has gained better acceptance in other countries, so negative effects on consumer demand in the domestic market would probably not be matched in export markets. For bulk sales of dried fruits and nuts domestically, consumer labeling indicating the radiation treatment might pose some logistics problems.

General comments

Irradiation disinfestation of California dried fruits and tree nuts has been demonstrated to be a technologically feasible option in terms of its efficacy, safety, and product quality results. Under current conditions it does not meet economic feasibility criteria when compared with available alternatives, although this could change if some of the chemical alternatives were to become unavailable. A final set of disadvantages is that live (though damaged) insects may remain in the products for up to two months—a distinct liability for product marketing; and only limited protection is afforded against reinfestation via the mating of sterile insects with new entrants. Current regulations do not allow repeated irradiation.

Other Possible Methods

Freezing of stored dried fruits and nuts is technically feasible for control of pest infestation, but is not economically feasible on a large scale, although it is practical for home use. Some research

has been conducted on the use of heat to kill insects on raisins. A vapor heat treatment has been developed in Japan which forces vapor through the commodity, heating it to 38-50°C (100-120°F) for up to eight hours. Disadvantages of this method are that it is expensive and may damage the product, especially nuts with high oil contents.

Conclusion

Storage is a necessary component of the dried fruit and nut industry as it is currently organized. Given field infestation by some pests (e.g., the codling moth) and the inevitable infiltration of storage facilities by others, some form of insect control program is essential.

At present the industry is heavily reliant on two chemical insecticides, methyl bromide and phosphine, with some use in the prune industry of pyrethrin fogging. The continued use of both of the major fumigants is in jeopardy: methyl bromide because of the suspected carcinogenicity of residues and other deleterious health effects; and phosphine due to the development of resistance in one pest specie. Pyrethrin fogging is not used for initial disinfestation, but is a preventative treatment against reinfestation of flying insects.

Unless alternatives are adopted, the withdrawal of methyl bromide and increased insect tolerance to phosphine could be devastating to California's dried fruit and nut industry, with consequences for the state's economy as a whole. Dried fruits and nuts are important to California's agricultural economy, and can be very important to local areas.³ Economic losses would not be confined to this industry, and effects in terms of lost output, wages and tax revenues could be expected to percolate throughout the state. Using factors estimated for California (Goldman and O'Regan, 1983), for every 1 percent decline in marketings (farm level), state income will decline by \$13.8 million at 1986 prices.

Fortunately there are two major types of treatments which are technically feasible as substitutes for the currently used pesticides: controlled atmospheres and irradiation disinfestation. Comparative cost studies of these methods, neither of which is currently in commercial use in the industry, indicate that one method of controlled atmosphere

generation, use of on-site low oxygen atmosphere generators, is competitive with chemical disinfestation on a cost basis, with per pound treatment costs falling between those of methyl bromide and phosphine. It may, however, require construction of additional storage capacity given the length of time involved with each treatment. Sealing of existing concrete or metal storage chambers is estimated to cost about \$5 per 100 cubic feet, with an annual maintenance cost of 17.5 cents per 100 cubic feet of storage space; average costs to build new storage chambers are \$1 per cubic foot; covering stacked bins (of dried fruits or nuts) costs about 79 cents per ton per year; and requirements for additional in-plant fumigation space for packing to order or immediate shipment could be as much as six times existing capacity (Rhodes, 1986). The other method, irradiation, was not found to be cost competitive with either the current chemical fumigants or with controlled atmosphere disinfestation.

Demand in the domestic market and in major foreign importing countries for California almonds (Bushnell and King, 1986) and natural Thompson seedless raisins (Nuckton, French, and King, 1988) has been thoroughly studied, with statistical evidence indicating in both cases that demand for these products is not very sensitive to price changes. Less is known about the pass-through of processor cost changes to retail prices for dried fruits and nuts, but according to available cost studies, insect disinfestation (whether with chemical fumigation or, prospectively, with controlled atmospheres) represents only a small fraction of processor's total costs. The coincidence of these two aspects implies that small per pound changes in processor costs due to a shift in disinfestation methods (even if fully passed through to consumer prices) would not appreciably change product demand or industry size.

However, if an industrywide shift to irradiation disinfestation occurred, some changes could be expected: Processor costs would increase some, triggering a small but noticeable reduction in sales if cost increases were passed along in prices; a further drop in demand could occur due to consumer hesitations about irradiation; and since efficiency is related to size, an already concentrated market segment could become even more centralized at the processor/packer level.

³For example, all of the state's Thompson Seedless raisins are grown within 75 miles of Fresno (Nuckton, French, and King, 1988).

Summary Table. Options and alternatives for insect disinfestation of dried fruits and nuts.

CHARACTERISTIC	Chemical Fumigation:		Alternatives:	
	Methyl Bromide	Phosphine	Controlled Atmospheres (low O ₂ &/or high CO ₂)	Irradiation
Treatment duration	up to 24 hrs + purging/aeration	2-3 days + purging/aeration	3-7 days at 27°C (80.6°F) +purging/aeration	relatively short exposures
Effectiveness	100% kill rate.	100% kill rate.	Can achieve 100% kill rate.	Some larvae may survive up to 2 mos.
Protection against reinfestation	NONE, unless combined w/ nightly pyrethrin or Vapona fogs; requires refumigation.	Same as Methyl bromide.	NONE. Requires repeated treatments or continuous maintenance of the CA.	Some limited protection due to possible presence of sterilized males. Reirradiation not allowed.
Quality of product	Good	Good	Good-may be better than with chemical fumigation.	Good at recommended levels.
Health effects: Workers	Highly toxic if directly exposed.	Highly toxic if directly exposed.	Presumed safer than chemical fumigation.	Safe if facility properly shielded and operated.
Consumers	Methyl bromide leaves residues which may be carcinogenic.	No known hazards.	No known hazards.	No known hazards.
Environmental effect	May involve release of toxic chemicals into environment.	May involve release of toxic chemicals into environment.	Does not pollute environment; somewhat energy-intensive; good potential for co-generation.	Some versions involve transportation & use of radioactive materials.
Approximate annual cost of treatment (cents/lb):			(low O ₂ generator)	
Almonds	-	<0.1¢	0.1-0.25¢	.36-1.0¢
Walnuts	<0.1 ¢	-	0.25-0.5¢	.42-3.6¢
Raisins	<0.3¢	0.6¢	0.5¢	.43-1.4¢
Prunes	<0.1 ¢	-	0.5¢	.43-2.1¢
Other considerations	Requires little capital investment; same per lb cost for small and large operators; could be withdrawn from market or require Prop. 65 identification in California	Has some potential insect resistance problems; same per lb cost for any size operator.	Longer kill times could require construction of additional treatment chambers at some locations or alteration of existing storage facilities to make them gas-tight. Elevated temperatures may affect shelf life of nuts.	Requires large capital investment; more economical for large operators; requires labeling of treated product w/ potential for consumer resistance.

References

- Bailey, S. W. and H. J. Banks. "A Review of Recent Studies of the Effects of Controlled Atmospheres on Stored Product Pests." In *Developments in Agricultural Engineering 1: Controlled Atmosphere Storage of Grains*. J. Shejbal, ed. New York: Elsevier Scientific Publishing Co., 1980.
- Brandl, D. G., E. L. Soderstrom and Fred E. Schreiber. "Effects of Low-Oxygen Atmospheres Containing Different Concentrations of Carbon Dioxide on Mortality of the Navel Orangeworm, *Amyelosis transitella* Walker (Lepidoptera: Pyralidae)." *Journal of Economic Entomology* 76(1983):828-830.
- Bunch, Karen L. *Food Consumption, Prices and Expenditures 1985*. U.S. Department of Agriculture, Economic Research Service, Statistical Bulletin No. 749, January 1987.
- Bushnell, Peter G. and Gordon A. King. *The Domestic and Export Markets for California Almonds*. University of California, Giannini Foundation of Agricultural Economics, Research Report No. 334, 1986.
- California Crop and Livestock Reporting Service. *California Fruit and Nut Statistics*. Various issues.
- California Crop and Livestock Reporting Service. *California Fruit and Nut Acreage*. 1986 and annual issues.
- California Department of Food and Agriculture. *California Agricultural Statistical Review 1986*.
- California Department of Food and Agriculture. *California Agricultural Exports*. Annual Bulletin and Statistical Appendix 1986.
- Davis, Robert and Edward G. Jay. "The Current Status of Controlled Atmospheres as a Method of Insect Control." *Proceedings of the Second National Controlled Atmosphere Research Conference*. Michigan State University, E. Lansing, Michigan, April 1977.
- Gardner, Philip D., E. L. Soderstrom, John L. Baritelle and Karin Nolan De Lozano. *Assessing Alternative Methods of Pest Control in Raisin Storage*. University of California, Division of Agricultural Sciences, Bulletin No. 1906, November 1982.
- Goldman, George E. and Marian C. O'Regan. *Estimating Economic Impacts in California: The State Input-Output Model*. University of California, Cooperative Extension, Division of Agricultural Sciences, Special Publication No. 3286, January 1983.
- Mitchell, F. G. and A. A. Kader. "Postharvest Treatments for Insect Control." In *Postharvest Technology of Horticultural Crops*, University of California, Division of Agriculture and Natural Resources, Publication No. 3311, 1985, pp. 100-103.
- Morrison, Rosanna Mentzer and Tanya Robertson. *Food Irradiation: New Perspectives on a Controversial Technology*. U.S. Department of Agriculture, Economic Research Service, December 1985.
- Nuckton, Carole Frank, Ben C. French, and Gordon A. King. *An Econometric Analysis of the California Raisin Industry*. University of California, Giannini Foundation of Agricultural Economics, Research Report No. 339, December 1988.
- Rhodes, A. A., ed. *Irradiation Disinfestation of Dried Fruits and Nuts*. U.S. Department of Agriculture, Agricultural Research Service and Economic Research Service, June 1986.
- Rowe, V. K. "Toxicological Hazards and Properties of Commonly-Used Grain Fumigants." Reprinted from *Pest Control*, September 1957.
- Soderstrom, E. L., Philip D. Gardner, John L. Baritelle, Karin Nolan De Lozano and David G. Brandl. "Economic Cost Evaluation of a Generated Low-Oxygen Atmosphere as an Alternative Fumigant in the Bulk Storage of Raisins." *Journal of Economic Entomology* 77(1984):457-461.
- Soderstrom, Edwin L. and David G. Brandl. "Low-Oxygen Atmosphere for Postharvest Insect Control in Bulk-Stored Raisin." *Journal of Economic Entomology* 77(1984):440-445.
- Soderstrom, Edwin L. and David G. Brandl. "Controlled Atmospheres to Reduce Post Harvest Insect Damage to Horticultural Crops." *Proceedings of the 4th National Controlled Atmosphere Research Conference*. North Carolina State University, Raleigh, July 1985, pp. 207-212.
- Storey, Charles L. "Mortality of Various Stored Product Insects in Low Oxygen Atmospheres Produced by an Exothermic Inert Atmosphere Generator." In *Developments in Agricultural Engineering 1: Controlled Atmosphere Storage of Grains*. J. Shejbal, ed. New York: Elsevier Scientific Publishing Co., 1980, pp. 85-92.
- U.S. Department of Agriculture, Economic Research Service. *Foreign Agricultural Trade of the United States (FATUS)*. Calendar Year Supplement 1986.
- Vail, P. B., J. L. Baritelle, A. A. Rhodes, D. Sloan, J. A. Johnson, A. D. Burditt and G. Fuller. *Irradiation Disinfestation of Dried Fruits and Nuts*. Report to the Prune Advisory Board, February 1987.

EXHIBIT J



ANNUAL REVIEWS

CONNECT WITH OUR EXPERTS

Log in | Register | Mobile | Activate | Help | Item 0

This Journal | Journals | General Info | Advanced Search

JOURNALS

SUBSCRIPTIONS

AUTHORS

LIBRARIANS & AGENTS

ABOUT

Home / Journals / Entomology / List of Issues / Volume 47, 2002 / Fields, pp. 331-359

Add to Favorites

Email Page To a Friend

ENTOMOLOGY

Volume 47, 2002

REVIEW CONTENT

ABSTRACT

FULL-TEXT HTML

FULL-TEXT PDF

SUPPLEMENTAL MATERIALS

CURRENT EDITORIAL COMMITTEE

ABSTRACT

Prev. | Next

ALTERNATIVES TO METHYL BROMIDE TREATMENTS FOR STORED-PRODUCT AND QUARANTINE INSECTS¹

Annual Review of Entomology

Vol. 47: 331-359 (Volume publication date January 2002)

DOI: 10.1146/annurev.ento.47.091201.145217

Paul G. Fields and Noel D. G. White
Cereal Research Centre, Agriculture and Agri-Food Canada, Winnipeg,
Manitoba, R3T 2M9; Canada e-mail: pfields@em.agr.ca nwhite@em.agr.ca

FULL-TEXT | PDF (316 KB) | Supplemental Materials | Permissions | Reprints

Citation: PubMed | Web of Science® | Download | Email notification |

Web of Science®: Related Records® | Times Cited: 146

ABSTRACT

Methyl bromide is used to control insects as a space fumigant in flour and feed mills and ship holds, as a product fumigant for some fruit and cereals, and for general quarantine purposes. Methyl bromide acts rapidly, controlling insects in less than 48 h in space fumigations, and it has a wide spectrum of activity, controlling not only insects but also nematodes and plant-pathogenic microbes. This chemical will be banned in 2005 in developed countries, except for exceptional quarantine purposes, because it depletes ozone in the atmosphere. Many alternatives have been tested as replacements for methyl bromide, from physical control methods such as heat, cold, and sanitation to fumigant replacements such as phosphine, sulfuryl fluoride, and carbonyl sulfide, among others. Individual situations will require their own type of pest control techniques, but the most promising include integrated pest management tactics and combinations of treatments such as phosphine, carbon dioxide, and heat.

Go to full-text...

FULL ACCESS RIGHTS ARE REQUIRED TO ACCESS THIS REVIEW

Many individuals can gain access to the full-text through their institution's site license. Before purchasing this article or a subscription, we encourage you to check your library's holdings.

If you don't have access through your institution's site license, you may gain access in one of the following ways.

Purchase access to this review article using a credit card.

(Grants access for 24 hours after purchase - registration required)
Review Price: \$32.00(USD)

PURCHASE ARTICLE ACCESS

Rent this article through DeepDyve - free trial subscription available.



BROWSE RELATED REVIEWS

USERS ALSO READ

CHAIN OF REVIEWS

THIS REVIEW IS CITED BY

FIND RELATED REVIEWS

Search for articles by the same authors or containing the same key words. Select below.

SEARCH IN:

Annual Reviews ▼

BY AUTHORS:

- ☐ Paul G. Fields and
☐ Noel D. G. White

KEYWORDS:

- ☐ ozone
☐ flour mills
☐ warehouses
☐ phosphine
☐ heat
☐ cold
☐ sulfuryl fluoride
☐ fumigation

SEARCH



GET MORE FROM ANNUAL REVIEWS!

SUBSCRIBE AND PURCHASE

Options include online-only, print plus online and print only.

MANAGE YOUR ALERTS

Annual Reviews can alert you when new review articles are added to the site.

RECOMMEND TO LIBRARY

For institutional access, we can help you recommend the journals to your librarian.

Already A Subscriber
Purchased Pay per View Access
in the Last 24 Hours?
Enter your username and
password to gain access to
this review.

User Name
Password
☒ Remember me

[Register](#) | [Forgot password](#) | [Institution Login](#)

Institutional Subscribers/Librarians

A site license allows your patrons to access Annual Reviews
publications seamlessly. For further information, and to obtain
pricing for your institution, visit the Librarian Resource Center.

[COPYRIGHT 2016](#) | [SUPPLEMENTAL MATERIALS](#) | [ANNUAL REVIEWS DIRECTORY](#) | [PRIVACY POLICY](#) | [CONTACT US](#)



Powered by Atypoon® Literatum

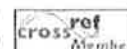


EXHIBIT K

From: Elizabeth Forsyth
To: Idalmis Vaquero
Subject: FW: Public Records Request N-2016-11-1; Rivermaid Trading Company
Date: Wednesday, November 30, 2016 3:36:07 PM
Attachments: [N-2016-11-1 pkt1.pdf](#)
[N-2016-11-1 pkt2.pdf](#)
[N-2016-11-1 pkt3.pdf](#)
[N-2016-11-1 pkt4.pdf](#)

-----Original Message-----

From: Theresa Haywood [<mailto:Theresa.Haywood@valleyair.org>]
Sent: Monday, November 07, 2016 1:39 PM
To: Elizabeth Forsyth
Subject: Public Records Request N-2016-11-1; Rivermaid Trading Company

November 07, 2016

Elizabeth Forsyth
Earthjustice
800 Wilshire Blvd, Suite 1000
Los Angeles, CA 90017

SUBJECT: Public Records Request N-2016-11-1; Rivermaid Trading Company

Dear Elizabeth Forsyth:

The San Joaquin Valley Air Pollution Control District has completed your Public Records Request for the above mentioned location.

For requested item "Documentation from United States Filter Corporation providing that carbon absorption systems are "able to control about 20% of their weight in VOCs", used to estimate BACT for project N-1160591", this information has been used for various projects in the District, and was referenced from verbal communication between the process engineer and vendor on September 10, 2002 (BACT analysis under District project N-1030527). No phone log correspondence could be located.

For requested item "Cost estimate from Calgon providing the cost of carbon used to estimate BACT for project N-1160591", this information has been used for various projects in the District, and was referenced from verbal communication between the process engineer and vendor on April 2, 2009 (BACT analysis under District project N-1091164). No phone log correspondence could be located.

The remaining items you requested are enclosed. If you have any questions concerning this information, please contact me at the number below.

Respectfully,

Theresa Haywood
Senior Office Assistant
San Joaquin Valley
Air Pollution Control District
4800 Enterprise Way
Modesto, CA 95356.8718
Phone: (209) 557.6406
Fax: (209) 557.6475

Theresa.Haywood@valleyair.org
Service * Teamwork * Attitude * Respect

EXHIBIT L

Purchase

Export

Search ScienceDirect

Advanced search

Article outline

Abstract

Keywords

1. Introduction

2. Materials and methods

3. Results and discussion

Acknowledgements

References

Journal of Stored Products Research

Volume 36, Issue 1, January 2000, Pages 65–74



Methyl bromide adsorption on activated carbon to control emissions from commodity fumigations

James G. Leesch^a, Gerhard F. Knapp^b, Bruce E. Mackey^c^a USDA-Agricultural Research Service, Horticultural Crops Research Laboratory, 2021 South Peach Avenue, Fresno, CA 93727-5951, USA^b GFK Consulting Ltd, 63 Calle de Industrias, Suite 548, San Clemente, CA 92672, USA^c USDA-Agricultural Research Service, Pacific-West Area Office, 800 Buchanan St., Albany, CA 94710, USA

Accepted 9 June 1999, Available online 8 November 1999

Show less

Figures and tables

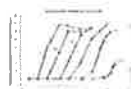
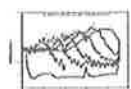


Table 1

Choose an option to locate/access this article:

Check if you have access
through your login credentials
or your institution

Purchase \$35.95

Get Full Text Elsewhere

Check access

ADVERTISEMENT

[http://dx.doi.org/10.1016/S0022-474X\(99\)00028-4](http://dx.doi.org/10.1016/S0022-474X(99)00028-4)

Get rights and content

Abstract

A process to control emissions of methyl bromide (MB) into the atmosphere following the fumigation of commodities has been developed. The process consists of adsorbing the MB in the vent-stream from a fumigation process onto activated carbon (carbon). Research was undertaken to observe the effects of (1) temperature, (2) relative humidity (r.h.), (3) the concentration of MB in the vent-stream, and (4) carbon type on the amount of MB that could be adsorbed (loaded) on the activated carbon. Temperature had the most effect on the loading, followed by r.h., for a given type of carbon. The loading decreased as temperature and r.h. increased. For a given temperature and r.h., the loading varied significantly for different carbon types. These differences were consistent with the type of pore structures of the carbons, which in turn is determined by the raw materials and by the activation procedures used during the carbon manufacturing process. Temperatures in the carbon column rose in response to the adsorption of MB. By monitoring the temperatures, the adsorption zone could be followed throughout the column from the inlet at the start of an adsorption run to column exhaustion, or breakthrough at the end of the trial. Breakthrough was reached when the MB concentration in the column exhaust stream reached 500 ppm (2 mg/l) MB. Relative humidity of the vent-stream was less critical than first anticipated because of the heating of the column. The temperature increase due to the heat of adsorption lowered the r.h. at the adsorption zone which led to the increased adsorption capacity normally associated with low humidities.

Keywords

[About ScienceDirect](#) [Remote access](#) [Shopping cart](#) [Contact and support](#)
[Terms and conditions](#) [Privacy policy](#)

Cookies are used by this site. For more information, visit the cookies page.

Copyright © 2016 Elsevier B.V. or its licensors or contributors. ScienceDirect ® is a registered trademark of Elsevier B.V.

Recommended articles

Adsorption and catalytic decomposition of methyl b...
2001, Atmospheric Environment [more](#)

Effects of water on the removal of methyl bromide u...
2010, Carbon [more](#)

Recapturing and decomposing methyl bromide in fu...
1996, Journal of Hazardous Materials [more](#)

[View more articles »](#)

[Citing articles \(19\)](#)

[Related book content](#)

EXHIBIT M

Section 3

VOC Controls

Section 3.1

VOC Recapture Controls

Chapter 1

Carbon Adsorbers

William M. Vatavuk
Innovative Strategies and Economics Group, OAQPS
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

William L. Klotz
Chas. T. Main, Inc.
Charlotte, NC 28224

Robert L. Stallings
Ozone Policy and Strategies Group, OZQPS
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

September 1999

Contents

1.0	Introduction	1-3
1.1	Types of Adsorbers	1-3
1.1.1	Fixed-bed Units	1-3
1.1.2	Cannister Units	1-5
1.1.3	Adsorption Theory	1-6
1.2	Design Procedure	1-12
1.2.1	Sizing Parameters	1-12
1.2.2	Determining Adsorption and Desorption Times	1-13
1.2.3	Estimating Carbon Requirement	1-15
1.2.3.1	Overview of Carbon Estimation Procedures	1-15
1.2.3.2	Carbon Estimation Procedure Used in Manual	1-15
1.3	Estimating Total Capital Investment	1-17
1.3.1	Fixed-Bed Systems	1-17
1.3.1.1	Carbon Cost	1-17
1.3.1.2	Vessel Cost	1-18
1.3.1.3	Total Purchased Cost	1-21
1.3.1.4	Total Capital Investment	1-23
1.3.2	Cannister Systems	1-23
1.4	Estimating Total Annual Cost	1-24
1.4.1	Direct Annual Costs	1-24
1.4.1.1	Steam 1-28 1-25	1-25
1.4.1.2	Cooling Water	1-26
1.4.1.3	Electricity	1-29
1.4.1.4	Carbon Replacement	1-29
1.4.1.5	Solid Waste Disposal	1-30
1.4.1.6	Operating and Supervisory Labor	1-30
1.4.1.7	Maintenance Labor and Materials	1-30
1.4.2	Indirect Annual Costs	1-30
1.4.3	Recovery Credits	1-31
1.4.4	Total Annual Cost	1-32
1.4.5	Example Problem	1-32

1.0 Introduction

In air pollution control, adsorption is employed to remove volatile organic compounds (VOCs) from low to medium concentration gas streams, when a stringent outlet concentration must be met and/or recovery of the VOC is desired. Adsorption itself is a phenomenon where gas molecules passing through a bed of solid particles are selectively held there by attractive forces which are weaker and less specific than those of chemical bonds. During adsorption, a gas molecule migrates from the gas stream to the surface of the solid where it is held by physical attraction releasing energy—the “heat of adsorption”, which typically equals or exceeds the heat of condensation. Adsorptive capacity of the solid for the gas tends to increase with the gas phase concentration, molecular weight, diffusivity, polarity, and boiling point. Gases form actual chemical bonds with the adsorbent surface groups. This phenomenon is termed “chemisorption”.

Most gases (“adsorbates”) can be removed (“desorbed”) from the adsorbent by heating to a sufficiently high temperature, usually via steam or (increasingly) hot combustion gases, or by reducing the pressure to a sufficiently low value (vacuum desorption). The physically adsorbed species in the smallest pores of the solid and the chemisorbed species may require rather high temperatures to be removed, and for all practical purposes cannot be desorbed during regeneration. For example, approximately 3 to 5 percent of organics adsorbed on virgin activated carbon is either chemisorbed or very strongly physically adsorbed and is difficult to desorb during regeneration.[1]

Adsorbents in large scale use include activated carbon, silica gel, activated alumina, synthetic zeolites, fuller’s earth, and other clays. This section is oriented toward the use of activated carbon, a commonly used adsorbent for VOCs.

1.1 Types of Adsorbers

Five types of adsorption equipment are used in collecting gases: (1) fixed regenerable beds; (2) disposable/rechargeable canisters; (3) traveling bed adsorbers; (4) fluid bed adsorbers; and (5) chromatographic baghouses.[2] Of these, the most commonly used in air pollution control are fixed-bed systems and canister types. This section addresses only fixed-bed and canister units.

1.1.1 Fixed-bed Units

Fixed-bed units can be sized for controlling continuous, VOC-containing streams over a wide range of flow rates, ranging from several hundred to several hundred thousand cubic feet per minute (cfm). The VOC concentration of streams that can be treated by fixed-bed adsorbers can be as low as several parts per billion by volume (ppbv) in the case of some toxic chemicals or as

high as 25% of the VOCs' lower explosive limit (LEL). (For most VOCs, the LEL ranges from 2500 to 10,000 ppmv.[3])

Fixed-bed adsorbers may be operated in either intermittent or continuous modes. In intermittent operation, the adsorber removes VOC for a specified time (the "adsorption time"), which corresponds to the time during which the controlled source is emitting VOC. After the adsorber and the source are shut down (e.g., overnight), the unit begins the desorption cycle during which the captured VOC is removed from the carbon. This cycle, in turn, consists of three steps: (1) regeneration of the carbon by heating, generally by blowing steam through the bed in the direction opposite to the gas flow;¹ (2) drying of the bed, with compressed air or a fan; and (3) cooling the bed to its operating temperature via a fan. (In most designs, the same fan can be used both for bed drying and cooling.) At the end of the desorption cycle (which usually lasts 1 to 1½ hours), the unit sits idle until the source starts up again.

In continuous operation a regenerated carbon bed is always available for adsorption, so that the controlled source can operate continuously without shut down. For example, two carbon beds can be provided: while one is adsorbing, the second is desorbing/idled. As each bed must be large enough to handle the entire gas flow while adsorbing, twice as much carbon must be provided than an intermittent system handling the same flow. If the desorption cycle is significantly shorter than the adsorption cycle, it may be more economical to have three, four, or even more beds operating in the system. This can reduce the amount of extra carbon capacity needed or provide some additional benefits, relative to maintaining a low VOC content in the effluent. (See Section 1.2 for a more thorough discussion of this.)

A typical two-bed, continuously operated adsorber system is shown in Figure 3.1. One of the two beds is adsorbing at all times, while the other is desorbing/idled. As shown here, the VOC-laden gas enters vessel #1 through valve A, passes through the carbon bed (shown by the shading) and exits through valve B, from whence it passes to the stack. Meanwhile, vessel #2 is in the desorption cycle. Steam enters through valve C, flows through the bed and exits through D. The steam-VOC vapor mixture passes to a condenser, where cooling water condenses the entire mixture. If part of the VOC is immiscible in water, the condensate next passes to a decanter, where the VOC and water layers are separated. The VOC layer is conveyed to storage. If impure, it may receive additional purification by distillation. Depending on its quality (i.e., quantity of dissolved organics), the water layer is usually discharged to a wastewater treatment facility.

¹ Although steam is the most commonly used regenerant, there are situations where it should not be used. An example would be a degreasing operation that emits halogenated VOCs. Steaming might cause the VOCs to decompose.

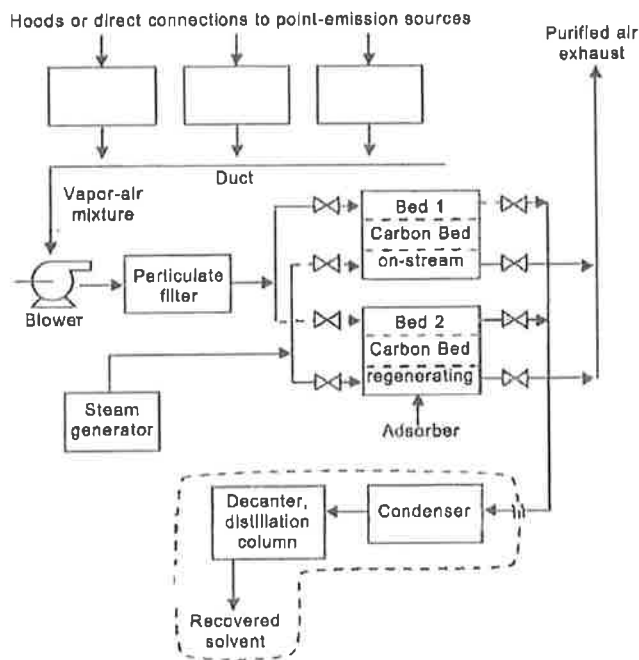


Figure 1.1: Typical-Two-Bed, Continuously Operated Fixed Bed Carbon Adsorber System

1.1.2 Cannister Units

Cannister-type adsorbers originally referred to relatively small returnable containers, such as 55-gallon drums. Cannisters differ from fixed-bed units, in that they are normally limited to controlling lower-volume and intermittent gas streams, such as those emitted by storage tank vents, where process economics dictate that off-site regeneration is appropriate. The carbon cannisters are not intended for desorption on-site. However, the carbon may be regenerated at a central facility. The term cannister is becoming something of a misnomer as much of the growth in the industry is in larger vessels without regeneration capabilities. Calgon provided information on standard systems as large as 8,000 cfm and carbon capacities of 2,000 pounds; TIGG Corporation reported systems as large as 30,000 cfm. [4][5]

Once the carbon reaches a certain VOC content, the unit is shut down and either the carbon or the cannister is replaced. The carbon or cannister is then returned to a reclamation facility or regenerated at the central facility. Each cannister unit consists of a vessel, activated carbon, inlet connection and distributor leading to the carbon bed, and an outlet connection for the purified gas stream. In one design (Calgon's Ventsorb®), 180 lbs of carbon are installed on an 8-inch gravel bed, in a 55-gallon drum with an internal collector. The type of carbon used depends on the nature of the VOC to be treated [6]. Non-regenerable vessels can be placed in a series, this protects against breakthrough because in the event that the first cannister or vessel becomes saturated with VOC, the second then becomes the primary carbon adsorber. One option would be to periodically remove the most saturated cannister or carbon bed and add a fresh cannister or carbon bed to the clean end. Periodic sampling for breakthrough between the carbon beds would assure that replacement occurred frequently enough to avoid breakthrough to the atmosphere. This approach also improves cost effectiveness of carbon replacement because the carbon is at or near its saturation point when it is replaced.

In theory, a cannister unit would remain in service longer than a regenerable unit would stay in its adsorption cycle due to a higher theoretical capacity for fresh carbon compared to carbon regenerated on-site. The service life is based on a service factor determined by the ratio of the theoretical capacity to the working capacity. Determining service factors help to insure the allowable outlet concentration from being exceeded. In reality, however, poor operating practice may result in the cannister remaining connected until the carbon is near or at saturation. This is because: (1) the carbon (and often the vessel) will probably be disposed of, so there is the temptation to operate it until the carbon is saturated; and (2) unlike fixed-bed units, whose outlet VOC concentrations are usually not monitored continuously (via flame ionization detectors, typically), cannisters are usually not monitored. Adequate recordkeeping and periodic monitoring for breakthrough can be supported by bed life modeling provided by vendors to ensure that cannister replacement occurs with sufficient frequency and that breakthrough does not occur.

1.1.3 Adsorption Theory

At equilibrium, the quantity of gas that is adsorbed on activated carbon is a function of the adsorption temperature and pressure, the chemical species being adsorbed, and the carbon characteristics, such as carbon particle size and pore structure. For a given adsorbent-VOC combination at a given temperature, an adsorption isotherm can be constructed which relates the mass of adsorbate per unit weight of adsorbent ("equilibrium adsorptivity") to the partial pressure of the VOC in the gas stream. The adsorptivity increases with increasing VOC partial pressure and decreases with increasing temperature.

A family of adsorption isotherms having the shape typical of adsorption on activated carbon is plotted in Figure 3.2. This and other isotherms whose shapes are convex upward throughout,

are designated "Type I" isotherms. The Freundlich isotherm, which can be fit to a portion of a Type I curve, is commonly used in industrial design.[2]

$$W_e = k P_m^m \quad (1.1)$$

where

w_e	=	equilibrium adsorptivity (lb adsorbate/lb adsorbent)
P	=	partial pressure of VOC in gas stream (psia)
k, m	=	empirical parameters

The treatment of adsorption from gas mixtures is complex and beyond the scope of this chapter. Except where the VOC in these mixtures have nearly identical adsorption isotherms, one VOC in a mixture will tend to displace another on the carbon surface. Generally, VOCs with lower vapor pressures will displace those with higher vapor pressure, resulting in the former displacing the latter previously adsorbed. Thus, during the course of the adsorption cycle the carbon's capacity for a higher vapor pressure constituent decreases. This phenomenon should be considered when sizing the adsorber. To be conservative, one would normally base the adsorption cycle requirements on the least adsorbable component in a mixture and the desorption cycle on the most adsorbable component.[1]

The equilibrium adsorptivity is the maximum amount of adsorbate the carbon can hold at a given temperature and VOC partial pressure. In actual control systems where there are not two beds operating in series, however, the entire carbon bed is never allowed to reach equilibrium. Instead, once the outlet concentration reaches a preset limit (the "breakthrough concentration"), the adsorber is shut down for desorption or (in the case of canister units) replacement and disposal. At the point where the vessel is shut down, the average bed VOC concentration may only be 50% or less of the equilibrium concentration. That is, the carbon bed may be at equilibrium ("saturated") at the gas inlet, but contain only a small quantity of VOC near the outlet.

As Equation 3.1 indicates, the Freundlich isotherm is a power function that plots as a straight line on log-log paper. Conveniently, for the concentrations/partial pressures normally encountered in carbon adsorber operation, most VOC-activated carbon adsorption conforms to Equation 3.1. At very low concentrations, typical of breakthrough concentrations, a linear approximation (on arithmetic coordinates) to the Freundlich isotherm is adequate. However, the Freundlich isotherm does not accurately represent the isotherm at high gas concentrations and thus should be used with care as such concentrations are approached.

Adsorptivity data for selected VOCs were obtained from Calgon Corporation, a vendor of activated carbon.[6] The vendor presents adsorptivity data in two forms: a set of graphs displaying equilibrium isotherms [6] and as a modification of the Dubinin-Radushkevich (D-R) equation, a semi-empirical equation that predicts the adsorptivity of a compound based on its adsorption

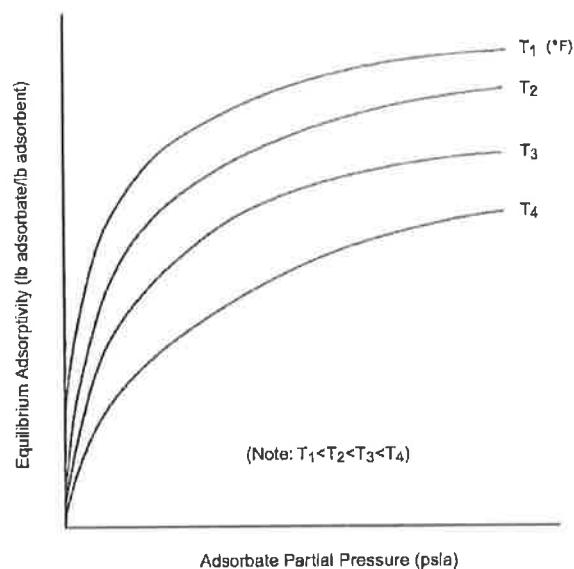


Figure 1.2: Type I Adsorption Isotherms for Hypothetical Adsorbate

potential and polarizability.[8] In this Manual, the modified D-R equation is referred to as the Calgon fifth-order polynomial. The data displayed in the Calgon graphs [6] has been fit to the Freundlich equation. The resulting Freundlich parameters are shown in Table 1.1 for a limited number of chemicals. The adsorbates listed include aromatics (e.g., benzene, toluene), chlorinated aliphatics (dichloroethane), and one ketone (acetone). However, the list is far from all-inclusive.

Notice that a range of partial pressures is listed with each set of parameters, k and m . (Note: In one case (m-xylene) the isotherm was so curvilinear that it had to be split into two parts, each with a different set of parameters.) This is the range to which the parameters apply. Extrapolation beyond this range—especially at the high end—can introduce inaccuracy to the calculated adsorptivity.

But high-end extrapolation may not be necessary, as the following will show. In most air pollution control applications, the system pressure is approximately one atmosphere (14.696 psia). The upper end of the partial pressure ranges in Table 1.1 goes from 0.04 to 0.05 psia. According to Dalton's Law, at a total system pressure of one atmosphere this corresponds to an adsorbate concentration in the waste gas of 2,720 to 3,400 ppmv. Now, as discussed in Section 1.1.2, the adsorbate concentration is usually kept at 25% of the lower explosive limit (LEL).² For many VOCs, the LEL ranges from 1 to 1.5 volume %, so that 25% of the LEL would be 0.25 to

² Although, Factory Mutual Insurance will reportedly permit operation at up to 50% of the LEL, if proper VOC monitoring is used.

0.375% or 2,500 to 3,750 ppmv, which approximates the high end of the partial pressure ranges in Table 1.1.

Finally, each set of parameters applies to a fixed adsorption temperature, ranging from 77° to 104° F. These temperatures reflect typical operating conditions, although adsorption can take

Table 1.1: Parameters for Selected Adsorption Isotherms [6]^a

Adsorbate	Adsorption Temp (°F)	Isotherm Parameters		Range of Isotherm ^b (psia)
		<i>k</i>	<i>m</i>	
Benzene	77	0.597	0.176	0.0001-0.05
Chlorobenzene	77	1.05	0.188	0.0001-0.01
Cyclohexane	100	0.505	0.210	0.0001-0.05
Dichloroethane	77	0.976	0.281	0.0001-0.04
Phenol	104	0.855	0.153	0.0001-0.03
Trichloroethane	77	1.06	0.161	0.0001-0.04
Vinyl Chloride	100	0.200	0.477	0.0001-0.05
m-Xylene	77	0.708	0.113	0.0001-0.001
	77	0.527	0.0703	0.001-0.05
Acrylonitrile	100	0.935	0.424	0.0001-0.015
Acetone	100	0.412	0.389	0.0001-0.05
Toluene	77	0.551	0.110	0.001-0.05

^a Each isotherm is of the form $W_s = kP^m$. (See text for definition of terms.) Data are for adsorption of Calgon type "BPL" carbon.

^b Equation should not be extrapolated outside these ranges.

The Calgon fifth-order polynomial is somewhat more accurate than the Freundlich parameters from Table 1.1. The polynomial contains a temperature parameter, and it allows one to estimate adsorption isotherms for compounds not shown in Table 1.1 if pure component data are available. The pure component data required are the saturation pressure, liquid molar volume, and the refractive index. It is, however, somewhat more complex to use than the Freundlich equation. The Calgon fifth-order polynomial is as follows:

The mass loading, w_e , is calculated from

$$w_e = \frac{0.01 G}{V_m} MW_{ads} \quad (1.2)$$

place as low as 32°F and even higher than 104°F. As the adsorption temperature increases to much higher levels, however, the equilibrium adsorptivity decreases to such an extent that VOC recovery by carbon adsorption may become economically impractical.

where

w_e	=	mass loading, i.e., equilibrium adsorptivity (g adsorbate per g carbon) ³
G	=	carbon loading at equilibrium (cm ³ liquid adsorbate per 100 g carbon)
V_m	=	liquid molar volume of adsorbate (cm ³ per g-mole).
MW_{uds}	=	molecular weight of Adsorbute

Note that the terms in Equation 1.2 are given in metric units, not English. This has been done because the carbon loading, G , is calculated from a regression equation in which all the terms are expressed in metric units. This equation for G is the Calgon fifth-order polynomial:

$$\log_{10}(G) = A_0 + A_1Y + A_2Y^2 + A_3Y^3 + A_4Y^4 + A_5Y^5 \quad (1.3)$$

where

A_0	=	1.71
A_1	=	-1.46×10^{-2}
A_2	=	-1.65×10^{-3}
A_3	=	-4.11×10^{-4}
A_4	=	$+3.14 \times 10^{-5}$
A_5	=	-6.75×10^{-7}

and Y is calculated from several equations which follow.

The first step in calculating Y is to calculate $\mathcal{K}$. This can be done by calculating the adsorption potential, ϵ :

$$\epsilon = RT \ln \left(\frac{P_s}{P_t} \right) \quad (1.4)$$

where

R	=	1.987 (calories per g-mole-K)
T	=	absolute temperature (K)
P_s	=	vapor pressure of adsorbate at the temperature T (kPa)
P_t	=	partial pressure of adsorbate (kPa).

³ This, of course, is equal to lb adsorbate per lb carbon.

The χ is calculated from:

$$\chi = \frac{\epsilon}{(2.303 R V_m)} \quad (1.5)$$

By substituting for ϵ in the above equation, χ can alternatively be calculated from⁴:

$$\chi = \left(\frac{T}{V_m} \right) \log_{10} \left(\frac{P_s}{P_i} \right) \quad (1.6)$$

The next step in calculating Y is to calculate the relative polarizability, Γ .

$$\Gamma = \frac{\Theta_i}{\Theta_o} \quad (1.7)$$

where

$$Y = \frac{\chi}{\Gamma}$$

Θ_i	=	polarizability of component i per unit volume, where component i is the adsorbate
Θ_o	=	polarizability of component o per unit volume, where component o is the reference component, n-heptane.

For the adsorbate or the reference compound, using the appropriate refractive index of adsorbate, n , the polarizability is calculated from:

$$\Theta = \frac{n^2 - 1}{n^2 + 2} \quad (1.8)$$

Once χ and Γ are known, Y can be calculated from:

$$(1.9)$$

Calgon also has a proprietary, seventh-order form in which two additional coefficients are added to the Calgon fifth-order polynomial, but the degree of fit reportedly is improved only modestly.[8] Additional sources of isotherm data include the activated carbon vendors, handbooks (such as Perry's Chemical Engineer's Handbook), and the literature.

⁴ Alternatively, if the available values for T , P , P_s , and V_m are in English units, they may be substituted into this equation without conversion. However, to make the result dimensionally consistent with Equation 1.3, it would have to be multiplied by a conversion factor, 34.7.

1.2 Design Procedure

1.2.1 Sizing Parameters

Data received from adsorber vendors indicate that the size and purchase cost of a fixed-bed or canister carbon adsorber system primarily depend on five parameters:

1. The volumetric flow of the VOC laden gas passing through the carbon bed(s);
2. The inlet and outlet *VOC* mass loadings of the gas stream;
3. The adsorption time (i.e., the time a carbon bed remains on-line to adsorb VOC before being taken off-line for desorption of the bed);
4. The working capacity of the activated carbon in regenerative systems or the *equilibrium capacity* in the case of non-regenerative systems;
5. The humidity of the gas stream, especially in the effect of humidity on capacity in relation to halogens.

In addition, the cost could also be affected by other stream conditions, such as the presence/absence of excessive amounts of particulate, moisture, or other substances which would require the use of extensive pretreatment and/or corrosive-resistant construction materials.

The purchased cost depends to a large extent on the volumetric flow (usually measured in actual ft³/min). The flow, in turn, determines the size of the vessels housing the carbon, the capacities of the fan and motor needed to convey the waste gas through the system, and the diameter of the ducting.

Also important are the VOC inlet and outlet gas stream loadings, the adsorption time, and the working or equilibrium capacity of the carbon. These variables determine the amount and cost of carbon charged to the system initially and, in turn, the cost of replacing that carbon after it is exhausted (typically, five years after startup). Moreover, the amount of the carbon charge affects the size and cost of the auxiliary equipment (condenser, decanter, bed drying/cooling fan), because the sizes of these items are tied to the amount of VOC removed by the bed. The amount of carbon also has a bearing on the size and cost of the vessels.

A carbon adsorber vendor [9] supplied data that illustrate the dependency of the equipment cost on the amount of the carbon charge. Costs were obtained for fixed-bed adsorbers sized to handle three gas flow rates ranging from 4,000 to 100,000 scfm and to treat inlet VOC (toluene) concentrations of 500 and 5,000 ppm. Each adsorber was assumed to have an eight-hour

adsorption time. As one might expect, the equipment costs for units handling higher gas flow rates were higher than those handling lower gas flow rates. Likewise, at each of the gas flow rates, the units sized to treat the 5,000 ppm VOC streams had higher equipment costs than those sized to treat the 500 ppm concentration. These cost differences ranged from 23 to 29% and averaged 27%. These higher costs were partly needed to pay for the additional carbon required to treat the higher concentration streams. But some of these higher costs were also needed for enlarging the adsorber vessels to accommodate the additional carbon and for the added structural steel to support the larger vessels. Also, larger condensers, decanters, cooling water pumps, etc., were necessary to treat the more concentrated streams. (See Section 1.3.)

The VOC inlet loading is set by the source parameters, while the outlet loading is set by the VOC emission limit. (For example, in many states, the average VOC outlet concentration from adsorbers may not exceed 25 ppm.)

1.2.2 Determining Adsorption and Desorption Times

The relative times for adsorption and desorption and the adsorber bed configuration (i.e., whether single or multiple and series or parallel adsorption beds are used) establish the adsorption/desorption cycle profile. The cycle profile is important in determining carbon and vessel requirements and in establishing desorption auxiliary equipment and utility requirements. An example will illustrate. In the simplest case, an adsorber would be controlling a process which emits a relatively small amount of VOC intermittently—say, during one 8-hour shift per day. During the remaining 16 hours the system would either be desorbing or on standby. Properly sized, such a system would only require a single bed, which would contain enough carbon to treat eight hours worth of gas flow at the specified inlet concentration, temperature, and pressure. Multiple beds, operating in parallel, would be needed to treat large gas flows ($>100,000$ actual ft^3/min , generally)[9], as there are practical limits to the sizes to which adsorber vessels can be built. But, regardless of whether a single bed or multiple beds were used, the system would only be on-line for part of the day.

However, if the process were operating continuously (24 hours), an extra carbon bed would have to be installed to provide adsorptive capacity during the time the first bed is being regenerated. The amount of this extra capacity must depend on the number of carbon beds that would be adsorbing at any one time, the length of the adsorption period relative to the desorption period, and whether the beds were operating in parallel or in series. If one bed were adsorbing, a second would be needed to come on-line when the first was shut down for desorption. In this case, 100% extra capacity would be needed. Similarly, if five beds in parallel were operating in a staggered adsorption cycle, only one extra bed would be needed and the extra capacity would be 20% (i.e., $1/5$)—provided, of course, that the adsorption time were at least five times as long as the desorption time. The relationship between adsorption time, desorption time, and the required extra capacity can be generalized.

$$M_c = M_{ci} f \quad (1.10)$$

where

$$\begin{array}{ll} M_c, M_{ci} = & \text{amounts of carbon required for continuous or intermittent control of a} \\ & \text{given source, respectively (lbs)} \\ f = & \text{extra capacity factor (dimensionless)} \end{array}$$

This equation shows the relationship between M_c and M_{ci} . Section 1.2.3 shows how to calculate these quantities.

The factor, f , is related to the number of beds adsorbing (N_A) and desorbing (N_D) in a continuous system as follows:

$$f = 1 + \frac{N_D}{N_A} \quad (1.11)$$

(Note: N_A is also the number of beds in an intermittent system that would be adsorbing at any given time. The total number of beds in the system would be $N_A + N_D$.)

It can be shown that the number of desorbing beds required in a continuous system (N_D) is related to the desorption time (θ_D), adsorption time (θ_A), and the number of adsorbing beds, as follows:

$$\theta_D \leq \theta_A \left(\frac{N_D}{N_A} \right) \quad (1.12)$$

(Note: θ_D is the total time needed for bed regeneration, drying, and cooling.)

For instance, for an eight-hour adsorption time, in a continuously operated system of seven beds (six adsorbing, one desorbing) θ_D would have to be 1-1/3 hours or less (8 hours/6 beds). Otherwise, additional beds would have to be added to provide sufficient extra capacity during desorption.

1.2.3 Estimating Carbon Requirement

1.2.3.1 Overview of Carbon Estimation Procedures

Obtaining the carbon requirement (M_c or M_{eq}) is not as straightforward as determining the other adsorber design parameters. When estimating the carbon charge, the sophistication of the approach used depends on the data and calculational tools available.

One approach for obtaining the carbon requirement is a rigorous one which considers the unsteady-state energy and mass transfer phenomena occurring in the adsorbent bed. Such a procedure necessarily involves a number of assumptions in formulating and solving the problem. Such a procedure is beyond the scope of this Manual at the present time, although ongoing work in the Agency is addressing this approach.

In preparing this section of the Manual, we have adopted a rule-of-thumb procedure for estimating the carbon requirement. This procedure, while approximate in nature, appears to have the acceptance of vendors and field personnel. It is sometimes employed by adsorber vendors to make rough estimates of carbon requirement and is relatively simple and easy to use. It normally yields results incorporating a safety margin, the size of which depends on the bed depth (short beds would have less of a safety margin than deep beds), the effectiveness of regeneration, the particular adsorbate and the presence or absence of impurities in the stream being treated.

1.2.3.2 Carbon Estimation Procedure Used in Manual

The rule-of-thumb carbon estimation procedure is based on the "working capacity" (W_c , lb VOC/lb carbon). This is the difference per unit mass of carbon between the amount of VOC on the carbon at the end of the adsorption cycle and the amount remaining on the carbon at the end of the desorption cycle. It should not be confused with the "equilibrium capacity" (W_{eq}) defined above in Section 1.1.3. Recall that the equilibrium capacity measures the capacity of virgin activated carbon when the VOC has been in contact with it (at a constant temperature and partial pressure) long enough to reach equilibrium. In adsorber design, it would not be feasible to allow the bed to reach equilibrium. If it were, the outlet concentration would rapidly increase beyond the allowable outlet (or "breakthrough") concentration until the outlet concentration reached the inlet concentration. During this period the adsorber would be violating the emission limit. With non-regenerable (cannister) type systems, placing multiple vessels in a series can substantially decrease concerns of breakthrough.

The working capacity is some fraction of the equilibrium capacity. Like the equilibrium adsorptivity, the working capacity depends upon the temperature, the VOC partial pressure, and the VOC composition. The working capacity also depends on the flow rate and the carbon bed parameters.

The working capacity, along with the adsorption time and VOC inlet loading, is used to compute the carbon requirement for a cannister adsorber or for an intermittently operated fixed-bed adsorber as follows:

$$M_{c_i} = \frac{m_{voc}}{w_c} \theta_A \quad (1.13)$$

where

m_{voc} = VOC inlet loading (lb/h)

Combining this with Equations 1.10 and 1.11 yields the general equation for estimating the system total carbon charge for a continuously operated system:

$$M_c = \frac{m_{voc}}{w_c} \theta_A \left(1 + \frac{N_D}{N_A} \right) \quad (1.14)$$

Values for w_c may be obtained from knowledge of operating units. If no value for w_c is available for the VOC (or VOC mixture) in question, the working capacity may be estimated at 50% of the equilibrium capacity, as follows:

$$w_c \approx 0.5w_{e(max)} \quad (1.15)$$

where

$w_{e(max)}$ = the equilibrium capacity (lb VOC/lb carbon) taken at the adsorber inlet (i.e., the point of maximum VOC concentration).

(Note: To be conservative, this 50% figure should be lowered if short desorption cycles, very high vapor pressure constituents, high moisture contents significant amounts of impurities, or difficult-to-desorb VOCs are involved. Furthermore, the presence of strongly adsorbed impurities in the inlet VOC stream may significantly shorten carbon life.)

As Equation 1.14 shows, the carbon requirement is directly proportional to the adsorption time. This would tend to indicate that a system could be designed with a shorter adsorption time to minimize the carbon requirement (and equipment cost). There is a trade-off here not readily apparent from Equation 1.14, however. Certainly, a shorter adsorption time would require less carbon. But, it would also mean that a carbon bed would have to be desorbed more frequently. This would mean that the regeneration steam would have to be supplied to the bed(s) more frequently to remove (in the long run) the same amount of VOC. Further, each time the bed is regenerated

the steam supplied must heat the vessel and carbon, as well as drive off the adsorbed VOC. And the bed must be dried and cooled after each desorption, regardless of the amount of VOC removed. Thus, if the bed is regenerated too frequently, the bed drying/cooling fan must operate more often, increasing its power consumption. Also, more frequent regeneration tends to shorten the carbon life. As a rule-of-thumb, the optimum regeneration frequency for fixed-bed adsorbers treating streams with moderate to high VOC inlet loadings is once every 8 to 12 hours.[1]

1.3 Estimating Total Capital Investment

Entirely different procedures should be used to estimate the purchased costs of fixed-bed and cannister-type adsorbers. Therefore, they will be discussed separately.

1.3.1 Fixed-Bed Systems

As indicated in the previous section, the purchased cost is a function of the volumetric flow rate, VOC inlet and outlet loadings, the adsorption time, and the working capacity of the activated carbon. As Figure 3.1 shows, the adsorber system is made up of several different items. Of these, the adsorber vessels and the carbon comprise from one-half to nearly 90% of the total equipment cost. (See Section 1.3.1.3.) There is also auxiliary equipment, such as fans, pumps, condensers, decanters, and internal piping. But because these usually comprise a small part of the total purchased cost, they may be “factored” from the costs of the carbon and vessels without introducing significant error. The costs of these major items will be considered separately.

1.3.1.1 Carbon Cost

Carbon Cost, C_c , in dollars (\$) is simply the product of the initial carbon requirement (M_c) and the current price of carbon. As adsorber vendors buy carbon in very large quantities (million-pound lots or larger), their cost is somewhat lower than the list price. For larger systems (other than cannister) Calgon reports typical carbon costs to be \$0.75 to \$1.25 for virgin carbon and \$0.50 to \$0.75 for reactivated carbon (mid-1999 dollars). A typical of \$1.00/lb is used in the calculation below.[5][10] Thus:

$$C_c = 1.00 M_c \quad (1.16)$$

1.3.1.2 Vessel Cost

The cost of an adsorber vessel is primarily determined by its dimensions which, in turn, depend upon the amount of carbon it must hold and the superficial gas velocity through the bed that must be maintained for optimum adsorption. The desired superficial velocity is used to calculate the cross-sectional area of the bed perpendicular to the gas flow. An acceptable superficial velocity is established empirically, considering desired removal efficiency, the carbon particle size and bed

porosity, and other factors. For example, one adsorber vendor recommends a superficial bed velocity of 85 ft/min[9], while an activated carbon manufacturer cautions against exceeding 60 ft/min in systems operating at one atmosphere.[7] Another vendor uses a 65 ft/min superficial face velocity in sizing its adsorber vessels.[10] Lastly, there are practical limits to vessel dimensions which also influence their sizing. That is, due to shipping restrictions, vessel diameters rarely exceed 12 feet, while their length is generally limited to 50 feet.[10]

The cost of a vessel is usually correlated with its weight. However, as the weight is often difficult to obtain or calculate, the cost may be estimated from the external surface area. This is true because the vessel material cost—and the cost of fabricating that material—is directly proportional to its surface area. The surface area (S , ft²) of a vessel is a function of its length (L , ft) and diameter (D , ft), which in turn, depend upon the superficial bed face velocity, the L/D ratio, and other factors.

Most commonly, adsorber vessels are cylindrical in shape and erected horizontally (as in Figure 1.1). Vessels configured in this manner are generally subjected to the constraint that the carbon volume occupies no more than 1/3 of the vessel volume [9][10]. It can be shown that this constraint limits the bed depth to no more than:

$$\text{Maximum bed depth} \approx \frac{\pi D}{12} \quad (1.17)$$

The vessel length, L , and diameter, D , can be estimated by solving two relationships, namely, (1) the equation relating carbon volume, and thus vessel volume, to L and D , and (2) the equation relating volumetric flow rate, superficial velocity, and cross-section normal to flow. If one assumes that the carbon bulk density is 30 lb/ft³, then one can show that:

$$D = \frac{0.127 M_c v_b}{Q} \quad (1.18)$$

$$L = \frac{7.87}{M'_c} \left(\frac{Q'}{v_b} \right)^2 \quad (1.19)$$

where

D	=	vessel diameter (ft)
L	=	vessel length (ft)
v_b	=	bed superficial velocity (ft/min)
M_c	=	carbon requirement <i>per vessel</i> (lbs)
Q	=	volumetric flow rate <i>per adsorbing vessel</i> (acfm)

Because the constants in Equations 1.18 and 1.19 are not dimensionless, one must be careful to use the units specified in these equations.

Although other design considerations can result in different values of L and D , these equations result in L and D which are acceptable from the standpoint of "study" cost estimation for horizontal, cylindrical vessels which are larger than 2-3 feet in diameter.

The carbon requirement and flow rate for each adsorber vessel can be calculated as follows:

$$M_c = \frac{M_e}{(N_A + N_D)} \quad (1.20)$$

$$Q = \frac{Q}{N_A}$$

At gas flow rates (Q) of less than 9,000 scfm, it is usually more feasible to erect the adsorber vessels vertically instead of horizontally.[10] If so, the vessel diameter can be calculated from the volumetric flow rate per adsorbing vessel and the bed superficial velocity as follows:

$$D = \left(\frac{4Q'}{\pi v_b} \right)^{1/2} \quad (1.21)$$

The vertical vessel length will depend principally on the carbon bed thickness. Additional space must be included below the carbon bed for bed support and above and below the bed for distribution and disengaging of the gas stream and for physical access to the carbon bed. In smaller diameter vessels, access to both sides of the bed is usually not required. However, 1 to 1 1/2 feet must be provided on each side for gas distribution and disengagement, or 2 to 3 feet overall. For longer vessels, 2 to 3 feet at each end of the vessel is typically provided for access space.

Given the mass of carbon in the bed, the carbon bulk density, and the bed diameter (i.e., the cross-sectional area normal to flow), determining the carbon bed thickness is straight forward using the following equation:

$$t_b = \frac{\text{volume of carbon}}{\text{cross-sectional area normal to flow}} = \frac{\left(\frac{M_c}{\rho_b} \right)}{\left(\frac{Q'}{v_b} \right)} \quad (1.22)$$

where

$$\rho_b = \text{carbon bulk density (lb/ft}^3\text{, assume 30 lb/ft}^3\text{)}$$

The vessel length is, therefore,

$$L = t_b + t_{a,g} \quad (1.23)$$

where

$$\begin{aligned} t_{a,g} &= \text{access / gas distribution allowance} \\ &= 2 \text{ to } 6 \text{ feet (depending on vertical vessel diameter)} \end{aligned}$$

Finally, use the following equation to calculate the surface area of either a horizontal or vertical vessel:

$$(1.24)$$

$$C_v = 271 S^{0.778} \quad (1.25)$$

where

$$C_v = \text{vessel cost (fall 1999 \$), F.O.B. vender}^5$$

and

$$97 \leq S \leq 2110 \text{ ft}^2 \quad (1.25a)$$

These units would be made of 304 stainless steel, which is the most common material used in fabricating adsorber vessels. [9][10] However, to obtain the cost of a vessel fabricated of another material, multiply C_v by an adjustment factor (F_m). A few of these factors are listed in Table 1.2.

1.3.1.3 Total Purchased Cost

As stated earlier, the costs of such items as the fans, pumps, condenser, decanter, instrumentation, and internal piping can be factored from the sum of the costs for the carbon and vessels. Based on four data points derived from costs supplied by an equipment vendor [10], we found that, depending on the total gas flow rate (Q), the ratio (R_c) of the total adsorber equipment cost to the cost of the vessels and carbon ranged from 1.14 to 2.24. These data points spanned a gas flow rate range of approximately 4,000 to 500,000 acfm. The following regression formula fit these four points:

$$R_c = 5.82 Q^{-0.133} \quad (1.26)$$

⁵ Two vendors provided information for the 1999 updates, neither felt that modifications to the capital costs of adsorber system between 1989 and 1999 were appropriate. The major change for 1999 was a decreases in the price of carbon.[4][5]

Table 1.2: Adjustment Factors to Obtain Costs for Fabricated Material

Material	F _m Factor	Reference(s)
Stainless steel, 316	1.3	[7,8,9]
Carpenter 20 CB-3	1.9	[9]
Montel-400	2.3	[7,9]
Nickel-200	3.2	[9]
Titanium	4.5	[9]

where

Q is in the range of 4, 000 to 500,000 acfm
Correlation coefficient (r) = 0.872

Similar equations can be developed for other vessel shapes, configurations, etc.

Based on vendor data, we developed a correlation between adsorber vessel cost and surface area:[10]

The total adsorber equipment cost (C_A) would be the product of R_e and the sum of the carbon and vessel costs, or:

$$C_A = R_e [C_c + C_v (N_A + N_D)] \quad (1.27)$$

1.3.1.4 Total Capital Investment

As discussed in Section 1, in the methodology used in this Manual, the total capital investment (TCI) is estimated from the total purchased cost via an overall direct/indirect installation cost factor. A breakdown of that factor for carbon adsorbers is shown in Table 1.3. As Section 1.2 indicates, the TCI also includes costs for land, working capital, and off-site facilities, which are not included in the direct/indirect installation factor. However as these items are rarely required with adsorber systems, they will not be considered here. Further, no factors have been provided for site preparation (SP) and buildings (Bldg.), as these site-specific costs depend very little on the purchased equipment cost.

Table 1.3: Capital Cost Factors for Carbon Adsorbers [11]

Direct Costs	
Purchased equipment costs	
Adsorber + auxiliary equipment ^a	As estimated, A
Instrumentation ^b	0.10 A
Sales taxes	0.03 A
Freight	0.05 A
Purchased equipment cost, PEC	B = 1.18 A
Direct Installation costs	
Foundations & supports	0.08 B
Handling & erection	0.14 B
Electrical	0.04 B
Piping	0.02 B
Insulation	0.01 B
Painting	0.01 B
Direct installation costs	0.30 B
Site preparation	As required, SP
Buildings	As required, Bldg.
Total Direct Costs, DC	1.30 B + SP + Bldg.
Indirect Costs (installation)	
Engineering	0.10 B
Construction and field expenses	0.05 B
Contractor fees	0.10 B
Start-up	0.02 B
Performance test	0.01 B
Contingencies	0.03 B
Total Indirect Costs, IC	0.31 B
Total Capital Investment = DC + IC	1.61 B + SP + Bldg.

- ^a Ductwork and any other equipment normally not included with unit furnished by adsorber vendor.
^b Instrumentation and controls often furnished with the adsorber, and thus included in the EC.

Note that the installation factor is applied to the total purchased equipment cost, which includes the cost of such auxiliary equipment as the stack and external ductwork and such costs as freight and sales taxes (if applicable). ("External ductwork" is that ducting needed to convey the exhaust gas from the source to the adsorber system, and then from the adsorber to the stack. Costs for ductwork and stacks are shown elsewhere in this Manual) Normally, the adjustment would also cover the instrumentation cost, but this cost is usually included with the adsorber equipment cost. Finally, note that these factors reflect "average" installation conditions and could vary considerably, depending upon the installation circumstances.

1.3.2 Cannister Systems

Once the carbon requirement is estimated using the above procedure, the number of cannisters is determined. This is done simply by dividing the total carbon requirement (M_c) by the amount of carbon contained by each cannister (typically, 150 lbs.). This quotient, rounded to the next highest digit, yields the required number of cannisters to control the vent in question.

Costs for a typical cannister (Calgon's Ventsorb®) are listed in Table 1.4. These costs include the vessel, carbon, and connections, but do not include taxes, freight, or installation charges. Note that the cost per unit decreases as the quantity purchased increases. Each cannister contains Calgon's "BPL" carbon (4 x 10 mesh), which is commonly used in industrial adsorption. However, to treat certain VOCs, more expensive specialty carbons (e.g., "FCA 4 x 10") are needed. These carbons can increase the equipment cost by 60% or more.[6] As is indicated in the caption of Table 1.4, these prices are in mid-1999 dollars.

The price of 180 pound carbon cannisters is approximately \$700 in small quantities and approximately \$600 (mid -1999 dollars) in larger quantities. [5] Current trends are toward the use of larger cannisters. Calgon supplies large cannisters of 1,000 to 2,000 pound capacity where the carbon is typically exchanged in the field. Calgon reports costs per pound of carbon ranging from \$0.50 to \$2.00 depending on mesh, activity and type with a conservative median price of \$1.50 per pound. Calgon also reports the widespread use of larger non-regenerable fixed beds either 12 feet in diameter (113 square feet capable of handling 6,000 cfm) and 8x20 foot beds (160 square feet capable of handling 8,000 cfm). These non-regenerable fixed bed absorbers are usually atmospheric designs made of thin steel with an internal coating to inhibit corrosion. For 1,000 pound cannisters, Calgon reports typical installation costs of \$3,200 and equipment costs of \$5,600 and for 2,000 pound cannisters these costs are \$4,600 and \$7,800 respectively. For

Table 1.4: Equipment Costs (Mid 1999\$) for a
Typical Canister Adsorber [5]

Quantity	Equipment Costs for Each Piece* in Dollars (\$)
1-3	679
4-9	640
10-29	600
30	585

* These costs are F.O.B., Pittsburgh, PA. They do not include taxes and freight charges.

onsite carbon replacement services, Calgon estimates carbon costs to be \$2.00 to \$2.50 per pound for virgin carbon and \$1.50 to \$1.80 for reactivated carbon. Annual maintenance costs are reported to range from 3% to 10% of the installed capital costs.

As fewer installation materials and labor are required to install a cannister unit than a fixed-bed system, the composite installation factor is consequently lower. The only costs required are those needed to place the cannisters at, and connect them to, the source. This involves a small amount of piping only; little or no electrical work, painting, foundations, or the like would be needed. Twenty percent of the sum of the cannister(s) cost, freight charges, and applicable sales taxes would cover this installation cost.

1.4 Estimating Total Annual Cost

As Section of this Manual explains, the total annual cost is comprised of three components: direct costs, indirect costs, and recovery credits. These will be considered separately.

1.4.1 Direct Annual Costs

These include the following expenditures: steam, cooling water, electricity, carbon replacement, operating and supervisor labor, and maintenance labor and materials. Of these, only electricity and solid waste disposal or carbon replacement/regeneration would apply to the cannister-type adsorbers.

1.4.1.1 Steam

As explained in Section 1.1, steam is used during the desorption cycle. The quantity of steam required will depend on the amount of carbon in the vessel, the vessel dimensions, the type and amount of VOC adsorbed, and other variables. Experience has shown that the steam requirement ranges from approximately 3 to 4 lbs of steam/lb of adsorbed VOC.[9][10] Using the midpoint of this range, we can develop the following expression for the annual steam cost:

$$C_s = 3.50 \times 10^{-3} m_{voc} \theta_s p_s \quad (1.28)$$

where

C_s	=	steam cost (\$/yr)
θ_s	=	system operating hours (h/yr)
m_{voc}	=	VOC inlet loading (lbs/h)
p_s	=	steam price (\$/thous. lbs)

If steam price data are unavailable, one can estimate its cost at 120% of the fuel cost. For example, if the local price of natural gas were \$5.00/million BTU, the estimated steam price would be \$6.00/million BTU which is approximately \$6.00/thousand lbs. (The 20% factor covers the capital and annual costs of producing the steam.)

1.4.1.2 Cooling Water

Cooling water is consumed by the condenser in which the steam-VOC mixture leaving the desorbed carbon bed is totally condensed. Most of the condenser duty is comprised of the latent heat of vaporization (ΔH_v) of the steam and VOC. As the VOC ΔH_v are usually small compared to the steam ΔH_v , (about 1000 BTU/lb), the VOC ΔH_v may be ignored. So may the sensible heat of cooling the water-VOC condensate from the condenser inlet temperature (about 212°F) to the outlet temperature. Therefore, the cooling water requirement is essentially a function of the steam usage and the allowable temperature rise in the coolant, which is typically 30° to 40°F.[9] Using the average temperature rise (35°F), we can write:

$$C_{cw} = 3.43 \frac{C_s}{p_s} p_{cw} \quad (1.29)$$

where

$$\begin{aligned} C_{cw} &= \text{cooling water cost (\$/yr)} \\ p_{cw} &= \text{cooling water price (\$/thous. gal.)} \end{aligned}$$

If the cooling water price is unavailable, use \$0.15 to \$0.30/thousand gallons.

1.4.1.3 Electricity

In fixed-bed adsorbers, electricity is consumed by the system fan, bed drying/cooling fan, cooling water pump, and solvent pump(s). Both the system and bed fans must be sized to overcome the pressure drop through the carbon beds. But, while the system fan must continuously convey the total gas flow through the system, the bed cooling fan is only used during a part of the desorption cycle (one-half hour or less).

For both fans, the horsepower needed depends both on the gas flow and the pressure drop through the carbon bed. The pressure drop through the bed (ΔP_b) depends on several variables, such as the adsorption temperature, bed velocity, bed characteristics (e.g., void fraction), and thickness. But, for a given temperature and carbon, the pressure drop per unit thickness depends solely on the gas velocity. For instance, for Calgon's "PCB" carbon (4 x 10 mesh), the following relationship holds:[8]

$$\frac{\Delta P_b}{t_b} = 0.03679 v_b + 1.107 \times 10^{-4} v_b^2 \quad (1.30)$$

where

$$\begin{aligned} \Delta P_b / t_b &= \text{pressure drop through bed (inches of water/foot of carbon)} \\ v_b &= \text{superficial bed velocity (ft/min)} \end{aligned}$$

As Equation 1.22 shows, the bed thickness (t_b , ft) is the quotient of the bed volume (V_b) and the bed cross-sectional area (A_b). For a 30 lb/ft³ carbon bed density, this becomes:

$$t_b = \frac{V_b}{A_b} = \frac{0.0333 M'_c}{A_b} \quad (1.31)$$

(For vertically erected vessels, $A_b = Q/v_b$, while for horizontally erected cylindrical vessels, $A = LD$.) Once ΔP_b is known, the system fan horsepower requirement (hp_{sf}) can be calculated:

$$hp_{sf} = 2.50 \times 10^{-4} Q \Delta P_s \quad (1.32)$$

where

$$\begin{aligned} Q &= \text{gas volumetric flow through system (acfm)} \\ \Delta P_s &= \text{total system pressure drop} = \Delta P_b + 1 \end{aligned}$$

(The extra inch accounts for miscellaneous pressure losses through the external ductwork and other parts of the system.[9]⁶ However, if extra long duct runs and/or preconditioning equipment are needed, the miscellaneous losses could be much higher.)

This equation incorporates a fan efficiency of 70% and a motor efficiency of 90%, or 63% overall.

The horsepower requirement for the bed drying/cooling fan (hp_{cf}) is computed similarly. While the bed fan pressure drop would still be ΔP_b , the gas flow and operating times would be different. For typical adsorber operating conditions, the drying/cooling air requirement would be 50 to 150 ft³/lb carbon, depending on the bed moisture content, required temperature drop, and other factors. The operating time (θ_{cf}) would be the product of the drying/cooling time per desorption cycle and the number of cycles per year. It can be shown that:

$$\theta_{cf} = 0.4 \theta_D \left(\frac{N_A \theta_A}{\theta_A} \right) \quad (1.33)$$

(The "0.4" allows for the fact that as a rule-of-thumb, approximately 40% of the desorption cycle is used for bed drying/cooling.)

The cooling water pump horsepower requirement (hp_{cwp}) would be computed as follows:

$$hp_{cwp} = \frac{2.52 \times 10^{-4} q_{cw} H s}{\eta} \quad (1.34)$$

where

q_{cw}	=	cooling water flow (gal/min)
H	=	required head (nominally 100 feet of water)
s	=	specific gravity of fluid relative to water at 60°F
η	=	combined pump-motor efficiency.

The annual operating hours for the cooling water pump (1_{cwp}) would be computed using Equation 1.33, after substituting "0.6" for 0.4. The 0.6 factor accounts for the fact that the cooling water pump is only used during the steaming portion of the regeneration, while the condenser is in operation.

Equation 1.34 may also be used to compute the solvent pump horsepower requirement. In the latter case, the flow (q_s) would be different of course, although the same head—100 ft. of water—could be used. The specific gravity would depend on the composition and temperature of the condensed solvent. For example, the specific gravity of toluene at 100°F would be approximately 0.86 at 70°F. (However, the solvent pump horsepower is usually very small—usually < 0.1 hp.—so its electricity consumption can usually be neglected.)

Once the various horsepower are calculated, the electricity usage (in kWh) is calculated, by multiplying each horsepower value by 0.746 (the factor for converting hp to kilowatts) and the number of hours each fan or pump operates annually. For the system fan, the hours would be the annual operating hours for the system (θ_s). But, as discussed above, the operating times for the bed drying/cooling fan and cooling water pump would be different.

To obtain the annual electricity cost, simply multiply kWh by the electricity price (in \$/kWh) that applies to the facility being controlled.

For cannister units, use Equation 1.32 to calculate the fan horsepower requirement. However, instead of P_b use the following to compute the total cannister pressure drop P_c inches of water:[7]

$$\Delta P_c = 0.0471 Q_c + 9.29 \times 10^{-4} Q_c^2 \quad (1.35)$$

⁶ To obtain a more precise estimate of ductwork pressure drop, refer to Section 2 of this Manual.

where

Q_c = flow through the cannister (acfm).

1.4.1.4 Carbon Replacement

As discussed above, the carbon has a different economic life than the rest of the adsorber system. Therefore, its replacement cost must be calculated separately. Employing the procedure detailed in Section 1, we have:

$$CRC_c = CRF_c (1.08 C_c + C_{cl}) \quad (1.36)$$

where

CRF_c = capital recovery factor for the carbon
 1.08 = taxes and freight factor
 C_c, C_{cl} = initial cost of carbon (F.O.B. vendor) and carbon replacement labor cost, respectively (\$)

The replacement labor cost covers the labor cost for removing spent carbon from vessels and replacing it with virgin or regenerated carbon. The cost would vary with the amount of carbon being replaced, the labor rates, and other factors. For example, to remove and replace a 50,000 pound carbon charge would require about 16 person-days, which, at typical wage rates, is equivalent to approximately \$0.05/lb replaced.[13]

A typical life for the carbon is five years. However, if the inlet contains VOCs that are very difficult to desorb, tend to polymerize, or react with other constituents, a shorter carbon lifetime—perhaps as low as *two* years—would be likely.[1] For a five-year life and 7% interest rate, $CRF_c = 0.2439$.

1.4.1.5 Solid Waste Disposal

Disposal costs are rarely incurred with fixed-bed adsorbers, because the carbon is almost always regenerated in place, not discarded. The carbon in cannister units should also be regenerated in most cases. For larger vessels, common practice is for a carbon vendor to pick up the spent carbon and replace it with fresh carbon. The spent carbon is then returned to a central facility for regeneration. EPA encourages both solvent recovery and reuse of spent carbon as pollution prevention and waste minimization techniques.

In some cases, the nature of the solvents, including their extremely hazardous nature or the difficulty in desorbing them from the carbon may make disposal the preferred option. In these cases, an entire cannister—carbon, drum, connections, etc.—may be shipped to a secure landfill. The cost of landfill disposal could vary considerably, depending on the number of cannisters disposed of, the location of the landfill, etc. Based on data obtained from two large landfills, for instance, the disposal cost would range from approximately \$35 to \$65 per cannister excluding transportation costs.[14][15]

1.4.1.6 Operating and Supervisory Labor

The operating labor for adsorbers is relatively low, as most systems are automated and require little attention. One-half operator hour per shift is typical.[12] The annual labor cost would then be the product of this labor requirement and the operating labor wage rate (\$/h) which, naturally, would vary according to the facility location, type of industry, etc. Add to this 15% to cover supervisory labor, as Section 1.2 suggests.

1.4.1.7 Maintenance Labor and Materials

Use 0.5 hours/shift for maintenance labor [12] and the applicable maintenance wage rate. If the latter data are unavailable, estimate the maintenance wage rate at 110% of the operating

labor rate, as Section 1 suggests. Finally, for maintenance materials, add an amount equal to the maintenance labor, also per Section 1.

1.4.2 Indirect Annual Costs

These include such costs as capital recovery, property, taxes, insurance, overhead, and administrative costs ("G&A"). The capital recovery cost is based on the equipment lifetime and the annual interest rate employed. (See Section 1.2 for a thorough discussion of the capital recovery cost and the variables that determine it.) For adsorbers, the system lifetime is typically ten years, except for the carbon, which, as stated above, typically needs to be replaced after five years. Therefore, when figuring the system capital recovery cost, one should base it on the installed capital cost less the cost of replacing the carbon (i.e., the carbon cost plus the cost of labor necessary to replace it). Substituting the initial carbon and replacement labor costs from Equation 1.36, we obtain:

$$CRC_s = [TCI - (1.08C_c + C_{cl})] CRF_s \quad (1.37)$$

where

CRC_s	=	capital recovery cost for adsorber system (\$/yr)
TCI	=	total capital investment (\$)
1.08	=	taxes and freight factor
C_c, C_{cl}	=	initial carbon cost (F.O.B. vendor) and carbon replacement cost, respectively (\$)
CRF_s	=	capital recovery factor for adsorber system (defined in Section 1.2).

For a ten-year life and a 7% annual interest rate, the CRF_s would be 0.1424.

As Section 1.2 indicates, the suggested factor to use for property taxes, insurance, and administrative charges is 4% of the TCI . Finally, the overhead is calculated as 60% of the sum of operating, supervisory, and maintenance labor, and maintenance materials.

The above procedure applies to cannister units as well, except in those case where the entire unit and not just the carbon is replaced. The piping and ducting cost can usually be considered a capital investment with a useful life of ten years. However, whether the cannister itself would be treated as a capital or an operating expense would depend on the particular application and would need to be evaluated on a case-by-case basis.

1.4.3 Recovery Credits

These apply to the VOC which is adsorbed, then desorbed, condensed, and separated from the steam condensate. If the recovered VOC is sufficiently pure, it can be sold. However, if the VOC layer contains impurities or is a mixture of compounds, it would require further treatment, such as distillation. Purification and separation costs are beyond the scope of this chapter. Needless to say, the costs of these operations would offset the revenues generated by the sale of the VOC. Finally, as an alternative to reselling it, the VOC could be burned as fuel and valued accordingly. In any case, the following equation can be used to calculate these credits:

$$RC = m_{voc} \theta_s P_{voc} E \quad (1.38)$$

where

RC	=	recovery credit (\$/yr)
m_{voc}	=	VOC inlet loading (lbs/h)
θ_s	=	system operating hours (h/yr)
P_{voc}	=	resale value of the recovered VOC (\$/lb)
E	=	adsorber VOC control efficiency

By definition, the efficiency (E) is the difference between the inlet and outlet VOC mass loading, divided by the inlet loading. However, during an adsorption cycle the outlet VOC loading will increase from essentially zero at the start of the cycle to the breakthrough concentration at the end of the cycle. Because the efficiency is a function of time, it should be calculated via integration over the length of the adsorption cycle. To do this would require knowledge of the temporal variation of the outlet loading during the adsorption cycle. If this knowledge is not available to the Manual user, a conservative approximation of the efficiency may be made by setting the outlet loading equal to the breakthrough concentration.

1.4.4 Total Annual Cost

Finally, as explained in Section 1, the total annual cost (TAC) is the sum of the direct and indirect annual costs, less any recovery credits, or:

$$TAC = DC + IC - RC \quad (1.39)$$

1.4.5 Example Problem

A source at a printing plant emitting 100 lb/h of toluene is to be controlled by a carbon adsorber. The plant proposes to operate the adsorber in a continuous mode for 8,640 h/yr (360 days). While operating, two carbon beds will be adsorbing, while a third will be desorbing/on stand by. For its convenience, the plant has selected adsorption and desorption times of 12 and 5 hours, respectively. The total waste gas flow is 10,000 acfm at the adsorber inlet conditions (one atmosphere and 77°F). The waste gas contains negligible quantities of particulate matter and moisture. Further, the applicable VOC regulation requires the adsorber to achieve a mean removal efficiency of 98% during the entire adsorption cycle. Finally, assume that the recovered toluene is recycled at the source. Estimate the total capital investment and total annual cost for the adsorber system.

Carbon Working Capacity: At the stated flow and pollutant loading, the toluene inlet concentration is 710 ppm. This corresponds to a partial pressure of 0.0104 psia. Substituting this partial pressure and the toluene isotherm parameters (from Table 1) into Equation 1, we obtain an equilibrium capacity of 0.333 lb/lb. By applying the rule-of-thumb discussed above (page 4-19), we obtain a working capacity of 0.167 lb/lb (*i.e.*, 0.333/2).

Carbon Requirement: As stated above, this adsorber would have two beds on-line and a third off-line. Equation 3.12 can answer this question. Substitution of the adsorption time and numbers of adsorbing and desorbing beds yields:

$$\text{Desorption time} = \theta_D \leq \theta_A \left(\frac{N_D}{N_A} \right) = 12h \times 0.5 = 6h$$

Because the stated desorption time (5 hours) is less than 6 hours, the proposed bed configuration is feasible. Next, calculate the carbon requirement (M_c) from Equation 3.14:

$$M_c = \frac{m_{voc}}{w_c} \theta_A \left(1 + \frac{N_D}{N_A} \right) = \frac{100 \text{ lb/h} \times (12 \text{ h}) \times (1 + 0.5)}{0.167 \text{ lb/lb}} = 10,800 \text{ lbs}$$

From Equation 3.16, the carbon cost is:

$$C_c = 1.00 M_c = \$10,800$$

Adsorber Vessel Dimensions: Assume that the vessels will be erected horizontally and select a superficial bed velocity (v_b) of 75 ft/min. Next, calculate the vessel diameter (D), length (L), and surface area (S) from Equations 3.18, 3.19, and 3.24, respectively. [Note: In these equations, $M'_c = M_c (N_A + N_D) = 3,600 \text{ lb}$ and $Q = Q/N_A = 5,000 \text{ acfm}$.]

$$D = \frac{0.127 M'_c v_b}{Q} = \frac{0.127 (3,600) (75)}{5,000} = 6.86 \text{ ft}$$

$$L = \frac{7.87}{M'_c} \left(\frac{Q}{v_b} \right)^2 = \frac{7.87}{3,600} \left(\frac{5,000}{75} \right)^2 = 9.72 \text{ ft}$$

$$S = \pi D \left(L + \frac{D}{2} \right) = 283 \text{ ft}^2$$

Because S falls between 97 and 2,110 ft², Equation 1.25 can be used to calculate the cost per vessel, C_v (assuming 304 stainless steel construction). Thus:

$$C_v = 271 S^{0.778} = \$21,900$$

Adsorber Equipment Cost: Recall that the adsorber equipment cost is comprised of the adsorber vessels, carbon, and the condenser, decanter, fan, pumps and other equipment usually included in the adsorber price. The cost of the latter items are “factored” from the combined cost of the vessels and carbon. Combining Equations 1.26 and 1.27, we have:

$$C_A = 5.82 Q^{-0.133} \left[C_c + (N_A + N_D) C_v \right]$$

Substitution of the above values yields:

$$C_A = \$130,800$$

Cost of Auxiliary Equipment: Assume that costs for the following auxiliary equipment have been estimated from data in other parts of the Manual:

Ductwork	\$16,500
Dampers	7,200
Stack	8,500
Total	\$32,000

Total Capital Investment: The total capital investment is factored from the sum of the adsorber unit and auxiliary equipment cost, as displayed in Table 1.5. Note that no line item cost has been shown for instrumentation, for this cost is typically included in the adsorber price.

Therefore:

$$\text{Purchased Equipment Cost} = \text{"B"} = 1.08 \times \text{"A"} = 1.08 \times (\$130,800 + \$32,200) = \$176,040$$

And:

$$\text{Total Capital Investment (rounded)} = 1.61 \times \text{"B"} = \$283,400$$

Annual Costs: Table 1.5 gives the direct and indirect annual costs for the carbon adsorber system, as calculated from the factors in Section 1.1.4. Except for electricity, the calculations in the table show how these costs were derived. The following discussion will deal with the electricity cost.

First, recall that the electricity includes the power for the system fan, bed drying/cooling fan, and the cooling water pump. (The solvent pump motor is normally so small that its power consumption may be neglected.) These consumptions are calculated as follows:

System fan is calculated from Equation 1.32:

$$kWh_{sf} = 0.746 kW/hp \times 250 \times 10^{-4} Q \Delta P_s \theta_s$$

Table 1.5: Capital Cost Factors for Carbon Adsorber System Example Problem

Cost Item	Factor
Direct Costs	
Purchased equipment costs	
Adsorber vessels and carbon	\$130,800
Auxiliary equipment	<u>32,200</u>
Sum = A	\$163,000
Instrumentation, 0.1 A	
Sales taxes, 0.03 A	4,890
Freight, 0.05 A	<u>8,150</u>
Purchased equipment cost, PEC	\$176,040
Direct installation costs	
Foundations & supports, 0.08 B	14,083
Handling & erection, 0.14 B	24,646
Electrical, 0.04 B	7,042
Piping, 0.02 B	3,521
Insulation for ductwork, 0.01 B	1,760
Painting, 0.02 B	<u>1,760</u>
Direct installation costs	\$52,812
Site preparation	
Buildings	
Total Direct Costs, DC	\$228,852
Indirect Costs (installation)	
Engineering, 0.10 B	17,604
Construction and field expenses, 0.05 B	8,802
Contractor fees, 0.10 B	17,604
Start-up, 0.02 B	3,521
Performance test, 0.01 B	1,760
Contingencies, 0.03 B	<u>5,281</u>
Total Indirect Costs, IC	\$54,572
Total Capital Investment (rounded)	\$283,400

^a The cost for this is included in the adsorber equipment cost.

But:

$$\Delta P_s \text{ (inches water)} = \Delta P_s + 1 = t_b (0.03679 v_b + 1.107 \times 10^{-4} v_b^2) + 1$$

(The latter expression was derived from Equation 1.30, assuming that the carbon used in this example system is Calgon's "PCB", 4 x 10 mesh size.)

By assuming a carbon bed density, of 30 lb/ft³, Equation 1.31 can be used to calculate the bed thickness (t_b):

$$\text{Bed thickness} = t_b = \frac{0.0333 M'_c}{A_b} = \frac{0.0333 M'_c}{LD} = 1.80 \text{ ft}$$

Thus:

$$\Delta P_s = 1 + 1.80 (0.03679 \times 75 + 1.107 \times 10^{-4} \times 75^2) = 7.09 \text{ inches}$$

and finally:

$$\begin{aligned} kWh_{sf} &= 0.746 \times 2.5 \times 10^{-4} \times 7.09 \text{ in.} \times 10,000 \text{ acfm} \times 8,640 \text{ h/yr} \\ &= 114,200 \text{ kWh/yr} \end{aligned}$$

Bed drying/cooling fan: During the drying/cooling cycle, the pressure drop through the bed also equals P_b . However, as Section 1.4.1.3 indicates, the flow and operating time are different. For the air flow, take the midpoint of the range (100 ft³ air/lb carbon) and divide by 2 hours (the bed drying/cooling time), yielding: 100 ft³/lb x 3,600 lbs x 1/120 min = 3,000 acfm. Substituting this into Equation 1.32 results in:

$$2.50 \times 10^{-4} \times 7.09 \text{ inches} \times 3,000 \text{ acfm} = 5.32 \text{ hp}$$

From Equation 1.33, we get:

$$\Theta_{cf} = 0.4 \times 5h \times 2 \times \frac{8,640h}{12h} = 12h$$

Thus:

$$kWh_{cf} = 0.746 kW/hp \times 5.32hp \times 2,880h = 11,400 kWh/yr$$

Cooling water pump: The cooling water pump horsepower is calculated from Equation 1.34. Here, $\eta = 63\%$ and $H = 100$ ft. The cooling water flow (q_{cw}) is the quotient of the annual cooling water requirement and the annual pump operating time. From the data in Table 1.6, we obtain the cooling water requirement: 10,400,000 gal/yr. The pump annual operating time is obtained from Equation 1.33 (substituting 0.6 for 0.4), or $cwp = (0.6)(5 h)(2)(8,640)/12 = 4,320$ h/yr.

Thus:

$$hp_{cwp} = \frac{(2.52 \times 10^{-4}) (100 ft)}{0.63} \times \frac{10,400,000 gal/yr}{4,320 h/yr \times 60 min/yr} = 1.60hp$$

Thus:

$$hp_{cwp} = \frac{(2.52 \times 10^{-4}) (100 ft)}{0.63} \times \frac{10,400,000 gal/yr}{4,320 h/yr \times 60 min/yr} = 1.60hp$$

And:

$$kWh_{cwp} = 0.746 kW/h \times 1.60hp \times 4,320 h/yr = 5,160 kWh/yr$$

Summing the individual power consumptions, we get the value shown in Table 1.5: 131,000kWh/yr

Recovery Credit: As Table 3.6 indicates, a credit for the recovered toluene has been taken. However, to account for miscellaneous losses and contamination, the toluene is arbitrarily valued at one-half the November 1989 market price of \$0.0533/lb(= \$111/ton).[16]

Total Annual Cost: The sum of the direct and indirect annual costs, less the toluene recovery credit, yields a net total annual cost of \$76,100. Clearly, this “bottom line” is very sensitive to the recovery credit and, in turn, the value given the recovered toluene. For instance, if it had been valued at the full market price (\$221/ton), the credit would have doubled and the total annual cost would have been \$29,200. Thus when incorporating recovery credits, it is imperative to select the value of the recovered product carefully.

Table 1.6: Annual Costs for Carbon Adsorber Systems, Example Problem

Cost Item	Calculations	Cost
Direct Annual Costs, DC		
Operating Labor		
Operator	0.5h/shift x 3 shifts/day x 360 days/yr x \$12/hr	\$6,480
Supervisor	15% of operator = 0.15 x 6,480	970
Operating materials		
Maintenance Labor	0.5h/shift x 3 shifts/day x 360 days/yr x \$13.20/hr	7,130
Material	100% of maintenance labor	7,130
Replacement Parts, Carbon	(5-year life)	
Replacement Labor	0.2439 (\$0.05/lb x 10,800 lb)	130
Carbon Cost ^a	0.2439 (\$21,600 x 1.08)	5,690
Utilities		
Electricity	\$0.06 kWh x 131,000 kWh/yr	7,860
Steam	3.5 lb/lb VOC x \$6/103 x 100 lb VOC/hr x 8,640 hr/yr	18,140
Cooling Water	3.43 gal/lb steam x [(3.5 x 100 x 8,640) lb steam x \$0.20/103 gal.] / yr	2,070
Total DC		\$55,600
Indirect Annual Costs, IC		
Overhead	60% of sum of operating labor, maintenance labor, & maintenance materials = 0.6 (6,480 + 970 + 7,130 + 7,130)	13,030
Administrative charges	2% of Total Capital Investment = 0.02 (\$316,000)	6,320
Property tax	1% of Total Capital Investment = 0.01 (\$316,000)	3,160
Insurance	1% of Total Capital Investment = 0.01 (\$316,000)	3,160
Capital recovery ^b	0.1424 [316,000 - 0.05 (10,800) - 1.08 (21,600)]	41,600
Total IC		\$67,270
Recovery Credit (toluene)		(46,820)
Total Annual Cost (rounded)		\$76,100

^a The 1.08 factor is for freight and sales taxes.

^b The capital recovery cost factor, CRF, is a function of the adsorber or equipment life and the opportunity cost of the capital (i.e., interest rate). For example, for a 10 year equipment life and a 7% interest rate, CRF = 0.1424.

References

- [1] Correspondence: Robert L. Stallings and William Klotz (Research Triangle Institute, Research Triangle Park, NC) to William M. Vatauvuk (U.S. EPA, OAQPS, Research Triangle Park, NC), June 24, 1986.
- [2] Calvert, Seymour and Englund, Harold M. (eds.), *Handbook of Air Pollution Control Technology*, John Wiley & Sons, New York, 1984, pp. 135-192.
- [3] *Handbook of Chemistry and Physics*, 54th Edition, The Chemical Rubber Company, Cleveland, 1973-74, pp. D85-D92.
- [4] Correspondence: Wayne G. Schulinger and Georgiana Riley (TIGG Corporation, Pittsburgh, PA) to Janet Groeber (SAIC, Cincinnati, OH), October 11, 1999.
- [5] Correspondence: Mark H. Stenzel (Calgon Carbon Corporation, Pittsburgh, PA) to Janet Groeber (SAIC, Cincinnati, OH), August 24, 1999.
- [6] "Calgon Ventsorb® for Industrial Air Purification" (Bulletin 23-56a), Calgon Corporation, Pittsburgh, 1986.
- [7] *Adsorption Handbook*, Calgon Corporation, Pittsburgh, 1980.
- [8] Rogers, Tony, "Comparison of BED SIZE and Calgon Adsorption Isotherms", Research Triangle Institute (Research Triangle Park, NC), January 20, 1988.
- [9] Correspondence: Richard Selznick (Baron Blakeslee, Inc., Westfield, NJ) to William M. Vatauvuk (U.S. EPA, OAQPS, Research Triangle Park, NC), April 23, 1986.
- [10] Correspondence: Denny Clodfelter (M&W Industries, Inc., Rural Hall, NC) to William M. Vatauvuk (U.S. EPA, OAQPS, Research Triangle Park, NC), September 25, 1989.
- [11] Matley, Jay (ed.), *Modern Cost Engineering*, McGraw-Hill Publications Co., New York, 1984, p. 142.
- [12] Vatauvuk, William M. and Neveril, Robert, "Estimating Costs of Air Pollution Control Systems, Part II: Factors for Estimating Capital and Operating Costs," *Chemical Engineering*, November 3, 1980, pp. 157-162.

- [13] Telephone conversation: Robert L. Stallings (Research Triangle Institute, Research Triangle Park, NC) with William M. Vatauvuk (U.S. EPA, OAQPS, Research Triangle Park, NC), September 11, 1986.
- [14] Correspondence: William Kitto (Chemwaste, Sulphur, LA) to William M. Vatauvuk (U.S. EPA, OAQPS, Research Triangle Park, NC), July 25, 1986.
- [15] Correspondence: Jerry Locklear (GSX, Pinewood, SC) to William M. Vatauvuk (U.S. EPA, OAQPS, Research Triangle Park, NC), July 25, 1986.
- [16] *Chemical Marketing Reporter*, December 2, 1989.

TECHNICAL REPORT DATA <i>(Please read Instructions on reverse before completing)</i>		
1 REPORT NO. 452/B-02-001	2	3 RECIPIENT'S ACCESSION NO.
4 TITLE AND SUBTITLE The EPA Air Pollution Control Cost Manual		5. REPORT DATE January, 2002
		6. PERFORMING ORGANIZATION CODE
7 AUTHOR(S) Daniel Charles Mussatti		8 PERFORMING ORGANIZATION REPORT NO.
9 PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Air Quality Standards and Strategies Division Innovative Strategies and Economics Group Research Triangle Park, NC 27711		10 PROGRAM ELEMENT NO.
		11 CONTRACT/GRANT NO.
12 SPONSORING AGENCY NAME AND ADDRESS Director Office of Air Quality Planning and Standards Office of Air and Radiation U.S. Environmental Protection Agency Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Final
		14 SPONSORING AGENCY CODE EPA/200/04
15. SUPPLEMENTARY NOTES Updates and revises EPA 453/b-96-001, OAQPS Control Cost Manual, fifth edition (in English only)		
16. ABSTRACT In Spanish, this document provides a detailed methodology for the proper sizing and costing of numerous air pollution control devices for planning and permitting purposes. Includes costing for volatile organic compounds (VOCs); particulate matter (PM); oxides of nitrogen (NOx); SO2, SO3, and other acid gasses; and hazardous air pollutants (HAPs).		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Economics Cost Engineering cost Sizing Estimation Design	Air Pollution control Incinerators Absorbers Adsorbers Filters Condensers Electrostatic Precipitators Scrubbers	
18 DISTRIBUTION STATEMENT Release Unlimited	19 SECURITY CLASS (Report) Unclassified	21. NO OF PAGES 1,400
	20 SECURITY CLASS (Page) Unclassified	22. PRICE

EXHIBIT N



November 01, 2016

Quote: NP110116907

Elizabeth Forsyth
Earth Justice
800 Wilshire Blvd, Suite 1000
Los Angeles, CA 90017

Dear Elizabeth,

Thank you for your interest in the products and services of Calgon Carbon Corporation. We are pleased to respond to your request for quotation.

Product: OVC 4X8

Packaging: 1,000 lb super sacks

Quantity: 10,000 lbs

Price: \$1.87/lb

Payment Terms: Net 30 days or MasterCard, VISA, American Express or Discover cards

Freight: PPA

Availability: From inventory in Santa Fe Springs, CA

Carbon Acceptance Information: Calgon Carbon offers reactivation services so that the spent carbon can be recycled through the reactivation process. Before we can accept the spent carbon for reactivation, we are required by our operating permits to sample and analyze all spent carbons prior to their initial shipment to ensure a safe and environmentally friendly reactivation process. Each approval is then required to be revalidated through submittal of a new profile and sample for testing at a frequency of not less than once every five years. The standard fees for initial approval and project revalidation are as follows:

Non-RCRA Acceptance: \$400.00

RCRA Acceptance: \$1,000.00

In rare instances, additional testing is required and additional costs will apply. Carbon Acceptance testing will take approximately 3-4 weeks once the sample and paperwork are received by Calgon Carbon Corporation. Reactivation is not available for impregnated activated carbons.

Spent Carbon Handling: The Fees listed above include handling of all spent carbon generated in the treatment application provided: 1) the spent carbon satisfies all spent carbon acceptance criteria established by Calgon Carbon; 2) the spent carbon is classified non hazardous as defined under the Federal Resource Conservation and Recovery Act (RCRA). If it is subsequently determined that the spent carbon generated is a Hazardous Waste as defined by RCRA, then the return of the spent carbon will be subject to a RCRA Spent Carbon Reactivation Fee in the amount of \$0.25 for each pound of spent carbon returned on a dry weight basis. The fee will be determined at the time an order is placed for exchange of activated carbon or at the

time a return of spent carbon is scheduled if purchase of replacement activated carbon is not required

This quote does not include any applicable taxes or freight. Standard lead time is 7-10 business days after receipt of a purchase order.

If "Rush Shipment" is necessary, there will be a service charge as follows:

- A flat fee of \$500 will be applied to every complete order that must ship the same day it is received. Order must be received before noon EST.
- A flat fee of \$400 will be applied to every complete order that must ship the day after it is received.
- A flat fee of \$300 will be applied to every complete order that must ship two days after it is received.

Quote is valid for 30 days.

Shipment must take place within 30 days after receipt of a purchase order.

Pricing beyond the terms stated above is subject to change. Calgon Carbon Corporation Terms and Conditions apply.

If you would like to proceed with this offer, please email or fax a purchase order or credit card information to customer relations at 412-787-6323 or customerrelations@calgoncarbon.com.

Be sure to include your shipping address, delivery date, and reference the above quotation number on your purchase order. Please contact me with any additional questions.

Sincerely,

Nicole Passarella
Calgon Carbon Corporation
Technical Account Representative I
NPassarella@calgoncarbon.com
412-787-6848

EXHIBIT O



White Paper

Carbon Adsorption & Reactivation:

Turning Obligation Into Opportunity in the Chemical Process Industry

Robert Deithorn

Product Market Director, Calgon Carbon Corporation



Chemical, petrochemical, and oil-refining plants are process-intensive operations with regulatory requirements to protect the surrounding water and air from the effects of industrial pollution. These external demands are matched by equally compelling internal pressures to address product purification needs, find alternatives to utilizing costly and often scarce fresh water in production processes, reduce the carbon footprint, and operate efficiently and profitably.



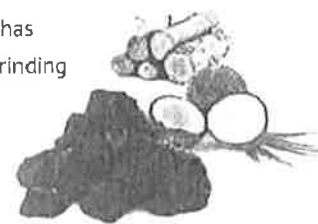
For more than 40 years, activated carbon, through a process called "physical adsorption," has proven to be a cost-effective material in the removal of organic contaminants from liquids and gases in both industrial process and environmental applications. Granular activated carbon (GAC) has a tremendous adsorptive capacity, an affinity for a wide variety of organics, the ability to be tailored to suit specific applications, and can be economically reactivated for reuse.

In the chemical process industry (CPI), GAC is widely used in liquid and gas purification, and to purify and reuse industrial process water. GAC can also be employed to meet regulatory requirements in wastewater treatment, groundwater remediation, and for volatile organic compound (VOC) abatement in vapor phase applications. One such example is the highly regulated benzene, a hazardous VOC. Additionally, recycling, or thermally reactivating spent carbon, gives CPI plants the opportunity to reduce cost and waste, save energy, lower CO₂ emissions, and conserve natural resources while reducing the long-term liability of spent-carbon disposal.

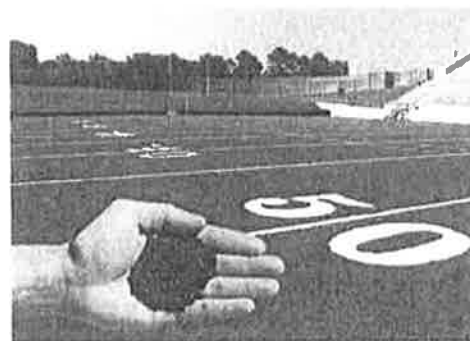
The use of GAC for organic contaminant removal from the liquid and vapor phase continues to grow as chemical companies seek the most cost-effective and proven solutions to address a host of applications within each plant. In fact, GAC has been classified as a U.S. Environmental Protection Agency (EPA) Best Available Technology (BAT) for removal of many organic contaminants.

Organics that are readily adsorbed by GAC include: aromatic solvents (benzene, toluene, and nitrobenzenes); chlorinated aromatics (PCBs, chlorobenzenes, and chloronaphthalene); phenols and chlorophenols; fuels (gasoline, kerosene, and oil); polynuclear aromatics, also known as PNAs, (acenaphthene and benzopyrenes); and pesticides and herbicides (DDT, aldrin, chlordane, and heptachlor).

The primary raw materials used to make GAC are materials with a high carbon content, such as coal, wood, peat, or coconut shells. A standard, unimpregnated, bituminous coal-based material is most often used for adsorption of organic contaminants in industrial applications because this material has a wide range of pore sizes to adsorb a broad variety of organic chemicals. Re-agglomerated carbon is generally preferred over direct activated because it is a more robust material, with a fully developed porosity, and, at the same time, has the necessary strength to withstand use and reuse. Re-agglomerated GAC is produced by grinding the raw material to a powder, adding a suitable binder for hardness, re-compacting, and crushing to the specified size. The carbon-based material is then thermally activated in a furnace using a controlled atmosphere and high heat. The final steps in production include screening to remove unwanted oversized and undersized material followed by packaging.



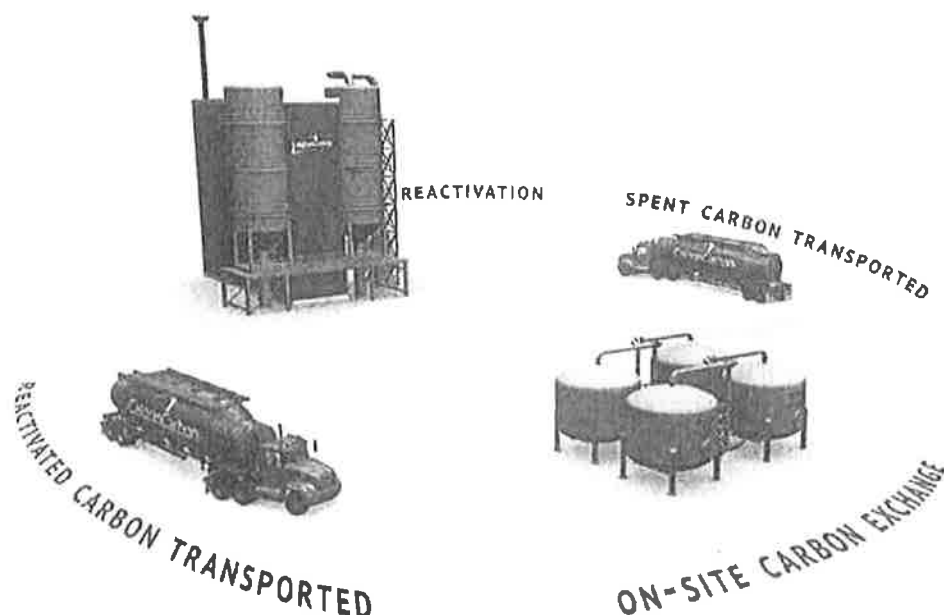
The resultant product has an incredibly large surface area per unit volume and a network of submicroscopic pores where adsorption takes place. The walls of the pores provide the surface layer carbon molecules that are essential for adsorption. GAC has the highest volume of adsorbing porosity of any material known to humankind. Amazingly, five grams of reagglomerated carbon have the surface area of one football field.



Adsorption is the adhesion of the molecules of liquids, gases, and dissolved substances to the surface of solids because of physical or chemical forces. Physical adsorption is the primary means by which GAC works to remove contaminants from liquids and gases. Carbon's highly porous nature provides a large surface area for contaminant molecules to collect. Physical adsorption occurs because all molecules exert attractive forces, especially those at the surface of a solid (carbon pores in this case), and these surface molecules seek other molecules to adhere to. Solid substances are called "adsorbents" and attracted surface molecules of a liquid or gas are called "adsorbates." Adsorption effectiveness can be measured through capacity tests that measure the mass of adsorbate removed per unit weight or unit volume of activated carbon.

To ensure optimal GAC adsorption operations, installations at chemical plants typically include carbon adsorption equipment with the associated transfer piping. These systems can be operated with single or multi-stage treatment vessels, depending on the desired treatment objective.

During the carbon adsorption process, the available surface and pores of the GAC begin to fill up with chemicals. At some point, the required performance criteria will not be met, and the carbon is said to be "spent." At a manufacturing plant, this is determined when the effluent quality of the carbon treatment vessel begins to



approach the quality of the influent. The spent activated carbon must be disposed of and replaced, or recycled for reuse, so the carbon adsorption process can continue.

Three options for dealing with spent carbon include shipping it to a landfill or incinerator, regeneration, or reactivation. The landfill and incineration options necessitate the purchase of new carbon and may not be environmentally friendly. Regeneration and reactivation allow for reuse of the activated carbon. Regeneration and reactivation are possible options for a company looking to reduce its carbon footprint and save money. Regeneration (chemical or steam) may be more favorable than the landfill option, but only if it is used to recover and reuse a valuable adsorbate. It is generally not applied for strictly environmental reasons because it is usually less efficient than reactivation. High-temperature thermal reactivation is the preferred method for reuse of the activated carbon because if the reactivation is efficient, most of the adsorption capacity can be restored.

Due to the "green" environmental advantages and bottom-line cost savings that it offers, reactivation has been growing in use throughout the CPI. If profiling and testing identify reactivation as an option, plants can have their spent activated carbon recycled for reuse, eliminating the costs and long-term liability associated with disposal. Reactivation utilizes a high-temperature thermal process, whereby adsorbed organic compounds are destroyed, and the GAC's adsorptive capacity is restored. Reactivating spent GAC results in a cost savings of typically 20 to 40 percent over the purchase of virgin GAC.

Reactivation is better for the environment, significantly reducing the CO₂ footprint associated with the production and use of virgin GAC. With reactivation, up to 95 percent of the virgin activated carbon capacity is recovered. The reactivated carbon can then be blended with a small amount of virgin carbon to make up for the minor loss of volume. GAC has a nearly infinite reactivation capability, meaning it rarely ends up in a landfill or incinerator. Depending on the economics and volume of spent activated carbon produced, some plants may have on-site reactivation facilities or contract for reactivation and reuse services from a company that offers off-site reactivation service.

Reactivated carbon is considered an environmentally friendly product since reactivation produces only about 20 percent of the greenhouse gases generated by the production of virgin activated carbon.

Field Services associated with reactivation programs include: spent activated carbon analyses; spent activated carbon removal and packaging; non-hazardous and/or hazardous waste handling; transportation to the reactivation plant; carbon vessel inspection with minor repair; and vessel reloading with reactivated carbon.

Reactivated carbon is considered an environmentally friendly product since reactivation produces only about 20 percent of the greenhouse gases generated by the production of virgin activated carbon. Reactivation ends the chain of custody for adsorbed contaminants, eliminating spent carbon handling and disposal liabilities. Some facilities may qualify to receive environmental credits issued by regulatory agencies for waste minimization due to the fact that reactivated carbon is considered a recovered resource.

In addition to the "green" solution offered by reactivated carbon, GAC adsorption offers many other environmental benefits to chemical manufacturers. GAC technology helps plants maintain emissions permit levels, meet state and local environmental requirements, and adhere to EPA guidelines and regulations such as the Resource Conservation and Recovery Act (RCRA), the Clean Water Act, and the Clean Air Act, particularly its NESHAP (National Emission Standard for Hazardous Air Pollutants) program and benzene regulations.

A successful long-term growth strategy requires that companies take a proactive stance with regard to sustainability. While carbon adsorption is considered a “mature” technology used to treat many of the same organic contaminants for over four decades, one area that has the potential to expand its use is contaminants of emerging concern (CECs) and other increasing environmental issues. The EPA maintains a contaminant candidate list (CCL) of CECs, detailing substances not currently regulated by the federal government but which the EPA may consider for future regulation. Some carbon manufacturers provide forward-looking assistance to the CPI by monitoring the EC list, offering a preview of what federal and state rules may require for treatment technologies, and utilizing their R&D component to advance the use of activated carbon and treatment methods for removing ECs.

A successful long-term growth strategy requires that companies take a proactive stance with regard to sustainability.

How does a chemical facility determine if GAC adsorption is the best technology to meet its organic contaminant removal needs? Prior to the design of a GAC system, a pilot plant study should be performed to determine if the technology will meet discharge permit

requirements, and to quantify optimum flow rate, bed depth, and operating capacity on FOR a particular liquid or gas. This information is required to determine the dimensions and number of carbon contactors required for continuous treatment. Carbon manufacturers can then accurately predict the viability, capital and operational costs of applying adsorption treatment at a chemical plant. These costs can be compared to other applicable technologies.

Carbon adsorption and reactivation systems are at work in chemical, petrochemical, and oil-refining plants around the world. The case studies below detail three examples of GAC adsorption programs undertaken recently at facilities in the United States.

Every chemical manufacturer must balance the ongoing demands of achieving regulatory compliance while maintaining operational profitability and creating high-quality products. For organic contaminant removal from liquids and gases in industrial process applications, GAC remains a proven, reliable way to satisfy environmental management demands and product purification needs. Furthermore, use of reactivated carbon instead of virgin carbon for organic contaminant removal offers additional cost efficiencies and environmental benefits.

GAC Adsorption Case Studies

Case Study 1: VOC Abatement in Maintenance, Startup, Shutdown (MSS)

Challenge: Regulations in many states require VOC abatement to meet permit requirements associated with MSS activities. A large oil refinery in Texas needed to comply with MSS permit requirements established by the Texas Commission on Environmental Quality (TCEQ). The refinery also wanted to mitigate hazardous waste liability, reduce its carbon footprint, and contain costs. Refineries typically use vacuum trucks equipped with sumps and vacuum tanks to clean up gasoline spills at the facility, an activity classified under MSS. The laydown yard where the vacuum tanks and sumps are cleaned can also be classified as an MSS site. Gasoline contains the volatile aromatic compounds benzene, toluene, ethylbenzene, and xylene (BTEX), among others. The majority of the VOC abatement for MSS conformance is needed for benzene, which is highly regulated under the Benzene National Emission Standard for Hazard Air Pollutants (NESHAP). It is necessary to capture the VOC emissions coming off the vacuum tanks and at the laydown yard.

Solution: Because the EPA designates use of a carbon adsorption system as a Best Available Control Technology (BACT) for VOC remediation at chemical facilities, many refineries select this option. The vacuum trucks are equipped with a scrubber for primary treatment followed by carbon adsorber canisters to provide secondary treatment of VOC emissions coming off the trucks and vacuum tanks. Each carbon canister typically holds 1,000 pounds of GAC for treating air sources up to 750 cfm.

At the laydown yard/MSS site, air movers typically consist of two carbon beds containing 12,500 pounds of GAC with a flow rate of 10,000 scfm for the high-volume air emissions. Reactivated vapor phase activated carbon is typically used in these emissions control activities. The reactivated carbon is a cost-effective alternative to virgin carbon. It also contributes to a lower overall CO₂ footprint for adsorption because it can be recycled and reused with the need for new raw materials.

This solution allowed the refinery to meet VOC environmental regulations and permit requirements, while reducing its carbon footprint and costs by using GAC adsorption technology along with off-site reactivation and reuse.

Case Study 2: Environmental Responsibility at a Chemical Facility in the Southern U.S.

Challenge: A large, multi-national chemical manufacturer was seeking an environmentally friendly industrial wastewater recycling and reclamation solution at one of its facilities in the Southern U.S. The plant wanted to reuse its process wastewater, thus decreasing its raw water intake from a nearby river and reducing its discharge volume to a local wastewater treatment plant.

The plant sought to reduce costs by purifying and reusing its industrial wastewater generated from the manufacturing processes. A principal concern was whether carbon adsorption could adequately purify the industrial wastewater for reuse due to the fact that the waste stream contained organic contaminants that were detrimental to their final product.

Solution: The chemical manufacturer was already using GAC adsorption technology to handle other product purification needs. After researching available options, it was determined that GAC offered the best potential for the removal of dissolved process contaminants and impurities in its industrial wastewater. So, in late 2011, the carbon manufacturer conducted an organic contaminant removal trial at the plant using a portable liquid treatment unit and acid-washed virgin GAC. When the trial results proved satisfactory, the plant decided to purchase a full-scale carbon adsorption system. The modular carbon adsorption system was configured as two adsorbers with connecting piping, with each adsorber containing 20,000 pounds of GAC and treating up to 100 gpm. The process wastewater was purified through GAC adsorption and recycled into the plant process, thereby reducing raw water intake from the nearby river as well as the volume of wastewater sent to the local wastewater treatment plant. In addition, the facility chose to have its spent activated carbon reactivated by the carbon manufacturer, who provides off-site reactivation services.

Through the use of a GAC adsorption system, the chemical manufacturer was able to remove organic contaminants effectively from its process wastewater, thereby purifying the water for reuse. In the process, the plant also demonstrated environmental responsibility by decreasing its raw water intake from a nearby river and reducing its influent at a local wastewater treatment plant. Additionally, by reducing its raw water intake, the plant minimized its impact on the river and allowed it to function in a more natural manner.

Case Study 3: Organic Compound Reduction in Plant Wastewater

Challenge: In 2011, a prominent chemical manufacturer invested a large amount of capital at its factory in the Southern U.S. to meet skyrocketing demand for one of its products. The product and its derivatives are used in a broad range of chemical compounds that have applications in industrial, consumer, agricultural, and pharmaceutical end-use products.

The plant was seeking a cost-saving alternative to wastewater disposal. If the factory could find an in-house treatment for the industrial wastewater to reduce its organic chemical content, the water could go to water treatment in the plant instead of disposal.

Solution: An engineer at the chemical facility contacted a carbon manufacturer after exploring available options for the organic contaminant removal in its wastewater. A solution with a rapid turnaround time from design to delivery was required. The carbon manufacturer quickly made a recommendation, conducted pilot testing for suitability, and installed a modular carbon adsorption system configured as two adsorbers with connecting piping, with each adsorber containing 20,000 pounds of GAC and treating up to 100 gpm. The system was custom-designed to allow process wastewater to be purified through GAC adsorption. Instead of virgin carbon, the refinery reduced its carbon footprint and costs by purchasing a large volume of reactivated-grade carbon and implementing an ongoing protocol for spent activated carbon reactivation by the carbon manufacturer. The chemical plant leased the carbon adsorption equipment from the carbon manufacturer, who also provided Field Service personnel for equipment maintenance and troubleshooting.

The chemical plant met its cost savings goal by selecting a carbon adsorption system that could effectively reduce and remove organic contaminants in its industrial wastewater so the water could go to water treatment in the plant instead of disposal. The use of reactivated GAC instead of virgin activated carbon also provided cost savings as well as a reduction in the carbon footprint when compared to the use of virgin activated carbon.



About Calgon Carbon Corporation

Calgon Carbon Corporation (NYSE: CCC) is a global leader in services and solutions for making water and air safer and cleaner and for purifying food, beverage, and industrial process streams. Headquartered in Pittsburgh, Pennsylvania, U.S., Calgon Carbon employs approximately 1,100 people at more than 15 carbon manufacturing, reactivation, and equipment fabrication facilities in the U.S., Asia, and Europe. The company also has more than 20 sales and service centers throughout the world. In Europe, Calgon Carbon is known as Chemviron Carbon.

Corporate Headquarters

Calgon Carbon Corporation

400 Calgon Carbon Drive
Pittsburgh, PA 15230, USA
Toll-Free 800-4CARBON
info@calgoncarbon-us.com

Calgon Carbon Japan

Central Building 8F, Kyobashi 11-5,
Chuo-ku, Tokyo 104-0031, Japan
Tel 81-3-5205-0664

Chemviron Carbon

European Operations of
Calgon Carbon Corporation
Zoning Industriel C de Feluy
B-7181 Feluy, Belgium
Tel +32 (0) 64 51 1811
Fax +32 (0) 64 54 1591

Calgon Carbon Asia

China

Shanghai Sales Office
Room 2008, No. 1468 Nan Jing Rd West
United Plaza, Shanghai, China 200040
Toll-Free 400 880 6068
Tel 86-21-6289-8100
Fax 86-21-6289-8120
chinasales@calgoncarbon-as.com

Singapore

9 Temasek Boulevard
#26-02 Suntec Tower Two
Singapore 038989
Tel +65 6221 3500
Fax +65 6221 3554
singaporesales@calgoncarbon-as.com

Taiwan

Room C, 12F., No. 303, Sec. 4
Chung Hsiao E. Road
Taipei, Taiwan 10696
Tel 886-2-2773-2346
Fax 886-2-2773-2347
taiwansales@calgoncarbon-as.com

EXHIBIT P

6011 East Pine Street, Lodi, CA to 6058 East Pine Street, Lodi, CA 95240 - Google Maps

6011 East Pine Street, Lodi, CA to 6058 East Pine Street,
Lodi, CA 95240

1 min
56 ft



via E Pine St

APPENDIX G

District Responses to Public Comments

Public's Comments on Proposed Project for the Installation of a New Fumigation Chamber

On December 2, 2016, the District received comments from Earthjustice on the proposed project. The comments and the District responses to each comment are given in the following section.

Comment #1

CEQA requires the preparation of an Environmental Impact Report (EIR) whenever a public agency proposes to approve a project that may have a significant effect on the environment. (Pub. Resources Code § 21151.) The Air District claims that this project is categorically exempt under CEQA's "common sense exemption" for projects that have insignificant environmental impacts (14 Cal. Code Regs. (CEQA Guidelines) § 15061, subd. (b)(3)), as well as under CEQA Guideline § 15301, which exempts minor alterations at existing facilities from CEQA review. Because neither exemption applies to this project, which releases 10,000 pounds a year of a highly and ozone-depleting toxic chemical into the community, the Air District must conduct CEQA review before approving this project.

CEQA's common sense exemption provides that projects are exempt from CEQA when "it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment." (CEQA Guidelines, § 15061, subd. (b)(3); *Muzzy Ranch*, 41 Cal.4th at pp. 386-87.) The Air District bears the burden in showing that this exemption is appropriate. (*Muzzy Ranch Co. v. Solano County Airport Land Use Com'n* (2007) 41 Cal.4th 372, 387; *Rominger v. County of Colusa* (2014) 229 Cal.App.4th 690, 704; Kostka & Zischke, Practice Under the Cal. Environmental Quality Act (2016) § 5.129, p. 5-120 [noting that the showing that must be made by the agency "is a stringent one"].)

Here, the District concluded, without analysis, that "the activity will not have a significant effect on the environment." (Authority to Construct Application Review at 15.) But the Air District has failed to show with "certainty" that there is no possibility of a significant environmental effect. Given the large quantities of a highly toxic and ozone depleting substance emitted without control by the project, it cannot be said with certainty that this project will not have a significant effect on the environment.

Response to Comment #1

CEQA requires each public agency to adopt objectives, criteria, and specific procedures consistent with CEQA Statutes and the CEQA Guidelines for

administering its responsibilities under CEQA, including the orderly evaluation of projects and preparation of environmental documents. The District adopted its *Environmental Review Guidelines* (ERG) in 2001. The basic purposes of CEQA are to:

- Inform governmental decision-makers and the public about the potential, significant environmental effects of proposed activities;
- Identify the ways that environmental damage can be avoided or significantly reduced;
- Prevent significant, avoidable damage to the environment by requiring changes in projects through the use of alternatives or mitigation measures when the governmental agency finds the changes to be feasible; and
- Disclose to the public the reasons why a governmental agency approved the project in the manner the agency chose if significant environmental effects are involved.

The District is the Lead Agency for this project because there is no other agency with broader statutory authority over this project. The District performed an assessment (this document) to determine whether or not any potential environmental impacts for this project are significant under CEQA. Further details of this analysis are presented below:

Criteria Pollutants - Operational Emissions: Permitted Sources

District implementation of New Source Review (NSR) ensures that there are no net increases in emissions above specified thresholds from New and Modified Stationary Sources for all nonattainment pollutants and their precursors from stationary source emissions which require District-issued permits. The project-related stationary source criteria pollutant emissions are below the District CEQA thresholds of significance for all pollutants (see table below):

Pollutant	CEQA Significance Thresholds for Permitted Equipment and Activities (tpy)	Proposed Project Potential to Emit (tpy)	Significant Criteria Emissions Under CEQA?
CO	100	0	NO
NOx	10	0	NO
VOC	10	5	NO
SOx	27	0	NO
PM10	15	0	NO
PM2.5	15	0	NO

Criteria Pollutants - Operational Emissions: Non-Permitted Sources

The non-permitted operational criteria emissions (i.e., from sources which are not subject to District permitting requirements) for the project, consisting of those emissions generated from new vehicle miles traveled or rail traffic, are below the District's established levels of significance for non-permitted equipment and activities, which are the same thresholds as those identified above for Permitted equipment and activities (e.g. 10 tons of NO_x per year). The proposed project is below the District's conservative significance screening threshold of 47 one-way truck trips per day, and is therefore below the significance threshold for all pollutants. In conclusion, operational emissions for non-permitted sources are below the District CEQA thresholds of significance for all pollutants.

Criteria Pollutants - Construction

A project may be subject to further District CEQA analysis if the project involves construction activities such as disturbing soil outside the perimeter of the existing facility. The project does not involve demolition, excavation, and/or grading construction activities that encompass an area exceeding 20,000 SF (inside or outside the perimeter of the existing facility). This project involves the installation of a fumigation chamber inside an existing building. As such, there would be minimal construction activities. Therefore, construction emissions would be considered to be below the District CEQA thresholds of significance.

Toxic Air Contaminants

As part of the application review process, the District performed a Risk Management Review (RMR). Conservative assumptions were utilized to determine the worst-case risk to all possible receptors. Please note that the values used to arrive at the project risk level have many safety factors built in. The purpose of those safety factors is to ensure that the most sensitive receptors (children, elderly, pregnant women and people with weakened immune systems) are protected.

In 2015, the state Office of Environmental Health Hazard Assessment (OEHHA) adopted changes to *Air Toxics Hot Spots Program Guidance Manual for the Preparation of Risk Assessments* (Risk Assessment Guidelines). These revisions were mainly designed to provide enhanced protection of children and other sensitive receptors.

To ensure the greatest health protection, the District's incorporated all of OEHHA's suggested revisions that increased calculated risk, but did not incorporate those changes that decreased calculated risk. The District's revised risk management policies, incorporated the following:

- More health protective 95th percentile breathing rate for both children AND

adults, instead of OEHHA's proposed 95th percentile for children only and 80th percentile for adults,

- More health protective 70-year residential exposure instead of OEHHA's proposed 30-year, unless the expected project life is shorter,
- More health protective 40-year worker exposure instead of OEHHA's proposed 25-year, unless the expected project life is shorter,
- More health protective receptor (point-specific) impacts instead of OEHHA's spatial averaging method,
- All of the OEHHA changes that increase calculated risk for children.

The District's current thresholds of significance for toxic air contaminant (TAC) emissions from the operations of both permitted and non-permitted sources are combined and presented in the following table.

Evaluated under these new methodologies, the proposed project health risk values are within acceptable limits (see table below), and as such, are not expected to pose a significant health risk to any receptor.

Maximally Exposed Individual risk Category	CEQA Significance Thresholds for Toxic Air Contaminant (TAC) Emissions	Proposed Project	Significant Toxic Air Contaminant Emissions Under CEQA?
*Carcinogens	≥ 20 in one million	N/A	NO
Non-Carcinogen (Acute)	≥ 1	0.68	NO
Non-Carcinogen (Chronic)	≥ 1	0.01	NO

*Carcinogens were not calculated since there are no risk factors associated with any of the Toxic Air Contaminants (TACs) for this project.

Other Impacts (e.g. Water Quality, Noise, Odor Nuisance, etc.)

The District assessed the other possible environmental impacts of the proposed project as well. The proposed project is below all of the District's established screening levels of significance for non-permitted equipment and activities (*District Policy APR 2010 - CEQA Implementation*). In addition, Rivermaid is a facility that processes and packages agricultural commodities, which already includes fumigation as an operational activity. The operation is an allowed-use by the County of San Joaquin, and is surrounded by similar industrial operations. As such, the District has concluded that the project will not have any significant adverse effects on the environment due to these other impacts.

Greenhouse Gases (GHGs)

Stationary Source GHGs:

The project involves the use of Methyl Bromide for fumigation. Methyl Bromide is not considered a greenhouse gas. As such the project would not result in an increase in project specific greenhouse gas emissions. Therefore, the project would have a less than cumulatively significant impact on global climate change.

Mobile Source GHGs:

On December 17, 2009, the District's Governing Board adopted a policy, APR 2005, *Addressing GHG Emission Impacts for Stationary Source Projects Under CEQA When Serving as the Lead Agency*, for addressing GHG emission impacts when the District is Lead Agency under CEQA and approved the District's guidance document for use by other agencies when addressing GHG impacts as lead agencies under CEQA. Under this policy, the District's determination of significance of project-specific GHG emissions is founded on the principal that projects with GHG emission reductions consistent with AB 32 emission reduction targets are considered to have a less than significant impact on global climate change. Consistent with District Policy 2005, projects complying with an approved GHG emission reduction plan or GHG mitigation program, which avoids or substantially reduces GHG emissions within the geographic area in which the project is located, would be determined to have a less than significant individual and cumulative impact for GHG emission.

The California Air Resources Board (ARB) adopted a Cap-and-Trade regulation as part of one of the strategies identified for AB 32. This Cap-and-Trade regulation is a statewide plan, supported by a CEQA compliant environmental review document, aimed at reducing or mitigating GHG emissions from targeted industries. Facilities required to comply with the Cap-and-Trade regulation are subject to an industry-wide cap on overall GHG emissions. Any growth in emissions must be accounted for under that cap such that a corresponding and equivalent reduction in emissions must occur to allow any increase. Further, the cap decreases over time, resulting in an overall decrease in GHG emissions.

Under District policy APR 2025, *CEQA Determinations of Significance for Projects Subject to ARB's GHG Cap-and-Trade Regulation*, the District finds that the Cap-and-Trade is a regulation plan approved by ARB, consistent with AB32 emission reduction targets, and supported by a CEQA compliant environmental review document. As such, consistent with District Policy 2005, projects complying with Cap-and-Trade

requirements are determined to have a less than significant individual and cumulative impact for GHG emissions.

Industries covered by Cap-and-Trade are identified in the regulation under section 95811, Covered Entities:

1. Group 1: Large industrial facilities

These types of facilities are subject to Cap and Trade, and the specific companies covered are listed at <http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm>, Section 95811 (a), under the "Publically Available Market Information" section (list maintained by the California Air Resources Board).

2. Group 2: Electricity generation facilities located in California, or electricity importers

These types of facilities are subject to Cap and Trade (section 95811, b).

3. Group 3: Suppliers of Natural Gas, Suppliers of Reformulated Gasoline Blendstock for Oxygenate Blending and Distillate Fuel Oil, Suppliers of Liquefied Petroleum Gas, and Suppliers of Blended Fuels

These entities are subject to Cap and Trade compliance obligations which must cover all fuels (except jet fuels) identified in section 95811 (c) through (f) of the Cap-and-Trade regulation delivered to end users in California, less the fuel delivered to covered entities (group 1 above).

Mobile source GHG emissions are subject to the Cap-and-Trade regulation. Therefore, as discussed above, consistent with District Policies APR 2005 and APR 2025, the District concludes that the GHG emissions increases associated with this project would have a less than significant individual and cumulative impact on global climate change.

District CEQA Findings:

As discussed above, the District reviewed and assessed if there would be any potential significant impacts to the environment, and determined that the proposed project will not result in a potentially significant impact to the environment. As such, the project is exempt per the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment (e.g.: general CEQA "common sense" exemption.)

In addition, the size of the proposed project is approximately 2,200 ft². CEQA Guideline for Categorical Exemptions, specifically 15301(e) (Existing Facilities), allows for addition to existing structures that will not result in an increase in size of existing structure (not to exceed 10,000 ft²). The size of the proposed project is less than the 10,000 ft² and is within the scope of the exemption. Additionally, the proposed project consists of operation and alteration of an existing facility, for the purpose of using the (Existing Facilities) exemption, "[t]he key consideration is whether the project would involve negligible or no expansion of an existing use" (CEQA Guidelines, §15301). The CEQA Guidelines do not define the term "negligible expansion". As explained in subdivision (e), the exemption includes "[a]dditions to existing structures provided that the addition will not result in an increase of more than: (1) 50 percent of the floor area of the structures before the addition, or 2,500 square feet, whichever is less; or (2) 10,000 square feet [under certain circumstances]..." (CEQA Guidelines, §15301, subd. (e)(1) & (e)(2)).

In conclusion, the District finds that the project is exempt per the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment (CEQA Guidelines §15061(b)(3)), and is also categorically exempt from the provisions of CEQA pursuant to CEQA Guideline §15301 (Existing Facilities).

In addition, Rivermaid has submitted additional comments for this ATC project, and the District concurs with Rivermaid's statement. See Appendix G3 for more details.

Comment #2

Methyl bromide is a highly toxic gas. Exposure to methyl bromide can cause convulsions, coma, and long-term neuromuscular and cognitive deficits. It is an odorless, colorless gas, which means that it lacks adequate warning properties, and significant exposures can occur before symptoms are evident. It has caused serious and sometimes fatal poisonings, including to workers using methyl bromide during fumigation. The project's use and venting of methyl bromide without control therefore has the obvious potential to "create a significant hazard to the public . . . through the routine . . . use . . . of hazardous materials," and the Air District must conduct environmental review under CEQA. (CEQA Checklist, § VIII(a).)

The Authority to Construct Application Review provides no evidence that this project will not present a significant public health and safety hazard. It fails entirely to evaluate the risks to workers at the fumigation site.

Response to Comment #2

The District agrees with the commenter that methyl bromide is a toxic substance; and in addition, the Office of Environmental Health Hazard Assessment (OEHHA) made the determination that Methyl Bromide is a hazardous substance. The commenter should note that the primary purpose of the District is to protect public health. As such, the District's risk management review process is very conservative. However, the District disagrees with the commenter that there is obvious potential for significant risk due to an increase in emissions. In fact, upon the conclusion of the District's risk management review, the project is less than significant.

As part of the ATC application review process, the District performed a Risk Management Review (RMR). Conservative assumptions were utilized to determine the worst-case risk to all possible receptors. Please note that the values used to arrive at the project risk level have many safety factors built in. The purpose of those safety factors is to ensure that the most sensitive receptors, such as children, elderly, pregnant women and people with weakened immune systems, are protected (see response to comment 1 for more detail).

Regarding on-site facility workers, the resulting risk exposure falls outside the scope of the District's jurisdiction. Onsite workers are protected by CAL/OSHA; and as such, their risk exposure is not evaluated by the District.

Comment #3

And while the Review includes a risk management report for offsite-receptors, as discussed in more detail in section IV, *infra*, the risk management report's conclusions are not supported because (1) it inaccurately calculates the distance to the closest receptor; (2) does not support its assumption that methyl bromide releases would be limited to 272.1 lbs/hour; and (3) its conclusions regarding the hazard risk at the facility are in conflict with earlier calculations at the same facility.

Response to Comment #3

The District has performed additional modeling which evaluates a short term location where the public may have access. The distance to the closest receptor is measured from the location of the new/modified unit to the closest receptor. For the Risk Management review conducted by the District, the distance from the emission unit to the closest residence is approximately 125 meters, to the South. The distance to the closest business receptor is approximately 110 meters, to the North. This analysis indicates that the risk will be below the District allowable levels.

In order to meet the requirements of the health risk assessment a condition has been added to the permit limiting Methyl Bromide emissions to no more than 300 lbs per day. Engineering calculations indicate that the maximum emission rate would be 272.1 lbs in any one hour. As such, a condition is placed to specifically limit to 272.1 lbs in any given rolling hour. Therefore, to ensure health risks will not exceed District allowable levels, permit conditions have been placed on the permit to lessen any potential impacts to sensitive receptors.

In regards to risk associated with earlier projects at the same facility, the district performed the assessment as proposed at the time. Any calculations and/or health risk associated with past projects was not evaluated at the time of this project. For accuracy purposes, the District utilizes the best available data at the time of processing any particular project.

Comment #4

Not only is methyl bromide highly toxic, it is a potent ozone-depleting substance. Under the Montreal Protocol, EPA must phase out most uses of methyl bromide entirely, and as of 2014, only 158 tons of methyl bromide remained for use in the United States. Although EPA's phase-out does not include quarantine and preshipment uses, these quarantine and preshipment uses are themselves limited, and should only be applications to meet "official requirements" and not "informal or purely contractual or commercial arrangements not required under official regulations." (Protection of Stratospheric Ozone: Process for Exempting Quarantine and Preshipment Applications of Methyl Bromide, 68 Fed. Reg. 238-01, 241 (Jan. 2, 2003).)

There is no evidence in the Authority to Construct Application Review that the use of methyl bromide in this project complies with the narrow exception for quarantine and preshipment uses of methyl bromide and is therefore consistent with the Montreal Protocol and domestic policy and regulations implementing the Protocol. Because the project has the potential to conflict with federal and international regulations and policy concerning ozone depletion, the Air District must conduct environmental review under CEQA. (See, e.g., CEQA Checklist, § III(a) [lead agencies must evaluate conflicts with air quality plans].) The common sense exemption to CEQA does not apply.

Response to Comment #4

Information was provided by the applicant that requires pre-shipment controls for cherries traveling to Japanese, Korean and Australian markets require the use of Methyl Bromide as the only acceptable fumigant. Therefore, the use of Methyl Bromide in this project indeed complies with the exception for pre-shipment

control purposes per CFR Title 40, Part 82, Subpart A §82.3, and to meet the international phytosanitary standards requirements¹. See information in Appendix G1 of this document.

Comment #5

The project is also not exempt from CEQA under the existing facilities exemption. The Section 15301 categorical exemption applies to the “operation, repair, maintenance . . . or minor alteration of existing public or private structures, facilities . . . involving *negligible or no expansion of use beyond that existing at the time of the lead agency’s determination.*” (CEQA Guidelines §15301, emphasis added.) Section 15301 plainly states that “[t]he key consideration is whether the project involves negligible or no expansion of an existing use.” (*Ibid.*) Section 15301 lists sixteen types of minor activities that may avail themselves of the exemption from environmental review. They include, but are not limited to: interior or exterior alterations “involving such things as interior partitions, plumbing, and electrical conveyances”; maintenance of existing highways and streets; and the “restoration or rehabilitation of deteriorated or damaged structures, facilities, or mechanical equipment to meet current standards of public health and safety.” (*Ibid.*)

Fumigation chambers resulting in the release of 10,000 pounds per year of methyl bromide are not listed on the enumerated categories of projects exempt under Guideline § 15301 and the Air District, therefore, may not completely forego environmental review. (CEQA Guidelines § 15301; *see also Azusa Land Reclamation Co. v. Main San Gabriel Basin Watermaster* (1997) 52 Cal.App.4th 1165, 1194-95 [landfill expansion did not fall within the categories enumerated by Guidelines].)

Further, the fumigation chamber proposed here does not otherwise qualify for the Section 15301 exemption, which only applies to projects with “negligible or no expansion of an existing use.” (CEQA Guidelines §15301.) This project will construct a new 2,200 square foot fumigation chamber, resulting in the release of 10,000 pounds per year of methyl bromide, and will more than double the VOC emissions of the facility. This is not a “negligible” expansion of an existing use. Moreover, the “rationale for the existing facilities exemption is that the environmental effects of the operation of such facilities must already have been considered.” (*Azusa Land*, 52 Cal.App.4th at 1194.) Here, there does not appear to be prior environmental review for the facility, making use of the existing facilities exemption particularly inappropriate. Accordingly, construction of the new fumigation chamber does not fit within the types of activities covered by the exemption – i.e., those involving *negligible* or *no* expansion.

¹ <http://ozone.unep.org/Publications/UNEP-Ozone-Secretariat-MP-Brochure.pdf>

Decisions interpreting the Section 15301 exemption confirm that it was meant to be limited to minor activities which, unlike the planned construction of the fumigation chamber, do not expand uses beyond those existing at the time an agency approves a particular project. For example, in *County of Amador v. El Dorado County Water Agency* (1999) 76 Cal. App.4th 931, 967, the court found that the transfer of ownership of a hydroelectric project and approval to use an additional 17,000 acre-feet of water was a “major change in focus” of the project, and did not fall within the Section 15301 exemption. The court recited the language of the Guidelines which states that “[t]he key consideration is whether the project involves negligible or no expansion of an existing use,” and found that because the project would enable additional water consumption, it did not constitute a “negligible expansion of current use.” (*Ibid.* at p. 967.) Similarly, in *Azusa Land*, the court concluded that a permit allowing reopening of a landfill for disposal of municipal solid waste did not qualify for the Section 15301 exemption. (52 Cal.App.4th at pp. 1194-95.) The permit would have allowed dumping of additional quantities of waste, thereby placing the activity outside the type of “minor alteration” allowed by the Guidelines. (*Ibid.* at p. 1194; *c.f.*, *Santa Monica Chamber of Commerce v. City of Santa Monica* (2002) 101 Cal.App.4th 786, 793 [exemption applied because “no additional parking spaces or structures are being added to the parking stock in the relevant area”].)

Just like in *County of Amador* and *Azusa Land*, construction of the fumigation chamber would provide the Rivermaid Trading with entirely new capacity to fumigate products, and would more than double the facility’s existing VOC emissions. Adding a new fumigation chamber and more than doubling emissions amounts to considerably more than a “negligible expansion of current use,” and the exemption cannot apply here. (*County of Amador*, 76 Cal.App.4th at p. 967.) Thus, to comply with CEQA, the Air District must conduct at least an initial study. (See CEQA Guidelines §15063, subd. (a); *Save Our Carmel River*, 141 al.App.4th at p. 688.)

Response to Comment #5

Although the proposed operation of fumigation chambers resulting in the release of less than significant amounts of methyl bromide is not listed in the enumerated categories of projects exempt under Guideline § 15301. Per CEQA Guidelines 15301, “The types of “existing facilities” itemized are not intended to be all-inclusive of the types of projects which might fall within Class 1” existing facilities exemption. The primary business of Rivermaid Trading Company is the processing and packing of agricultural commodities, which includes an existing methyl bromide fumigation operation. Furthermore, the size of the proposed project is approximately 2,200 square feet. The exemption under CEQA Guidelines 15301 (Existing Facilities) (e) allows for additions to existing structures that will not result in an increase in size of existing structure (not to exceed 10,000 square feet). The size of the proposed project is less than the

10,000 square feet. Therefore, both the expansion of an existing use, and the increase in size of the existing project are within the scope of the exemption. Please see response to comment #1 for additional information.

In addition, Rivermaid has submitted additional comments for this ATC project, and the District concurs with Rivermaid's statement. See Appendix G3 for more details.

Comment #6

Even if the existing facilities exemption applied—which it does not—a CEQA categorical exemption may not be invoked to forego environmental review where “there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances.” (CEQA Guidelines §15300.2, subd. (c).) This exception requiring CEQA review trumps an otherwise lawful categorical exemption from review where: (1) a fair argument can be made that there is a “reasonable possibility that the activity will have a significant effect on the environment,” and (2) this effect is due to “unusual circumstances.” (CEQA Guidelines 15300.2, subd. (c); *Berkeley Hillside Preservation v. City of Berkeley* (2015) 60 Cal.4th 1086, 1097-98.)

An unusual circumstance exists when the “project has some feature that distinguishes it from others in the exempt class, such as its size or location.” (*Berkeley Hillside Preservation*, 60 Cal.4th at 1105.) The existing facilities exemption typically covers ongoing operation, repair, or minor alterations of existing facilities. The construction of a new project to vent 10,000 pounds of a toxic chemical distinguishes this project from those typical of the existing facilities exemption, providing an unusual circumstance. (See *McQueen v. Bd. of Directors* (1988) 202 Cal.App.3d 1136, 1148-49 [“known existence of PCB and other hazardous wastes on property to be acquired is an unusual circumstance threatening the environment”], *disapproved on other grounds*, *W. States Petroleum Assn. v. Superior Court* (1995) 9 Cal.4th 559; *see also*, *Azusa Land*, 52 Cal.App.4th at p.1207 [risk of landfill contaminating groundwater constituted unusual circumstance].)

Once an “unusual circumstance” has been established, the party invoking the exception “need only show a reasonable possibility of a significant effect due to that unusual circumstance.” (*Berkeley Hillside*, 60 Cal.4th at p. 1105.) As explained above, this Project has a reasonable possibility of a significant environmental impact because it will expose workers and offsite receptors to a highly toxic chemical, and because use of methyl bromide may conflict with national and international law encouraging the phase out of this potent ozone-depleting gas. The Air District must conduct CEQA review.

Response to Comment #6

The primary function of the facility is processing and packing agricultural commodities, which already includes fumigation as an operational activity. The new secondary fumigation chamber is an additional emission unit to the existing operation. The proposed project is not considered to have an unusual circumstance.

Regardless, and as discussed in the Response to Comment #1 above, there is no potential significant impact to the environment. Please see response to comment #1 for additional information.

Comment #7

As discussed above, the Air District must conduct CEQA review on the potentially significant impacts of the project, which proposes to vent 10,000 pounds of methyl bromide into the surrounding community with no pollution controls. The Air District's review of significant impacts must include an analysis of alternatives to the project, as well as mitigation measures. (Public Resources Code §§ 21002, 21002.1(a), 21100(b)(4), 21150; Public Resources Code §§ 21002.1(a), 21100(b)(3); CEQA Guidelines § 15126.4.)

The Air District must review alternatives to fumigation with methyl bromide, including a "no-project" alternative. Several alternatives to methyl bromide exist as quarantine treatments for cherries, including control atmospheric heat treatments, introduction of carbon dioxide into storage chambers, generation of low oxygen atmospheres by burning oxygen, as well as other fumigant replacements. The Air District should also evaluate whether lower quantities of methyl bromide would still meet project objectives, and whether there are alternatives sites for the fumigation chamber located away from businesses and residences.

The Air District must also review and describe potential mitigation measures. At a minimum, the Air District must disclose and evaluate mitigation measures to restrict the amount of methyl bromide released into the atmosphere, as well as measures to ensure worker and community safety.

Response to Comment #7

The District performed an assessment (this document) for the proposed project. As discussed in the previous responses above, the District determined the project qualifies for the general CEQA "common sense" exemption since there are no potentially significant environmental impacts. Additionally, the proposed project also qualifies for the CEQA exemption 15301 (Existing Facilities).

Therefore, since the project was determined to be exempt from CEQA, CEQA does not require mitigation measures to be incorporated into the proposed project or potential project alternatives to be analyzed.

Regardless, the State's Department of Pesticide Regulation and the USDA hold authority in California to regulate fumigants in their pesticide uses, including determining whether alternatives should be used in specific applications of individual pesticides. The District did examine whether alternatives existed as a means of accomplishing the same pesticide goals while reducing air pollution emissions. District staff concluded that alternatives were not available for use in Rivermaid's operation, as the majority of the products that will be fumigated at the facility will be cherries exported to various countries in Asia, including Japan, Korea, and Australia, etc., which must be fumigated using Methyl Bromide (MeBr). Further, as discussed in response to comment #4 above, in order to meet the international phytosanitary standards requirements, no fumigant other than methyl bromide could be used in Rivermaid's operation.

The proposed new chamber will be located next to the existing chamber within the existing facility, which will result in the least possible health impact on receptors. Alternative sites would involve the relocation and/or construction of various support structures and equipment that would result in a much greater impact to the public.

United States Department of Agriculture (USDA) – Animal and Plant Health Inspection Service (APHIS) Treatment Manual², has specific requirements on the aeration period, the type of respiratory protection device to be used, and the gas concentration level inside the fumigation chamber before the chamber's door may be opened for operator reentry.

Table 2-5-4 of this manual states, if the gas concentration level in the chamber is 6 ppm or higher, the fumigator should perform the following to ensure worker safety: 1) conduct two additional air washes, 2) take gas concentration readings, 3) if concentration readings are 5 ppm or less, continue aeration for 30 minutes, 4) confirm the gas concentration remain at 5 ppm or less, and 6) release the commodity. The fumigator is required to keep records for all treatments conducted in the chamber and submit the records to the APHIS. Therefore, the MeBr concentration inside the chamber must reach 5 ppm or less (which is also the OSHA requirement) before the chamber door is allowed to open. The following conditions will be added to minimize emissions:

- The concentration of methyl bromide in the fumigation chamber shall not exceed 5 ppm at any time that the fumigation chamber doors are open. APHIS-approved thermal conductivity gas analyzer or infrared spectroscopy gas monitoring device shall be used to ensure compliance with this requirement. [District Rule 2201]

² https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf

- There shall be no emissions of methyl bromide from valves, flanges, or other connectors, and APHIS-approved leak detection device shall be used to ensure compliance with this requirement. [District Rule 2201]
- The permittee shall keep records of the data collected from all methyl bromide analyzers and leak detection devices to demonstrate compliance with the emissions limits on this permit. [District Rule 2201]

Comment #8

The Air District asserts that installation of a carbon absorption system, which would remove 95% of the methyl bromide from the atmosphere, is not cost effective, because the Air District's calculated cost of \$21,053/ton slightly exceeds the District's cost effectiveness threshold of \$17,500/ton. However, the Air District's assumptions regarding cost per pound of carbon is inflated, and its assumption of carbon absorption rate is overly conservative and conflicts with the Air District's own prior assumptions, leading to an overinflation of costs. Using more accurate cost assumptions and the Air District's prior prediction of carbon absorption rate, carbon absorption is cost effective. It must be adopted as BACT.

First, the Air District assumed the carbon would capture only 20% of its weight in VOCs, citing "verbal communication" with an unidentified "process engineer and vendor" in 2002. But in a prior application review for a methyl bromide fumigation chamber at the same facility, the Air District assumed a 30% adsorption ratio for methyl bromide per a "SDUPA study." Second, the Air District calculated the cost assuming that carbon is needed to capture 100% of the methyl bromide released, even while acknowledging that 5% of emissions go uncontrolled. Finally, the Air District assumed a relatively high cost per pound of carbon, citing a "verbal communication" to Calgon Carbon in 2009 (\$2.00/lb.). In contrast, EPA's official guidance for assuming costs of carbon filtration of VOCs states that a conservative median price for carbon is \$1.50 per pound, and our own recent inquiry to Calgon Carbon provided an written cost estimate of \$1.87 per pound.

Using these inputs, a carbon adsorption system would be cost effective.

Annual carbon requirement, assuming Air District's prior assumption that carbon can capture 30% of its weight and 5 % is uncaptured = $(.95 \times 10,000) / (.3) = 31,667$

The cost of carbon using EPA cost estimates = $31,667 \times 1.5 = \$47,500$

The cost of carbon using Calgon cost estimates = $31,667 \times 1.87 = \$59,217$

Cost of VOC reduction using EPA and Air District estimates = $\$47,500 / 4.75 \text{ tons} = \$10,000/\text{ton}$

Cost of VOC reduction using Calgon and Scientific literature estimates
=\$59,217/4.75 tons = **\$12,467/ton**

Accordingly, installation of a carbon absorption system is less than \$17,500/ton and therefore cost effective. It must be adopted as BACT.

Response to Comment #8

In response to the comment received, a more detailed cost effectiveness analysis is provided below.

Equipment Cost

The District received a cost quote on January 19, 2017 from Calgon Corporation, a carbon adsorption system supplier, for an activated carbon system sufficient to control 95% of the emissions from the proposed fumigation chamber. See Appendix G2 for details.

Per information provided by Calgon, two Protect RO-10 units connected in parallel is recommended for the proposed fumigation operation. Each Protect RO-10 unit holds 10,000 pounds of VPR 4X10 reactivated carbon. The cost of each Protect RO-10 unit filled with VPR 4X10 reactivated carbons is \$89,250. The capital cost of the carbon adsorption system is \$178,500 (\$89,250 x 2). This cost does not include sales tax, freight expenses, operational and maintenance costs, site preparation, etc.

In addition, the spent carbons contain MeBr which is considered a hazardous waste per Resource Conservation and Recovery Act (RCRA)³, and Calgon will charge one time RCRA hazardous reactivation testing fee of \$1,000 for the reactivation services.

The total initial capital investment = \$178,500 + \$1,000 = \$179,500

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10} - 1} \right] = 0.163$ per District policy, amortizing over 10 years at 10%

Therefore,
Annualized Capital Investment = \$179,500 x 0.163 = \$29,259

³ <https://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol27/xml/CFR-2012-title40-vol27-part261.xml>

Carbon Exchange Cost

Per information provided by Calgon on January 19, 2017, carbon exchange is required after each aeration period of six hours for the proposed fumigation operation. The cost of exchanging these units would be \$4,200 for the service plus \$0.98/lb for VPR 4X10 carbon replacement.

Based on the annual MeBr usage of 10,000 pounds per year and 300.0 lb-MeBr per cycle, the maximum number of fumigation cycles is calculated to 33 cycles per year.

The annual carbon exchange service cost is \$138,600/year (\$4,200/service x 33 services/year). The annual cost of the replacement VPR 4X10 carbon is calculated to \$646,800/year (\$0.98/lb-carbon x 10,000 lb-carbon/unit x 2 units/cycle x 33 cycles/year).

Therefore, the total annual carbon exchange cost is calculated to:

$$\text{Cost} = \$138,600/\text{yr} + \$646,800/\text{yr} = \$785,400/\text{yr}$$

Electricity Cost:

$$\text{Power}_{\text{fan}} = \frac{(1.17 \times 10^{-4}) \times Q \times \Delta P}{\epsilon}$$

Where,

ΔP : Pressure drop across system is assumed to 4 in. H₂O

ϵ : Efficiency for fan and motor is assumed to 0.6

Q: Exhaust flow rate = 12,000 cfm

$$\text{Power}_{\text{fan}} = 9.36 \text{ kW}$$

Per PG&E Electric Schedule AG-1, Rate B with summer season, the electric rate is \$0.23689/kW-hr⁴.

Thus,

$$\begin{aligned} \text{Electricity cost} &= (\$0.23689/\text{kWh})(9.36 \text{ kW})(6 \text{ hr/day})(33 \text{ days/yr}) \\ &= \$439/\text{yr} \end{aligned}$$

Total Annual Costs:

$$\begin{aligned} \text{Total Cost} &= \$29,259/\text{yr} + \$785,400/\text{yr} + \$439/\text{yr} \\ &= \$815,098/\text{yr} \end{aligned}$$

⁴ Per PG&E Electric Schedule AG-1, http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHS_AG-1.pdf This facility has more than one single-motor installed and the total horsepower rating of the equipment is more than 15 hp, so Rate B is used. In addition, cherries fumigation operation is a seasonal operation which normally operates from 1st to 2nd quarter. Therefore, be conservative summer season rate is used.

$$\begin{aligned}\text{Controlled VOC emissions} &= 10,000 \text{ lb-VOC/yr} \times 1 \text{ tons-VOC}/2,000 \text{ lb-VOC} \times 0.95 \\ &= 4.75 \text{ ton-VOC/yr}\end{aligned}$$

Cost of VOC reduction is calculated as follows:

$$\begin{aligned}\text{Cost of VOC reduction} &= \text{cost of carbon} \div \text{controlled VOC emissions} \\ &= \$815,098/\text{yr} \div 4.75 \text{ ton-VOC/yr} \\ &= \$171,600/\text{ton-VOC}\end{aligned}$$

Since the calculated cost of VOC reduction greatly exceeds the VOC cost effective threshold of \$17,500/ton, use of a carbon adsorption system is not cost effective and will be removed from consideration at this time.

Comment #9

The use of reactivated carbon is a cost-effective alternative to the use of virgin carbon. The Air District refused to analyze this option, on the basis that the District is in the process of removing the option from the District's BACT guidance and because "the use of onsite carbon bed re-activation is not directly related to the amount of fumigant used during the fumigation operation." (Authority to Construct Application Review Top-Down BACT Analysis at 2.) The Air District, however, has not explained why the technology is not technologically feasible, and has not attempted to show that it would not be cost-effective. The Air District should analyze this option.

Response to Comment #9

For fumigation facilities that use large quantities of fumigant, onsite carbon bed reactivation is a cost-saving alternative to shipping saturated carbon canisters offsite for reactivation. Onsite reactivation of saturated carbon canisters using a chemical scrubber only controls emissions from the reactivation process; it has no effect on controlling emissions from the fumigation chamber venting process. The use of an onsite carbon re-activation system is solely at the discretion of the facility to reduce their operating costs. It was never the District's intent to require a facility to use onsite carbon re-activation if the facility had not proposed to use it.

Based on currently available information, the District believes that the onsite carbon re-activation would only be economically beneficial to large scale methyl bromide fumigation operations, i.e. annual methyl bromide usage greater than or equal to 100,000 pounds. In addition, as mentioned above, the use of an onsite carbon reactivation system has no benefit on improving the control efficiency of carbon adsorption control system.

Consequently, the cost effectiveness analysis presented for this project assumed that the spent carbon canisters are sealed transferred to an offsite reactivation facility specifically designed to conduct the regeneration in a safe, controlled environment. Furthermore, the Protect RO-10 units evaluated in the response to Comment #7 above can use either reactivated carbon or virgin carbon.

Therefore, use of a carbon adsorption system with onsite reactivation using a chemical scrubber is eliminated from further analysis because the onsite reactivation system has no effect on controlling emissions from the fumigation chamber venting process, and Rivermaid's methyl bromide fumigant usage is less than 100,000 pounds per year.

Comment #10

The Air District conducted a risk management report, concluding that the health risks would not exceed allowable levels and therefore Toxic Best Available Control Technology was not required. But this risk management report looked only at the risk to offsite receptors, and did not analyze the risk to workers at the facility from exposure to methyl bromide. Moreover, the analysis parameters the report used were inaccurate.

First, the risk management report assumed that the closest residence was 125 meters from the site, but there appears to be no basis for this conclusion. According to Google Maps, there is a gift shop adjoining the site of the fumigation chamber, and there are homes immediately adjacent to and across the street from the facility, or about 17 meters (56 feet) from the site. The application itself stated that the closest residence was 250 feet, and closest business 360 feet—76 meters and 110 meters respectively. Even a prior risk management report for a prior methyl bromide fumigation chamber at the precise location assumed that the closest receptor was 82 meters away. The risk management report should be revised to adopt the most conservative assumption of the closest offsite receptor.

Second, the risk management report assumed that methyl bromide increases would be limited to 272.1 lbs./hour. But the permit allows for 300 pounds of methyl bromide to be used per day, and assumes that "all MeBr used is emitted to the atmosphere." (Authority to Construct Application Review at 2.) Although the permit assumes that not all 300 pounds would be emitted in one hour, this assumption is not supported. Accordingly, the risk management report should have used more conservative assumption all 300 pounds would be emitted in an hour, when analyzing risk to offsite receptors.

Finally, the risk management report's conclusions regarding the acute and chronic hazard index are inconsistent with the prior risk management report for

the facility. The prior report was for an earlier methyl bromide fumigation chamber at the same address, predicted to emit 9,000 lbs. of methyl bromide each year (as opposed to 10,000 lbs. for this project). The prior risk management report predicted a chronic hazard index of .39 and an acute hazard index of .15. The current larger project, in contrast, predicts a chronic hazard index of only .01, and an acute hazard index of .68. Given that these are nearly identical projects in the same location, the stark differences in hazard calculations are suspect and unexplained. The District should ensure the calculations have been performed correctly and provide an explanation for the disparity.

Response to Comment #10

As noted in response from comment #2, on-site facility worker receptors are protected by CAL OSHA, and their risk exposure is not evaluated by the District. Examples where the evaluation of health impacts to on-site receptors are military base housing, prisons, universities, day care facilities, or locations where the public may have regular access for the appropriate exposure period (e.g., a lunch time café or museum for acute exposures).

Regarding residences, the distance to the closest receptor is measured from the location of the new/modified unit to the closest receptor. For the Risk Management review conducted by the District, the distance to the closest residence is approximately 125 meters, to the South. The distance to the closest business receptor is approximately 110 meters, to the North. These distances are established as the best available data. The commenter notes a distance of 82 meters, which would not be accurate. In regards to the on-site gift shop, the District's the modeling runs have the hourly maximum impact to be located 380 meters to the southeast of the new stack location. The District contacted the facility and only on occasion are fruit stands are present on site. The District has assessed the health impact for short term exposures (non-cancer acute) to toxic air contaminants generated by the project on gift shop patrons. This analysis indicates that the risk will be below the District significance levels.

Regarding the hourly volume of methyl bromide released, the assumption of 90.7% ($272.1 \text{ lb/cycle} \div 300 \text{ lb/cycle} \times 100\%$) of injected methyl bromide will be released into atmosphere during the first hour of chamber aeration was derived based on actual emissions measurements conducted in a similar fumigation operation, detailed as follow:

Commodity was loaded in an air tight fumigation chamber. Methyl bromide was introduced into the chamber. Chamber aeration was started upon the completion of the fumigation cycle. Measurements were taken with the use of a portable analyzer, Fumiscopes immediately prior to aeration and at two hours after aeration. The difference between these two measurements was 39 oz/ft^3 ($43 \text{ oz/ft}^3 - 4 \text{ oz/ft}^3$), which represented 90.7% ($39 \text{ oz/ft}^3 \div 43 \text{ oz/ft}^3 \times 100\%$) of

injected methyl bromide was emitted during the two-hour aeration period. As a conservative estimate, the District assumes 90.7% of injected methyl bromide was emitted into the atmosphere during the first hour of chamber aeration. Therefore, the hourly methyl bromide emission rate is limited to 272.1 pounds per hour instead of 300 pounds per hour for the proposed methyl bromide fumigation operation.

With regards to risk differences between the current project and previous projects, the current project has significant difference in exhausting parameters which would not result in a linear relationship when compared to the previous analysis.

In addition, Rivermaid has submitted additional comments for this ATC project, and the District concurs with Rivermaid's statement. See Appendix G3 for more details.

Appendix G1

Supplemental information from California Cherries Export Association



December 14, 2016

Arnaud Marjollet
Director of Permit Services
San Joaquin Valley Unified Air Pollution Control District
4800 Enterprise Way
Modesto, CA 95356

RE: Earthjustice comments on Rivermaid Trading's Project N-1160591

Dear Mr. Marjollet:

On behalf of the California Cherry Export Association I want to provide the following factual information in response to Earthjustice's comments in regards to Rivermaid's Trading Project N-1160591.

In general I question Earthjustice's understanding of the protections in place in order to safely provide the appropriate treatment of cherries to satisfy import requirements of world markets. Specifically the air districts' s documentation refers to carbon adsorption while Earthjustice is referring to carbon absorption – seemingly minor detail but it's the difference between knowing what you're doing and not.

The California Cherry Industry is comprised of 600 growers and 23 packing facilities that operate across the state from Bakersfield to Marysville with the center of cherry production and packing in the Stockton/Lodi area. On average the California Cherry industry exports approximately 25 percent of the cherries produced in the state with an average of 51% of those cherries being sent to the Japan, Korean and Australian Markets. All which require fumigation to enter the market.

Fumigation with Methyl Bromide is a safeguard put in place by importing countries to prevent the entry and or spread of unwanted invasive pests. Methyl Bromide is the most widely used fumigant for quarantine purposes. It is a preferred fumigant for most of the quarantine authorities around the world because of its good penetrating ability, rapid action and high toxicity to a broad spectrum of insects and pests.

Fumigation requirements are determined and set forth by the Government of each export market and are specified below. At this time the respective agriculture agencies in these markets only accept Methyl Bromide as the fumigant. The Cherry Industry in the United States has and continues to research alternative fumigants and export treatments none which have been accepted by these export markets.

Sincerely,

Chris Zanobini
Manager

1521 I Street – Sacramento, CA 95814 – 916-441-1063 – fax 916-446-1063 – www.calcherry.com

Japan

The Sweet Cherry Fumigation Work Plan is attached at Attachment A

For export to Japan, U.S. cherries must be fumigated pre-shipment with methyl bromide according to the following procedures:

1. Cherries for Japan must be fumigated with MB for 2 hours at one of the dosage rates specified in #7 below, depending on the cherry pulp and ambient temperatures.
2. The quantity of fruit to be fumigated shall not exceed 50% of the volume of the chamber
3. The load factor for the chamber will be calculated based on the outside dimensions of the bins or fumigation containers.
4. Bins or pallets must be arranged to allow access for pulp and ambient temperature checks and proper air circulation.
5. Ten pulp temperatures (core temperatures) will be taken by the APHIS Cooperator at random throughout the chamber load.
 - a. If one or more pulp temperatures are below the lower minimum of 42.8 degrees F., the "cold" bins will have to be identified and either removed or allowed to "warm up" to above 42.8 degrees F.
6. Ambient air temperature of the chamber will be taken by the APHIS Cooperator (minimum 42.8 degrees F.)
7. The lowest of the pulp temperatures and the ambient temperature in the chamber will determine the dosage of MB needed for the fumigation under the following treatment schedule:
 - 6 to less than 12C (42.8F to less than 53.6F) = 4 pounds of 4.5 pounds MB per 1000 cubic feet (64 g/m3 or 72 g/m3)
 - 12 to less than 17C (53.6F to less than 62.6F) = 3 pounds of 3.5 pounds MB per 1000 cubic feet (48 g/m3 or 56 g/m3)
 - 17 to less than 22C (62.6F to less than 71.6F) = 2.5 pounds MB per 1000 cubic feet (40 g/m3)
 - 22C+ (71.6F) and above = 2 pounds MB per 1000 cubic feet (32 g/m3)

If the ambient temperature is below the coldest temperature for the scheduled dosage rate (determined by pulp temperatures), the ambient temperature should determine the dosage (Example: If the lowest pulp temperature is 54F, but the ambient temperature in the chamber is 52F, the correct dosage is 4 lbs. /1000 cu. ft. or 4.5 lbs./1000 cu.ft.)

8. Cherries are not to be further cooled during fumigation.
9. The chamber is sealed, the event record put in operation, and circulating fans are turned on.
10. The correct dosage of MB is introduced as measured by the weight of the gas cylinder before and after gas introduction (Note: To ensure accurate dosage, methyl bromide weights should be determined using grams, or rounded up if the measurement is made in pounds).
11. The fumigator will check the chamber for leaks around doors and openings with a halide detector or colorimetric tubes (Draeger, Kitigawa or equivalent).
12. The circulation fan needs to be operated during the fumigation.
13. At the end of the fumigation, the normal aeration process will be followed and the necessary records kept.

Korea

For reference, fumigation import requirements for cherries to Korea can be found in Attachment B

For export to South Korea, U.S. cherries must be fumigated pre-shipment with methyl bromide according to the following schedule:

Methyl Bromide: Chamber fumigation at normal atmospheric pressure		
Temperature	Minimum Dosage (g/m3)	Time (Hours)
(6° C to less than 12° C) 42.8° F to 53.6° F	64 g/m3	2
(12° C to less than 17° C) 53.6° F to 62.6° F	48 g/m3	2
(17° C to less than 22° C) 62.6° F to 71.6° F	40 g/m3	2
(22° C+) 71.6° F and above	32 g/m3	2

Australia**General Requirements**

For the most recent work plan for California cherries destined to Australia please view the Offshore Pre-Shipment Inspection of California Cherries issued by the Australia Department of Agriculture and Water Resources (DAWR), is attached as Attachment C.

The DAWR Biosecurity Import Conditions database (BICON) entry detailing the complete guidelines for the export of California sweet cherries to Australia is available as Attachment D.

CHAPTER 1

Import Requirements for Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S. – Fumigation Protocol

1. Scope of Application

Fresh fruits of U.S. cherry which are produced in the following areas recognized as free of *Blumeriella jaapii* (Cherry Leaf Spot; CLS) and are treated with Methyl Bromide (MB) before shipping can be imported into Korea in accordance with the conditions set by these requirements.

☐ Pest Free Areas of *Blumeriella jaapii*

- 16 counties in California : Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Benito, San Joaquin, Santa Clara, Stanislaus, Tulare, Butte, Yolo and Yuba
- 11 counties in Washington : Adams, Benton, Chelan, Douglas, Franklin, Grant, Kittitas, Klickitat, Okanogan, Walla Walla, Yakima
- 7 counties in Idaho : Ada, Canyon, Gem, Payette, Twin Falls, Washington, Owyhee
- 3 counties in Oregon : Umatilla, Wasco, Hood River

2. Means of Conveyance

The fresh fruits of cherry shall be imported by ship cargo, air cargo or air passenger baggage.

3. Maintenance of CLS Freedom

- a. The status of freedom from *Blumeriella jaapii* in each county established as free of the disease under Section 1 of these requirements must be verified through monitoring.
- b. The USDA's Animal and Plant Health Inspection Service (hereinafter referred to as "APHIS") must immediately inform Animal and Plant Quarantine Agency of Korea (hereinafter referred to as "QIA") of any finding of *Blumeriella jaapii* as a result of the monitoring and suspend export of cherry from the relevant county to Korea.
- c. If *Blumeriella jaapii* is found in any county designated as free of the disease, APHIS shall inform QIA of the details of the detection.

- d. QIA may request for APHIS to confirm monitoring methods and results for any county designated as free of *Blumeriella jaapii*.

4. Treatment in Producing Area

The fresh fruits of U.S. cherry for export to Korea shall be treated in bulk in facilities approved by APHIS according to the following schedules, and the result of the treatment shall be confirmed by APHIS.

Fumigant	Minimum Dosage	Temperature	Duration	Atmosphere
Methyl Bromide	64g/m ³	6 to <12 °C	2hours	NAP
	48g/m ³	12 to <17 °C	2hours	
	40g/m ³	17 to <22 °C	2hours	
	32g/m ³	22 °C or above	2hours	

5. Packing and Packing Place

The fresh fruits of US cherry fumigated in accordance with the Section 4 of these requirements should be packed with the packing materials which can prevent the re-infestation of harmful pests at the place which is equipped with the facilities necessary for preventing the invasion of those pests.

6. Export Inspection and Certification

- a. The fumigated fresh fruits of U.S. cherry should be inspected by APHIS, and should accompany a phytosanitary certificate issued by APHIS. In addition to inspecting for other quarantine pests of Korea, the inspectors should check the symptoms on cherry fruit by *Stigmia carpophila* or *Blumeriella jaapii*.

- b. The phytosanitary certificate shall bear the followings:

- 1) Treatment (chemicals, dosage, temperature and duration etc.)
- 2) Place of origin by county name
- 3) Additional declaration

"As a result of the inspection this shipment of cherries is believed to be free of *Stigmia carpophila* and *Blumeriella jaapii*."

- c. Each package or pallet of fresh cherry shall be sealed and shall bear a mark which indicates the fact that the shipment of fresh fruits has passed the inspection by APHIS.

7. Import Inspection

The shipment of fresh cherry shall be inspected by QIA in accordance with Korean Plant Protection Act at the point of entry.

- a. If the shipment is found to fall under any of the followings, the consignment shall be rejected.
 - 1) A shipment which is not accompanied by a phytosanitary certificate, or which is accompanied by a phytosanitary certificate which does not bear the information prescribed in the above Paragraph 6-b.
 - 2) In case that the following live quarantine pests of Korea are detected.
 - *Cydia pomonella*, *Grapholita prunivora*, *Anarsia lineatella*, *Rhagoletis indifferens*, *Rhagoletis pomonella*, *Rhagoletis fausta*, *Epiphyas postvittana*
- b. If cartons or pallets within a shipment are found to have no seal or passed mark, those cartons or pallets shall be rejected.
- c. If packages are damaged, those cartons or pallets shall be rejected.
- d. If *Blumeriella jaapii* or *Stigmata carpophila* are detected on cherry fruit at import inspection, the consignments shall be rejected. The importation of fresh cherry from the relevant country where *Blumeriella jaapii* was found shall be suspended until APHIS and QIA identify the reasons and corrects them.
- e. If other live quarantine pests of Korea are intercepted, the infested consignments should be treated according to the Korean Plant Protection Act and its related regulations.

CHAPTER 2

Import Requirements for Fresh Cherry Fruits from California – Systems Approach (Non-fumigation) Protocol

1. Scope of Application

Fresh cherry fruits produced from 16 counties in California where *Blumeriella jaapii* (cherry leaf spot) free status is maintained according to the import requirements of Chapter 1, can be imported to Korea based on requirements set by this notification.

- 16 counties in California: Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Benito, San Joaquin, Santa Clara, Stanislaus, Tulare, Butte, Yolo and Yuba

2. Quarantine Pests

- Cherry Leaf Spot (*Blumeriella jaapii*)
- Shot Hole (*Stigmina carpophila*)
- Codling Moth (*Cydia pomonella*)
- Lesser Appleworm (*Grapholita prunivora*)
- Peach Twig Borer (*Anarsia lineatella*)
- Western Cherry Fruit Fly (*Rhagoletis indifferens*)
- Black Cherry Fruit Fly (*Rhagoletis fausta*)
- Apple Maggot (*Rhagoletis pomonella*)
- Light Brown Apple Moth (*Epiphyas postvittana*)

3. Registration of Export Orchards and Packing Houses

- a. Orchards producing cherry fruit for export to Korea shall be registered with the USDA, Animal Plant Health Inspection Service (hereinafter referred to as APHIS).
- b. Packing houses wishing to sort and pack cherry fruit for export to Korea shall be registered with APHIS.
- c. APHIS shall inform QIA of the list of export packing houses each year before commencement of export.

4. Pest Control in Export Orchards

Growers shall implement appropriate control measures according to the guidelines of the Federal State Cooperative Extension Service in order to prevent incursion of Korea's quarantine pests in export orchards. APHIS will ensure that registered export orchards are managed in accordance with the guidelines of the Federal State Cooperative Extension Service.

5. Codling Moth Trap Monitoring

- a. Each participating cherry orchard will be monitored for the presence of codling moth adults using pheromone lures as recommended by the commercial pest consultant, beginning when the fruit is ½ inch (1.25cm) in diameter and continuing until harvest. For varieties with multiple harvest dates, traps will be monitored until the final harvest of fruit.
- b. A minimum of two traps shall be placed in an orchard.
- c. If the size of the orchard exceeds 14 hectares, one additional trap per 7 hectares shall be placed.
 - <14 hectares = 2 traps
 - 14-21 hectares = 3 traps
 - > 21 hectares = 3 traps plus 1 additional trap for every 7 hectares
- d. Traps shall be placed thoroughly inside the orchard if possible; otherwise one trap shall be placed every 300 meters along the edge of the orchard. If the orchard is located adjacent to a walnut orchard, one of the traps must be placed on the border of the cherry orchard closest to the walnut orchard.
- e. Trap monitoring will be conducted by commercial pest consultants. Traps will be monitored weekly and the results of trap monitoring will be recorded on the standard form developed by APHIS. APHIS shall provide the monitoring record upon request by the QIA.
- f. Pheromone lures will be replaced at least every 4 weeks.
- g. APHIS and/or California County Departments of Agriculture will conduct oversight monitoring of the trapping program.
- h. If as a result of the survey above, the trap threshold exceeds 5.0 codling moths per trap per week in the California production region, APHIS will disqualify the orchard from the systems approach for the current production year. For the remainder of the current export

season, fruit from the disqualified orchard may be fumigated and certified in accordance with the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.

6. Certification of Pest Free Areas for Fruit Flies

- a. California State and/or County Departments of Agriculture shall carry out monitoring survey of fruit flies on a regular basis according to the "Immediate Action Plan for Response to Detection of Western Cherry Fruit Fly and Black Cherry Fruit Fly in Pest Free Areas of California" (hereinafter referred to as Immediate Action Plan; Appendix 1)
- b. QIA may request APHIS for the results of monitoring of fruit flies and for additional information about the survey.
- c. Upon detection of Western Cherry Fruit Fly (WCFF) or Black Cherry Fruit Fly (BCFF), the relevant California County Department of Agriculture shall immediately inform APHIS and implement the measures of the Immediate Action Plan. If a population of WCFF or BCFF is determined to exist (defined as detections of a larva, pupa, or mated female; or when two or more adults are detected within one mile of each other during the same life cycle), the County Department of Agriculture shall implement eradication measures.
- d. APHIS shall inform QIA immediately upon detection of WCFF or BCFF. When a population of WCFF or BCFF is determined to exist, APHIS shall suspend the export of cherries from the relevant county to Korea under the systems approach program until eradication is confirmed.
- e. The negative trapping period of three generations including the life cycle of first detection is needed for eradication of WCFF or BCFF.
- f. Fruit from suspended counties may be fumigated and certified in accordance with the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.
- g. APHIS shall inform QIA of any revisions to the Immediate Action Plan.

7. Fresh Fruit Inspection

- a. APHIS and/or APHIS Cooperators shall carry out fresh fruit inspection by each orchard lot.

- b. Arrival inspection: When harvested fresh fruits arrive at packing houses, packing facility personnel, under the guidance of APHIS Cooperators, shall select a random sample of 300 fruits per delivery of each orchard lot for inspection using the sugar floatation method. Fruits from lots in which no quarantine pests are detected shall be sorted.
- c. Additional inspection: During the sorting process of fresh sweet cherries, a sample of 700 fruits shall be collected by each orchard lot and they shall be inspected for infection of quarantine pests using the sugar floatation method.
- d. In case any WCFF or BCFF is detected at fresh fruit inspection, the export of fresh cherries under the systems approach from the relevant counties shall be suspended until eradication is confirmed.
- f. In case any live quarantine pests, excluding fruit flies, are found at fresh fruit inspection, the export from the relevant orchard under the systems approach program shall be suspended for the remaining period of that season.
- g. APHIS and/or APHIS Cooperators shall keep the result of fresh fruit inspection and provide the inspection record upon QIA's request.

8. Export Inspection

- a. APHIS and/or APHIS cooperators shall check to ensure that no quarantine pests of Korea are present by inspecting a random sample consisting of at least 1 percent of each consignment and including a minimum of two cartons per lot before commencement of export.
- b. APHIS shall inform QIA upon detection of any live quarantine pests of Korea at export inspection.
- c. In case any WCFF or BCFF is detected at the export inspection, the export of fresh cherries under the systems approach from the relevant county shall be suspended until eradication is confirmed.
- d. In case any live quarantine pests, excluding fruit flies, are found at the export inspection, the export from the relevant orchard shall be suspended under the systems approach for the remainder of the current export season.
- e. Fruit from suspended orchards and/or suspended counties may be fumigated and certified in accordance with the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.

9. Management in Export Packing Houses

- a. APHIS and/or APHIS Cooperators shall check the phytosanitary conditions of export packing houses each year before commencement of export and verify that measures are in place to ensure that the inside of export packing houses are disinfected on a regular basis.
- b. Export packing houses shall be equipped appropriately in order to prevent pest re-contamination (e.g. insect screen, air curtains, rubber curtains and automated doors or other insect-proof measures). Alternatively, if no insect-proof measures are installed, fruits shall be packed with plastic bags or other insect-proof packaging immediately after sorting to prevent the re-infestation of harmful pests.
- c. Fresh cherry fruits for export to Korea shall be separated from cherries produced from non-export orchards and any other fresh fruits during sorting, and shall not be mixed together with other fruits during storing or loading.
- d. The sorting process shall comply with general commercial sorting process, and shall certainly include the washing process to remove pests attached to fruit surface and contaminants.
- e. Fresh cherries for export to Korea shall have no contaminants such as leaves, twigs and soil and shall be packed to prevent re-contamination of pests during storage and transportation.
- f. The outside of each packed carton shall be marked with the registered grower lot number for the export orchard and the name of the packing house. The outside of each packed carton or assembled pallet shall be marked with the label "For Korea".
- g. Each package or pallet of fresh cherry shall be sealed and shall bear a mark which indicates the fact that the shipment of fresh fruits has passed the inspection by APHIS. In case of a ship cargo, the seal number and container number shall be included on the shipping documents or phytosanitary certificate.

10. Phytosanitary Certificates

- a. Import fresh cherry cargo shall be accompanied by a phytosanitary certificate issued by APHIS or APHIS Cooperators with the following additional declaration: "This consignment complies with the requirements agreed by the QIA and has been inspected and found to be free of *Blumeriella jaapii*, *Stigmina carpophila*, *Cydia pomonella*, *Grapholita prunivora*, *Anarsia lineatella*, *Rhagoletis indifferens*, *Rhagoletis fausta*,

Rhagoletis pomonella, and *Epiphyas postvittana*.”

- b. The phytosanitary certificate shall include the place of origin by county name and the name of the export packing house.

11. Import Inspection

Korean plant quarantine inspectors shall conduct import inspection of fresh cherry from the US in import ports and airports.

- a. The fresh cherries shall be rejected in case they fall under any of the following:
 - 1) in case no phytosanitary certificate is accompanied, or the information required under Section 10 is not marked on the accompanying phytosanitary certificate.
 - 2) in case any of Korea’s quarantine pests are intercepted in Section 2.
 - 3) in case the container number or the seal number of a ship cargo described on the shipping documents or phytosanitary certificate do not match the presented shipment.
- b. In case the registered grower lot number or the name of the packing house is not marked outside of packing cartons, or in case the label “For Korea” is not marked on the outside of packing cartons or pallets, the relevant cartons or pallets shall be rejected.
- c. In case a carton or pallet that has no sealing or mark of approval is found, the relevant carton or pallet shall be rejected.
- d. In case the packing is destroyed, the relevant carton or pallet shall be rejected.
- e. In case any live *Cydia pomonella*, *Rhagoletis indifferens*, *Rhagoletis fausta*, or *Rhagoletis pomonella* are intercepted at import inspection, export of fresh cherries from California under systems approach shall be suspended until the cause is identified and corrective actions are made. During the export suspension, the cherry fruits can be exported if they are certified and fumigated according to “Import Requirements for Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the US” of Chapter 1.
- f. In case any live *Anarsia lineatella*, *Epiphyas postvittana*, or *Grapholita prunivora* are intercepted at import inspection, export from the relevant orchard under the systems approach shall be suspended for the remainder of the current export season. Fruit from suspended orchards may be exported if they are certified and fumigated according the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.
- g. If *Blumeriella jaapii* or *Stigmia carpophila* is detected on cherry fruit at import inspection, the consignment shall be rejected. And thereafter, the importation of fresh

cherry from the relevant county where *Blumeriella jaapii* was found shall be suspended until APHIS and QIA identify the reasons and corrects them.

- h. In case a new pest that has not been assessed is found, necessary quarantine measures shall be determined after undergoing pest risk analysis.

12. On-site Survey

- a. QIA shall conduct on-site survey each year during the export season for a specific period of time on implementation of trap survey of codling moth, fresh fruit inspection, fruit fly monitoring, conditions for immediate action or other post-harvest sanitary management system. Once the quarantine safety of program is confirmed, the need to continue the on-site survey will be reviewed.
- b. All expenses required for on-site survey shall be covered by the US according to the QIA Standards for Overseas Travel Expenses.
- c. APHIS shall provide QIA with an invitation letter including on-site survey before departure from Korea.

13. Others

- a. Details of the inspection procedures which were not mentioned in the import requirements shall refer to the Korean Plant Protection Act and its related regulations.
- b. If the detection of quarantine pests or the non-compliance of requirements continues, these import requirements for U.S. cherry fruits may be suspended or reviewed.

[Appendix 1]

**Immediate Action Plan for Response to Detection of Western Cherry Fruit Fly and
Black Cherry Fruit Fly in Pest Free Areas of California**

1. Detection trapping for Western Cherry Fruit Fly (WCFF) (*Rhagoletis indifferens*) and Black Cherry Fruit Fly (BCFF) (*Rhagoletis fausta*) is conducted as part of the general fruit fly detection program in California and uses the Pherocon AM™ trap, the McPhail trap and/or the ChamP™ trap; general purpose traps that detect a wide variety of fruit flies. Each type of trap is described as follows:
 - Pherocon AM™ trap is a yellow two-sided panel trap that incorporates two odor attractants (ammonium acetate and protein hydrolysate) serving as feeding stimuli into the sticky capture surface.
 - McPhail trap is a glass trap with a water reservoir containing dissolved compounds (Torula yeast and borax pellets) that act as a food attractant; flies enter from below through the opening and drown in the solution.
 - ChamP™ trap is a hollow, yellow panel trap with two perforated sticky sides, that when folded resembles a large tea bag. An ammonium bicarbonate lure that serves as a food attractant is placed in the center of the trap and is dispersed through the round holes in the side panels.
2. Traps are hung in suitable host trees at a density ranging from 2-5 traps per square mile, dependent on the location (urban, rural residential, other). ChamP™ and McPhail traps are deployed year round (most of southern California); from April 1st through November 30th (San Francisco area and some parts of southern California); from November 1st through May 31st (Imperial County); from September 1st through June 30th (Coachella Valley in Riverside County); and from May 1st through October 31st in the rest of the state where climatic conditions are favorable for fruit fly establishment. Pherocon AM™ traps are deployed from no later than May 1st through September 30th or October 31st, depending on the location.
3. Traps are inspected every one to four weeks, depending on trap type and location, and traps with sticky panels are replaced at least every four weeks. Traps are relocated as necessary to maintain traps in host trees with mature or nearly mature fruit.
4. In the event that WCFF or BCFF is detected in the pest free areas of California, the local County Agricultural Commissioner, under the guidance of California Department of Agriculture (CDFA), will implement a response n eradication program that includes the following actions:
 - Delimitation trapping with *Rhagoletis* (Pherocon AM™) yellow panel traps within a 0.5 mile radius from the detection(s).
 - Fruit cutting to detect larvae and eggs on the detection property and adjacent properties, and, if two or more flies are found, on all properties up to 200 meters from any find(s).
 - Implementation of eradication activities if a population of WCFF or BCFF is determined to exist (defined as detections of a mated female, larvae, or pupae; or if two flies are found within one mile of each other and within a time period equal to one life cycle of the fly. Eradication activities include:
 - Treatments applied to the area within 200 meters from any find(s) during the

- fruiting season using insecticides and bait.
 - Fruit stripping once, if necessary, of hosts on infested properties and adjacent properties.
 - Hold notices preventing the movement of potentially infested fruit and other carriers (soil, etc.) placed on all infested properties.
 - Post-treatment monitoring at delimitation trapping levels.
5. The County Agricultural Commissioners will work closely with CDFA in the development and implementation of the delimitation and eradication program and additionally may develop a county-specific response plan. County-specific response plans will mirror the requirements outlined in the San Joaquin County response plan.

CHAPTER 1

Import Requirements for Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S. – Fumigation Protocol

1. Scope of Application

Fresh fruits of U.S. cherry which are produced in the following areas recognized as free of *Blumeriella jaapii* (Cherry Leaf Spot; CLS) and are treated with Methyl Bromide (MB) before shipping can be imported into Korea in accordance with the conditions set by these requirements.

☐ Pest Free Areas of *Blumeriella jaapii*

- 16 counties in California : Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Benito, San Joaquin, Santa Clara, Stanislaus, Tulare, Butte, Yolo and Yuba
- 11 counties in Washington : Adams, Benton, Chelan, Douglas, Franklin, Grant, Kittitas, Klickitat, Okanogan, Walla Walla, Yakima
- 7 counties in Idaho : Ada, Canyon, Gem, Payette, Twin Falls, Washington, Owyhee
- 3 counties in Oregon : Umatilla, Wasco, Hood River

2. Means of Conveyance

The fresh fruits of cherry shall be imported by ship cargo, air cargo or air passenger baggage.

3. Maintenance of CLS Freedom

- a. The status of freedom from *Blumeriella jaapii* in each county established as free of the disease under Section 1 of these requirements must be verified through monitoring.
- b. The USDA's Animal and Plant Health Inspection Service (hereinafter referred to as "APHIS") must immediately inform Animal and Plant Quarantine Agency of Korea (hereinafter referred to as "QIA") of any finding of *Blumeriella jaapii* as a result of the monitoring and suspend export of cherry from the relevant county to Korea.
- c. If *Blumeriella jaapii* is found in any county designated as free of the disease, APHIS shall inform QIA of the details of the detection.

- d. QIA may request for APHIS to confirm monitoring methods and results for any county designated as free of *Blumeriella jaapii*.

4. Treatment in Producing Area

The fresh fruits of U.S. cherry for export to Korea shall be treated in bulk in facilities approved by APHIS according to the following schedules, and the result of the treatment shall be confirmed by APHIS.

Fumigant	Minimum Dosage	Temperature	Duration	Atmosphere
Methyl Bromide	64g/m ³	6 to <12 °C	2hours	NAP
	48g/m ³	12 to <17 °C	2hours	
	40g/m ³	17 to <22 °C	2hours	
	32g/m ³	22 °C or above	2hours	

5. Packing and Packing Place

The fresh fruits of US cherry fumigated in accordance with the Section 4 of these requirements should be packed with the packing materials which can prevent the re-infestation of harmful pests at the place which is equipped with the facilities necessary for preventing the invasion of those pests.

6. Export Inspection and Certification

- a. The fumigated fresh fruits of U.S. cherry should be inspected by APHIS, and should accompany a phytosanitary certificate issued by APHIS. In addition to inspecting for other quarantine pests of Korea, the inspectors should check the symptoms on cherry fruit by *Stigmina carpophila* or *Blumeriella jaapii*.

- b. The phytosanitary certificate shall bear the followings:

- 1) Treatment (chemicals, dosage, temperature and duration etc.)
- 2) Place of origin by county name
- 3) Additional declaration

"As a result of the inspection this shipment of cherries is believed to be free of *Stigmina carpophila* and *Blumeriella jaapii*."

- c. Each package or pallet of fresh cherry shall be sealed and shall bear a mark which indicates the fact that the shipment of fresh fruits has passed the inspection by APHIS.

7. Import Inspection

The shipment of fresh cherry shall be inspected by QIA in accordance with Korean Plant Protection Act at the point of entry.

- a. If the shipment is found to fall under any of the followings, the consignment shall be rejected.
 - 1) A shipment which is not accompanied by a phytosanitary certificate, or which is accompanied by a phytosanitary certificate which does not bear the information prescribed in the above Paragraph 6-b.
 - 2) In case that the following live quarantine pests of Korea are detected.
 - *Cydia pomonella*, *Grapholita prunivora*, *Anarsia lineatella*, *Rhagoletis indifferens*, *Rhagoletis pomonella*, *Rhagoletis fausta*, *Epiphyas postvittana*
- b. If cartons or pallets within a shipment are found to have no seal or passed mark, those cartons or pallets shall be rejected.
- c. If packages are damaged, those cartons or pallets shall be rejected.
- d. If *Blumeriella jaapii* or *Stigmata carpophila* are detected on cherry fruit at import inspection, the consignments shall be rejected. The importation of fresh cherry from the relevant county where *Blumeriella jaapii* was found shall be suspended until APHIS and QIA identify the reasons and corrects them.
- e. If other live quarantine pests of Korea are intercepted, the infested consignments should be treated according to the Korean Plant Protection Act and its related regulations.

CHAPTER 2

Import Requirements for Fresh Cherry Fruits from California – Systems Approach (Non-fumigation) Protocol

1. Scope of Application

Fresh cherry fruits produced from 16 counties in California where *Blumeriella jaapii* (cherry leaf spot) free status is maintained according to the import requirements of Chapter 1, can be imported to Korea based on requirements set by this notification.

- 16 counties in California: Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Benito, San Joaquin, Santa Clara, Stanislaus, Tulare, Butte, Yolo and Yuba

2. Quarantine Pests

- Cherry Leaf Spot (*Blumeriella jaapii*)
- Shot Hole (*Stigmina carpophila*)
- Codling Moth (*Cydia pomonella*)
- Lesser Appleworm (*Grapholita prunivora*)
- Peach Twig Borer (*Anarsia lineatella*)
- Western Cherry Fruit Fly (*Rhagoletis indifferens*)
- Black Cherry Fruit Fly (*Rhagoletis fausta*)
- Apple Maggot (*Rhagoletis pomonella*)
- Light Brown Apple Moth (*Epiphyas postvittana*)

3. Registration of Export Orchards and Packing Houses

- a. Orchards producing cherry fruit for export to Korea shall be registered with the USDA, Animal Plant Health Inspection Service (hereinafter referred to as APHIS).
- b. Packing houses wishing to sort and pack cherry fruit for export to Korea shall be registered with APHIS.
- c. APHIS shall inform QIA of the list of export packing houses each year before commencement of export.

4. Pest Control in Export Orchards

Growers shall implement appropriate control measures according to the guidelines of the Federal State Cooperative Extension Service in order to prevent incursion of Korea's quarantine pests in export orchards. APHIS will ensure that registered export orchards are managed in accordance with the guidelines of the Federal State Cooperative Extension Service.

5. Codling Moth Trap Monitoring

- a. Each participating cherry orchard will be monitored for the presence of codling moth adults using pheromone lures as recommended by the commercial pest consultant, beginning when the fruit is ½ inch (1.25cm) in diameter and continuing until harvest. For varieties with multiple harvest dates, traps will be monitored until the final harvest of fruit.
- b. A minimum of two traps shall be placed in an orchard.
- c. If the size of the orchard exceeds 14 hectares, one additional trap per 7 hectares shall be placed.
 - <14 hectares = 2 traps
 - 14-21 hectares = 3 traps
 - > 21 hectares = 3 traps plus 1 additional trap for every 7 hectares
- d. Traps shall be placed thoroughly inside the orchard if possible; otherwise one trap shall be placed every 300 meters along the edge of the orchard. If the orchard is located adjacent to a walnut orchard, one of the traps must be placed on the border of the cherry orchard closest to the walnut orchard.
- e. Trap monitoring will be conducted by commercial pest consultants. Traps will be monitored weekly and the results of trap monitoring will be recorded on the standard form developed by APHIS. APHIS shall provide the monitoring record upon request by the QIA.
- f. Pheromone lures will be replaced at least every 4 weeks.
- g. APHIS and/or California County Departments of Agriculture will conduct oversight monitoring of the trapping program.
- h. If as a result of the survey above, the trap threshold exceeds 5.0 codling moths per trap per week in the California production region, APHIS will disqualify the orchard from the systems approach for the current production year. For the remainder of the current export

season, fruit from the disqualified orchard may be fumigated and certified in accordance with the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.

6. Certification of Pest Free Areas for Fruit Flies

- a. California State and/or County Departments of Agriculture shall carry out monitoring survey of fruit flies on a regular basis according to the "Immediate Action Plan for Response to Detection of Western Cherry Fruit Fly and Black Cherry Fruit Fly in Pest Free Areas of California" (hereinafter referred to as Immediate Action Plan; Appendix 1)
- b. QIA may request APHIS for the results of monitoring of fruit flies and for additional information about the survey.
- c. Upon detection of Western Cherry Fruit Fly (WCFF) or Black Cherry Fruit Fly (BCFF), the relevant California County Department of Agriculture shall immediately inform APHIS and implement the measures of the Immediate Action Plan. If a population of WCFF or BCFF is determined to exist (defined as detections of a larva, pupa, or mated female; or when two or more adults are detected within one mile of each other during the same life cycle), the County Department of Agriculture shall implement eradication measures.
- d. APHIS shall inform QIA immediately upon detection of WCFF or BCFF. When a population of WCFF or BCFF is determined to exist, APHIS shall suspend the export of cherries from the relevant county to Korea under the systems approach program until eradication is confirmed.
- e. The negative trapping period of three generations including the life cycle of first detection is needed for eradication of WCFF or BCFF.
- f. Fruit from suspended counties may be fumigated and certified in accordance with the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.
- g. APHIS shall inform QIA of any revisions to the Immediate Action Plan.

7. Fresh Fruit Inspection

- a. APHIS and/or APHIS Cooperators shall carry out fresh fruit inspection by each orchard lot.

- b. Arrival inspection: When harvested fresh fruits arrive at packing houses, packing facility personnel, under the guidance of APHIS Cooperators, shall select a random sample of 300 fruits per delivery of each orchard lot for inspection using the sugar floatation method. Fruits from lots in which no quarantine pests are detected shall be sorted.
- c. Additional inspection: During the sorting process of fresh sweet cherries, a sample of 700 fruits shall be collected by each orchard lot and they shall be inspected for infection of quarantine pests using the sugar floatation method.
- d. In case any WCFF or BCFF is detected at fresh fruit inspection, the export of fresh cherries under the systems approach from the relevant counties shall be suspended until eradication is confirmed.
- f. In case any live quarantine pests, excluding fruit flies, are found at fresh fruit inspection, the export from the relevant orchard under the systems approach program shall be suspended for the remaining period of that season.
- g. APHIS and/or APHIS Cooperators shall keep the result of fresh fruit inspection and provide the inspection record upon QIA's request.

8. Export Inspection

- a. APHIS and/or APHIS cooperators shall check to ensure that no quarantine pests of Korea are present by inspecting a random sample consisting of at least 1 percent of each consignment and including a minimum of two cartons per lot before commencement of export.
- b. APHIS shall inform QIA upon detection of any live quarantine pests of Korea at export inspection.
- c. In case any WCFF or BCFF is detected at the export inspection, the export of fresh cherries under the systems approach from the relevant county shall be suspended until eradication is confirmed.
- d. In case any live quarantine pests, excluding fruit flies, are found at the export inspection, the export from the relevant orchard shall be suspended under the systems approach for the remainder of the current export season.
- e. Fruit from suspended orchards and/or suspended counties may be fumigated and certified in accordance with the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.

9. Management in Export Packing Houses

- a. APHIS and/or APHIS Cooperators shall check the phytosanitary conditions of export packing houses each year before commencement of export and verify that measures are in place to ensure that the inside of export packing houses are disinfected on a regular basis.
- b. Export packing houses shall be equipped appropriately in order to prevent pest re-contamination (e.g. insect screen, air curtains, rubber curtains and automated doors or other insect-proof measures). Alternatively, if no insect-proof measures are installed, fruits shall be packed with plastic bags or other insect-proof packaging immediately after sorting to prevent the re-infestation of harmful pests.
- c. Fresh cherry fruits for export to Korea shall be separated from cherries produced from non-export orchards and any other fresh fruits during sorting, and shall not be mixed together with other fruits during storing or loading.
- d. The sorting process shall comply with general commercial sorting process, and shall certainly include the washing process to remove pests attached to fruit surface and contaminants.
- e. Fresh cherries for export to Korea shall have no contaminants such as leaves, twigs and soil and shall be packed to prevent re-contamination of pests during storage and transportation.
- f. The outside of each packed carton shall be marked with the registered grower lot number for the export orchard and the name of the packing house. The outside of each packed carton or assembled pallet shall be marked with the label "For Korea".
- g. Each package or pallet of fresh cherry shall be sealed and shall bear a mark which indicates the fact that the shipment of fresh fruits has passed the inspection by APHIS. In case of a ship cargo, the seal number and container number shall be included on the shipping documents or phytosanitary certificate.

10. Phytosanitary Certificates

- a. Import fresh cherry cargo shall be accompanied by a phytosanitary certificate issued by APHIS or APHIS Cooperators with the following additional declaration: "This consignment complies with the requirements agreed by the QIA and has been inspected and found to be free of *Blumeriella jaapii*, *Stigmata carpophila*, *Cydia pomonella*, *Grapholita prunivora*, *Anarsia lineatella*, *Rhagoletis indifferens*, *Rhagoletis fausta*,

Rhagoletis pomonella, and *Epiphyas postvittana*.”

- b. The phytosanitary certificate shall include the place of origin by county name and the name of the export packing house.

11. Import Inspection

Korean plant quarantine inspectors shall conduct import inspection of fresh cherry from the US in import ports and airports.

- a. The fresh cherries shall be rejected in case they fall under any of the following:
 - 1) in case no phytosanitary certificate is accompanied, or the information required under Section 10 is not marked on the accompanying phytosanitary certificate.
 - 2) in case any of Korea’s quarantine pests are intercepted in Section 2.
 - 3) in case the container number or the seal number of a ship cargo described on the shipping documents or phytosanitary certificate do not match the presented shipment.
- b. In case the registered grower lot number or the name of the packing house is not marked outside of packing cartons, or in case the label “For Korea” is not marked on the outside of packing cartons or pallets, the relevant cartons or pallets shall be rejected.
- c. In case a carton or pallet that has no sealing or mark of approval is found, the relevant carton or pallet shall be rejected.
- d. In case the packing is destroyed, the relevant carton or pallet shall be rejected.
- e. In case any live *Cydia pomonella*, *Rhagoletis indifferens*, *Rhagoletis fausta*, or *Rhagoletis pomonella* are intercepted at import inspection, export of fresh cherries from California under systems approach shall be suspended until the cause is identified and corrective actions are made. During the export suspension, the cherry fruits can be exported if they are certified and fumigated according to “Import Requirements for Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the US” of Chapter 1.
- f. In case any live *Anarsia lineatella*, *Epiphyas postvittana*, or *Grapholita prunivora* are intercepted at import inspection, export from the relevant orchard under the systems approach shall be suspended for the remainder of the current export season. Fruit from suspended orchards may be exported if they are certified and fumigated according the "Import Requirements of Fresh Cherry Fruits from the Pest Free Areas of Cherry Leaf Spot in the U.S." of Chapter 1.
- g. If *Blumeriella jaapii* or *Stigmia carpophila* is detected on cherry fruit at import inspection, the consignment shall be rejected. And thereafter, the importation of fresh

cherry from the relevant county where *Blumeriella jaapii* was found shall be suspended until APHIS and QIA identify the reasons and corrects them.

- h. In case a new pest that has not been assessed is found, necessary quarantine measures shall be determined after undergoing pest risk analysis.

12. On-site Survey

- a. QIA shall conduct on-site survey each year during the export season for a specific period of time on implementation of trap survey of codling moth, fresh fruit inspection, fruit fly monitoring, conditions for immediate action or other post-harvest sanitary management system. Once the quarantine safety of program is confirmed, the need to continue the on-site survey will be reviewed.
- b. All expenses required for on-site survey shall be covered by the US according to the QIA Standards for Overseas Travel Expenses.
- c. APHIS shall provide QIA with an invitation letter including on-site survey before departure from Korea.

13. Others

- a. Details of the inspection procedures which were not mentioned in the import requirements shall refer to the Korean Plant Protection Act and its related regulations.
- b. If the detection of quarantine pests or the non-compliance of requirements continues, these import requirements for U.S. cherry fruits may be suspended or reviewed.

[Appendix 1]

Immediate Action Plan for Response to Detection of Western Cherry Fruit Fly and Black Cherry Fruit Fly in Pest Free Areas of California

1. Detection trapping for Western Cherry Fruit Fly (WCFF) (*Rhagoletis indifferens*) and Black Cherry Fruit Fly (BCFF) (*Rhagoletis fausta*) is conducted as part of the general fruit fly detection program in California and uses the Pherocon AM™ trap, the McPhail trap and/or the ChamP™ trap; general purpose traps that detect a wide variety of fruit flies. Each type of trap is described as follows:
 - Pherocon AM™ trap is a yellow two-sided panel trap that incorporates two odor attractants (ammonium acetate and protein hydrolysate) serving as feeding stimuli into the sticky capture surface.
 - McPhail trap is a glass trap with a water reservoir containing dissolved compounds (Torula yeast and borax pellets) that act as a food attractant; flies enter from below through the opening and drown in the solution.
 - ChamP™ trap is a hollow, yellow panel trap with two perforated sticky sides, that when folded resembles a large tea bag. An ammonium bicarbonate lure that serves as a food attractant is placed in the center of the trap and is dispersed through the round holes in the side panels.
2. Traps are hung in suitable host trees at a density ranging from 2-5 traps per square mile, dependent on the location (urban, rural residential, other). ChamP™ and McPhail traps are deployed year round (most of southern California); from April 1st through November 30th (San Francisco area and some parts of southern California); from November 1st through May 31st (Imperial County); from September 1st through June 30th (Coachella Valley in Riverside County); and from May 1st through October 31st in the rest of the state where climatic conditions are favorable for fruit fly establishment. Pherocon AM™ traps are deployed from no later than May 1st through September 30th or October 31st, depending on the location.
3. Traps are inspected every one to four weeks, depending on trap type and location, and traps with sticky panels are replaced at least every four weeks. Traps are relocated as necessary to maintain traps in host trees with mature or nearly mature fruit.
4. In the event that WCFF or BCFF is detected in the pest free areas of California, the local County Agricultural Commissioner, under the guidance of California Department of Agriculture (CDFA), will implement a response n eradication program that includes the following actions:
 - Delimitation trapping with *Rhagoletis* (Pherocon AM™) yellow panel traps within a 0.5 mile radius from the detection(s).
 - Fruit cutting to detect larvae and eggs on the detection property and adjacent properties, and, if two or more flies are found, on all properties up to 200 meters from any find(s).
 - Implementation of eradication activities if a population of WCFF or BCFF is determined to exist (defined as detections of a mated female, larvae, or pupae; or if two flies are found within one mile of each other and within a time period equal to one life cycle of the fly. Eradication activities include:
 - Treatments applied to the area within 200 meters from any find(s) during the

- fruiting season using insecticides and bait.
 - Fruit stripping once, if necessary, of hosts on infested properties and adjacent properties.
 - Hold notices preventing the movement of potentially infested fruit and other carriers (soil, etc.) placed on all infested properties.
 - Post-treatment monitoring at delimitation trapping levels.
5. The County Agricultural Commissioners will work closely with CDFA in the development and implementation of the delimitation and eradication program and additionally may develop a county-specific response plan. County-specific response plans will mirror the requirements outlined in the San Joaquin County response plan.

**WORK PLAN
FOR DAFF OFFSHORE PRE-
SHIPMENT INSPECTION
OF
CALIFORNIA CHERRIES**

2014 Season
May 14, 2014

TABLE OF CONTENTS

1.	Definitions	
2.	Operational Requirements	page 3
2.1	Responsibilities	page 3
2.1.1	Program management and coordination	page 3
2.1.2	Liaison with exporters for scheduling of inspections	page 3
2.2	Eligible fruit	page 4
2.2.1	California counties eligible to export to Australia	page 4
2.2.2	Pest free area and non-host status pests	page 4
2.3	Requests for Offshore Pre-Shipment Inspection	page 4
2.4	Nomination and Tracking of Inspection and Fumigation Lots	page 4
2.5	Inspection Location	page 4
2.6	Product Identification	page 5
2.7	Methyl Bromide Fumigation	page 5
2.8	Records	page 7
2.9	Storage	page 7
2.10	Export inspection by APHIS/authorized officers	page 7
2.11	<u>DoA</u> Offshore Pre-Shipment Inspection	page 7
2.12	Non Compliance	page 9
2.13	Loading for Export and Product Verification	page 10 2.14
	Phytosanitary Certification	page 10
2.15	Program Review	Page 11

Work Plan for the Offshore Pre-Shipment Inspection of California Sweet Cherries

1. Definitions

ACO	Authorized Certification Official
APHIS	Animal and Plant Health Inspection Service (USDA)
CDFA	California Department of Food and Agriculture
DoA	Department of Agriculture (Australia)
Fumigation Lot	Comprises all cherries in a single methyl bromide fumigation
ICON	DoA Import Conditions database
Inspection Lot	Comprises all eligible cherries (identified by fumigation numbers and grower lot numbers or codes) as recorded on relevant NOI's, and presented for DAFF offshore pre-shipment inspection
MB	methyl bromide
NOI	Notice of Intent to Export
OPI	Offshore Pre-Shipment Inspection (formerly known as preclearance); DAFF quarantine inspection conducted offshore (in the country exporting the produce)
Participant	Any grower, packing facility, fumigation or shipping facility or other entity that is registered by APHIS for the purpose of handling California cherries to Australia
Top Up	Replacing inspected boxes with "fresh" boxes of similar cherries from the same inspection lot and fumigation lot
USDA	United States Department of Agriculture
Verification	The process (in Australia) of reconciling export certification and product description with respective consignments and labeling requirements

2. Operational Requirements

This document sets out the main operational requirements of the California Cherry Offshore Pre-Shipment Inspection (OPI) to ensure effective operation of the program. Please ensure that these requirements are followed.

2.1 Responsibilities

2.1.1 Program management and coordination

APHIS is to nominate a contact person to coordinate all operational aspects and, where necessary, provide liaison with APHIS/DoA management as/if need arises.

2.1.2 Liaison with exporters for scheduling of inspections

The California cherry industry is to nominate a designated industry liaison who will be responsible for scheduling of inspections.

2.2 Eligible fruit

2.2.1 California counties eligible to export cherries to Australia

Cherries are eligible for entry into Australia sourced from the following California counties: Butte, Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Benito, San Joaquin, Santa Clara, Stanislaus, Tulare, Yolo and Yuba

2.2.2 Pest Free Area and Non Host Status quarantine pests

Scientific evidence indicating the absence of pests from areas designated as "Pest Free Area" or where "Non-Host Status" applies in California (Attachment 1) has been provided by APHIS. APHIS must verify maintenance of such status for these pests by routine crop monitoring/surveillance. DoA must be notified immediately of any change in the "Pest Free Area" or "Non-Host" status of any of these pests.

2.3 Requests for Offshore Pre-Shipment Inspection

Participant requests for inspection will be made through the designated industry liaison person who will work with the APHIS and DoA inspectors to schedule inspections in an efficient manner. A copy of the relevant form is at Attachment 2. Any variations to scheduled inspection bookings must be notified to the designated industry liaison person as early as possible to allow changes to be conveyed to the DAFF and APHIS inspectors.

2.4 Nomination and Tracking of Inspection and Fumigation Lots

A Notice of Intent to Export (NOI) will be the primary document that confirms OPI of California cherry consignments in accordance with this Work Plan. A copy of an NOI is included as Attachment 3 for reference purposes.

The packing facility, which may also be the treatment provider and/exporter/freight forwarder, must complete an NOI prior to any DoA inspection. The NOI will describe the fruit in the consignment (by grower lot number and fumigation number) that the participant wants included in the inspection lot for identification purposes and the maintenance of traceability. To assist DoA with the selection of a representative inspection sample, the participant will provide a summary indicating the volumes that each grower has contributed to the inspection lot.

An "inspection lot" comprises all eligible product covered by the relevant NOI(s) and may comprise cherries fumigated with methyl bromide (MB) within a 36 hour period in the same facility (in accordance with section 2.9).

A "fumigation lot" comprises all product from one or more growers treated in a single fumigation chamber at one point in time. Methyl bromide fumigations may include product destined for other markets provided the fumigation parameters are the same or more stringent and meet Australian requirements.

2.5 Inspection Location

All product inspection locations must meet DoA requirements (refer to Attachment 4).

For cherries, DoA requires that:

- there is a registration system in place whereby all participants are registered and are aware of the Australian quarantine requirements;
- there are management/inspection systems in place (which will include “standard operating procedures”) to address these requirements;
- there are provisions for trace back to a specific grower lot identified in the NOI for OPI and for the consignment arriving in Australia;
- freight forwarders/agents who undertake assembling of airfreight consignments must be aware of their responsibilities and duties to ensure the quarantine integrity and product security of California cherries destined for Australia under this Work Plan is not compromised.
- It is the participant's responsibility to ensure that their freight forwarder(s)/agent(s)
 - understand their responsibilities and duties and
 - accept, and are responsible for, the quarantine requirements for their consignments.
- APHIS must ensure that all participants who perform critical functions (e.g. receipt and processing of fruit, fumigations, transport, storage, and load out), meet agreed competencies for these functions.

2.6 Product Identification

All cherries for export must be free from trash and must meet Australia's import conditions. Trash refers to soil, contaminant seeds, splinters, twigs, fresh or dry leaves and other plant material, other than the fruit stalk/pedice. Bracts, peduncles as in cluster of stems, floral remnants/involucre are all considered quarantine materials.

All cartons must be marked with the corresponding grower lot number and fumigation lot number to allow trace back to the grower.

Wood packaging and pallets must be treated in accordance with a DoA approved method or be ISPM15 compliant. Refer to the DoA publication “Cargo containers Quarantine Aspects and Procedures” which can be found at the following web address:

<http://www.daff.gov.au/aqis/import/cargo/aspects-procedures>

2.7 Methyl Bromide Fumigation

2.9.2 Cherries must be fumigated pre-shipment with methyl bromide for 2 hours according to the table below and supervised by APHIS or APHIS cooperators:

- 48 g/m³ at pulp temperature of 13.9° C (57°F) or greater, not more than 30.1% chamber load
- 56 g/m³ at pulp temperature of 12.2° C (54° F) or greater, not more than 30.1% chamber load
- 64 g/m³ at pulp temperature of 10.6° C (51°F) or greater, not more than 30.1% chamber load
- 72 g/m³ at pulp temperature of 8.3° C (47° F) or greater, not more than 30.1% chamber load

Fruit must not be fumigated if either the air or fruit pulp temperature falls below 8.3° C (47° F)

- a) Fruit that has undergone successful fumigation can only be presented for DoA OPI. Records as evidence of fumigation must be provided to the DoA inspector along with the NOI prior to inspection.
- b) The respective quarantine services in both Australia and the US will follow their normal standard operating procedures to certify fumigation facilities and measure gas concentrations in fumigations.
- c) Establishments that will be undertaking pre-shipment cherry MB fumigation under this OPI program for Australia will be registered by APHIS for this purpose.
- d) Establishments will undergo fumigation testing to ensure that the chambers can deliver and maintain MB fumigation in accordance with the applicable USDA standards. The APHIS PPQ Treatment Manual will be used as the benchmark to ensure testing is performed consistently across all facilities and States.
- e) Fumigation records for the inspection lot covered by the NOI and records of chamber testing in the US will be made available to the DoA officer if requested.
- f) MB fumigation establishments will ensure that they have systems in place that will assure that treated and untreated product is identified and segregated at all times whilst on the premises.
- g) MB fumigation establishments will ensure that there are records that identify each fumigation lot (and the specific chamber where the lot was fumigated, if there is more than one chamber in the facility) and include details with the actual fumigation records for each lot treated.
- h) Ten field bins or containers selected at random from each fumigation chamber prior to treatment will be sampled for the purposes of measuring product temperature.
 - The pulp temperature of the cherries from each sample will be measured and recorded.
 - Ambient air temperature of the chamber will be taken by the APHIS cooperator.
 - The lowest of the temperatures of the readings from pulp and the ambient air temperature in the chamber will be used to calculate the MB dosage rate.
- i) All data pertaining to the MB fumigation will be recorded. The number and identification of field bins to be treated, the time and date of the fumigation, the temperature data from each bin as tested above, the lowest temperature recorded, the MB dose rate as calculated and reference to the chamber capacity and the volume of product treated.

j) Once a chamber has demonstrated its ability to hold gas (in accordance with the applicable standards of USDA), commercial MB fumigation can proceed. For new MB fumigation facilities in California, an initial gas concentration reading will be required for the first commercial MB fumigation.

k) A DoA inspector may monitor fumigations.

2.8 Records

Participants are to keep appropriate records to enable trace-back of product as assembled in the NOI, through the packing house/cold storage to each supplying grower.

2.9 Storage

Packed product and packaging is to be protected from pest recontamination following fumigation, during and after packing, during OPI, storage, transport, and at depot/consolidation point, and at the shipment point (i.e. at distribution points).

Fruit that has undergone OPI must be maintained in secured conditions, clearly labelled and segregated by a minimum of 1 meter from non-inspected cherries or other fruit. In a cold storage environment, a clear space of 100mm in all directions from other product will suffice.

When fruit that has undergone OPI is transported from an approved packing house it must be protected from pest recontamination. If product is not transported in a separate truck then an impermeable barrier (e.g. temporary plywood bulkhead, tarpaulin, shrink wrap, cardboard sheet etc.) needs to be inserted between fruit that has undergone OPI and product intended for OPI and any other fruit.

Registered participants will be audited by DoA as required during the season to verify that the following requirements are continuing to be met:

- there is an effective system in operation at each facility to ensure that fruit that has undergone OPI and product intended for OPI are kept separate.
 - at any time fruit that has undergone OPI is moved, the transport systems used must ensure that the integrity of the passed product is maintained.
 - the filing systems relating to fruit that has undergone OPI, as defined by a DoA signed NOI, to that product held in storage are accurate and up to Date.
- DoA reserves the right to request a list of registered participants during the season.

2.10 APHIS authorized export inspection

APHIS/County inspection staff will examine the entire contents of the opened cartons and then select inspection sample to undertake the required inspection. The number of boxes inspected and inspection outcomes will be recorded. Any cut cherries may be replaced with sound fruit. However the replacement fruit must be sourced from carton/s that are part of the inspected lot.

2.11 DoA Offshore Pre-Shipment Inspection

The DoA OPI may comprise cherries co-joined from multiple MB fumigation lots which could have been fumigated over a period up to a maximum of 36 consecutive hours. Co-joined fumigation lots must be from the same fumigation facility.

Participants are to remove pallets or boxes from cold storage as directed by DoA. This will be on a random basis so all pallets or boxes in the inspection lot must be in one place and accessible at the time of inspection.

The DoA OPI officer will undertake inspection on packed fruit post MB fumigation of lots per NOI submitted by participants, in accordance with DoA inspection requirements. OPI will be undertaken on a sequential basis following APHIS, State, or County inspections.

Sufficient boxes will be selected at random from the nominated lot to ensure a 600 unit inspection can be completed. Where the inspection lot presented to the DoA inspector contains less than 1000 fruit, then the inspection will be carried out on a randomly selected sample of 450 fruit or on the entire shipment (for consignments containing 450 fruit or less). All product will be removed from each selected box and the empty box examined for debris and/or leaf material and live pests.

2.12 Non-compliance

If, during the APHIS authorized export inspection, a detection of a live life stage of a pest including quarantine pests (see *Attachments 1 and 5*) occurs, the fruit in the inspection lot will be rejected from export to Australia and will not be presented for DAFF OPI.

Further, as any live insect pest detection may mean a treatment failure or a breach of post treatment security of the fruit, APHIS must undertake an investigation to determine the cause of the failure and to put in place corrective actions including suspension of the fumigator. Records of interceptions and corrective actions must be kept be made available to DoA.

Any presence of suspected pests for which pest free areas status applies (Attachment 1) must be identified, investigated and reported to DoA.

In the event of any live pest interception, including mite eggs, DoA inspection must continue until a 600 unit sample is completed.

If a live pest (external or internal stages) is detected during inspection in association with the fruit or with the packaging that cannot be readily identified at the time of the inspection, the inspection should be completed and the lot put on "hold" until the pest is identified and appropriate action is determined.

DoA reserves the right to direct APHIS to investigate any failures to determine if it was a fumigation failure and suspend a fumigation chamber on any live pest detection, including non-host status pests (Attachment 1) or other quarantine pests (Attachment 5), be detected during inspections. The suspended chamber may be reinstated pending favourable results of an investigation conducted to the satisfaction of DoA. Reinstatement of the suspended chamber into the program will be undertaken only when APHIS and DoA are satisfied that appropriate corrective action has been taken. If the failure was due to other reasons (i.e post-treatment security) then corrective actions must be put in place to the satisfaction of APHIS and DoA before the packing facility is allowed to pack cherries for export to Australia.

If product from any one facility continually fails inspection, DoA reserves the right to direct APHIS to conduct an audit of the cherry operational system and to suspend the affected facility. The suspended facility will only be reinstated once APHIS and DoA are satisfied that appropriate corrective action has been taken.

The inspection lot must be free of trash (soil, splinters, twigs, fresh or dry leaves and plant material other than the fruit stalk) and contaminant seeds. If not, the lot will be rejected for export to Australia.

Consignments rejected at OPI in the US with trash must be held pending remedial action. Appropriate remedial action may include: 1) sorting or reconditioning of the specific grower lot/s where trash was detected and re-inspection of the fruit covered under the same NOI; 2) withdrawal of the specific grower lot/s detected with trash from the inspection lot and re-inspection of the remaining inspection lots under a new NOI; or 3) withdrawal of the entire inspection lot in the NOI from export to Australia.

For reconditioning and re-inspection, DoA will not provide any more than 2 reinspections on reconditioned grower lots on any NOI.

Participants are to reassemble pallets immediately after completion of OPI. When reassembling pallets, the inspected boxes may be replaced with other "top up" boxes, provided the top up boxes are sourced from the same MB fumigation lot (when required and if undertaken in the US) and where possible comprising fruit from the same grower.

If the lot passes inspection, the DoA officer will sign and stamp the NOI. The original is to be retained by the DoA officer, and copies provided to APHIS (or Authorized Certification Official) and the participant. Other copies specific to each consignment must be marked to identify which pallets from the original inspection lot are included in a consignment (i.e., tick, asterisk, or underline etc. Text highlighter is not recommended as it is difficult to photocopy or fax). Such copies will be attached to the appropriate phytosanitary certificate accompanying each specific consignment. Participants may use copies of the NOI as inventory worksheets.

Lots that fail DoA inspection must be clearly identified with a label indicating that the lot is rejected for export to Australia.

Rejected product must be physically separated in storage from other cherries, which are either awaiting DoA inspection or have passed DoA inspection.

Separation distance must be a minimum of 1 meter in all directions from other products under ambient temperature storage conditions, or a minimum of 100 mm in all

directions in a cold storage environment.

Product rejected for Australia or on hold pending investigation is not eligible for export to Australia and cannot be re-presented for another DoA inspection.

2.13 Loading for Export and Product Verification

Verification of consignment details will be aided if box markings are visible without having to break down the consignment. Where grower lot codes are stamped on individual boxes, these should be loaded so that identification numbers are placed towards the door of the containers. Where lot codes are stamped on individual boxes, a tolerance of up to 2 percent of the boxes in the consignment will be allowed for missing or smeared box stamps, provided the total number of boxes does not exceed the number declared on the NOI.

The loading of containers should be periodically monitored as time allows by APHIS or an APHIS accredited person to confirm that only cherries that have undergone OPI and been passed by a DoA officer are shipped to Australia, and that product segregation and security arrangements are being complied with at the loading facility. Where monitoring is undertaken, a record of the monitoring should be kept on file (for trace-back purposes) at the loading facility.

The loading of containers will be monitored by randomly monitoring the grower lot numbers marked on cartons and matching those numbers with those listed on the NOI.

The procedures noted in the points listed above are to be carried out for the first load of the season from each loading facility and subsequently for each month that loading facility is participating in this program.

2.14 Phytosanitary Certification

Prepared Phytosanitary certificates are to be submitted to APHIS/DoA with the following information:

Additional Declarations:

"Department of Agriculture Offshore Pre-Shipment Inspection undertaken in (Name of State) in accordance with the Work Plan for the offshore pre-shipment inspection of cherries to Australia".

AND

"The cherries in this consignment were grown in (Name(s) of County/Counties and State), and were fumigated and packed in (Name(s) of County/Counties and State). The cherries in this consignments were grown, fumigated and packed in Counties that are free of fruit flies, except *Rhagoletis* spp., or in areas that are located in excess of 15 kilometers from the epicenter of any exotic fruit fly declared areas."

Distinguishing marks:

The packing house details (name) and the grower lot number(s) must be recorded under the Distinguishing Marks section.

Verification on arrival of consignments that have undergone OPI will involve reconciling product details (i.e., packing/treatment facility and grower lot references) between the NOI and the phytosanitary certificate.

If consignments of cherries that have undergone OPI cannot be verified as such on arrival in Australia, the consignment may be subject to an on-arrival inspection.

Methyl Bromide Fumigation:

- Details of pre-shipment MB fumigation, including dosage, fumigation duration, cherry pulp and chamber air temperatures and date must be included in the treatment section of the Phytosanitary certificate. In cases where a consignment comprises product from multiple fumigation lots, each dose must be recorded in direct reference to the fumigation temperature for that fumigation.

Example: 48 g/m³ for 2 hours at 13.9°C and 56 g/m³ for 2 hours at 12.2°C

The name of the MB fumigation facility must be included in the "additional information" section.

Other information:

- Have the NOI referenced in the phytosanitary certificate and have a copy of the relevant NOI(s) with the lot codes marked, attached (stapled) to the phytosanitary certificate included in that consignment.
- If only part of the block covered by a NOI is to be shipped, reconciliation on arrival in Australia will be helped if the relevant lot codes are marked on the copy of the NOI and on the Phytosanitary certificate.

Failure to meet the above requirements will result in product losing its OPI status.

Depending on the nature of the non-compliance the grower, the packing house/cold storage and/or exporter may be suspended from the program.

2.15 Program Review

The Work Plan for the Offshore Pre-Shipment Inspection of California cherries to Australia shall be reviewed after each export season and will be subject to consideration by the Director of Animal and Plant Quarantine.

ATTACHMENT 1

Pests absent from areas designated as “Pest Free Area” (PFA) or for which “Non-Host Status” (NHS) applies.

Pest	Common name	Official control program in California	Presence in California	Presence in Australia
Insects				
<i>Ceratitis capitata</i>	Medfly	Pest free area	No	Yes (under official control)
<i>Bactrocera dorsalis</i>	Oriental fruit fly	Pest free area	No	No
<i>Anastrepha serpentina</i>	Sapote fruit fly	Pest free area	No	No
<i>Anastrepha suspensa</i>	Caribbean fruit fly	Pest free area	No	No
<i>Anastrepha ludens</i>	Mexican fruit fly	Pest free area	No	No
<i>Conotrachelus nenuphar</i>	Plum curculio	Pest free area	No	No
<i>Rhagoletis cingulata</i>	Eastern cherry fruit fly	Pest free area	No	No
Diseases				
<i>Plum pox potyvirus</i>		Pest free area	No	No

ATTACHMENT 2

TO: APHIS/Industry Inspection Coordinator (DoA Inspections)

FAX: _____

REQUEST FOR OFFSHORE PRE-SHIPMENT INSPECTION - CHERRIES

Participant's Name (Packer-treatment provider/exporter):

Date and Time Inspection Required:

Location Where Inspection to be Carried Out:

Contact Name to Finalize Details:

Contact Phone Number:

Number of Grower Lots by fumigation lot/s and quantities of fruit (by grower lot) to be inspected:

ATTACHMENT 3

Notice of Intent to Export Cherries to Australia

DoA Number		This number must be referenced on Phytosanitary certificate

Packing Facility
County (where inspection occurred)

Fumigation Lot Number	Grower Lot Number	Quantity	Fumigation Lot Number	Grower Lot Number	Quantity

DECLARATION: "I declare that the produce represented on this document has been produced in accordance with the packing house/cold storage's documented quality system and meets Australian Import requirements".

Participants Signature

(or nominated representatives) _____

RESULT: PASS/FAIL

DoA NAME: _____ STAMP

DoA SIGNATURE: _____

DATE: ____/____/____

If rejected:

Growers Mark: _____

Packer: _____ Code: _____

Reason for Rejection: _____

ATTACHMENT 4

REQUIREMENTS FOR OFFSHORE PRE-SHIPMENT INSPECTION LOCATIONS

All locations should be registered by APHIS/County Departments of Agriculture and meet the following requirements:

Inspection Facilities

- A suitable work area, which is kept, clean and free of other material or equipment.
- A workbench of minimum 2 meters by 1.2 meters, which is preferably white laminate or suitable white inspection tray or white paper supplied.
- Lighting directly over the inspection table of minimum 600 lux. (Two fluorescent tubes placed approximately 1 meter above the inspection table will obtain this measure of light).
- Access to an electric outlet.
- Clear of main traffic areas and other operations and not located within or at the entrance of a cool room. There must be sufficient area to work effectively and move freely within the inspection area (As a guide, a work area of 9m² and maintained at a moderate temperature.);
- Located in a designated non-smoking area.
- Magnification lamp or suitable equivalent.
- Other equipment necessary for the collection/detection of quarantine pests.

Cold storage

- Capacity to segregate product following inspection.
- Facility to load/unload product under cover with reasonable quarantine security.

Other Facilities

- Access to a photocopier within the Operators facility.
- Equipment for the re-strapping of pallets (depending on how product is to be shipped).

Staff Assistance

- Assistance with selection samples.
- Re-strapping of pallets.

Management

- Responsibility for communication directly with the OPI co-coordinator on OPI arrangements.
- Responsibility for the organization of lots.
- Responsibility for ensuring adequate resources are available.

- Responsibility for ensuring that OPI equipment is serviced and in a good state of repair;
- The ability to prepare documentation and keep inventory records.

Product Security

- After OPI, product must be segregated from non-OPI product. In a cold storage a 100mm clear space or physical barrier is required. For product stored in ambient temperatures 1 meter clear space or physical barrier is required.

ATTACHMENT 5

Pest list: Fresh cherries from United States of America (California and the Pacific North West States of Idaho, Oregon, and Washington)

ARTHROPODS	GENUS/SPECIES	COMMON NAME
ACARINA	<i>Eotetranychus carpini borealis</i>	Yellow spider mite
	<i>Tetranychus mcdaniell</i>	McDaniel spider mite
	<i>Tetranychus pacificus</i>	Pacific spider mite
COLEOPTERA	<i>Anthonomus quadrigibbus</i>	Apple curculio
DIPTERA	<i>Drosophila suzukii</i>	Spotted wing drosophila or SWD
	<i>Rhagoletis fausta</i>	Black cherry fruit fly
	<i>Rhagoletis indifferens</i>	Western cherry fruit fly
	<i>Rhagoletis pomonella</i>	Apple maggot
HEMIPTERA	<i>Lygus lineolaris</i>	Tarnished plant bug
	<i>Philaenus spumarius</i>	Meadow froghopper
HYMENOPTERA	<i>Hoplocampa cookie</i>	Cherry fruit sawfly
LEPIDOPTERA	<i>Acrobasis tricolorella</i>	
	<i>Alsophila pometaria</i>	Fall cankerworm
	<i>Anarsia lineatella</i>	Peach twig borer moth
	<i>Archips argyrospilus</i>	Fruit-tree leafroller
	<i>Archips rosanus</i>	European leafroller
	<i>Choristoneura rosaceana</i>	Oblique-banded leafroller
	<i>Grapholitha packardii</i>	Cherry fruit worm
	<i>Grapholitha prunivora</i>	Lesser apple fruit worm
	<i>Operophtera brumata</i>	Winter moth
	<i>Orgyia antiqua</i>	Rusty tussock moth
	<i>Pandemis pyrusana</i>	Apple pandemis
	<i>Peridroma saucia</i>	Variegated cutworm moth
	<i>Xestia c-nigrum</i>	Spotted cutworm
	<i>Oecanthus fultoni</i>	Snowy tree cricket
THYSANOPTERA	<i>Taeniothrips inconsequens</i>	Pear thrips

FUNGI	GENUS/SPECIES	COMMON NAME
Ascomycotina	<i>Blumeriella jaapii</i>	Cherry leaf spot
	<i>Lambertella jasmine</i>	
	<i>Lambertella pruni</i>	
	<i>Lambertella spp.</i>	
	<i>Monilinia fructigena</i>	Brown rot (not recorded from California, Idaho, Oregon, or Washington)
	<i>Podosphaera clandestine</i>	Powdery Mildew
	<i>Podosphaera tridactyla</i>	Powdery Mildew

Import Conditions

[Search](#)[Import Questions](#)[Import Conditions](#)[Onshore Outcomes](#)

Case: Fresh stone fruit for human consumption Effective: 06 Feb 2016

Grown in the United States — Cherries — From California, Idaho, Oregon or Washington — From a permitted county — Inspected prior to shipment

Import Conditions

The following Import Conditions are applicable to this Import scenario. The department will assess the suitability of your import against the import conditions.

- a. The following import conditions apply to *Prunus avium*.
- b. Prior to the importation of goods into Australia, a valid import permit issued by the Department of Agriculture is required.

An import permit may be obtained by submitting an import permit application to the department (if viewed online, use the 'Apply Now' button at the bottom of this page).

- c. Cherries are permitted into Australia from the state of California and from the Pacific Northwest states of Oregon, Washington and Idaho only, and from the following specific counties within these states:

California: Butte, Calaveras, Contra Costa, Fresno, Kern, Kings, Madera, Merced, Sacramento, San Benito, San Joaquin, Santa Clara, Stanislaus, Tulare, Yolo and Yuba.

Idaho: Ada, Canyon, Gem, Owyhee, Payette and Washington.

Washington: Adams, Benton, Chelan, Douglas, Franklin, Grant, Kittitas, Klickitat, Okanogan, Walla Walla and Yakima.

Oregon: Umatilla, Union, Wasco and Hood River.

- d. Prior to export, the plants or plant products must be inspected or tested by the National Plant Protection Organisation (NPPO) according to appropriate procedures and be considered free from biosecurity pests.

To demonstrate compliance with this requirement you must present the following on a Phytosanitary certificate:

The declaration "*This is to certify that the plants, plant products or other regulated articles described herein have been inspected and/or tested according to appropriate official procedures and are considered to be free from the quarantine pests specified by the importing contracting party and to conform with the current phytosanitary requirements of the importing contracting party, including those for regulated non-quarantine pests.*"

If the phytosanitary certificate is issued after dispatch; the date of inspection must be identified as an additional declaration.

- e. The consignment must be free from pests, diseases and inspected prior to shipment.

To demonstrate compliance with this requirement you must present the following on a Phytosanitary certificate:

Case Options

- [Bookmark Options](#)
- [Email current scenario](#)
- [Save / Print](#)

Case details

- [Overview](#)
- [Appendices](#)
- [Alerts](#)
- [Changes](#)
- [History](#)
- [On-arrival Procedures](#)

Questions I have answered

- [Country of origin](#)
- [Stonefruit type](#)
- [Stonefruit state of origin](#)
- [Cherries from permitted counties](#)
- [Pre-clearance](#)

The additional declaration *"The cherries in this consignment were grown in [name(s) of county/counties and state], and were fumigated and packed in [name(s) of county/counties and state]. The cherries in this consignment were grown, fumigated, and packed either in counties that are free of fruit flies except Rhagoletis spp. or in areas that are located in excess of 15 kilometres from the epicenter of any exotic fruit fly declared areas."*

AND

For cherries that have undergone OPI, the additional declaration must also be included:
"Department of Agriculture offshore pre-shipment inspection undertaken in [state] in accordance with the work plan for the offshore pre-shipment inspection of cherries to Australia."

- f. The consignment must be fumigated prior to shipment at a rate of 48 g/m³ for two hours at pulp temperatures of 13.9°C ¹ or greater at 30.1% chamber load.

To demonstrate compliance with this requirement you must present the following on a Phytosanitary certificate:

1. Evidence that the goods have been fumigated with methyl bromide at [insert applied dosage X g/m³] for [X hours] at [insert minimum temperature degrees Celsius]
2. The date of fumigation
3. The name of the fumigation facility

Warnings and Information Notices

Fumigation must be with methyl bromide for 2 hours according to one of the schedules below and supervised by the United States Department of Agriculture (USDA):

1. 72 g/m³ for two hours at pulp temperatures of 8.3°C or greater at 30.1% chamber load.
2. 64 g/m³ for two hours at pulp temperatures of 10.6°C or greater at 30.1% chamber load.
-  1 3. 56 g/m³ for two hours at pulp temperatures of 12.2°C or greater at 30.1% chamber load.
4. 48 g/m³ for two hours at pulp temperatures of 13.9°C or greater at 30.1% chamber load.

Fruit must not be fumigated if either the air or fruit pulp temperatures fall below 8.3°C. Where the air and pulp temperatures are different, the lower temperature must be used for calculating the concentration of methyl bromide required.

- g. The consignment must have been inspected offshore and found to be free of live insects, disease symptoms, seed, soil and other debris.

To demonstrate compliance with this requirement you must present the following on a Notice of Intent (NOI):

Evidence that the DOI/NOI must be signed and stamped by a Department of Agriculture inspecting officer and be marked as "passed".

All passed pallets or cartons in the consignment should be identified on the NOI by underlining, circling or otherwise marking the pallet card or grower lot numbers, preferably with an ink pen. The use of a highlighter pen should be avoided as the highlights may not be detected on a photocopy or facsimile.

- h. An original phytosanitary certificate must accompany each consignment and must be correctly completed, see information on the International Plant Protection Convention (IPPC) website .

ⁱ Consignments that have a phytosanitary certificate which is not correctly endorsed, or where

i. Consignments that have a phytosanitary certificate which is not correctly endorsed, or where the original phytosanitary certificate has not been sighted by the Department of Agriculture, will be held pending presentation of a correctly filled out and original phytosanitary certificate. The Department will accept appropriately amended or re-issued phytosanitary certificates (including faxed or scanned copies transmitted directly to the Department from the certifying authority).

j. The goods must be clean and free of prohibited seed, soil, animal and plant debris and other biosecurity risk material prior to arrival in Australia.

k. Details of any mandatory pre-shipment treatments must be included and certified on the phytosanitary certificate, unless otherwise specified. Information relating to any other treatment/s applied to the commodity at the exporter's discretion must be provided on a commercial treatment certificate.

l. The cherries must be packed in new packaging. All consignments of cherries must be identified by one of the following means:

1. Each individual carton must be marked with the relevant lot code i.e. grower lot number for California, and state or federal lot number for Pacific North West.
2. For palletised fruit, each individual carton must be stamped with the relevant lot code, (i.e. grower lot number or a similar identifying mark, or pallet cards or stickers must be attached to each pallet). Each pallet card or sticker must be uniquely numbered or include information to enable traceback i.e. to grower lot codes.
3. When pallet cards or stickers are used to identify consignments of cherries, they must be securely fastened to the pallet to withstand handling encountered during handling and shipping.
4. If the consignments of cherries that have undergone OPI cannot be verified as such on arrival in Australia, the consignment may be subject to an on-arrival inspection.
5. If a pallet of cherries identified with pallet cards or stickers is broken down prior to loading into airfreight or sea freight containers, all cartons deconsolidated from the pallet must be stamped with the pallet card number.
 - 5.1 the pallet card is to remain with the unstrapped pallet and must record details of the consignment(s) dispatched.

m. Each consignment must be secured (i.e. made insect-proof) prior to shipment to maintain its quarantine integrity on arrival using a secure packaging option.

n. Open (door ajar) dry boxes that are used to ship produce that requires airing during transport are acceptable provided the containers are secured by replacing or closing the doors prior to movement from the wharf to the inspection site. Alternative security can be provided by securely meshing, screening or covering with a heavy plastic sheet or tarp over the open containers.

o. Quarantine integrity and traceability of cherries

The details of the packing house and relevant lot codes (i.e. grower lot numbers) for California consignments or State or Federal lot numbers for Pacific North West consignments must be recorded under the "distinguishing marks" section on the phytosanitary certificate.

Cherries are usually air-freighted to Australia. The container or aircan number/s and container seal number(s) are preferred but not mandatory. Where available, these details must be included on the phytosanitary certificates under 'distinguishing marks' or on the airway bill.

p. Additional requirements for offshore pre-shipment inspection (OPI):

The Department of Agriculture inspections will be on fruit covered in a single NOI and may comprise cherries packed in a continuous packing run, over a period up to a maximum of 36 consecutive hours. Co-joined treatment lots covered by a single NOI must be from the same treatment facility.

All fresh cherries that are presented for the department by the packing facility must be clearly labelled and legibly identified by grower lot numbers or pallet numbers on a 'Notice of Intention to Export' (NOI).

q. Interceptions during Department of Agriculture OPI in the US

Inspections in which live stages of quarantine pests are detected by the Department of Agriculture will not be passed for export to Australia and the NOI will be put on hold with the pest stages sent to the US entomologist for identification. The participant may elect to have the entire inspection lot withdrawn from the Australian program. However, the Department of Agriculture may liaise with USDA to investigate the cause of the failure and to implement corrective actions. Cherries that fail the Department of Agriculture inspection cannot be exported for on-arrival inspection in Australia.

r. Segregation and quarantine integrity of cherries that have passed OPI

Cherries that have passed OPI by the Department must be securely stored in an approved cold storage facility prior to shipping, and must be segregated from any other domestic or export products at all times.

s. On arrival clearance procedures for fruit that has undergone Department of Agriculture offshore pre-shipment inspection (OPI)

Cherries that have undergone OPI accompanied by the correct documentation as detailed above, may not be subject to a product inspection in Australia and can be cleared on documents. However, the Department of Agriculture reserves the right to undertake random verification or inspections of consignments that have undergone OPI, as required.

Should any discrepancy be found with the produce or certification (indicating a possible system breakdown), the produce will be detained until the cause of the breakdown is determined and advice provided of the appropriate remedial action. Corrective action in Australia may include further inspection, treatment or re-shipment.

No cherries will be permitted for the remainder of the current season from any US growers or packers that have been suspended by the Animal and Plant Health Inspection Service (APHIS) during the current cherry season.

- t. All consignments (other than those offshore pre-shipment inspected in the country of origin under an arrangement approved by the Department) are subject to inspection on arrival and any treatment necessary before release.
 - u. Inspection must occur at the first port of call. With the exception of goods that have undergone offshore pre-shipment inspection by the Department of Agriculture, no land-bridging of consignments will be permitted unless the goods have cleared quarantine.
 - v. If live insects of quarantine concern are detected the consignment will require treatment (where appropriate), or be exported or destroyed. Any required action will be at the importer's expense.
 - w. If disease symptoms are detected an assessment of the biosecurity risk will be made by a biosecurity plant pathologist to determine the options that may be available to the importer. Options may include further identification, treatment, export or destruction.
- Further identification may not result in the release of the goods and may incur substantial additional costs and time delays for the importer. Further identification will only be offered if it is deemed feasible and the importer agrees in writing to accept all costs and risks involved.
- x. If contaminants (e.g. seeds, trash, soil, feathers) are detected and determined to be of quarantine concern, the consignment will require remedial action to remove or treat the contaminants. If the contaminants cannot be effectively removed or treated, the consignment must be exported or destroyed.
 - y. Once biosecurity requirements have been met, it is the importer's responsibility to ensure that all imported food complies with the Imported Food Control Act 1992.

Warnings and Information Notices

The standards for labelling and composition of all food sold in Australia are set down in the Australia New Zealand Food Standards Code.

It is the responsibility of the importer to comply with the Act and ensure imported food meets the requirements of the Food Standards Code and any other relevant Australian standards or requirements.



The Department of Agriculture monitors food safety hazards and compliance with the Food Standards Code by means of the Imported Food Inspection Scheme [↗](#). The website provides information on how food is referred to the scheme.

Under the scheme the food may be held for inspection and testing. The inspection will involve a visual and label assessment and may also include sampling the food for testing.

All imported food is considered 'surveillance'. The tests that apply to surveillance food are detailed in Tests applied to surveillance food [↗](#).

z. Under the Quarantine Service Fees Determination 2005 [↗](#), fees are payable to the Department of Agriculture for all services. A list of all quarantine & export fees [↗](#) is available on the Department of Agriculture's website.

aa. Non-commodity information requirements for imported cargo also apply, please refer to the BICON case Non-Commodity Cargo Clearance.

Warnings and Information Notices



Timber packaging, pallets or dunnage associated with the consignment may be subject to inspection and treatment on arrival, unless sufficient evidence of a Department of Agriculture approved treatment is provided.

All documentation presented to the department to assist in determining the level of biosecurity risk posed by transportation pathways and packaging must also meet the requirements of the non-commodity case.

To apply for an import permit you must complete an application for Fruit or vegetables

[Apply Now](#)

What happens next?

When you are importing into Australia a departmental officer will assess the risk posed by your import and determine the appropriate outcome to apply. You may use the link below to view the likely outcomes for this particular import scenario. Please be aware that the assessment conducted may result in an outcome that is not listed.

[View Onshore Outcomes](#)

[Previous](#)

[Exit to find new Case](#)

Appendix G2

Cost information from Calgon Carbon Corporation

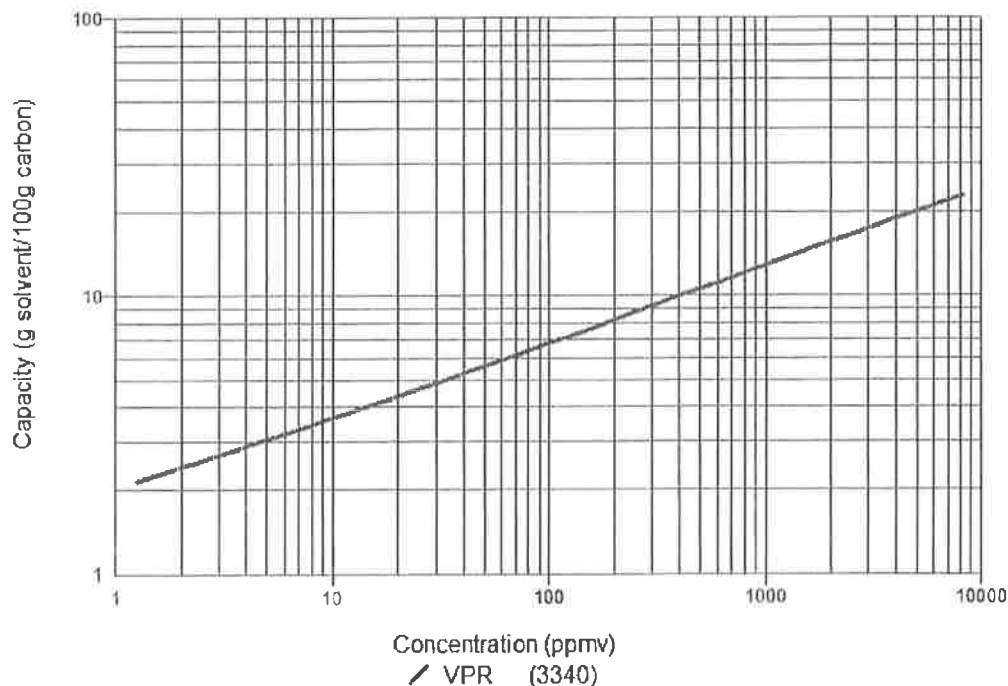
Wai-Man So

From: Nicole Passarella <NPassarella@calgoncarbon.com>
Sent: Thursday, January 19, 2017 7:51 PM
To: Wai-Man So
Subject: RE: Cost quote for a carbon adsorption system to control methyl bromide

Hi Wai Man,

- 1) How to come up the number of 13,130 pounds of carbon per batch run? If possible, could you please send me your calculation.
-This is done by Calgon Carbon's proprietary usage rate models.
- 2) You recommended operating two Protect RO-10 units in parallel, where flow rate is the only operating parameter concern for this recommendation?
-Yes, this is the most suitable equipment offering to withstand your flowrate. You would also want to take into account the 13,130 lb/ batch carbon exhaustion rate.
- 3) The price for a Protect RO-10 unit filled with VPR 4X10 reactivated carbon is \$89,250, how much VPR 4X10 reactivated carbon is filled in each unit, 10,000 pounds?
-Each unit holds 10,000 lbs of activated carbon.
- 4) The price of \$89,250 includes the labor cost for the removal of the spent carbon with fresh reactivated carbon, if not, what is the service cost?
-This is the initial placement fee for two units filled with activated carbon. The cost to exchange these units would be approximately \$4,200 for the service and \$0.98/ lb for replacement VPR 4X10 packaged in 900 lb super sacks. Product would need to ship out on a dedicated van truck from our Stockton, CA warehouse prior to the exchange.
- 5) For suggested VPR 4X10 reactivated carbon, what is the MeBr to carbon adsorption ratio for this type of carbon?

Isotherm for Methyl Bromide at 25 C and 14.7 psia



6) What is the VPR 4X10 reactivated carbon cost, in dollar per pound?

-\$0.98/ lb

7) As we know the spent carbons contain MeBr, which is considered a hazardous waste, Calgon will charge carbon acceptance cost of \$1,000 for each batch of carbon received, or just only one time for the life of the control system?

-This is a one time fee for a period of 5 years at which time you would be required to renew your Carbon Acceptance Number.

8) Based on the maximum MeBr emissions rate of 300 lb-MeBr/hour (also 300 lb-MeBr/24-hour period) along with the operating parameters, how many days the control system could operate prior to the carbon breakthrough?

-You would be required to change the carbon out every 6 hour batch or so

Regards,

Nicole Passarella
Calgon Carbon Corporation
Industrial and Food Business Unit
Technical Account Representative
NPassarella@calgoncarbon.com
412-787-6848

From: Wai-Man So <Wai-Man.So@valleyair.org>
To: Nicole Passarella <NPassarella@calgoncarbon.com>
Date: 01/17/2017 06:23 PM
Subject: RE: Cost quote for a carbon adsorption system to control methyl bromide

Good Afternoon Nicole,

Thank you for get back to me. I called and left a voice message to your office this afternoon for returning my call.

I understand you're currently out for business travel, so I summarized my questions below:

- 1) How to come up the number of 13,130 pounds of carbon per batch run? If possible, could you please send me your calculation.
- 2) You recommended operating two Protect RO-10 units in parallel, where flow rate is the only operating parameter concern for this recommendation?
- 3) The price for a Protect RO-10 unit filled with VPR 4X10 reactivated carbon is \$89,250, how much VPR 4X10 reactivated carbon is filled in each unit, 10,000 pounds?
- 4) The price of \$89,250 includes the labor cost for the removal of the spent carbon with fresh reactivated carbon, if not, what is the service cost?
- 5) For suggested VPR 4X10 reactivated carbon, what is the MeBr to carbon adsorption ratio for this type of carbon?
- 6) What is the VPR 4X10 reactivated carbon cost, in dollar per pound?
- 7) As we know the spent carbons contain MeBr, which is considered a hazardous waste, Calgon will charge carbon acceptance cost of \$1,000 for each batch of carbon received, or just only one time for the life of the control system?
- 8) Based on the maximum MeBr emissions rate of 300 lb-MeBr/hour (also 300 lb-MeBr/24-hour period) along with the operating parameters, how many days the control system could operate prior to the carbon breakthrough?

In addition, could you please forward me the formal quote for the system, so I can forward it to the applicant for consideration.

Thanks again for your assistance, and have a nice evening.

Wai-Man

From: Nicole Passarella [<mailto:NPassarella@calgoncarbon.com>]
Sent: Wednesday, January 11, 2017 2:55 PM
To: Wai-Man So
Subject: RE: Cost quote for a carbon adsorption system to control methyl bromide

Hi Wai-Man,

Based upon the application information provided (12158.49 acfm and 14.7 psia and 24 deg C), it is estimated that you will exhaust about 13,130 lbs of carbon per batch run. In order to handle this flow rate, we would recommend operating two Protect RO-10 Units in parallel.

Budgetary pricing for a Protect RO 10 Unit filled with VPR 4X10 reactivated carbon is \$89,250/ unit + applicable tax and freight. Please let me know if you would like to proceed with using activated carbon, and I can prepare you a formal proposal.

Regards,

Nicole Passarella
Calgon Carbon Corporation
Industrial and Food Business Unit
Technical Account Representative
NPassarella@calgoncarbon.com
412-787-6848

From: Wai-Man So <Wai-Man.So@valleyair.org>
To: Nicole Passarella <NPassarella@calgoncarbon.com>
Date: 01/09/2017 10:45 AM
Subject: RE: Cost quote for a carbon adsorption system to control methyl bromide

Happy New Year Nicole,

I just back to the office this morning.

Yes, the system will be operated under atmospheric pressure (14.7 psia).

Thanks, and please feel free to contact me if you have any further questions.

Wai-Man

From: Nicole Passarella [<mailto:NPassarella@calgoncarbon.com>]
Sent: Wednesday, January 4, 2017 10:43 AM
To: Wai-Man So
Subject: RE: Cost quote for a carbon adsorption system to control methyl bromide

Hi Wai-Man,

Can you please confirm the pressure that you are operating at? If you are operating near atmospheric conditions, then we would expect the pressure to be atmospheric (14.7 psia). The AQ listed 14.7 psig, so we wanted to confirm what you meant.

Thank you,

Nicole Passarella
Calgon Carbon Corporation
Industrial and Food Business Unit
Technical Account Representative
NPassarella@calgoncarbon.com
412-787-6848

From: Wai-Man So <Wai-Man.So@valleyair.org>
To: Nicole Passarella <NPassarella@calgoncarbon.com>
Date: 12/20/2016 06:52 PM
Subject: RE: Cost quote for a carbon adsorption system to control methyl bromide

Good Afternoon Nicole,

Thank you for your prompt response, and please find the application questionnaire for the proposed MeBr operation in the attachment.

The proposed chamber will be aerated maximum 6 hours in a 24-hour period (11 PM – 5 AM) and 34 days per year, with the maximum hourly MeBr emission of 300 pounds.

As MeBr is considered a hazardous waste with U029 code per 40 CFR 261, Subpart D, section 263.33, can that be recycled through the reactivation process? If Calgon will accept it, the one-time carbon acceptance cost is \$1,000?

Please feel free to contact me if you have any further questions or need any additional information.

Thanks again for your assistance.

Wai-Man

From: Nicole Passarella [<mailto:NPassarella@calgoncarbon.com>]
Sent: Tuesday, December 20, 2016 1:31 PM
To: Wai-Man So
Subject: Re: Cost quote for a carbon adsorption system to control methyl bromide

Hi Wai-Man,

Please complete and return the attached application questionnaire, so I can be sure that we captured all the information needed to evaluate your application.

1) Spent carbon that has adsorbed Methyl bromide can carry a hazardous waste U029 code. The P-

list and the U-list (discarded commercial chemical products.) These lists include specific commercial chemical products in an unused form. Some pesticides and some pharmaceutical products become hazardous waste when discarded. Wastes included on the P- and U-lists can be found in the regulations at 40 CFR §261.33.

I will advise on the remaining questions after evaluating carbon usage rate from the completed AQ.

Regards,

Nicole Passarella
Calgon Carbon Corporation
Industrial and Food Business Unit
Technical Account Representative
NPassarella@calgoncarbon.com
412-787-6848

From: Wai-Man So <Wai-Man.So@valleyair.org>
To: "npassarella@calgoncarbon.com" <npassarella@calgoncarbon.com>
Date: 12/20/2016 12:50 PM
Subject: Cost quote for a carbon adsorption system to control methyl bromide

Good Morning Ms. Passarella,

My name is Wai-Man, permitting engineer with the San Joaquin Valley APCD. I am working on a permit application for a methyl bromide (MeBr) fumigation operation, and the applicant is interested in a carbon adsorption system to control the MeBr emissions from the fumigation chamber.

I understand you had recently discussed with my co-worker regarding the cost of activated carbon (4 mm pellets – AP-460) for a coating operation. I also understand that the one-time carbon acceptance costs for RCRA and Non-RCRA materials are \$1,000 and \$400, respectively. Thank you so much for your always assistance to our District.

The proposed MeBr fumigation operation has the following operating parameters: 1) the hourly MeBr emission rate is in the range of 272 pounds to 300 pounds, and 2) the chamber exhaust airflow rate is 12,000 cfm. I have couple questions below:

- 1) Spent carbon with MeBr is considered RCRA or Non-RCRA material?
- 2) Which type of activated carbon with product ID (such as AP-460) is suitable for controlling MeBr emission?
- 3) The estimated MeBr to carbon adsorption ratio of the suggested carbon, in unit of percentage?
- 4) The capital cost of a carbon adsorption system that could handle the MeBr emissions from the above mentioned operation?
- 5) The price of the suggested carbon in dollar per pound?

Thank you in advance for your assistance on this issue.

Have a wonderful Christmas and Happy New Year.

Wai-Man So
Air Quality Engineer
San Joaquin Valley Air Pollution Control District
4800 Enterprise Way, Modesto, CA 95356

Phone (209) 557-6449 | Fax (209) 557-6475



HEALTHY AIR LIVING

www.healthyairliving.com

Make one change for clean air!

This email and attachment(s) contain proprietary and/or confidential information which is protected from disclosure. It is for the sole use of the intended recipient(s) and any unauthorized review, use, disclosure, or distribution is prohibited. If you are not the intended recipient(s), please contact the sender by reply email and destroy the original message and any copies of the message as well as any attachment(s) to the original message.

This email is for your information only and is not intended to be legally binding. Neither Calgon Carbon Corporation nor its affiliates or subsidiaries will have any legally binding obligation until execution by both parties of formal contract documents, all of the terms of which, including the terms herein, must first have been reviewed and approved by Calgon Carbon Corporation's Management and/or, if required by Calgon Carbon Corporation's authority limitations, its Board of Directors.

This email has been scanned by the Symantec Email Security.cloud service.
For more information please visit <http://www.symanteccloud.com>

Appendix G3

Rivermaid Comments to Earthjustice

T|L|G Thomas Law Group

TINA A. THOMAS
ASHLE T. CROCKER
AMY R. HIGUERA
MEGHAN M. DUNNAGAN
CHRISTOPHER J. BUTCHER

455 CAPITOL MALL, SUITE 801 | ONE KAISER PLAZA, SUITE 875
SACRAMENTO, CA 95814 | OAKLAND, CA 94612
Telephone: (916) 287-9292 Facsimile: (916) 737-5858
www.thomaslaw.com

NICHOLAS S. AVDIS
TODD W. SMITH
Of Counsel

March 20, 2017

Brian Clements
Permit Services Program Manager – Central Region
San Joaquin Valley Air Pollution Control District
1990 E. Gettysburg Ave.
Fresno, CA 93726

RE: Applicant's Responses to Comments from Earthjustice Concerning Project N-1160591

Dear Mr. Clements:

Thomas Law Group represents Rivermaid Trading Company (Rivermaid) with respect to the proposed fumigation project (project). Rivermaid agrees with the San Joaquin Valley Air Pollution Control District's (District) determination that issuance of the Authority to Construct Permit (ATC) is exempt from the California Environmental Quality Act (CEQA). We have reviewed the comment letter submitted by Earthjustice. We submit this letter for the District's consideration in responding to Earthjustice's letter.

Background Regarding the Proposed Project

The existing 19,743 square foot facility in which the proposed fumigation chamber would be operated is currently used to fumigate cherries and as cold storage for cherries that are processed, packaged, and distributed by Rivermaid. The quantity of cherries purchased by Rivermaid is constrained by its cold storage and packaging capacity. While the proposed project would increase the fumigation capacity of the existing facility, it would not increase the amount of cold storage and packaging capacity in Rivermaid's existing facility. Rather, because the proposed project would shift approximately 2,200 square feet of space in the existing facility to be used as part of the existing fumigation operation, the proposed project would result in approximately a ten percent (10%) reduction in the total amount of space available for cold storage and packaging in the 19,743 square foot facility.

As cherry deliveries to and from the existing facility are limited by the facility's cold storage and packaging capacity, the proposed project will not increase the number of one-way truck trips to the existing facility to deliver cherries. Additionally, the proposed project will not result in an increase in the number of one-way employee or fumigation-related delivery trips as compared to the existing operations. Rivermaid already has employee staffing for its fumigation operations. Rivermaid will not need to hire new employees or increase the number of employee

shifts during fumigation operations. Similarly, existing fumigation-related deliveries can supply both the existing fumigation operations and the proposed project. For these reasons, the proposed project would not result in any increase in operational one-way vehicle trips as compared to CEQA's baseline conditions because traffic generated by the existing operations are part of the baseline environmental conditions. (*North County Advocates v. City of Carlsbad* (2015) 241 Cal.App.4th 94, 101.)

Earthjustice's discussion regarding surrounding uses is not correct. The closest residential and business receptors are 125 and 110 meters from the proposed project respectively. With respect to the on-site gift shop referenced by Earthjustice, it is not open to the public. The facility solely processes gift orders placed through an online website. Furthermore, the gift shop is located approximately 213 meters from the fumigation facility. Rivermaid also operates an on-site fruit stand, which unlike the gift shop, provides direct sales to the public. The fruit stand is located approximately 46 meters from the fumigation facility. However, consistent with its ongoing operations, Rivermaid proposes only to operate the fumigation chamber outside of normal business hours (between 10 PM and 5 AM) and the District has included these proposed operational parameters in the conditions of approval for the ATC. Because the fruit stand only operates during normal business hours, the proposed project will not expose fruit stand customers to potential toxic air contaminants. Furthermore, the District's modeling demonstrates that the hourly maximum impact during operations would be located 380 meters to the southeast of the stack location. The on-site gift shop and fruit stand are located east of the stack location. Therefore, even if it is conservatively assumed that employees or members of the public visited the gift shop or fruit stand during a peak hour of fumigation operations, the District's health risk assessment correctly demonstrates that health impacts from short term exposures (non-cancer acute) to toxic air contaminants generated by the proposed project would be below the District's significance threshold.

Furthermore, Rivermaid's current fumigation facility uses Methyl Bromide. As required by the United States Department of Agriculture (USDA) – Animal and Plant Health Inspection Service (APHIS), Rivermaid maintains detailed records of all treatments conducted on the project site within the last five years. As the District is aware, facility records demonstrate that no Methyl Bromide exposure-related Cal/OSHA violations or other safety concerns have been documented on the project site in the past. Rivermaid's ongoing safe Methyl Bromide fumigation operations provide further support for the conclusion that the proposed project, which would be subject to the same employee safety regulations as the existing operations, would be operated in a manner that protects the safety of on-site workers. Therefore, Earthjustice's unsubstantiated suggestion that the proposed project would create a significant hazard to the public through the routine use of hazardous materials is erroneous.

The Proposed Project Qualifies for the Class 1 Categorical Exemption

The proposed project qualifies for the Class 1 categorical exemption, which is known as the existing facilities exemption. The "Class 1 [categorical exemption] consists of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of existing public or

private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use beyond that existing at the time of the lead agency's determination." (CEQA Guidelines, § 15301.) Substantial evidence demonstrates that the proposed project qualifies for the Class 1 categorical exemption.

First, the proposed project consists of "operation, ... permitting, ... or minor alteration of [an] existing... facilit[y]...." (CEQA Guidelines, § 15301.) Specifically, Rivermaid currently fumigates cherries within an existing 19,743 square foot facility on the project site. The proposed project would install an approximately 2,200 sq.ft. fumigation chamber within the existing facility. The proposed project would not expand the footprint of the existing facility; rather, the new chamber would be located within the footprint of the existing facility.

Second, as the proposed project consists of operation and alteration of an existing facility, for the purposes of utilizing the Class 1 exemption, "[t]he key consideration is whether the project involves negligible or no expansion of an existing use." (CEQA Guidelines, § 15301.) The CEQA Guidelines do not define the term "negligible expansion." However, the plain language of the Class 1 exemption provides clarity on the meaning of "negligible expansion" within the context of the Class 1 categorical exemption. As explained in subdivision (e), the exemption includes "[a]dditions to existing structures provided that the addition will not result in an increase of more than: (1) 50 percent of the floor area of the structures before the addition, or 2,500 square feet, whichever is less; or (2) 10,000 square feet [under certain circumstances]...." (CEQA Guidelines, § 15301, subd. (e)(1)-(2).) Furthermore, it should be noted that some courts have reframed this question to ask whether a proposed project includes a "significant expansion of use..." (See *North Coast Rivers Alliance v. Westlands Water Dist.* (2014) 227 Cal.App 4th 832, 867, quoting *Communities for a Better Environment v. South Coast Air Quality Management Dist.* (2010) 48 Cal.4th 310, 326.)

Here, as discussed, the proposed project does not increase the floor area of the existing 19,743 square foot facility. Instead, the proposed project only requires minimal construction activities within the existing building footprint. In total, the proposed project would modify approximately 2,200 sq.ft. within the existing 19,743 square foot facility. Even if this 2,200 sq.ft. internal modification were considered an addition for the purposes of CEQA Guidelines section 15301, subdivision (e), 2,200 sq.ft. is less than both "50 percent of the floor area of the structures before the addition, [and] 2,500 square feet..." (CEQA Guidelines, § 15301, subd. (e)(1).) Therefore, based on the plain language of the Class 1 exemption, the proposed project constitutes a negligible expansion of the existing fumigation facility.

Contrary to Earthjustice's suggestion, *Azusa Land Reclamation Co. v. Main San Gabriel Basin Watermaster* (1997) 52 Cal.App.4th 1165 (*Azusa*) does not stand for the proposition that the Class 1 categorical exemption only applies where the environmental impacts of the proposed project have previously been considered. Earthjustice's interpretation of *Azusa* directly conflicts with the purpose of CEQA's categorical exemptions. As explained by the California Supreme Court, "the Legislature, through the Guidelines, intended to enumerate classes of projects that are exempt from CEQA because, notwithstanding their potential effect on the environment, they

already ‘have been determined not to have a significant effect on the environment.’” (*Berkeley Hillside Preservation v. City of Berkeley* (2015) 60 Cal.4th 1086, 1102, quoting Pub. Resources Code, § 21084, subd. (a).) *Azusa* concerned a proposal to reopen a *closed* landfill to allow 3.2 million tons of additional solid waste to be deposited over a seven-year period. (*Azusa*, *supra*, 52 Cal.App.4th at pp. 1175-1176.) Resorting to the dictionary definition for further guidance, the court concluded that a landfill *did not constitute a “facility”* within the meaning of the Class 1 categorical exemption and, thus, the exemption was inapplicable. (*Id.* at pp. 1193-1194.) The proposed project is readily distinguishable from the facts in *Azusa*. The proposed project authorizes additional fumigation operations within the existing fumigation facility on the project site. Unlike the landfill in *Azusa*, Rivermaid’s existing 19,743 square foot facility constitutes a “facility” and the proposed project constitutes a “negligible expansion” of use, as those terms are used in the context of the Class 1 categorical exemption.

County of Amador v. El Dorado County Water Agency (1999) 76 Cal.App.4th 931 (*County of Amador*) is also distinguishable. In *County of Amador*, the court concluded that the project to purchase a hydroelectric power project from PG&E was not subject to the Class 1 existing facilities exemption because the proposed project did not constitute a negligible expansion of a current use. (*Id.* at p. 967.) In reaching its holding, the court explained that the existing hydroelectric project only utilized water for “nonconsumptive” purposes (i.e. to produce energy); however, in acquiring the hydroelectric project the agency intended not only to produce energy but also to utilize up to 17,000 acre feet of water for consumptive use. (*Ibid.*) The court concluded this change in the purpose of the operation of the project constituted a “major change in focus” and, thus, the Class 1 exemption was inapplicable because the project included more than a negligible expansion of an existing use. (*Ibid.*)

Here, unlike in *County of Amador*, no change in use is proposed by Rivermaid. The existing facility is used to fumigate agricultural products using Methyl Bromide. After approval of the proposed project, the existing facility would continue to be used to fumigate agricultural products. Furthermore, both now and under the proposed project, the same agricultural product (cherries) will be treated. Thus, unlike in *County of Amador*, the proposed project does not include a change in use of an existing facility.

The Unusual Circumstances Exception is Not Applicable

Earthjustice suggests that the proposed project must be considered unusual for the purposes of the unusual circumstances exception to the Class 1 categorical exemption because the proposed project includes the use of up to 10,000 pounds of Methyl Bromide per year as a fumigant. Earthjustice cites *McQueen v. Bd. of Dirs.* (1988) 202 Cal.App.3d 1136, 1149 (*McQueen*), to support its conclusion. Recently, the California Supreme Court issued *Berkeley Hillside Preservation v. City of Berkeley* (2015) 60 Cal.4th 1086 (*Berkeley Hillside*). *Berkeley Hillside* provides clear guidance on the proper application of the unusual circumstances exemption to CEQA’s categorical exemptions. *McQueen* is inapposite because it “did not involve a proposed project related to the operations at an ongoing facility” and pre-dates

Berkeley Hillside. (See *Citizens for Environmental Responsibility v. State ex rel. 14th Dist. Ag. Assn.* (2015) 242 Cal.App.4th 555, 584 (*Environmental Responsibility*).)

As explained in *Berkeley Hillside*, a two-part test applies to determine whether an unusual circumstance is present that excludes use of a categorical exemption. (*Berkeley Hillside*, *supra*, 60 Cal.4th at p. 1115.) First, the lead agency must consider “whether there are ‘unusual circumstances’...” (*Id.* at p. 1114.) “Whether a particular project presents circumstances that are unusual for projects in an exempt class is an essentially factual inquiry, founded on the application of the fact-finding tribunal’s experience with the mainsprings of human conduct.” (*Ibid.* (internal citations omitted).) This inquiry is subject to the substantial evidence standard of review, which means that all evidentiary conflicts must be resolved “in the agency’s favor and ... all legitimate and reasonable inferences [must be made] to uphold the agency’s finding.” (*Ibid.*)

Second, if a lead agency finds an unusual circumstance exists, the lead agency next asks if “there is a reasonable possibility [of] a significant effect on the environment due to unusual circumstances.” (*Id.* at p. 1115, quoting CEQA Guidelines, § 15300.2, subd. (c).) If this second inquiry is necessary, the lead agency applies the “fair argument” standard of review to determine whether the project may have a significant impact on the environment. (*Ibid.*)

In establishing this bifurcated test, the Court emphasized that “circumstances do not become unusual merely because a fair argument can be made that they *might* have a significant effect.” (*Ibid.* (italics added).) For environmental impacts to constitute an unusual circumstance, the lead agency must determine based on substantial evidence that “the project *will* have a significant environmental effect.” (*Id.* at p. 1105 (italics added).)

Earthjustice’s position appears to be that the District must conclude unusual circumstances exist because, in Earthjustice’s opinion, the proposed project has the potential to result in significant air quality and health impacts. This argument improperly condenses the *Berkeley Hillside* two-part unusual circumstance determination into a single inquiry.

Using the approach recommended by the California Supreme Court in *Berkeley Hillside*, unusual circumstances may exist where a “project has some characteristic or feature that distinguishes it from others in the exempt class, such as its size or location.” (*Walters v. City of Redondo Beach* (2016) 1 Cal.App.5th 809, 821 (*Walters*).) In determining whether unusual circumstances exist, an “apples-to-apples comparison” should be conducted by comparing the proposed project to other similar facilities exist within the region. (See *Environmental Responsibility*, *supra*, 242 Cal.App.4th at p. 577 [holding that a fair rodeo must be compared to other similar activities on a fair ground and not to other unrelated public facilities]; see also *Walters*, *supra*, 1 Cal.App.5th at p. 821 [“[t]he presence of comparable facilities in the immediate area adequately supports [an] implied finding that there were no ‘unusual circumstances’ precluding a categorical exemption”], quoting *Bloom v. McGurk* (1994) 26 Cal.App.4th 1307, 1316.)

Here, other fumigation facilities exist within the District's jurisdiction and in other agricultural areas of the state that utilize Methyl Bromide to fumigate cherries as well as other agricultural products. A few examples of other fumigation facilities within San Joaquin County include Felix Costa & Sons, Chinchiole Sternilt California, M & R Company, A&A Dasso Farm, Prima Frutta Packing Company, Delta Packing Company of Lodi, and Lodi Export Corporation. Additionally, as discussed, the facility in which the proposed fumigation chamber would be installed is currently an existing ongoing fumigation facility that uses Methyl Bromide. The proposed project, combined with the existing fumigation operations in the facility, are similar in size to other fumigation facilities in the region.

Next, it is appropriate to consider whether the location of the proposed project is unusual for any reason. As discussed previously, the fumigation facility is located approximately 125 meters from the closest residence and 110 meters from the closest business. In comparison, the closest business or residence to Lodi Export Corporation's fumigation facility is approximately 32 meters. Moreover, the average distance between the fumigation facilities operated by the seven above-named companies in San Joaquin Valley and the closest adjacent residence or business is approximately 116 meters, which is similar to the proposed project. (See attached satellite images of similar facilities.) Additionally, like all other permitted fumigation facilities, the proposed project is subject to USDA, CAL/OSHA, and related regulatory requirements relating to worker safety; thus, the proposed project will be operated in a similar manner as other existing fumigation operations within San Joaquin County.

Finally, Rivermaid has submitted evidence to the District establishing that several export markets currently require use of Methyl Bromide fumigation for cherries. Because of this requirement, Methyl Bromide continues to be used by many cherry processing and packaging facilities in California in order to allow for export to certain international markets.

The existence of other similar fumigation facilities in the region, including the existing facility on the project site, as well as existing international quarantine requirements demonstrate that the proposed project is not unusual.

Next, consistent with *Berkeley Hillside*, the District's analysis supporting the preliminary decision to issue the ATC considers whether the proposed project *will have* a significant impact on the environment. The District properly determined based on substantial evidence that the proposed project will not result in any significant impacts on the environment. Therefore, no unusual circumstance exists.

To apply to a proposed project, the unusual circumstance exception "require[s] findings of both unusual circumstances *and* a potentially significant effect." (*Berkeley Hillside*, *supra*, 60 Cal.4th at p. 1115 (original emphasis).) As unusual circumstances are not present, the District is not required to analyze the second prong further. Nevertheless, Rivermaid notes that the District's analysis supporting the preliminary decision to issue the ATC correctly concludes that

the proposed project does not have the potential to result in any potentially significant impacts on the environment.

For all of the above reasons, the unusual circumstances exception is not applicable to the proposed project. Rivermaid strongly supports the District's determination that the proposed project is exempt from CEQA as discussed in the preliminary decision to issue the ATC for the proposed project.

If the District has any questions concerning the above facts and analysis, please let us know.


Thank you,

Christopher J. Butcher
Counsel for Rivermaid

**NOTICE OF FINAL ACTION
FOR THE ISSUANCE OF
AUTHORITY TO CONSTRUCT PERMITS**

NOTICE IS HEREBY GIVEN that the Air Pollution Control Officer has issued the Authority to Construct permit to Rivermaid Trading, Company for the construction of a new fumigation chamber, at 6011 East Pine Street in Lodi.

All comments received following the District's preliminary decision on this project were considered.

Comments received by the District during the public notice period resulted in addition of some monitoring and recordkeeping requirements for workers safety purposes. These changes were minor and did not trigger additional public notification requirements, nor did they have any impact upon the Best Available Control Technology determination or on the amount of offsets required for project approval.

The application review for Project #1160591 is available for public inspection at http://www.valleyair.org/notices/public_notices_idx.htm, the SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT, 4800 ENTERPRISE WAY, MODESTO, CA 95356, and at any other District office. For additional information, please contact the District at (209) 557-6400.

**AVISO DE DECISIÓN FINAL
PARA LA OTORGACIÓN DE UN PERMISO DE
AUTORIDAD PARA CONSTRUIR**

POR EL PRESENTE SE NOTIFICA que el Director Ejecutivo del Distrito del Aire ha otorgado permisos de Autoridad para Construir a Rivermaid Trading, Company para la construcción de una nueva cámara de fumigación, en 6011 East Pine Street in Lodi.

Todos los comentarios que se recibieron siguiendo la decisión preliminar en este proyecto fueron considerados.

Los comentarios recibidos por el Distrito durante el periodo del aviso público resultaron en una adición de algunos requisitos de monitoreo y mantenimiento de registros para el propósito de seguridad de los trabajadores. Estos cambios fueron menores y no provocaron requisitos adicionales de aviso público, ni tuvieron un impacto sobre la determinación de Mejor Tecnología de Control Disponible o en la cantidad de compensaciones requeridas para la aprobación de este proyecto.

La revisión de la solicitud del Proyecto #1160591 está disponible para la inspección del público en http://www.valleyair.org/notices/public_notices_idx.htm, en el DISTRITO PARA EL CONTROL DE LA CONTAMINACIÓN DEL AIRE DEL VALLE DE SAN JOAQUIN, 4800 ENTERPRISE WAY, MODESTO, CA 95356, y en cualquiera de las oficinas del Distrito. Para más información en Español, por favor comuníquese con el Distrito al (209) 557-6400.

**NOTICE OF FINAL ACTION
FOR THE ISSUANCE OF
AUTHORITY TO CONSTRUCT PERMITS**

NOTICE IS HEREBY GIVEN that the Air Pollution Control Officer has issued the Authority to Construct permit to Rivermaid Trading, Company for the construction of a new fumigation chamber, at 6011 East Pine Street in Lodi.

All comments received following the District's preliminary decision on this project were considered.

Comments received by the District during the public notice period resulted in addition of some monitoring and recordkeeping requirements for workers safety purposes. These changes were minor and did not trigger additional public notification requirements, nor did they have any impact upon the Best Available Control Technology determination or on the amount of offsets required for project approval.

The application review for Project #1160591 is available for public inspection at http://www.valleyair.org/notices/public_notices_idx.htm, the SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT, 4800 ENTERPRISE WAY, MODESTO, CA 95356, and at any other District office. For additional information, please contact the District at (209) 557-6400.