CITY OF LEWISTON
STAFF REVIEW COMMITTEE MEETING
Thursday, April 16, 2020 – 9:00 P.M.
Lewiston City Building
27 Pine Street, Lewiston

In accordance with An Act To Implement Provisions Necessary to the Health, Welfare and Safety of the Citizens of Maine in Response to the COVID-19 Public Health Emergency, as enacted to read: Sec. G-1 1 MRSA §403-A Public proceedings through remote access during declaration of state of emergency due to COVID-19, this meeting will be held through ZOOM video conferencing. To participate in the meeting, please go to https://zoom.us/meeting/register/uZArdO6qpzovsJ8Uhv0Ut-cy1HMQay-3cw

Information regarding these application is available at https://www.lewistonmaine.gov/439/Staff-Review-Committee. Questions and comments on the application or meeting may be sent to jbuzzell@lewistonmaine.gov or by calling 207-513-3000, ext. 3232.

AGENDA

I. ROLL CALL

II. ADJUSTMENTS TO THE AGENDA

III. CORRESPONDENCE

IV. PUBLIC HEARINGS:

a) A minor development review application submitted by Terradyn Consultants, LLC on behalf of Highbrow Cultivation #2, LLC for the proposed change of use of an existing +/- 37,600 SF building located at 16 Bridge Street from a warehouse/ industrial supply use to a cannabis cultivation facility.

b) An application submitted by Thayer Corporation on behalf of Lavertus Holdings, LLC to renovate an existing manufacturing space to construct an extraction lab and supporting spaces at 96 Commercial Street

V. READING OF THE MINUTES: Motion to adopt the draft SRC minutes from December 5, 2019.

VI. ADJOURNMENT

The City of Lewiston is an EOE. For more information please visit our website www.lewistonmaine.gov and click on the Non-Discrimination Policy.

Pineland
Cumberland Hall
41 Campus Drive, Suite 101
New Gloucester, ME 04260

Portland
565 Congress Street, Suite 201
Portland, ME 04101

2012

March 13, 2020

City of Lewiston, Maine Planning Department
c/o Mr. David Hediger, Director of Planning & Code Enforcement
27 Pine Street
3rd Floor
Lewiston, ME 04240

Minor Development Review Application – 16 Bridge Street Cannabis Cultivation, Lewiston, Maine

On behalf of Highbrow Cultivation #2, LLC, we are pleased to submit the Minor Development Review Application for the proposed change of use for 16 Bridge Street. The project includes the change of use of an existing +/- 37,600 SF building from a warehouse/ industrial supply use to a cannabis cultivation facility.

EXISTING PROJECT SITE

The project site is located in the City of Lewiston's Urban Enterprises (UE) Zoning District, which has been identified as a zoning district appropriate for the cultivation of marijuana in the Lewiston Code of Ordinances, Article XV and Appendix A of the Zoning and land Use Code, Articles II, V, and XI. The project site is comprised of two parcels, totaling 1.31 Acres. The first parcel is the 16 Bridge Street property which is approximately 1.23 Acres and is fully developed. The property consists of consists of an existing +/- 37,600 SF building previously utilized as a warehouse/ industrial supply space and associated parking lot. The primary access to the site is through the main entrance located off of Bridge Street and a internal loading bay which is accessed via Spring Street. The second parcel is 14 Bridge Street which is a 0.08 Acre site that is currently vacant.

PROPOSED PROJECT

The Applicant proposes to renovate the existing building to grow and cultivate cannabis. The existing drive and parking area will be repaved within the existing limits of pavement. As part of the Change of Use the applicant is required to meet the approval criteria as outlined in Article XIII Section 4 of the City of Lewiston Zoning and Land Use Code and described below:

a) Utilization of the Site

The existing site is fully developed, there are no proposed changes to the existing utilization of the site.

b) Traffic Movement Into and Out of the Development Area

The proposed change of use is not expected to have any discernable traffic impacts to the immediate neighborhood. 30 employees will be employed at the facility with a maximum of 20

employees onsite at any given time. The estimated vehicular traffic can be obtained from the Trip Generation Manual published by the Institute of Transportation Engineers. Section 140 Manufacturing was selected as the closest comparable use and used as a basis for the calculations and is summarized as follows:

- Average Daily Trip Generation= 2.47 Trips/ Employee= **50 Trips/Day**
- Average Weekday AM Peak Hour= 0.37 Trips/Employee= **8 Trips/Hour**
- Average Weekday PM Peak Hour= 0.33 Trips/Employee= **7 Trips/Hour**

c) Access into the Site

Vehicular access into the site will not be altered due to the proposed change of use, the existing entrance drive located off of Bridge Street will remain and serve as the primary site entrance. Deliveries will continue to utilize the existing internal loading bay located along Spring Street.

d) Internal Vehicular Circulation

The proposed parking lot improvements have been designed in accordance with the City of Lewiston's Performance Standards. The Owner intends to employ approximately 30 employees at the site with a maximum of 20 employees onsite at any given time. The existing parking area has been maximized to provide 24 parking spaces onsite.

e) Pedestrian Circulation

No pedestrian circulation will be altered by the proposed change of use.

f) Stormwater Management

The site is fully developed, the proposed alterations to the entrance drive and parking area associated with the change of use result in a small decrease of approximately 1,193 SF of impervious area. The existing roof drain will be modified to separate it from the existing sanitary lateral. A new roof drain leader will be installed to the storm drain within West Bates Street.

g) Erosion Control

All necessary erosion control will be provided in accordance with Maine Department of Environmental Projection guidelines and have been detailed on the attached plans.

h) Water Supply

The existing water service will not be altered by the proposed change of use. The site will continue to utilize the existing service which feeds the building off of Spring Street.

i) Sewage Disposal

As mentioned above, the existing sewer lateral will be modified to remove the roof drains. The existing lateral to the into the sanitary sewer collection system is intended to remain.

j) Utilities

A new 3-phase transformer will be installed to upgrade the existing power supply that currently feeds the building. The Applicant is currently working with CMP to develop and plan for upgrading the existing building service, a summary of the applicants work with CMP is attached to this letter.

All other utilities will utilize existing service connections to the building.

k) Natural Features

The site is fully developed, this section is not applicable to the proposed change of use.

l) Groundwater Protection

The project area is not located on a sand or gravel aquifer.

m) Water and Air Pollution

The proposed development will not result in undue water or air pollution, the applicant will be installing a odor management system to mitigate any odor produced within the building. A Detailed odor Management Plan is attached to this letter.

n) Exterior Lighting

The building will utilize building mounted fixtures. All fixtures will be LED and feature a full cut-off design. See attached site plan for the locations of the fixtures, and example lighting cut sheets are attached to this letter.

o) Waste Disposal

The proposed site will utilize internal dumpsters for waste disposal for security reasons. There will be two streams of waste generated at the facility.

- Regular industrial waste will be separated into recyclable destinations held onsite within the internal loading dock area; a local waste vendor will be contracted to remove and dispose of waste at a licensed facility.
- A second source of waste is the byproduct from growing, harvesting, and trimming preparation of the cannabis plants, an outside firm will be contracted who specifically deals with this waste to process and transport to a licensed facility.

p) Lot Layout

This section is not applicable to the proposed change of use.

q) Landscaping

The existing building is situated along the property line, as such no landscaping is currently proposed.

r) Shoreland Relationship

The development will not adversely impact the water quality or shoreline of any adjacent water body.

s) Open Space
This section is not applicable to the proposed change of use.

t) Technical and Financial Capacity
cPort Credit Union has provided documentation supporting the proposed project, a copy is attached to this letter.

u) Buffering
A six-foot high stockade fence is proposed along the outer property lines of the project site to screen the building from neighboring properties.

v) Compliance with District Regulations
The site is located within the Urban Enterprise (UE) district. The proposed use of the building complies with the allow use within this zone.

w) Design consistent with performance standards:
In addition to the approval criteria above the proposed project is also subject to the performance standards of article XII as applicable. The follow performance standards apply the to the proposed change of use:

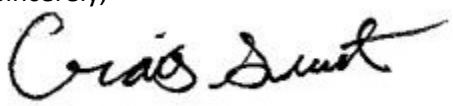
- Erosion and Sedimentation Control
- Off-street parking and loading

The following items are attached to this submittal:

- Development Review Application & Fee
- Plan Set (including Site Plan, Grading & Utility Plan, and Construction Details & Notes)
- Attachment 1: Right, Title, Interest
- Attachment 2: Electrical Capacity
- Attachment 3: Odor Control
- Attachment 4: Lighting Cut Sheets
- Attachment 5: Financial Capacity

We are hopeful that this application can be placed on the agenda for next available Staff Review Committee meeting. Thank you for your consideration, and please reach out to me at 207-370-2776 or craig@terradynconsultants.com if you have any questions as you review the enclosed plans and information.

Sincerely,



Craig Sweet, P.E.
Terradyn Consultants, LLC

Development Review Application

City of Auburn Planning and Permitting Department
City of Lewiston Department of Planning and Code Enforcement

PROJECT NAME: 16 Bridge Street Change of Use

PROPOSED DEVELOPMENT ADDRESS: 16 Bridge Street

PARCEL ID#: RE00001511 & RE00004942

REVIEW TYPE: Site Plan/Special Exception ☑ Site Plan Amendment ☐
Subdivision ☐ Subdivision Amendment ☐

PROJECT DESCRIPTION: Change of use of an existing building located at 16 Bridge Street for the Cultivation of Marijuana.

CONTACT INFORMATION:

Applicant Highbrow Cultivation #2, LLC	Property Owner
Name: 84 Marginal Way Ste 600	Name: Same as Applicant
Address: Portland, ME 04101	Address:
Zip Code	Zip Code
Work #: 207-310-1818	Work #:
Cell #:	Cell #:
Fax #:	Fax #:
Home #:	Home #:
Email: HighbrowMaine@gmail.com or Richelle@HighbrowMaine.com	Email:

Project Representative	Other professional representatives for the project (surveyors, engineers, etc.),
Name: Craig Sweet P.E. Terradyn Consultants, LLC	Name:
Address: 41 Campus Drive Suite 101 New Gloucester	Address:
Zip Code: 04260	Zip Code:
Work #: 207-926-5111	Work #:
Cell #: 207-370-2776	Cell #:
Fax #:	Fax #:
Home #:	Home #:
Email: Craig@Terradynconsultants.com	Email:

PROJECT DATA

The following information is required where applicable, in order to complete the application

IMPERVIOUS SURFACE AREA/RATIO

Existing Total Impervious Area	50,942	sq. ft.
Proposed Total Paved Area	12,049	sq. ft.
Proposed Total Impervious Area	49,749	sq. ft.
Proposed Impervious Net Change	-1,193	sq. ft.
Impervious surface ratio existing	94	% of lot area
Impervious surface ratio proposed	92	% of lot area

BUILDING AREA/LOT COVERAGE

Existing Building Footprint	37,700	sq. ft.
Proposed Building Footprint	37,700	sq. ft.
Proposed Building Footprint Net change	0	sq. ft.
Existing Total Building Floor Area	37,700	sq. ft.
Proposed Total Building Floor Area	37,700	sq. ft.
Proposed Building Floor Area Net Change	0	sq. ft
New Building	no	(yes or no)
Building Area/Lot coverage existing	70.2	% of lot area
Building Area/Lot coverage proposed	70.2	% of lot area

ZONING

Existing	UE	sq. ft.
Proposed, if applicable		

LAND USE

Existing	Warehouse/ Industrial Supply
Proposed	Marijuana Cultivation

RESIDENTIAL, IF APPLICABLE

Existing Number of Residential Units
Proposed Number of Residential Units
Subdivision, Proposed Number of Lots

PARKING SPACES

Existing Number of Parking Spaces	0
Proposed Number of Parking Spaces	24
Required Number of Parking Spaces	20
Number of Handicapped Parking Spaces	1

ESTIMATED COST OF PROJECT _____

DELEGATED REVIEW AUTHORITY CHECKLIST

SITE LOCATION OF DEVELOPMENT AND STORMWATER MANAGEMENT

Existing Impervious Area	50,942	sq. ft.
Proposed Disturbed Area	15,587	sq. ft.
Proposed Impervious Area	49,749	sq. ft.

1. *If the proposed disturbance is greater than one acre, then the applicant shall apply for a Maine Construction General Permit (MCGP) with MDEP.*
2. *If the proposed impervious area is greater than one acre including any impervious area crated since 11/16/05, then the applicant shall apply for a MDEP Stormwater Management Permit, Chapter 500, with the City.*
3. *If total impervious area (including structures, pavement, etc) is greater than 3 acres since 1971 but less than 7 acres, then the applicant shall apply for a Site Location of Development Permit with the City. If more than 7 acres then the application shall be made to MDEP unless determined otherwise.*
4. *If the development is a subdivision of more than 20 acres but less than 100 acres then the applicant shall apply for a Site Location of Development Permit with the City. If more than 100 acres then the application shall be made to MDEP unless determined otherwise.*

TRAFFIC ESTIMATE

Total traffic estimated in the peak hour-existing (Since July 1, 1997) 11 passenger car equivalents (PCE)

Total traffic estimated in the peak hour-proposed (Since July 1, 1997) 11 passenger car equivalents (PCE)

If the proposed increase in traffic exceeds 100 one-way trips in the peak hour then a traffic movement permit will be required.

Zoning Summary

1. Property is located in the UE zoning district.
2. Parcel Area: 1.23 acres / 53,875 square feet(sf). **RE00001511**

   Parcel Area: 0.08 acres / 3,485 square feet(sf). **RE00004942**

Regulations	Required/Allowed	Provided
Min Lot Area	N/A	No Change from existing
Street Frontage	N/A	No Change from existing
Min Front Yard	N/A	No Change from existing
Min Rear Yard	N/A	No Change from existing
Min Side Yard	N/A	No Change from existing
Max. Building Height	N/A	No Change from existing
Use Designation	N/A	No Change from existing
Parking Requirement		
Total Parking:	20/24	
Overlay zoning districts (if any):	none / none / none	

Urban impaired stream watershed? YES/NO If yes, watershed name NO

DocuSign Envelope ID: FADBF406-FEFE-4B91-8A7B-A736C46843FE

DEVELOPMENT REVIEW APPLICATION SUBMISSION

Submission shall include payment of fee and fifteen (15) complete packets containing the following materials:

1. Full size plans containing the information found in the attached sample plan checklist.
2. Application form that is completed and signed.
3. Cover letter stating the nature of the project.
4. All written submittals including evidence of right, title and interest.
5. Copy of the checklist completed for the proposal listing the material contained in the submitted application.

Refer to the application checklist for a detailed list of submittal requirements.

L/A's development review process and requirements have been made similar for convenience and to encourage development. Each Citys ordinances are available online at their prospective websites:
Auburn: www.auburnmaine.org under City Departments/ Planning and Permitting/Land Use Division/Zoning Ordinance
Lewiston: http://www.ci.lewiston.me.us/clerk/ordinances.htm Refer to Appendix A of the Code of Ordinances

I hereby certify that I am the Owner of record of the named property, or that the owner of record authorizes the proposed work and that I have been authorized by the owner to make this application as his/her authorized agent. I agree to conform to all applicable laws of this jurisdiction. In addition, I certify that the City's authorized representative shall have the authority to enter all areas covered by this permit at any reasonable hour to enforce the provisions of the codes applicable to this permit.

This application is for development review only; a Performance Guarantee, Inspection Fee, Building Permit Application and other associated fees and permits will be required prior to construction.

Signature of Applicant: DocuSigned by: 5733D25ACED54A4...	**Date:** March 10, 2020

Development Review Checklist

City of Auburn Planning and Permitting Department
City of Lewiston Department of Planning and Code Enforcement

THE FOLLOWING INFORMATION IS REQUIRED WHERE APPLICABLE TO BE SUBMITTED FOR AN APPLICATION TO BE COMPLETE

PROJECT NAME: 16 Bridge Street Cannabis Cultivation

PROPOSED DEVELOPMENT ADDRESS and PARCEL #: 16 Bridge Street Parcel# RE00001511
14 Bridge Street Parcel# RE00004942

Required Information		Check Submitted		Applicable Ordinance	
Site Plan		**Applicant**	**Staff**	**Lewiston**	**Auburn**
	Owner's Names/Address	X			
	Names of Development	X			
	Professionally Prepared Plan	X			
	Tax Map or Street/Parcel Number	X			
	Zoning of Property	X			
	Distance to Property Lines	N/A			
	Boundaries of Abutting land	N/A			
	Show Setbacks, Yards and Buffers	N/A			
	Airport Area of Influence (Auburn only)	N/A			
	Parking Space Calcs	X			
	Drive Openings/Locations	X			
	Subdivision Restrictions	N/A			
	Proposed Use	X			
	PB/BOA/Other Restrictions	N/A			
	Fire Department Review				
	Open Space/Lot Coverage	N/A			
	Lot Layout (Lewiston only)				
	Existing Building (s)	X			
	Existing Streets, etc.	X			
	Existing Driveways, etc.	X			
	Proposed Building(s)	N/A			
	Proposed Driveways	N/A			
Landscape Plan					
	Greenspace Requirements	N/A			
	Setbacks to Parking	N/A			
	Buffer Requirements	N/A			
	Street Tree Requirements	N/A			

	Screened Dumpsters	N/A			
	Additional Design Guidelines	N/A			
	Planting Schedule	N/A			
Stormwater & Erosion Control Plan					
	Compliance w/ chapter 500	N/A			
	Show Existing Surface Drainage	N/A			
	Direction of Flow	N/A			
	Location of Catch Basins, etc.	X			
	Drainage Calculations	N/A			
	Erosion Control Measures	X			
	Maine Construction General Permit	N/A			
	Bonding and Inspection Fees	N/A			
	Post-Construction Stormwater Plan	N/A			
	Inspection/monitoring requirements	N/A			
	Third Party Inspections (Lewiston only)	N/A			
Lighting Plan					
	Full cut-off fixtures	X			
	Meets Parking Lot Requirements	X			
Traffic Information					
	Access Management	N/A			
	Signage				
	PCE - Trips in Peak Hour	X			
	Vehicular Movements				
	Safety Concerns	X			
	Pedestrian Circulation	N/A			
	Police Traffic	N/A			
	Engineering Traffic	N/A			
Utility Plan					
	Water	X			
	Adequacy of Water Supply	N/A			
	Water main extension agreement	N/A			
	Sewer	X			
	Available city capacity	N/A			
	Electric				
	Natural Gas	N/A			
	Cable/Phone	N/A			
Natural Resources					
	Shoreland Zone	N/A			
	Flood Plain	N/A			
	Wetlands or Streams	N/A			
	Urban Impaired Stream	N/A			
	Phosphorus Check	N/A			
	Aquifer/Groundwater Protection	N/A			
	Applicable State Permits	N/A			

	No Name Pond Watershed (Lewiston only)	N/A			
	Lake Auburn Watershed (Auburn only)	N/A			
	Taylor Pond Watershed (Auburn only)	N/A			
Right Title or Interest					
	Verify	X			
	Document Existing Easements, Covenants, etc.	X			
Technical & Financial Capacity					
	Cost Est./Financial Capacity	X			
	Performance Guarantee	N/A			
State Subdivision Law					
	Verify/Check	N/A			
	Covenants/Deed Restrictions	N/A			
	Offers of Conveyance to City	N/A			
	Association Documents	N/A			
	Location of Proposed Streets & Sidewalks	N/A			
	Proposed Lot Lines, etc.	N/A			
	Data to Determine Lots, etc.	N/A			
	Subdivision Lots/Blocks	N/A			
	Specified Dedication of Land	N/A			
Additional Subdivision Standards					
	Single-Family Cluster (Lewiston only)	N/A			
	Multi-Unit Residential Development (Lewiston only)	N/A			
	Mobile Home Parks	N/A			
	Private Commercial or Industrial Subdivisions (Lewiston only)	N/A			
	PUD (Auburn only)	N/A			
A jpeg or pdf of the proposed site plan					
Final sets of the approved plans shall be submitted digitally to the City, on a CD or DVD, in AutoCAD format R 14 or greater, along with PDF images of the plans for archiving					

16 BRIDGE STREET

CANNABIS CULTIVATION

16 BRIDGE STREET - LEWISTON, MAINE

PREPARED BY:

CIVIL ENGINEER:
TERRADYN CONSULTANTS, LLC
41 CAMPUS DRIVE
SUITE 101
NEW GLOUCESTER, MAINE 04260
(207)926-5111

SHEET INDEX

C-0.0	COVER SHEET & LOCATION MAP
C-1.0	SITE LAYOUT PLAN
C-2.0	GRADING & UTILITY PLAN
C-3.0	DETAILS & NOTES
C-3.1	DETAILS

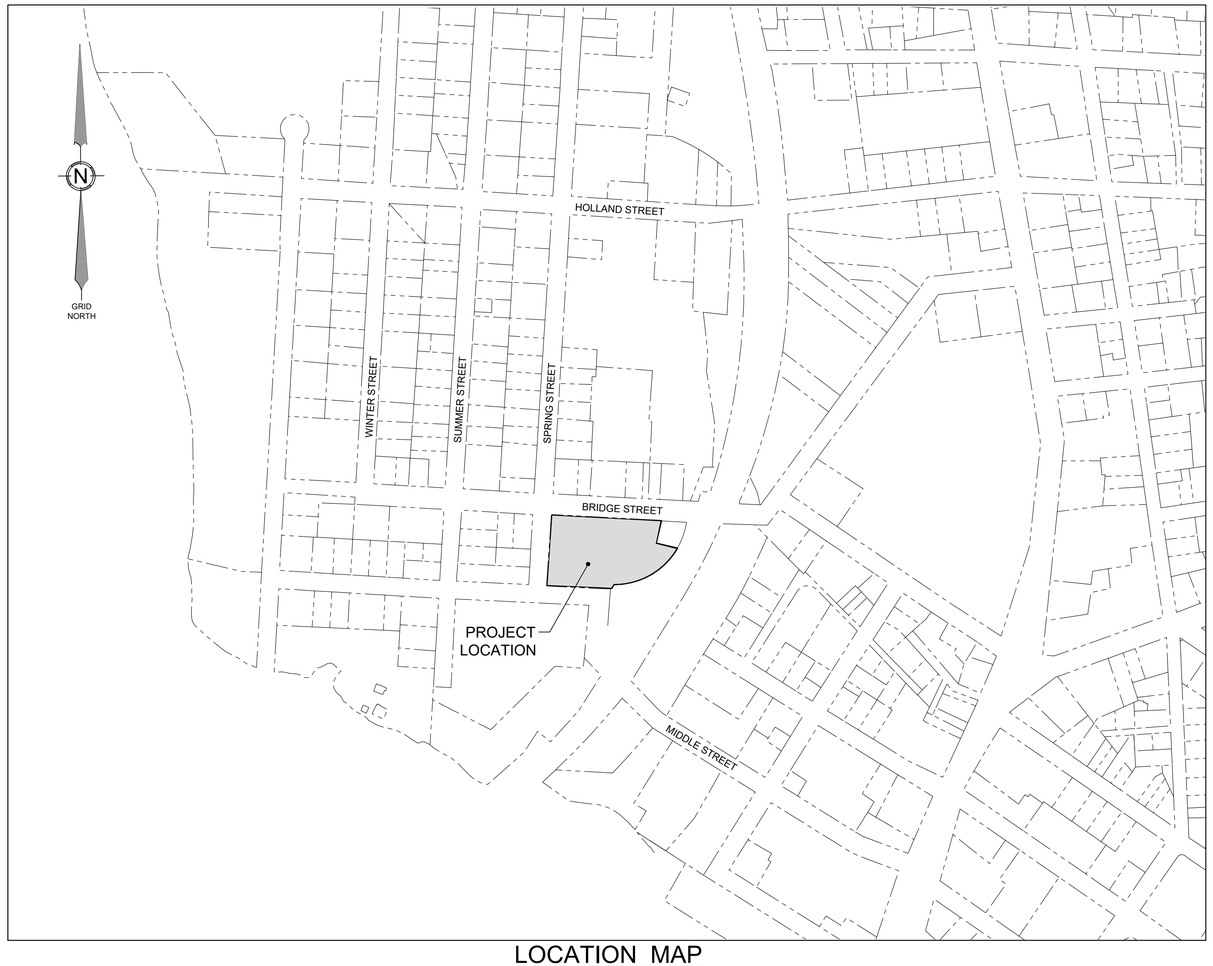
APPLICANT/OWNER:

HIGHBROW CULTIVATION #2, LLC
84 MARGINAL WAY SUITE 600
PORTLAND, MAINE 04101

PROJECT PARCEL SITE

CITY OF LEWISTON TAX ASSESSOR'S MAP & LOT NUMBERS

MAP	LOT
206	198 & 199



LOCATION MAP
1" = 200'

LEGEND

- EXISTING PROPERTY LINE
- PROPOSED PROPERTY LINE
- PROPOSED SETBACK LINE
- EXISTING SETBACK LINE
- EXISTING EASEMENT
- PROPOSED EASEMENT
- ROAD CENTERLINE
- 124 EXISTING MINOR CONTOUR
- 124 EXISTING MAJOR CONTOUR
- 124 PROPOSED CONTOUR
- SD EXISTING STORMDRAIN
- SD PROPOSED STORMDRAIN
- S EXISTING SANITARY SEWER
- S PROPOSED SANITRY SEWER
- W EXISTING WATER LINE
- W PROPOSED WATER LINE
- UD EXISTING UNDERDRAIN
- UD PROPSED UNDERDRAIN
- OHE EXISTING OVERHEAD ELECTRIC & TELEPHONE
- OHE PROPOSED OVERHEAD ELECTRIC & TELEPHONE
- UGE EXISTING UNDERGROUND ELECTRIC & TELEPHONE
- UGE PROPOSED UNDERGROUND ELECTRIC & TELEPHONE
- EXISTING EDGE OF PAVEMENT
- PROPOSED EDGE OF PAVEMENT
- EXISTING EDGE OF GRAVEL
- PROPOSED EDGE OF GRAVEL
- EXISTING CURB
- PROPOSED CURB
- EDGE OF WATER
- EXISTING TREE LINE
- PROPOSED TREE LINE
- CHAIN LINK FENCE
- PROPOSED FENCE
- EXISTING GUARDRAIL
- PROPOSED GUARDRAIL
- SF SILT FENCE
- EXISTING VALVE
- PROPOSED VALVE
- EXISTING HYDRANT
- PROPOSED HYDRANT
- EXISTING TRANSFORMER
- PROPOSED TRANSFORMER
- EXISTING LIGHT POLE
- PROPOSED LIGHT POLE
- EXISTING UTILITY POLE
- PROPOSED UTILITY POLE
- EXISTING CATCH BASIN
- PROPOSED CATCH BASIN
- EXISTING SEWER MANHOLE
- PROPOSED SEWER MANHOLE
- 30.20 EXISTING SPOT GRADE
- 30.20 PROPOSED SPOT GRADE
- EXISTING SIGN
- PROPOSED SIGN
- EXISTING BUILDING
- PROPOSED BUILDING
- PROPOSED PAVEMENT

GENERAL NOTES:

1. THE APPROVAL WILL EXPIRE IN ACCORDANCE WITH ARTICLE XIII, SECTION 11(a)(1) OF THE CITY OF LEWISTON CODE OF ORDINANCES. THAT SECTION STATES THAT IF DEVELOPMENT HAS NOT OCCURRED AS DEFINED WITHIN THE SCOPE OF THE CODE WITHIN TWO YEARS, DEVELOPMENT REVIEW APPROVAL SHALL EXPIRE. THE APPLICANT MAY NOT BEGIN CONSTRUCTION OR OPERATION OF THE DEVELOPMENT UNTIL A NEW APPROVAL IS GRANTED.

2. PRIOR TO ANY CERTIFICATE OF OCCUPANCY BEING ISSUED, EVIDENCE OF A FINAL INSPECTION OF THE STORMWATER SYSTEM SHALL BE PROVIDED TO THE CITY BY THE DESIGNING ENGINEER ALONG WITH A WRITTEN STATEMENT INDICATING THAT THE STORMWATER SYSTEM AND ALL SITE IMPROVEMENTS HAVE BEEN COMPLETED IN ACCORDANCE WITH THE APPROVED PLANS.

STATE OF MAINE
CRAIG SWEET
No. 15060
LICENSED
PROFESSIONAL ENGINEER

DATE: 3/9/2020
P.E.: CRAIG M SWEET

NO.	DATE	REVISIONS	APP'D BY

TERRADYN CONSULTANTS, LLC
41 CAMPUS DRIVE
SUITE 101
NEW GLOUCESTER, ME 04260
565 CONGRESS STREET
SUITE 201
PORTLAND, ME 04102
OFFICE: (207) 926-5111
www.terradynconsultants.com
Civil Engineering - Land Planning - Stormwater Design - Environmental Permitting

SHEET DESCRIPTION
COVER SHEET
16 BRIDGE STREET
LEWISTON, ME 04240

PREPARED FOR
HIGHBROW CULTIVATION #2, LLC
84 MARGINAL WAY SUITE 600
PORTLAND, MAINE 04101

DATE:	3/9/2020
SCALE:	AS NOTED
DESIGNED:	CMS
JOB NO:	2012
FILE:	
SHEET	C-0.0

PERMITTING SET- NOT FOR CONSTRUCTION

GENERAL NOTES

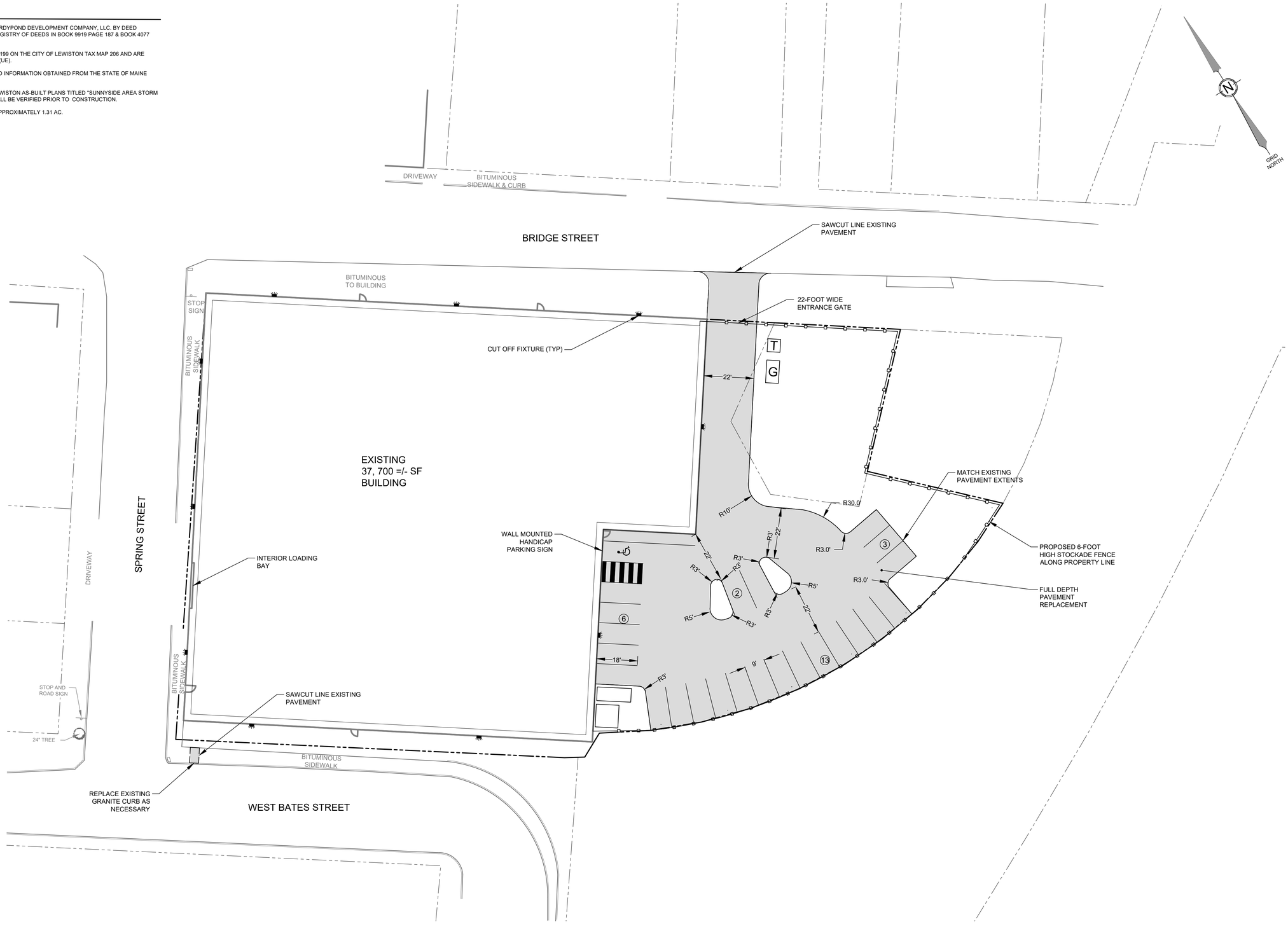
1. THE RECORD OWNER OF THE PARCELS IS HARDYPOND DEVELOPMENT COMPANY, LLC. BY DEED RECORDED IN THE ANDROSCOGGIN COUNTY REGISTRY OF DEEDS IN BOOK 9919 PAGE 187 & BOOK 4077 PAGE130.

2. THE PROPERTIES ARE SHOWN AS LOTS 198 & 199 ON THE CITY OF LEWISTON TAX MAP 206 AND ARE LOCATED IN THE URBAN ENTERPRISE DISTRICT (UE).

3. TOPOGRAPHY IS BASED UPON LIDAR DERIVED INFORMATION OBTAINED FROM THE STATE OF MAINE DEPARTMENT OF GIS.

4. EXISTING UTILITIES SHOWN FROM CITY OF LEWISTON AS-BUILT PLANS TITLED "SUNNYSIDE AREA STORM DRAIN PHASE III" ALL EXISTING CONDITIONS SHALL BE VERIFIED PRIOR TO CONSTRUCTION.

5. THE TOTAL AREA OF THIS PROJECT SITE IS APPROXIMATELY 1.31 AC.



GRAPHIC SCALE

20 0 10 20 20 60

(IN FEET)
1 inch = 20 ft.

PERMITTING SET- NOT FOR CONSTRUCTION

STATE OF MAINE
CRAIG SWEET
No. 15060
LICENSED
PROFESSIONAL ENGINEER

DATE: 03/09/2020
P.E.: CRAIG M SWEET

NO.	DATE	REVISIONS	APP'D BY

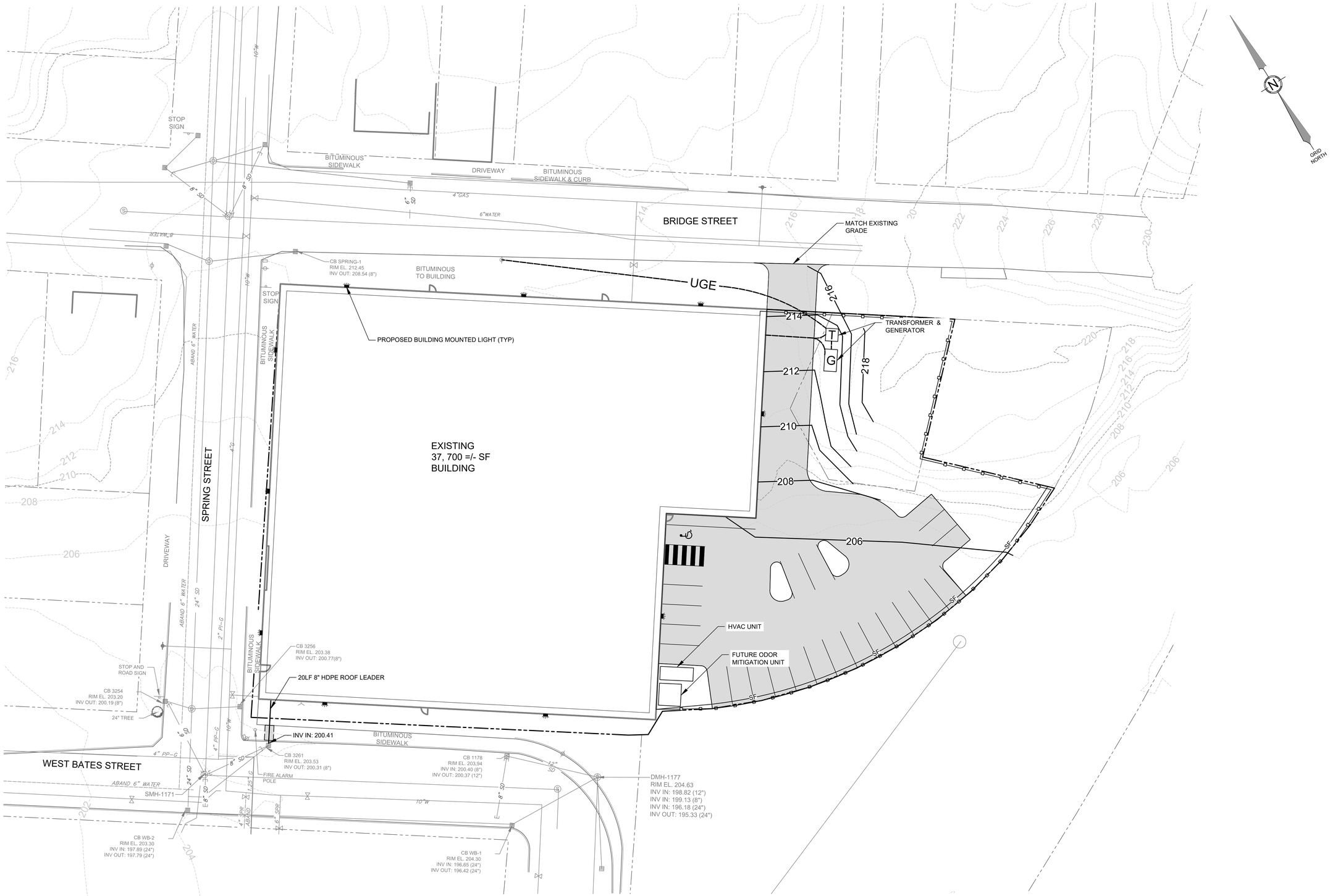
TERRADYN CONSULTANTS, LLC
41 CAMPUS DRIVE SUITE 101 NEW GLOUCESTER, ME 04260
565 CONGRESS STREET SUITE 201 PORTLAND, ME 04102
OFFICE: (207) 926-5111
www.terradynconsultants.com

Civil Engineering - Land Planning - Stormwater Design - Environmental Permitting

SHEET DESCRIPTION
SITE LAYOUT PLAN
16 BRIDGE STREET
LEWISTON, ME 04240

PREPARED FOR
HIGHBROW CULTIVATION #2, LLC
84 MARGINAL WAY SUITE 600
PORTLAND, MAINE 04101

DATE:	3/9/2020
SCALE:	1"=20'
DESIGNED:	CMS
JOB NO:	2012
FILE:	
SHEET	C-1.0



PERMITTING SET- NOT FOR CONSTRUCTION

STATE OF MAINE
CRAIG SWEET
No. 15060
LICENSED
PROFESSIONAL ENGINEER

DATE: 3/9/2020
P.E.: CRAIG M SWEET

NO.	DATE	REVISIONS	APPR. BY

TERRADYN CONSULTANTS, LLC
41 CAMPUS DRIVE
SUITE 101
NEW GLOUCESTER, ME 04260
565 CONGRESS STREET
SUITE 201
PORTLAND, ME 04102
OFFICE: (207) 926-5111
www.terradynconsultants.com

Civil Engineering - Land Planning - Stormwater Design - Environmental Permitting

SHEET DESCRIPTION
GRADING & UTILITY PLAN
16 BRIDGE STREET
LEWISTON, ME 04240

PREPARED FOR
HIGHBROW CULTIVATION #2, LLC
84 MARGINAL WAY SUITE 600
PORTLAND, MAINE 04101

DATE:	3/9/2020
SCALE:	1"=20'
DESIGNED:	CMS
JOB NO:	2012
FILE:	
SHEET	C-2.0

EROSION AND SEDIMENT CONTROL PLAN

Pre-Construction Phase
A person who conducts, or causes to be conducted, an activity that involves filling, displacing or exposing soil or other earthen materials shall take measures to prevent unreasonable erosion of soil or sediment beyond the project site or into a protected natural resource as defined in 38 mrsa § 480-b. Erosion control measures must be in place before the activity begins. Measures must remain in place and functional until the site is permanently stabilized. Adequate and timely temporary and permanent stabilization measures must be taken. The site must be maintained to prevent unreasonable erosion and sedimentation. Minimize disturbed areas and protect natural downgradient buffer areas to the extent practicable.

BMP Construction Phase
A. Sediment barriers. Prior to the beginning of any construction, properly install sediment barriers at the edge of any downgradient disturbed area and adjacent to any drainage channels within the proposed disturbed area. Maintain the sediment barriers until the disturbed area is permanently stabilized.

B. Construction entrance: Prior to any clearing or grubbing, a construction entrance shall be constructed at the intersection with the proposed access drive and the existing roadway to avoid tracking of mud, dust and debris from the site.

C. Riprap: Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum delay. Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate. Maintain temporary riprap, such as temporary check dams until the disturbed area is permanently stabilized.

D. Temporary stabilization. Stabilize with temporary seeding, mulch, or other non-erodable cover any exposed soils that will remain unworked for more than 14 days except, stabilize areas within 100 feet of a wetland or waterbody within 7 days or prior to a predicted storm event, whichever comes first. If hay or straw mulch is used, the application rate must be 2 bales (70-90 pounds) per 1000 sf or 1.5 to 2 tons (90-100 bales) per acre to cover 75 to 90% of the ground surface. Hay mulch must be kept moist or anchored to prevent wind blowing. An erosion control blanket or mat shall be used at the base of grassed waterways, steep slopes (15% or greater) and on any disturbed soil within 100 feet of lakes, streams and wetlands. Grading shall be planned so as to minimize the length of time between initial soil exposure and final grading. On large projects this should be accomplished by phasing the operation and completing the first phase up to final grading and seeding before starting the second phase, and so on.

E. Vegetated waterway. Upon final grading, the disturbed areas shall be immediately seeded to permanent vegetation and mulched and will not be used as outlets until a dense, vigorous vegetative cover has been obtained. Once soil is exposed for waterway construction, it should be immediately shaped, graded and stabilized. Vegetated waterways need to be stabilized early during the growing season (prior to september 15). If final seeding of waterways is delayed past september 15, emergency provisions such as sod or riprap may be required to stabilize the channel. Waterways should be fully stabilized prior to directing runoff to them.

Permanent stabilization defined
A. Seeded areas. For seeded areas, permanent stabilization means an 90% cover of the disturbed area with mature, healthy plants with no evidence of washing or rilling of the topsoil.

B. Sodded areas. For sodded areas, permanent stabilization means the complete binding of the sod roots into the underlying soil with no slumping of the sod or die-off.

C. Permanent mulch. For mulched areas, permanent mulching means total coverage of the exposed area with an approved mulch material. Erosion control mix may be used as mulch for permanent stabilization according to the approved application rates and limitations.

D. Riprap. For areas stabilized with riprap, permanent stabilization means that slopes stabilized with riprap have an appropriate backing of a well-graded gravel or approved geotextile to prevent soil movement from behind the riprap. Stone must be sized appropriately. It is recommended that angular stone be used.

E. Agricultural use. For construction projects on land used for agricultural purposes (e.G., pipelines across crop land), permanent stabilization may be accomplished by returning the disturbed land to agricultural use.

F. Paved areas. For paved areas, permanent stabilization means the placement of the compacted gravel subbase is completed.

G. Ditches, channels, and swales. For open channels, permanent stabilization means the channel is stabilized with mature vegetation at least three inches in height, with well-graded riprap, or with another non-erosive lining capable of withstanding the anticipated flow velocities and flow depths without reliance on check dams to slow flow. There must be no evidence of slumping of the lining, undercutting of the banks, or down-cutting of the channel.

General Construction Phase
The following erosion control measures shall be followed by the contractor throughout construction of this project:

A. All topsoil shall be collected, stockpiled, seeded with rye at 3 pounds/1,000 sf and mulched, and reused as required. Silt fencing shall be placed down gradient from the stockpiled loam. Stockpile to be located by designation of the owner and inspecting engineer.

B. The inspecting engineer at his/her discretion, may require additional erosion control measures and/or supplemental vegetative provisions to maintain stability of earthworks and finish graded areas. The contractor shall be responsible for providing and installing any supplemental measures as directed by the inspecting engineer. Failure to comply with the engineer's directions will result in discontinuation of construction activities.

C. Erosion control mesh shall be applied in accordance with the plans over all finish seeded areas as specified on the design plans.

D. All graded or disturbed areas including slopes shall be protected during clearing and construction in accordance with the approved erosion and sediment control plan until they are adequately stabilized.

E. All erosion, and sediment control practices and measures shall be constructed, applied and maintained in accordance with the approved erosion and sediment control plan.

F. Areas to be filled shall be cleared, grubbed and stripped of topsoil to remove trees, vegetation, roots or other objectionable materials.

G. Areas shall be scarified to a minimum depth of 3 inches prior to placement of topsoil.

H. All fills shall be compacted as required to reduce erosion, slippage, settlement, subsidence or other related problems. Fill intended to support buildings, structures and conduits, etc., shall be compacted in accordance with local requirements or codes.

I. All fills shall be placed and compacted in layers not to exceed 8 inches in thickness.

J. Except for approved landfills or non-structural fills, fill material shall be free of brush, rubbish, rocks, logs, stumps, building debris and other objectionable materials that would interfere with or prevent construction of satisfactory lifts.

K. Frozen material or soft, mucky or highly compressible materials shall not be incorporated into fill slopes or structural fills.

L. Fill shall not be placed on a frozen foundation.

M. Seeps or springs encountered during construction shall be handled appropriately.

N. All graded areas shall be permanently stabilized immediately following finished grading.

O. Remove any temporary control measures, such as silt fence, within 30 days after permanent stabilization is attained. Remove any accumulated sediments and stabilize.

Permanent vegetation
Permanent vegetative cover should be established on disturbed areas where permanent, long lived vegetative cover is needed to stabilize the soil, to reduce damages from sediment and runoff, and to enhance the environment.

Seedbed preparation
A. Grade as feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring, and maintenance.

B. Apply limestone and fertilizer according to soil tests such as those offered by the university of maine soil testing laboratory. Soil sample mailers are available from the local cooperative extension service office. If soil testing is not feasible on small or variable sites, or where timing is critical, fertilizer may be applied at the rate of 800 pounds per acre or 18.4 pounds per 1,000 square feet using 10-20-20 (n-p2o5-k2o) or equivalent. Apply ground limestone (equivalent to 50% calcium plus magnesium oxide) at a rate of 3 tons per acre (138 lb. Per 1,000 sq. Ft).

C. Work lime and fertilizer into the soil as nearly as practical to a depth of 4 inches with a disc, spring tooth harrow or other suitable equipment. The final harrowing operation should be on the general contour. Continue tillage until a reasonably uniform, fine seedbed is prepared. All but clay or silty soils and coarse sands should be rolled to firm the seedbed wherever feasible.D. Remove from the surface all stones 2 inches or larger in any dimension. Remove all other debris, such as wire, cable, tree roots, concrete, clods, lumps or other unsuitable material.

E. Inspect seedbed just before seeding. If traffic has left the soil compacted; the area must be tilled and firmed as above.

F. Permanent seeding should be made 45 days prior to the first killing frost or as a dormant seeding with mulch after the first killing frost and before snowfall. When crown vetch is seeded in later summer, at least 35% of the seed should be hard seed (unscarified). If seeding cannot be done within the seeding dates, mulch according to the temporary mulching bmp and overwinter stabilization and construction to protect the site and delay seeding until the next recommended seeding period.

G. Following seed bed prepartation, swale areas, fill areas and back slopes shall be seeded at a rate of 3 lbs./1,000 s.F. With a mixture of 35% creeping red h. Fescue, 6% red top, 24% kentucky bluegrass, 10% perennial ryegrass, 20% annual ryegrass and 5% white dutch clover.

I. Areas which have been temporarily or permanently seeded shall be mulched immediately following seeding.

J. Areas which cannot be seeded within the growing season shall be mulched for over-winter protection and the area should be seeded at the beginning of the growing season.

Winter construction phase
If an area is not stabilized with temporary or permanent measures by november 15, then the site must be protected with additional stabilization measures.

A. Permanent stabilization consists of at least 90% vegetation, pavement/gravel base or riprap.

B. Do not expose slopes or leave slopes exposed over the winter or for any other extended time of work suspension unless fully protected with mulch.

C. Apply hay mulch at twice the standard rate (150 lbs. Per 1,000 sf). The mulch must be thick enough such that the ground surface will not be visible and must be anchored.

D. Use mulch and mulch netting or an erosion control mulch blanket or all slopes greater than 8 % or other areas exposed to direct wind.

E. Install an erosion control blanket in all drainageways (bottom and sides) with a slope greater than 3 %.

F. See the vegetation measures for more information on seeding dates and types.

G. Winter excavation and earthwork shall be completed so that no more than 1 acre of the site is without stabilization at any one time.

H. An area within 100 feet of a protected natural resource must be protected with a double row of sediment barrier.

I. Temporary mulch must be applied within 7 days of soil exposure or prior to any storm event, but after every workday in areas within 100 feet from a protected natural resource.

J. Areas that have been brought to final grade must be permanently mulched that same day.

K. If snowfall is greater than 1 inch (fresh or cumulative), the snow shall be removed from the areas due to be seeded and mulched.

L. Loam shall be free of frozen clumps before it is applied.

M. All vegetated ditch lines that have not been stabilized by november 1, or will be worked during the winter construction period, must be stabilized with an appropriate stone lining backed by an appropriate gravel bed or geotextile unless specifically released from this standard by the department.

Maintenance and inspection phase
A. Contractor shall inspect disturbed and impervious areas, and erosion and stormwater control measures, areas used for storage that are exposed to precipitation, and locations where vehicles enter or exit the parcel at least once a week and before and after a storm event, prior to completion of permanent stabilization. A person with knowledge of erosion and stormwater must conduct the inspection. This person must be identified in the inspection log. If best management practices (bmps) need to be modified or if additional bmps are necessary, implementation must be completed within 7 calendar days and prior to any storm event (rainfall). All measures must be maintained in effective operating condition until areas are permanently stabilized.

B. A log (report) must be kept summarizing the scope of the inspection, name(s) and qualifications of the personnel making the inspection, the date(s) of the inspection, and major observations relating to operation of erosion and sedimentation controls and pollution prevention measures. Major observations must include: bmps that need to be maintained; location(s) of bmps that failed to operate as designed or proved inadequate for a particular location; and location(s) where additional bmps are needed that did not exist at the time of inspection. Follow-up to correct deficiencies or enhance controls must also be indicated in the log and dated, including what action was taken and when.

CONSTRUCTION NOTES

1. All work shall conform to the applicable codes and ordinances.

2. Contractor shall visit the site and familiarize him or herself with all conditions affecting the proposed work and shall make provisions as to the cost thereof. Contractor shall be responsible for familiarizing him or herself with all contract documents, field conditions and dimensions and confirming that the work may be accomplished as shown prior to proceeding with construction. Any discrepancies shall be brought to the attention of the engineer prior to the commencement of work.

3. Contractor shall notify engineer of all products or items noted as "existing" which are not found in the field.

4. Install all equipment and materials in accordance with manufacturer's recommendations and owner's requirements unless specifically otherwise indicated or where local codes or regulations take precedence.

5. Contractor shall verify all dimensions and conditions in the field prior to fabrication and erection of any material. Any unusual conditions shall be reported to the attention of the engineer.

6. Contractor shall clean and remove debris and sediment deposited on public streets, sidewalks, adjacent areas, or other public ways due to construction.

7. Contractor shall incorporate provisions as necessary in construction to protect existing structures, physical features, and maintain site stability during construction. Contractor shall restore all areas to original condition and as directed by design drawings.

8. Site contractor shall obtain all required permits prior to construction.

9. All erosion and sediment control measures shall be installed in accordance with "maine erosion and sedimentation control handbook for construction: best management practices" published by the cumberland county soil and water conservation district and maine department of environmental protection, march 2004 or latest edition. It shall be the responsibility of the contractor to possess a copy of the erosion control plan at all times.

10. The contractor is hereby cautioned that all site features shown hereon are based on field observations by the surveyor and by information provided by utility companies. The information is not to be relied on as being exact or complete. The contractor shall contact dig safe (1-888-digsafe) at least three (3) but not more than thirty (30) days prior to commencement of excavation or demolition to verify horizontal and vertical location of all utilities.

11. Contractor shall be aware that dig safe only notifies its "member" utilities about the dig. When notified, dig safe will advise contractor of member utilities in the area. Contractor is responsible for identifying and contacting non-member utilities directly. Non-member utilities may include town or city water and sewer districts and small local utilities, as well as usg public works systems.

12. Contractors shall be responsible for compliance with the requirements of 23 mrsa 3360-a. It shall be the responsibility of the contractor to coordinate with the appropriate utilities to obtain authorization prior to relocation of any existing utilities which conflict with the proposed improvements shown on these plans. If a utility conflict arises, the contractor shall immediately notify the owner, the municipality and appropriate utility company prior to proceeding with any relocation.

13. All pavement markings and directional signage shown on the plan shall conform to the manual of uniform traffic control devices (mutcd) standards.

14. All pavement joints shall be sawcut prior to paving to provide a durable and uniform joint.

15. No holes, trenches or structures shall be left open overnight in any excavation accessible to the public or in public rights-of-way.

16. All work within the public right-of-way shall require a M.D.O.T. Permit as well as permits from the town as applicable.

17. The proposed limits of clearing shown hereon are approximate based upon the proposed limits of site grading. The applicant reserves the right to perform normal forest management activities outside of the clearing limit as shown. Tree removal outside of the limits of clearing may be necessary to remove dead or dying trees or tree limbs. This removal is due to potential safety hazards and to promote proper forest growth.

18. Immediately upon completion of cuts/fills, the contractor shall stabilize disturbed areas in accordance with erosion control notes and as specified on plans.

19. The contractor shall be fully and solely responsible for the removal, replacement and rectification of all damaged and defective material and workmanship in connection with the contract work. The contractor shall replace or repair as directed by the owner all such damaged or defective materials which appear within a period of one year from the date of substantial completion.

20. All work performed by the general contractor and/or trade subcontractor shall conform to the requirements of local, state or federal laws, as well as any other governing requirements, whether or not specified on the drawings.

21. Where the terms "approved equal", "other approved", "equal to", "acceptable" or other general qualifying terms are used in these notes, it shall be understood that reference is made to the ruling and judgment of terradyn consultants, llc.

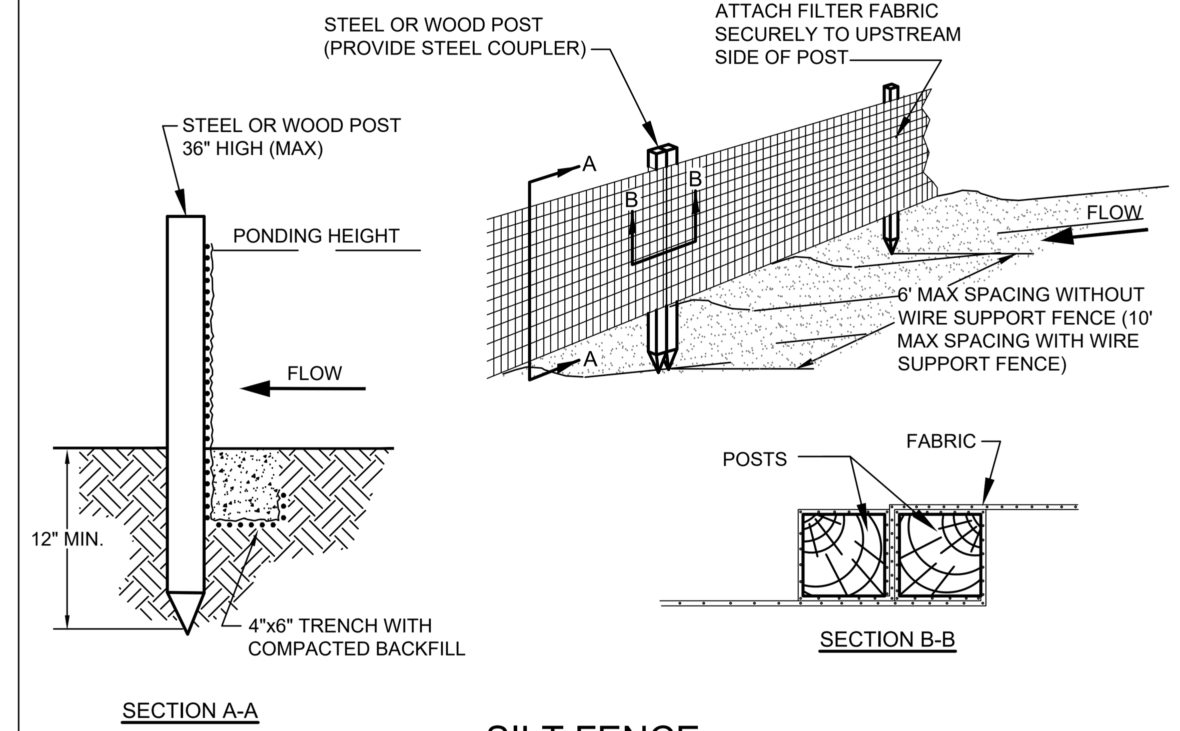
22. The general contractor shall provide all necessary protection for the work until turned over to the owner.

23. The general contractor shall maintain a current and complete set of construction drawings on site during all phases of construction for use of all trades.

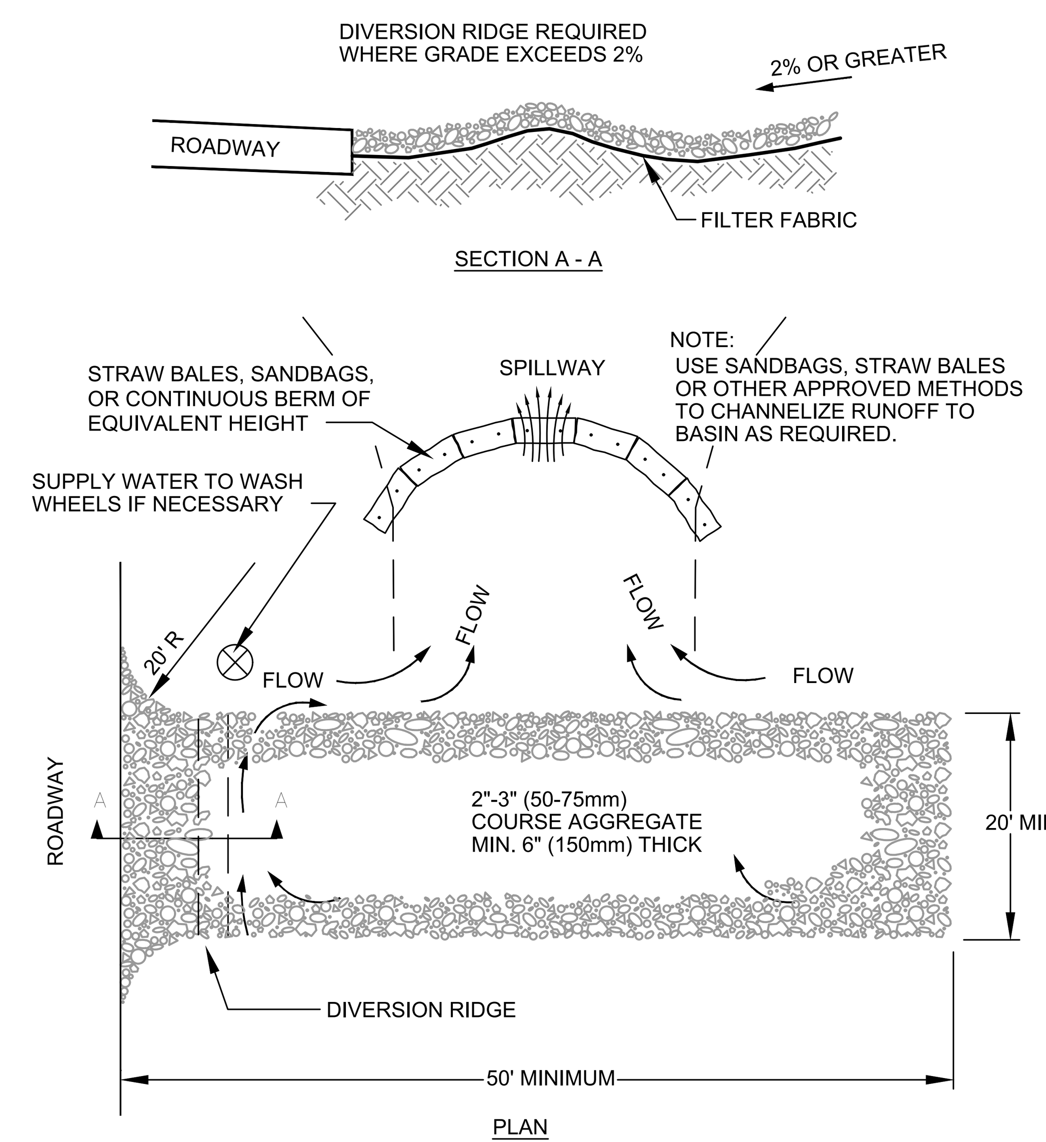
24. The contractor shall take full responsibility for any changes and deviation of approved plans not authorized by the architect/engineer and/or client/owner.

25. Details are intended to show end result of design. Any modification to suit field dimension and condition shall be submitted to the engineer for review and approval prior to any work.

26. Before the final acceptance of the project, the contractor shall remove all equipment and materials, repair or replace private or public property which may have been damaged or destroyed during construction, clean the areas within and adjacent to the project which have been obstructed by his/her operations, and leave the project area neat and presentable.



SILT FENCE
NOT TO SCALE

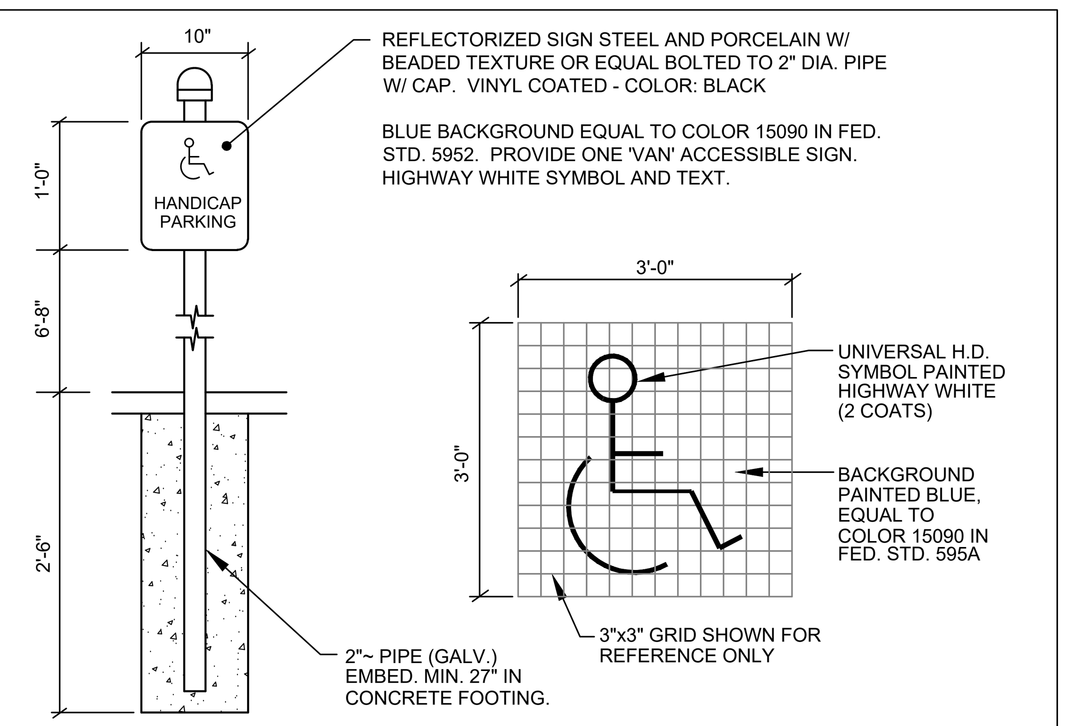


NOTES:
1. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION THAT WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHT-OF-WAYS. THIS MAY REQUIRE TOP DRESSING, REPAIR AND/OR CLEAN OUT OF ANY MEASURES USED TO TRAP SEDIMENT.

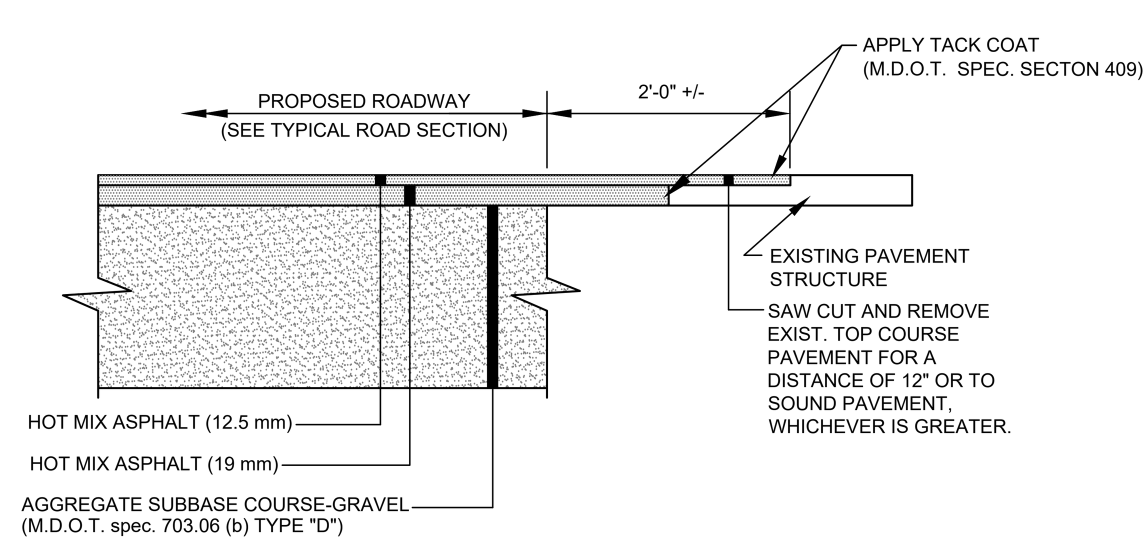
2. WHEN NECESSARY, WHEELS SHALL BE CLEANED PRIOR TO ENTRANCE ONTO PUBLIC RIGHT-OF-WAY.

3. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH CRUSHED STONE THAT DRAINS INTO AN APPROVED SEDIMENT TRAP OR SEDIMENT BASIN.

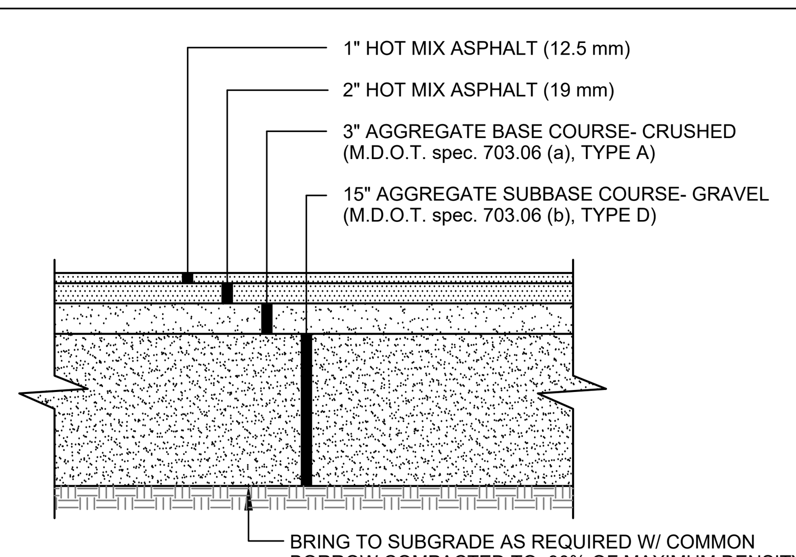
STABILIZED CONSTRUCTION ENTRANCE
NOT TO SCALE



HANDICAP SIGNS
NOT TO SCALE

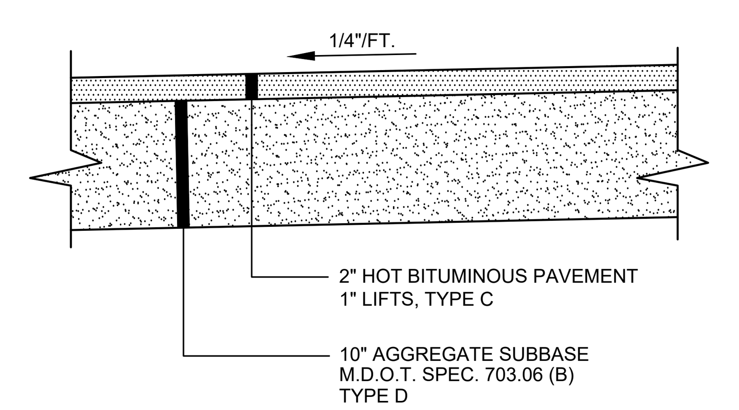


TYPICAL PAVEMENT JOINT
NOT TO SCALE



NOTES:
1. COMPACT GRAVEL SUBBASE COURSE TO 92% OF MAXIMUM DENSITY USING HEAVY ROLLER COMPACTION.
2. CONTRACTOR SHALL SET GRADE STAKES MARKING SUBBASE AND FINISH GRADE ELEVATIONS FOR CONSTRUCTION REFERENCE.

TYP. PAVED PARKING LOT SECTION
NOT TO SCALE



BITUMINOUS SIDEWALK
NOT TO SCALE

STATE OF MAINE
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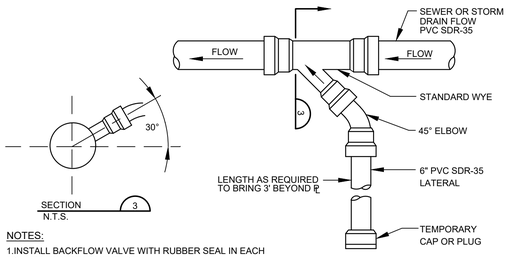
PERMITTING SET- NOT FOR CONSTRUCTION



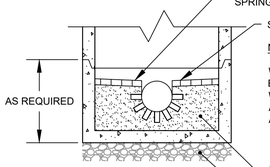
NOTES:

1.INSTALL BACKFLOW VALVE WITH RUBBER SEAL IN EACH FOUNDATION DRAIN SERVICE.

2. IF SUMP PUMP IS UTILIZED INSTALL CHECK VALVE AT SUMP PUMP.

SEWER / FOUNDATION DRAIN SERVICE CONNECTION

NOT TO SCALE



NOTE:

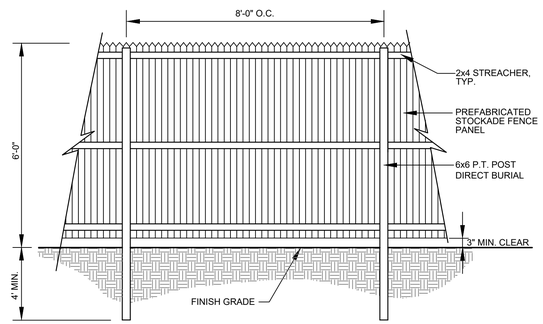
WHERE CHANGE IN ALIGNMENT OR SIDE FLOW ENTERS THE MANHOLE CONSTRUCT CHANNEL WITH A SMOOTH RADIAL CHANNEL TO ACCOMPLISH ALL JUNCTIONAL CHANGE OF ALIGNMENT WITHIN MANHOLE.

*NOTE:

CHANNEL MAY ALSO BE A PREFABRICATED FIBERLINER 2000 CHANNEL AS FABRICATED BY GDT, INC. OF ESSEX, CT OR EQUAL

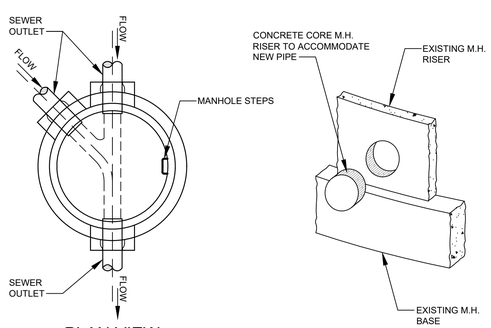
MANHOLE CHANNEL INVERT INSTALLATION

NOT TO SCALE

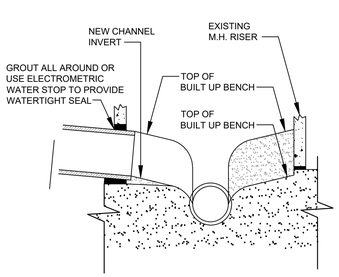


STOCKADE FENCE

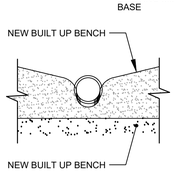
NOT TO SCALE



PLAN VIEW



SECTION A-A



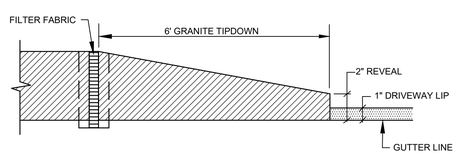
SECTION B-B

NOTES:

1. EXISTING MANHOLE BENCH SHALL BE THOROUGHLY CLEANED PRIOR TO CONSTRUCTING NEW BUILT UP BENCH. NEW BENCH SHALL BE CLASS "S" (Fc + 3,000 psi (20MPa)) CONCRETE W/ TYPE II PORTLAND CEMENT.
2. ALL CONNECTIONS TO EXISTING MANHOLES SHALL BE INSPECTED AND APPROVED BY SEWER DISTRICT.
3. SHAPE NEW CHANNEL TO PROVIDE FOR A SMOOTH TRANSITION OF FLOW FROM NEW INCOMING PIPE TO OUTGOING MAIN.

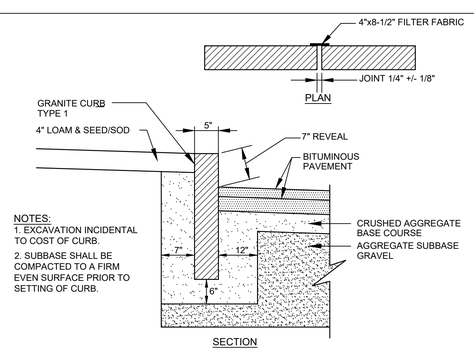
CONNECTION TO EXISTING MANHOLE

NOT TO SCALE



TYPICAL TIPDOWN CURB INSTALLATION

NOT TO SCALE



NOTES:

1. EXCAVATION INCIDENTAL TO COST OF CURB.
2. SUBBASE SHALL BE COMPACTED TO A FIRM EVEN SURFACE PRIOR TO SETTING OF CURB.

VERTICAL GRANITE CURB

NOT TO SCALE

PERMITTING SET- NOT FOR CONSTRUCTION

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DocuSign Envelope ID: 1794D3AC-7E0E-48C1-8A02-8F7CE5220359

CONTRACT FOR THE SALE OF COMMERCIAL REAL ESTATE

This contract is for the purchase and sale by **Hardypond Development Company, LLC** and/or its assigns (hereinafter called the "Purchaser"), this **31st** day of **January**, **2020** the sum of [redacted] as non-refundable earnest money deposit toward purchase and sale of certain real estate owned by **Frederick A. Hall, Jr.** (hereinafter called the "Seller") and located in the city/town of **Lewiston**, County of **Androscoggin**, State of Maine, described as follows: **16 Bridge Street Assessor's Reference Map 206, Lots 104, 198, & 199** and being fully more described at said County Registry of Deeds in Book **9919**, Page **187**, and Book **4077**, Page **130** upon the terms and conditions indicated below:

1. PERSONAL PROPERTY: The following items of personal property are included in this sale (if applicable):
   <None>
   <None>
   <None>

2. PURCHASE PRICE: The TOTAL purchase price being [redacted] with payments to be made as follows:

   Non-refundable Earnest money to be delivered on or before: **February 7, 2020** [redacted]
   Balance due at closing:

3. EARNEST MONEY/ACCEPTANCE: **Maine Realty Advisors** shall hold said earnest money in a non-interest bearing account and act as Escrow Agent until closing; this offer shall be valid until **February 5, 2020** at 5:00PM; and, in the event of the Seller's non-acceptance, this earnest money shall be returned promptly to the Purchaser.

4. TITLE: Within **Thirty (30)** days of the Effective Date (the "Title Review Period"), Purchaser shall notify Seller in writing (the "Title Objection Notice") of any matters affecting title to the property that are objectionable to Purchaser in Purchaser's sole discretion ("Title Defects"). If Seller has provided Purchaser with an existing title policy prior to the Effective Date, then Purchaser shall be deemed to have waived the right to object to any matter affecting title as of the Effective Date, except for any mortgage, tax lien, mechanics' lien, judgment lien, or other liens, encumbering the property (for which no objection is required), Purchaser's failure to specifically identify such matters in the Title Objection Notice, shall result in each matter not objected to being a "Permitted Encumbrance". Within seven (7) days of Seller's receipt of the Title Objection Notice, Seller shall notify Purchaser in writing whether or not Seller elects to cure any of the matters identified in the Title Objection Notice. If Seller elects to cure certain Title Defects, Seller shall use good faith efforts to cure such Title Defects and shall have a period of not more than Thirty (30) days after notice of Seller's election within which to cure any such Title Defects (the "Title Cure Period"), and the Closing Date shall be extended until Five (5) days after the expiration of the Title Cure Period. Seller agrees that, after the Effective Date, it shall not permit or suffer encumbrance of the property with any liens, easements, leases or other encumbrances without Purchaser's prior written consent except that Purchaser shall not unreasonably withhold or delay its consent to new leases. On or before the Closing Date, Seller shall remove at its sole cost any such matters affecting the title to the property suffered or created by or consented to by Seller after the

Effective Date that are not approved by Purchaser. If Seller elects not to cure any Title Defects or if Title Defects which Seller elects to cure are not cured within the Title Cure Period, Purchaser shall elect, by written notice to Seller on or before the Closing Date, as the same may be extended, either (i) to accept title to the property subject to such uncured Title Defects without reduction of the purchase price and without any liability on the part of Seller therefore, in which case such Title Defects shall be Permitted Encumbrances, or (ii) to terminate this Contract, whereupon the earnest money immediately shall be returned to Purchaser and neither party shall have any further obligations under this Contract.

5. DEED: In return for payment in full of the purchase price, Seller shall convey the property on or before **April 16, 2020** (the "Closing Date") to Purchaser by **Quit Claim with Covenant** Deed (the "Deed"), and the parties agree to execute and deliver on the Closing Date such other documents that are customary and/or reasonably necessary to complete the conveyance. It is a condition to Purchaser's obligations hereunder that title to the property shall be free and clear of all liens and encumbrances, except for the following matters, and shall otherwise be in compliance with the requirements of this Contract: (i) zoning restrictions and land use laws and regulations and permits and approvals issued pursuant thereto; (ii) current taxes and assessments attributable to periods from and after the Closing, which Purchaser shall be liable to pay; (iii) leases and occupancies disclosed to Purchaser pursuant to Section 19 herein; and (iv) any Permitted Encumbrance.

6. POSSESSION /OCCUPANCY: Possession/occupancy of premises shall be given to Purchaser immediately at closing, subject to any leases, unless otherwise agreed by both parties in writing, and (ii) Section 19 of this Agreement.

7. LEASES/TENANT SECURITY DEPOSITS: Seller agrees to transfer at closing to Purchaser all Seller's rights under the current leases to the property and all security deposits held by Seller pursuant to said leases. Seller shall provide Purchaser with any and all leases, including any amendments thereto, within **Fourteen (14)** days of the Effective Date.

8. RISK OF LOSS: Until the transfer of title, the risk of loss or damage to said premises by fire or otherwise, is assumed by the Seller unless otherwise agreed in writing. Said premises shall then be in substantially the same condition as at present, excepting reasonable use and wear. If the property is materially damaged or destroyed prior to closing, Purchaser may either terminate this Contract and be refunded the earnest money deposit, or close this transaction and accept the property in its as-is condition together with an assignment of the Seller's right to any insurance proceeds relating thereto.

9. PRORATIONS: The following items shall be prorated as of the Closing Date:

a. Real Estate Taxes based on the municipality's tax year. Seller is responsible for any unpaid taxes for prior years.
b. Fuel (to be paid for at then-current cash cost).
c. Metered utilities, such as water and sewer, shall be paid by the Seller through the date of closing.
d. Purchaser and Seller shall each pay one-half of the transfer tax as required by the laws of the State of Maine.
e. Rents, estimated monthly common area maintenance charges, estimated monthly property tax payments, and all other additional revenue received by Seller pursuant to leases or any other rights to use of the property by third parties.

10. DUE DILIGENCE: Purchaser's obligation to close under this Contract is conditioned upon Purchaser's personal satisfaction in its sole discretion with its investigations of the property, which may without limitation include survey, environmental assessment, engineering studies, wetlands and soils studies, zoning compliance (including compliance with State and local regulations relating to siting of cannabis businesses) or feasibility, floor plans, and code compliance (including compliance with State and local regulations relating to siting of

cannabis businesses). Within Five (5) Days of the Effective Date, Seller shall provide Purchaser with all surveys, plans, specifications, inspections, environmental assessments, engineering studies, title insurance policies, or other documents, in Seller's possession, related to the Property.

Purchaser and its agents shall have a right of entry upon the Property at all reasonable times for purposes of conducting its inspections.

All investigations will be done by professionals chosen and paid for by Purchaser. If the result of an investigation is unsatisfactory to Purchaser (in Purchaser's sole discretion), Purchaser may declare this contract null and void by notifying Seller in writing anytime before **March 31, 2020**. If Purchaser does not notify Seller that Purchaser's investigations are unsatisfactory within the time period set forth above, this contingency is waived by Purchaser.

11. FINANCING: INTENTIONALLY OMITTED.

12. AGENCY DISCLOSURE: **Frank Carr** of **Maine Realty Advisors** represents the Purchaser and **Tim Millett** of **Porta & Co. Commercial Real Estate** represents the Seller (hereinafter referred to as "Agencies"). No other agents, finders, intermediaries, or brokerages are involved in this transaction. A commission equal to **Six** (**6**%) of the purchase price will be paid as commission by Seller at the time of closing and split evenly amongst Agencies.

13. DEFAULT: If the Purchaser fails to consummate this transaction, and provided (i) that Seller is then ready, willing and able to consummate the sale of the property as contemplated by this Contract and (ii) that all conditions to Purchaser's obligation to consummate such purchase have been satisfied or waived in writing by Purchaser, Seller shall retain the earnest money as full and complete liquidated damages, it being agreed between the parties that the actual damages to Seller in the event of such breach are difficult to ascertain and/or prove and the earnest money is a reasonable estimate and forecast of such actual damages. The parties acknowledge that the payment of the earnest money is not intended as a forfeiture or penalty, but is intended to constitute liquidated damages to Seller. Should Seller retain the earnest money, this Contract shall terminate and neither party shall be under any further obligation hereunder. If the sale of the property as contemplated hereunder is not consummated solely by reason of Seller's default hereunder, and provided that Purchaser is then ready, willing and able to consummate the sale of the property as contemplated by this Contract, then Purchaser shall be entitled to (i) pursue any and all legal and/or equitable remedies; and/or (ii) terminate this contract and receive the earnest money from Seller. In the event of default by either party, the Escrow Agent shall not return the earnest money to Purchaser or turn over the deposit to the Seller without written releases from both parties. In the event of an undisputed default by either party, the Escrow Agent may deliver the earnest money to the party entitled to it under this Contract, with prior written notice to both parties pursuant to Maine Real Estate Commission regulations. If a dispute arises between Purchaser and Seller of the existence of a default hereunder, and if said dispute is not resolved by the parties within thirty (30) days, then the Escrow Agent may elect to file an action in interpleader and deposit the earnest money in the court pending resolution of said dispute, or otherwise disburse the earnest money pursuant to Maine Real Estate Commission regulations. Purchaser and Seller, jointly and severally, shall indemnify Escrow Agent for all costs, losses, expenses, and damages, including reasonable attorneys' fees, incurred by the Escrow Agent in connection with said action and/or in connection with any dispute relating to this Contract and/or the earnest money.

14. MEDIATION: Any dispute or claim arising out of or relating to this Contract or the premises addressed in this Contract shall be submitted to mediation in accordance with the Maine Residential Real Estate Mediation Rules of the American Arbitration Association. This clause shall survive the closing of this transaction.

15. PRIOR STATEMENTS: Any verbal presentations, statements and agreements are not valid unless contained herein. This Contract completely expresses the obligations of the parties. This is a Maine contract and shall be construed according to the laws of Maine.

16. HEIRS/ASSIGNS: This Contract is assignable. This Contract shall extend to and be obligatory upon heirs, personal representatives, successors, and assigns (if assignment is allowed by the terms of this Contract), of the respective parties.

17. COUNTERPARTS: This Contract may be signed on any number of identical counterparts, including electronically transmitted copies, with the same binding effect as if the signatures were on one instrument. Original or electronically transmitted signatures are binding.

18. BINDING CONTRACT: This Contract is a binding contract when signed by both Seller and Purchaser and when that fact has been communicated to all parties or to their agents. The Effective Date of the Contract is noted below. Time is of the essence of this Contract.

19. REVIEW OF LEASES AND INCOME AND EXPENSE INFORMATION: Seller represents: (a) that below is a complete list of all tenants occupying the property under leases or other tenancy arrangements or agreements (the "Leases"), (b) that the Leases are in full force and effect, (c) that to Seller's knowledge, all tenants under the Leases are in full compliance therewith and (d) that Seller is not in violation of its obligations under the Leases. The Seller shall provide the Purchaser with copies of all leases and income and expense information including condo fees regarding the subject property within Fourteen (14) days of the effective date of this contract. Purchaser shall have **Thirty** (**30**) days from such delivery to review leases and income and expense information regarding the property. If the result of the review is unsatisfactory to the Purchaser, Purchaser may declare the Contract null and void by notifying the Seller in writing within the specified number of days set forth above, and any earnest money shall be returned to the Purchaser. If the Purchaser does not notify the Seller that the review is unsatisfactory within the time period set forth above, this contingency is waived by the Purchaser. Seller represents and warrants that income and expense information provided to Purchaser will be true, accurate and complete in all material respects when given.

    Between the Effective Date, and the Closing, Seller (i) shall not modify, voluntarily terminate or enter into new leases or tenancy arrangements or agreements, and (ii) shall obtain Purchaser's written consent to any modification or termination of Leases (unless a Tenant is in default beyond any applicable cure period) and to any new lease that Seller proposes to enter into with respect to the property, Purchaser's consent not to be unreasonably withheld, conditioned or delayed. In the event that Seller modifies or terminates any Leases or enters into a new Lease without Purchaser's consent, Seller shall be in material default of this Contract. At the closing, Seller shall deliver written notice to the tenants and occupants of the property of the transfer of the property, and of the tenants' security deposits, to Purchaser. A list of the current tenants is as follows:

    See Exhibit A

20. CONFIDENTIALITY: Purchaser and Seller authorize the disclosure of the information herein to the real estate licensees, attorneys, lenders, appraisers, inspectors, investigators, potential tenants, and others involved in the transaction necessary for the purpose of closing this transaction. Purchaser and Seller authorize the lender and/or closing agent preparing the closing statement to release a copy of the closing statement to the parties and their licensees prior to, at and after the closing.

A COPY OF THIS CONTRACT IS TO BE RECEIVED BY ALL PARTIES AND, BY SIGNATURE, RECEIPT OF A COPY IS HEREBY ACKNOWLEDGED. IF NOT FULLY UNDERSTOOD CONSULT AN ATTORNEY.

DocuSign Envelope ID: 1794D3AC-7E0E-48C1-8A02-8F7CE5220359

PURCHASER:
HARDYPOND DEVELOPMENT COMPANY, LLC OR TBD RG

Name: **Robert Gaudreau** 1/31/2020 Date
Title: **Manager**

SELLER:
Frederick A. Hall, Jr.

DocuSigned by:
Fred Hall 2/3/2020
3714F4B994A246B...
Name: **Frederick A. Hall, Jr.** Date
Title: **Individual**

2/3/2020

Effective Date of Contract

DocuSign Envelope ID: 1794D3AC-7E0E-48C1-8A02-8F7CE5220359

Exhibit A

Current Tenants

Butler Bros
Gilman Electric

DocuSign Envelope ID: 8C5F860A-3C8A-4AE3-947F-F524B598C0DD

ASSIGNMENT AND ASSUMPTION OF PURCHASE AND SALE AGREEMENT

THIS ASSIGNMENT AND ASSUMPTION OF PURCHASE AND SALE AGREEMENT (the "Assignment") is dated as of March 5, 2020 (the "Effective Date") and is made by and between HARDYPOND DEVELOPMENT COMPANY, LLC ("Assignor"), and HIGHBROW CULTIVATION #2, LLC (the "Assignee").

WHEREAS, Assignor entered into a certain Contract for the Sale of Commercial Real Estate with Frederick A. Hall, Jr. (the "Seller") for the purchase of 16 Bridge Street in Lewiston, Maine (the "Property") dated February 3, 2020 (the "Agreement"); and

WHEREAS, the Assignor wishes to assign to the Assignee its rights and obligations under the Agreement with respect to the Property; and

WHEREAS, the Assignee agrees to accept an assignment of the Assignor's rights and obligations under the Agreement with respect to the Property; and

WHEREAS, the Seller consents to the assignment in accordance with the terms and conditions set forth herein.

NOW THEREFORE, in consideration of the premises and the mutual promises set forth below, the parties hereto hereby agree as follows:

1. Assignment. Assignor hereby assigns, sets over and transfers to Assignee all of its right, title and interest in and to, and obligations under, the Agreement with respect to the Property, as of the Effective Date.

2. Acceptance. The Assignee hereby assumes all obligations of Assignor under the Agreement with respect to the Property as of the Effective Date.

3. Further Assurances. Assignee and Assignor shall execute and deliver all such other instruments and take all such further actions as may be reasonably required to effect the foregoing assignment and assumption.

4. Successors and Assigns. This Assignment shall be binding upon and inure to the benefit of Assignee and Assignor and their respective successors and permitted assigns.

5. Counterparts. This Assignment may be executed in one or more counterparts, each of which will be deemed to be an original copy of this Assignment and all of which, when taken together, will be deemed to constitute one and the same agreement. The exchange of copies of this Assignment and of signature pages by facsimile or .PDF transmission shall constitute effective execution and delivery of this Assignment as to the parties and may be used in lieu of the original Assignment for all purposes. Signatures of the parties transmitted by facsimile or .PDF shall be deemed to be their original signatures for all purposes.

DocuSign Envelope ID: 8C5F860A-3C8A-4AE3-947F-F524B598C0DD

6. Governing Law. This Assignment, and any and all claims arising hereunder, shall be governed by, and construed in accordance with, the laws of the State of Maine without regard to any applicable conflicts of law.

IN WITNESS WHEREOF, the parties hereto have executed or caused this instrument to be duly executed and delivered as of the date first set forth above.

WITNESS:

Frank Carr

ASSIGNOR:

HARDYPOND DEVELOPMENT COMPANY, LLC

Name: Robert Gaudiello
Its: Pres

ASSIGNEE:

HIGHBROW CULTIVATION #2, LLC

Frank Carr

By:
Name: Jason Brossi
Its: Manager

The Seller joins herein and consents to the assignment of the Agreement from the Assignor to the Assignee as of the Effective Date.

WITNESS:

Tim Millett

DocuSigned by:
Frederick A. Hall
3714F4B994A246B...
Frederick A. Hall, Jr.

BK4077 PG130

21977

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QUITCLAIM RELEASE DEED
STATUTORY SHORT FORM
TITLE 33, §775

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H & K Realty Company, successor to Hall & Knight Company, a Maine corporation with a principal place of business at Lewiston, Maine, release to Frederick A. Hall, Jr. of Lewiston, County of Androscoggin and State of Maine, all of its right, title and interest in and to certain lots or parcels of land situated in the City of Lewiston, County of Androscoggin and State of Maine, as described in Exhibit A attached hereto and made a part hereof.

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WITNESS our hands and seals this 18 day of September, 1998.

NO MAINE R.E.
TRANSFER TAX PAID

H & K Realty Company

Raymond C. LeBlanc — Frederick A. Hall

By: Frederick A. Hall
Its: President

STATE OF MAINE
Androscoggin, ss.

Sept 18, 1998

Personally appeared the above-named Frederick A. Hall, in his capacity as President of H & K Realty Company and acknowledged the above instrument to be his free act and deed and the free act and deed of said corporation.

Before me,

SEAL

Meddy J. Perry

Notary Public/~~Attorney-at-Law~~
Printed
Name: Meddy J. PERRY
Expires 6/11/03

over

EXHIBIT A

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Parcel 1

Two certain lots or parcels of land situated in the City of Lewiston, County of Androscoggin, State of Maine, bounded and described as follows:

1. Commencing at an iron rod at the intersection of the northeasterly line of West Bates Street with the southeasterly line of Spring Street, one hundred (100) feet to the center of a passageway fifteen (15) feet wide running from Spring Street to land of Maine Central Railroad Company, said fifteen (15) foot passageway to be forever kept open for the use of this and the adjoining lots; thence southeasterly at a right angle, by a line parallel to and distant one hundred (100) feet from the northeasterly line of West Bates Street, about two hundred twenty-five (225) feet to land of the Maine Central Railroad Company; thence westerly by the northerly line of said Railroad Company's land about one hundred ten (110) feet to West Bates Street; thence northwesterly by the northeasterly line of West Bates Street about one hundred eighty (180) feet to Spring Street, and point of beginning. Containing about twenty thousand two hundred fifty (20,250) square feet.

2. Commencing at the intersection of the southwesterly line of Bridge Street, with the southeasterly line of Spring Street; thence southwesterly by the southeasterly line of said Spring Street one hundred (100) feet to the parcel of land above described; thence southeasterly by the northeasterly line of the parcel of land above described, about two hundred twenty-five (225) feet to land of the Maine Central Railroad Company; thence easterly by the northerly line of said Railroad Company's land to Bridge Street; thence northwesterly by the southwesterly line of Bridge Street to Spring Street and point of beginning; also all rights in a proposed passageway reserved in deed from the Franklin Company to Eben J. Ham dated June 6, 1897, recorded in Androscoggin County, Registry of Deeds, Book 165, Page 30, for the benefit of the premises herein described.

Being all and the same premises conveyed to John W. Wood and said Willis A. Trafton by Peter A. Isaacson, in his capacity as Receiver of Ham Realty Company, by deed dated October 21, 1939, recorded in said Registry of Deeds, Book 502, Page 481.

Parcel 2

A certain lot or parcel of land situated in the City of Lewiston, County of Androscoggin, State of Maine, bounded and described as follows:

Beginning at a point in the northwesterly side line of land conveyed by the Lewiston Water Power Company to the Androscoggin Railroad Company by deed dated June 17, 1851, recorded in Lincoln County Registry of Deeds, Book 195, Page 253; said northwesterly side line being one hundred fifty-nine and sixty-two hundredths (159.62) feet northwesterly of and concentric with the center or base line of location of Maine Central Railroad Company as

established by the Federal Valuation Survey dated June 30, 1916; said point being normally opposite said center or base line of location at Valuation Station 1254+40.0;

Thence northeasterly along the aforesaid northwesterly side line of land conveyed in said deed of Lewiston Water Power Company to Androscoggin Railroad Company one hundred twenty-four and seven hundredths (124.07) feet to the westerly corner of land conveyed by Maine Central Railroad Company to Katherine E. Tracy et al by deed dated December 17, 1937;

Thence southeasterly along the southwesterly side line of land conveyed in said deed of Maine Central Railroad Company to Katherine E. Tracy et al. and along the southwesterly side line of land conveyed by Maine Central Railroad Company to Ralph W. Peaslee et al. by deed dated December 17, 1937, one hundred four (104) feet to the southerly corner of land conveyed in said deed of Maine Central Railroad Company to Ralph W. Peaslee, et al.;

Thence southwesterly and westerly on a curve to the right of 23° 30' one hundred ninety-eight and thirty-five hundredths (198.35) feet to the point of beginning.

The grantor herein reserves unto itself, its successors and assigns, the right and privilege to maintain crossarms and wires as now located over the southeasterly portion of the parcel of land herein above described; said crossarms being attached to poles situated on land of the grantor adjacent to the southeasterly side line of said parcel of land.

The grantee, by the acceptance of this deed, hereby covenants and agrees for itself, its successors and assigns, to build and maintain at its sole expense along that portion of the above described premises owned, occupied or used by the grantor herein any fence which said grantee, its successors or assigns, may desire or require at any time hereafter, or which any law or government authority may require to be constructed by the grantor or the grantee, their successors or assigns. This covenant is to run with the land herein above conveyed and to be binding upon the grantee, its successors and assigns, forever.

Parcel 3 (99 Spring Street)

A certain lot or parcel of land with the buildings thereon, situated in the City of Lewiston, County of Androscoggin and State of Maine, and being lots numbered one hundred nine (109), one hundred ten (110), one hundred twenty-two (122), and one hundred twenty-three (123) as shown on a Plan of land of Nelson H. Monroe made by Rufus Prince in 1867, and recorded November 23, 1867, in the Androscoggin County Registry of Deeds, Book of Plans, Volume 1, Book 1, Page 18, said lots or parcels of land being more particularly bounded and described as follows, according to said Plan of Land to which reference is hereby made.

Beginning on the southeasterly line of Spring Street two hundred (200) feet northeasterly from the intersection of said southeasterly line of Spring Street with the northeasterly line of Holland Street; thence northeasterly by the said southeasterly line of Spring Street one hundred (100) feet to the line of land owned by the late James P. Murphy; thence southeasterly at right angles by the said James P. Murphy line two hundred (200) feet to the northwesterly line of Nash

Street, a proposed Street, as shown on the Plan of Land above-referred to; thence southwesterly by the said northwesterly line of said Nash Street one hundred (100) feet; thence northwesterly two hundred (200) feet to the said southeasterly line of Spring Street and the point of beginning.

Said Spring Street was originally known as Jones Street and is set forth on said Plan of Land as Jones Street.

This Grantor also conveys all right, title and interest which it owns in and to any streets which may run through or abut the above-described premises.

Being the same premises conveyed from Latium Management Corp. to Hall & Knight Company by deed dated April 19, 1989 and recorded in the Androscoggin County Registry of Deeds in Book 2395, Page 173.

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Parcel 4 (6 Spring Street)

A certain lot or parcel of land with the buildings thereon, situated in the City of Lewiston, County of Androscoggin and State of Maine, bounded and described as follows:

Commencing at a point on the northwest line of Spring Street at the most southerly corner of land conveyed by the Franklin Company to the City of Lewiston by deed dated July, 1867; thence running northwesterly by the southwesterly line of said City of Lewiston lot, one hundred (100) feet; thence southwesterly at a right angle fifty (50) feet; thence southeasterly at a right angle one hundred (100) feet to Spring Street; thence northeasterly by the northwesterly line of Spring Street fifty (50) feet tot he point of commencement.

Being the same premises conveyed by Armand J. Girardin and Louise Girardin to Hall & Knight Hardware Co. by deed dated Marcy 21, 1972 and recorded in the Androscoggin County Registry of Deeds in Book 1049, Page 451.

RECEIVED
ANDROSCOGGIN S.S.
98 OCT -1 AM 11:45
ATTEST:
REGISTER OF DEEDS

PARID: RE00001511 16 BRIDGE ST

Parcel

Parcel ID	RE00001511
Map/Lot	206/000/199
Property Location	16 BRIDGE ST
Property Class	Warehouse & Distribution Facilities
Land Area (acreage)	1.23

Owners

Owner	HALL FREDERICK A JR
Address	72 FRANKLIN ST
City	LEWISTON
State	ME
Zip	04240
Book	4077
Page	130

PARID: RE00001511 16 BRIDGE ST

Building Description

Card	1
Building Number	1
Structure Code/Description	398 - WAREHOUSE
Improvement Name	WAREHOUSE/ DIST
Units	
# of Identical Buildings	1
Year Built	1956
Gross SF (including basement)	47,150

Building Data

Card	Line	From Floor	To Floor	Area	Use Group	Exterior Walls	Wall Height	Heating
1	1	01	01	37,600	WAREHOUSE/ LT MFG	01	20	HOT WATER
1	2	M1	M1	9,550	WAREHOUSE/ LT MFG	00	0	NONE

Other Feature Details

Card	Int/Ext Line	Structure	Measurement 1	Measurement 2	Identical Units
1	1	OD4 - OVRHD DR-MTR-OP-RL-ST	1	124	1
1	1	SS1 - SPRINKLER SYS WET	37,600	0	1
1	1	OD4 - OVRHD DR-MTR-OP-RL-ST	1	400	1
1	1	OD4 - OVRHD DR-MTR-OP-RL-ST	1	240	1

PARID: RE00004942 14 BRIDGE ST

Parcel

Parcel ID	RE00004942
Map/Lot	206/000/198
Property Location	14 BRIDGE ST
Property Class	Vacant Land - Residential
Land Area (acreage)	.08

Owners

Owner	HALL FREDERICK A
Address	72 FRANKLIN ST
City	LEWISTON
State	ME
Zip	04240
Book	9919
Page	187

Bk 9919 Pg187 #15175
08-29-2018 @ 09:40a

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DLN 1001840035771

MAINE SHORT FORM QUITCLAIM DEED WITH COVENANT

I, **EDWARD E. LAVERDIERE**, of Mercer, Somerset County, Maine, for consideration paid, grant to **FREDERICK A. HALL**, whose mailing address is 72 Franklin Street, Lewiston, Maine 04240, with **QUITCLAIM COVENANT**, a certain lot or parcel of land, with any buildings thereon, situated in Lewiston, County of Androscoggin, and State of Maine, being further described in the attached Exhibit A.

The premises are conveyed subject to any easements and restrictions of record, and this deed includes all rights, easements, privileges and appurtenances belonging to the premises hereinabove described.

MAINE REAL ESTATE TRANSFER TAX PAID

WITNESS my hand this 28th day of August, 2018.

Witness

Edward E. Laverdiere

STATE OF MAINE
COUNTY OF ANDROSCOGGIN, SS

Then personally appeared the above named Edward E. Laverdiere, known to me, this 28th day of August, 2018 and acknowledged before me the foregoing instrument to be his free act and deed.

Notary Public
Name: _____
My commission expires: _____

BARTON M. KELSEA
NOTARY PUBLIC, MAINE
MY COMMISSION EXPIRES
AUGUST 28, 2023

O:\Androtc\WPDOCS\DIANET\- 2018\18-1000\18-1058 - Deed.oc.doc

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EXHIBIT A

14 Bridge Street, Lewiston, Maine

A certain lot or parcel of land, with the buildings thereon, located on the apparent southwesterly side line of Bridge Street, in the City of Lewiston, County of Androscoggin and State of Maine, being bounded and described as follows:

Beginning at an iron rod set on the apparent southwesterly side line of said Bridge Street at a point located South thirty-nine degrees, thirty-four minutes, eight seconds East (S 39° 34' 08" E) two hundred fifty-six and twenty hundredths (256.20) feet from the intersection of the apparent southeasterly sideline of Spring Street and the apparent southwesterly sideline of said Bridge Street;

Thence South thirty-nine degrees, thirty-four minutes, eight seconds East (S 39° 34' 08" E) along the apparent southwesterly sideline of said Bridge Street fifty-six and twenty-one hundredths (56.21) feet to an iron rod set at land now or formerly of Andrea S. Metayer;

Thence South sixty-five degrees, four minutes, thirty-three seconds West (S 65° 04' 33" W) along land now or formerly of said Metayer seventy-nine and two hundredths (79.02) feet to an iron rod set at land now or formerly of Hall & Knight Hardware Company (Deed Reference: Book 1558, Page 282);

Thence North thirty-nine degrees, thirty-four minutes, eight seconds West (N 39° 34' 08" W) along land now or formerly of said Hall & Knight Hardware Company thirty-nine and sixty-four hundredths (39.64) feet to an iron rod set;

Thence North forty-two degrees, forty-eight minutes, thirty-two seconds East (N 42° 48' 32" E) along land now or formerly of said Hall & Knight Hardware Company thirty-seven and sixty-eight hundredths (37.68) feet to an iron rod set;

Thence North sixty-two degrees, thirty-three minutes, fifty-two seconds East (N 62° 33' 52" E) along land now or formerly of said Hall & Knight Hardware Company forty (40) feet to the point of beginning.

Said lot containing 3918 sq. ft. (0.08 acres).

All bearings refer to magnetic north as observed March, 1990.

All iron rods set are 5/8" rebar with surveyor's identification cap.

Reference is made to a Standard Boundary Survey prepared for Edward E. Laverdiere dated March 29, 1990, revised April 9, 1990, by SurveyWorks, Inc. and recorded in Plan Book 35, Page 119.

FOR SOURCE OF TITLE reference is made to a Personal Representative's Deed of Distribution from the Estate of Marguerite Jalbert to Edward E. Laverdiere and Barbara Ouellette, as Trustee

under the will of Marguerite Jalbert, dated June 1, 1990 and recorded in the Androscoggin County Registry of Deeds in Book 2564, Page 151. Reference is further made to a Deed of Trustee from Barbara Ouellette, as Trustee under the will of Marguerite Jalbert to Edward E. Laverdiere dated June 7, 1990 and recorded in said Registry of Deeds in Book 2564, Page 154.

O:\Androtc\WPDOCS\DIANET\- 2018\18-1000\18-1058 - EXHIBIT A.docx

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ANDROSCOGGIN COUNTY
TINA M CHOUINARD
REGISTER OF DEEDS

PARID: RE00004942 14 BRIDGE ST

Sales History

Date	Amount	Book	Page
08/29/2018	$40,000	9919	187

PARID: RE00004942 14 BRIDGE ST

Parcel

Parcel ID	RE00004942
Map/Lot	206/000/198
Property Location	14 BRIDGE ST
Property Class	Vacant Land - Residential
Land Area (acreage)	.08

Owners

Owner	HALL FREDERICK A
Address	72 FRANKLIN ST
City	LEWISTON
State	ME
Zip	04240
Book	9919
Page	187

Electrical Capacity

to

Serve

Highbrow Cultivation #2, LLC

16 Bridge Street Lewiston, ME 04240

Submitted March 13, 2020

March 13, 2020

Mr. David Hediger
Director of Planning and Code Enforcement
City of Lewiston
27 Pine Street
Lewiston, ME 04240

Subj: CMP Capacity to Service 16 Bridge Street Lewiston, ME

Mr. David Hediger,

As of March 13, 2020, Highbrow Cultivation #2, LLC is unable to obtain a "Capacity to Serve" letter from Central Maine Power.

We **were** able to secure a Project number and a work order number.

CMP Project#3001-2011-323
Work Order#103-006-370-27

Initial work with CMP was to understand if the existing 3 Phase power on existing pole mounted transformers could handle the full buildout of the 16 Bridge St facility.

The full buildout can **not** be handled by the pole mounted transformers. A ground mounted transformer will be needed. Since the project was initiated with a request for "Capacity to Serve" under the full buildout scenario, CMP is unable to deliver that letter **at this time**. CMP has instituted a new policy that "Any new loads coming on at 500 kVA & over require a Planning Engineering study for approval before moving forward." Highbrow Cultivation #2 will commit to working with CMP on that study after bringing on the rest of the MEP design team and submitting that documentation to the City of Lewiston to complete this requirement.

Odor Management Plan

for

Highbrow Cultivation #2, LLC
16 Bridge Street
Lewiston, ME 04240

March 10, 2020

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1. Introduction

It is imperative for cannabis growers to understand the odors produced during cultivation and safely control them to maintain the quality of life for their neighbors and themselves. Highbrow is committed to working with the City of Lewiston to mitigate cannabis odor as good neighbors and corporate citizens. This odor mitigation plan was developed with thorough combined research of industry data, industry claims, industry products, as well as our own testing and experience. We have simplified our approach as **Buy it Right / Use it Right / Measure it Right.** This approach allows a process that preemptively addresses odor and also allows flexibility to change or expand odor mitigations procedures based upon verified data.

2. Odor Emissions Information

A complex mixture of chemicals makes up the cannabis odor. The scent can have many characteristics pungent, skunky, floral, fruity. It is created by the plant's essential oils (terpenes and terpenoids) which are strongest when the flower is in bud. Hydrocarbons also contribute to the odor. In general, the culprit is volatile organic compounds (VOCs). The concentration and mixture of odorous chemicals varies amongst sites. Many different cannabis strains can be grown, each with a unique scent profile. Over 200 individual compounds have been identified as terpenoids, making the chemical makeup of odors complex. Because smells and their chemistry can vary, it can be difficult to find an odor solution that works for every grower and every facility. Highbrow's research and experience indicates that approaches dealing with volatile organic compounds (VOCs), particulate matter (PM), as well as bacteria and molds are most effective.

[See Appendix A for a diligent study performed in 2015. Citation: Rice S, Koziel JA (2015) Characterizing the Smell of Marijuana by Odor Impact of Volatile Compounds: An Application of Simultaneous Chemical and Sensory Analysis. PLoS ONE 10(12): e0144160. https://doi.org/10.1371/journal.pone.0144160]

3. Facility Information

a. Facility Floor Plan

b. Odor-Emitting Activities & Phases

Clone & Propagation Rooms: These operations include the initial growing stage of new plants. The process emits plant terpenes into the atmosphere. Plants are moved from here to the Mother & Vegetative Rooms. Plants are in clone stage for 2-3 weeks. The process to move to the Mother & Vegetative Room is 4-8 hours.

Mother & Vegetative Rooms: These operations include the next growing stage of the new plants. The process emits plant terpenes into the atmosphere. Plants are moved from here to the Flower Rooms. Plants are in vegetative stage for 5 weeks. The process to move the Flower Rooms is 4-8 hours.

Flower Rooms: Trimming or budding operations including plant-stressing occur during a 56- day process. At the time of harvest, the rooms will be emptied and thoroughly cleaned. The plants are physically moved to the Storage Harvest Room in order to get product prepared for the drying and extraction processes. Plants are in the flowering stage for 56 days. The process to harvest and transport to Storage Harvest 1 day.

Storage Harvest Room: During the harvest process, unusable parts of the plant are removed and placed in sealed containers for anaerobic digestion. The usable parts of the plant are trimmed and prepared for drying. During the drying process moisture will be removed from the plants at which point plant terpene odors are released to the indoor environment. Once the plants are sufficiently dried or cured they will be trimmed. During the trimming process buds will be separated and waste-trim will be prepped for transportation to an extraction lab. Trimming processes will occur during all hours of operations.

4. **Odor Mitigation Best Practices**
   a. *Buy it Right* - Equipment
   An integrated well designed system will afford the best operational success and achieve the odor mitigation desired. Briefly, Highbrow is providing design guidance for the HVAC and building exhaust systems, but we have found specific systems we are proposing for odor control.

      i. HVAC & Building Exhaust System

      General: The HVAC systems installed at this facility will be considered "closed-loop" systems. Other than ventilation air, all of the HVAC equipment will recirculate [90%] (to be verified) of the air flow being distributed to the various applications areas throughout the facility. The rooms containing Cannabis plants or products not in sealed containers shall exhaust [10%] (to be verified) of recirculation flow to the outside thru odor mitigation devices.

Clone, Propagation, Mother, Vegetative, & Flower: Each room will have supplemental environmental control units installed to accommodate the cooling and dehumidification, monitoring and control for each room. Ventilation air will be provided as required for listed occupancy.

ii. Odor Mitigation System Design

Odor mitigation for the cultivation facility at 16 Bridge Street in Lewiston is based upon a published research study performed by urban-gro on their client's facility, Skinny Pineapple, in Lafayette, CO. Subsequent to this, Highbrow has begun implementing similar equipment at our medical cultivation facility in Detroit, ME. The study shows diligence in finding the right equipment, using the equipment right, and measuring for results. As noted above, volatile organic compounds (VOCs) in the terpenes produced by the cannabis plants are what need to be reduced. Implementing the equipment and measuring the results showed an 85% reduction in VOCs and a 99.7% reduction in particulate matter.

[See Appendix B: Case Study Element Air™ Solution Reduces Microbials, Particulates, And VOCs For Cannabis Cultivation Facility]

iii. Benchmarking of Specific Odor Control Equipment in the Market

1. Photocatalytic Oxidation (PCO)
   - PCO (Photo Catalytic Oxidation) uses UV light and a catalyst (usually titanium) to produce reactive oxygen species, hydroxyl radicals
   - PCO can be incorporated into an HVAC system or used in standalone unit.
   - PCO can have a germicidal effect on bacteria and virus.
   - PCO needs to bring the contaminated air to the unit, since the reactive oxygen species will not survive long last past the catalyst.
   See *Element Air™* spec sheet next page

Element Air™

A Division of RGF Environmental Group, Inc.

ELEMENT AIR™ TOWER

Air Purification System

Reduces:
- Pathogens
- Microbials
- Mold
- Odors/VOCs

Applications:
- Greenhouses
- Cultivation Rooms
- Large Harvest Rooms
- Processing Rooms

Advanced Oxidation Advantage

Most facilities do not check the air for microorganisms on a daily or monthly basis. Bacteria and mold can continuously breed within the environment and on plants. RGF® developed this air treatment system to provide continuous protection in sensitive air spaces.

As air passes through a REME/PHI oxidation chamber, high intensity UV light rays are targeted on a quad-metallic compound, destroying airborne microbes. The process develops a highly charged atmosphere of hydroxyl radicals, hydro-peroxides and super oxide ions. This atmosphere oxidizes contaminants in the air with friendly oxidizers, those which revert back to oxygen and hydrogen after the oxidation process. No chemical residue or dangerous compounds are emitted from the system. The system can reduce levels of airborne microbes and odors by up to 99%. Airborne contaminants in the form of bacteria, mold, and yeast continue to be one of the least addressed issues in most facilities. The unit was designed for grow house applications and does not emit any visible light, allowing to unit to run 24/7.

Pre-filter | H_2O_2 | UV Light | CFM

Element Air™ Tower - Air Purification System

Pre-filter

UV Light

H_2O_2

CFM

Free standing and wall mount available

Specifications:

Materials:	Anondized aluminium	
Dimensions:	18" wide x 20" deep x 78" high	
Weight:	70 lbs	
Electrical:	110 Volt 50/60Hz 2.36A 255W	
CFMs:	700 cfm	
Item#	**EA-T-G2 (free standing)**	**EA-T-WM-G2 (wall mount)**
Treatment Area:	12,000 cubic feet	12,000 cubic feet
Replacement Media:	EAT-Gen1-0000-RC (3)	EAT-Gen1-2575-RC (1)

CAN/CSA C22.2 No. 60335-1:2016
CAN/CSA C22.2 No. 250.0:2008
UL 1598:2008-09
EN 60335-2-65:2003/A11:2012
EN 60335-1:2012/A13:2017

WARNING

This unit is recommended to be placed in a room no smaller than 12,000 cubic feet (square feet times ceiling height). This unit has the potential to create high levels of ozone. The ozone levels will depend on the level of microorganisms or contaminants in the space. Ozone will revert to oxygen when it encounters a contaminant. Due to this reaction, ozone levels will always be lower when the levels of contaminants are high and vice versa. An ozone monitor is recommended to ensure safe levels.

Product does not meet California requirements; cannot be shipped to California.

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www.rgf.com

Doc# SPEC-EA-TWR Rev C App: LB

2. HEPA (High Efficiency Particulate Air) Media Filtration
   - Pleated type filter that has proven 99.97% efficient to trap particles 0.3 microns and larger.
   - Can be incorporated into central HVAC systems or used as stand alone units.
   - Is effective on particulate removal.
   - Cannot treat source of contaminants, can only filter contaminated air from entering an area.
   - Requires maintenance visits to replace used filters each year
   See *Element Air™* spec sheet next page

Element Air™

A Division of RGF Environmental Group, Inc.

ELEMENT AIR™ HEPA

Air Filtration System

Reduces:

- Odors
- VOCs
- Microbials
- Particulate

Applications:

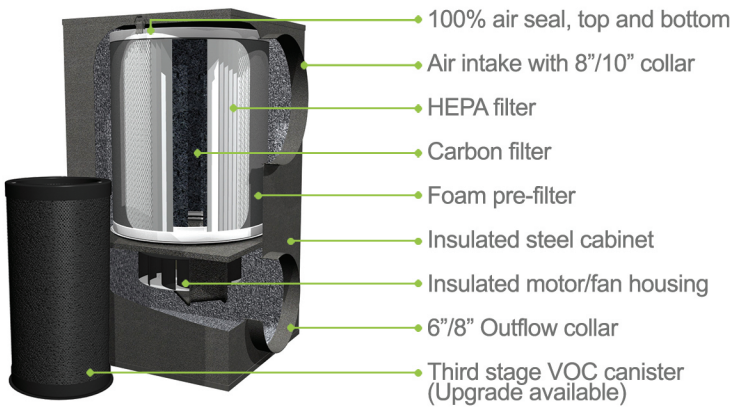
- Cultivation Rooms
- Large Harvest Rooms
- Green Houses
- Processing Rooms
- Offices
- Dry/Cure Rooms

Ducted HEPA Advantage

The Element Air™ HEPA ducted air filtration system is easily installed in your facility's HVAC or air handling system to provide 99.97% airborne particulate reduction without impacting air flow, static pressure or unit sizing. This whisper-quiet air filtration system is efficient in removing particles >0.3 microns in size. It is recommended for areas up to 5,000 sq. ft.

Carbon HEPA Pre Filter

Element Air™ HEPA - Air Filtration System



Features:

- No negative impact on AC blower static pressure
- Insulated cabinets for whisper-quiet operation
- Low maintenance; HEPA cartridges can last up to five years depending on the environment
- Energy efficient due to effective design and quality motors
- Our Microcon® filtration systems are constructed out of durable steel and finished with baked on powder coat paint
- Environmentally friendly
- VOC Canister contains carbon with 1,705,000 m^2 of adsorbent surface area for capturing chemicals

ITEM#	ELECTRICAL	DIMENSIONS	WEIGHT LBS.
EAM-350	120 VAC 50/60 HZ	2’ 3” H x 1’3“ W x 1’3“ L	40
EAM-675	120 VAC 50/60 HZ	2’ 3” H x 1’3“ W x 1’3“ L	40

Specifications:

Dimensions:	14.5”W x 27.5”H	
Motor/Fan:	Designed for continuous operation Run tested for 50,000+ hours	
	HEPA 350	**HEPA 675**
Coverage:	2,625 sq. ft.	5,000 sq. ft.
Inlet:	8” Duct Collar	10” Duct Collar
Outlet:	6” Duct Collar	8” Duct Collar
Weight:	30 lbs.	33 lbs.
Air Flow:	350 C.F.M.	675 C.F.M.
Electrical:	120V, 1.0 amps, 125 Watts	120V, 1.8 amps, 225 Watts

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3. Carbon Filters
   - Works via a process called adsorption whereby pollutants are trapped in carbon substrate.
   - Does NOT agglomerate particles and make HVAC system more efficient.
   - Passive technology; Highly reliant on airflow in order to be effective as air needs to bring contaminant to the filter.
   - Odor causing compounds are adsorbed into the pores of the carbon where they remain trapped.
   - Once the carbon is spent, it may be disposed then simply replaced.
   See *Element Air™* spec sheet next page

Element Air™

A Division of RGF Environmental Group, Inc.

ELEMENT AIR™ CARBON

Air Purification System

Reduces:

- Odors
- VOCs
- Microbials
- Particulate

Applications:

- Greenhouses
- Cultivation Rooms
- Large Harvest Rooms
- Processing Rooms

Activated Carbon Advantage

Terpene odors from cannabis growing operations cause operational challenges inside and outside of growing facilities. Element Air™ Carbon offers the industry's largest activated carbon adsorbers in combination with a proprietary air flow pattern to combat airborne odors, VOCs and microbial particulates.

Airborne terpenes, the major cause of odor in any cannabis grow, are quickly removed by our high-grade, tailored activated carbon filter media selected for its unique affinity for organic terpene molecules. Used in combination with the Element Air™ active air purification systems, unwanted odors and mold are reduced inside the growing facility to significantly improve the quality of indoor air and the facility exhaust air.

C

Carbon

CFM

Element Air™ Carbon - Air Purification System

CFM

Carbon

The Element Air™ Carbon adsorbers are available in three sizes to cover a wide range of air flows and grow sizes. Air flow ranges from 150 CFM to 400 CFM with the capacity to treat from 500 sq ft to 2,000 sq ft with one adsorber. Contact time is critical to odor removal performance and Element Air™ Carbon offers bed depths up to 32" with contact time over three seconds. Activated carbon filter media change-out is quick and easy with no messy refill required onsite. Once an Element Air™ Carbon adsorber reaches capacity, we'll exchange the entire drum and either dispose of the used carbon, or reactivate for continued use.

ITEM#	DRUM SIZE	LBS. CARBON	DIMENSIONS	WEIGHT LBS.	CFM	INLET	OUTLET
EAC-55	55 Gallon	150	4' 3" H x 2' Dia.	210	125	4" FPT	4"
EAC-85	85 Gallon	300	4' 5" H x 2' 4" Dia.	390	210	4" FPT	4"
EAC-110	110 Gallon	400	4' 6" H x 2' 7" Dia.	520	350	4" FPT	4"

Specifications:

Materials:	Steel with exterior enamel and interior epoxy		
Activated Carbon:	4x8 mesh granular activated carbon		
Electrical:	115V/208-230V, 60 HZ		
Warranty:	1 year		
Item#	**EAC-55**	**EAC-85**	**EAC-110**
Treatment Area:	500 to 1,000 sq ft	1,000 to 1,500 sq ft	1,500 to 2,000 sq ft
Replacement Media:	EAC-55-RM	EAC-85-RM	EAC-110-RM

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4. See Appendix C for Measures Researched but not chosen for initial installation. Future possibilities.

b. *Use it Right* - Standard Operating Procedures

   i. Administrative Controls
   Recordkeeping systems and forms will be implemented documenting maintenance on equipment as well as odor issues brought forward from the community.

   ii. Staff training procedures
   Highbrow has an extensive training program that includes training specifically for odor mitigation. The importance of keeping doors shut and changing carbon filters are among the other Standard Operating Procedures that all employees must follow. Highbrow will conduct weekly staff meetings at these meetings we discuss odor mitigation and discuss with all departments the importance of keeping up with the processes we have in place.

   iii. Sequential Operational Processes
   HVAC, exhaust systems, and odor mitigation will be sequenced in operation to balance airflow and conditioning so as to ensure a proper operation.

   iv. Maintenance Plan
   Highbrow will have a 2 month (or equivalent of 2 change outs per unit) supply of Carbon Filters and HEPA filters on site that will be re-ordered by the Operations manager to keep aligned with the facility maintenance program. If a filter needs to be changed sooner filters will be on premises to do so. If maintenance is needed it will be done immediately as to not affect the surrounding areas at the Highbrow Facility.

c. *Measure it Right* - Measuring, Monitoring, and Inspection
   To ensure continued success with the odor mitigation plan, Highbrow is committed to measuring, monitoring, and inspecting the facility. Equipment was

researched and Highbrow has tested these devices.

i. South Coast Air Quality Management District
South Coast AQMD develops, adopts and implements an Air Quality Management Plan for bringing the Southern California (Los Angeles) area into compliance with the clean air standards established by national and state governmental legislation. In their role they also test various devices for use by the public in determining air quality.

    1. Their Air Quality Sensor Performance Evaluation Center program performs thorough characterizations of currently available "low-cost" sensors under ambient (field) and controlled (laboratory) conditions.

        a. See South Coast AQMD PM Sensor Evaluations Appendix D with high ratings for Air Quality Egg

ii. Air Quality Egg's Indoor Egg by Wicked Device, LLC
This device will be tested by Highbrow to monitor odor producing rooms.

    1. Temperature, relative humidity, barometric pressure
    2. Add on for VOC and for Particulate Matter
    3. Configurable dashboards and downloadable historical information
    4. Subscription based service monitoring multiple devices
    5. Shareable database
    See spec next page

The Device

The Egg is a WiFi-enabled device that uses sensors to record changes in the levels of specified air contaminants. Each Egg can detect at least one air contaminant – NO_2, CO_2, CO, O_3, SO_2, particulates, and volatile organic compounds (VOC). It tracks any changes and automatically uploads the data to the cloud where it can be accessed through our web portal, mobile app, or by manual download by connecting the Egg to a computer.

- Seven air contaminant sensors to choose from
- Accurate, precise air quality measurement
- Durable and portable for field trips and off-site study
- All models equipped to measure temperature, relative humidity, and barometric pressure

iii. Monitoring and inspection

1. Every odor emitting room will be continuously monitored with daily inspections for odor. If a high volume of odor is detected by an employee by smell or instrumentation device, they will directly inform the Operations manager. If a filter needs to be changed it will be done so at this time. If doors are not closing by themselves, doors will be fixed as soon as the problem is detected.

iv. Third-party External Measuring Contract

Highbrow has found a testing firm in Maine that can perform the same EPA test as in the Skinny Pineapple case study. Highbrow will investigate performing this test to baseline its facility as a component of equipment commissioning.

1. ESH Associates Cumberland, ME

See **Appendix E** for **Initial Benchmarked Test Standard**

i. PA/625/R-96/010b January 1999 Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air - Second Edition
ii. Method TO-15: 15-1 through 15-62 Determination of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed By Gas Chromatography Mass Spectrometry (GC/MS)

Appendix A

Research Study

Characterizing the Smell of Marijuana by Odor Impact of Volatile Compounds: An Application of Simultaneous Chemical and Sensory Analysis

Somchai Rice , Jacek A. Koziel

Published: December 10, 2015 • https://doi.org/10.1371/journal.pone.0144160

Abstract

Recent US legislation permitting recreational use of marijuana in certain states brings the use of marijuana odor as probable cause for search and seizure to the forefront of forensic science, once again. This study showed the use of solid-phase microextraction with multidimensional gas chromatography—mass spectrometry and simultaneous human olfaction to characterize the total aroma of marijuana. The application of odor activity analysis offers an explanation as to why high volatile chemical concentration does not equate to most potent odor impact of a certain compound. This suggests that more attention should be focused on highly odorous compounds typically present in low concentrations, such as nonanal, decanol, o-cymene, benzaldehyde, which have more potent odor impact than previously reported marijuana headspace volatiles.

Citation: Rice S, Koziel JA (2015) Characterizing the Smell of Marijuana by Odor Impact of Volatile Compounds: An Application of Simultaneous Chemical and Sensory Analysis. PLoS ONE 10(12): e0144160. https://doi.org/10.1371/journal.pone.0144160

Editor: John I. Glendinning, Barnard College, Columbia University, UNITED STATES

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Data Availability: All relevant data are within the paper and its Supporting Information files.

Funding: The authors have no support or funding to report.

Competing interests: The authors have declared that no competing interests exist.

Introduction

Americans know the Fourth Amendment of the U.S. Constitution protects citizens from unreasonable search and seizure, without a warrant, by government bodies. Landmark legal cases have set a precedent of what is deemed probable cause (S1 Table). Courts are challenged to be consistent with using odor of marijuana as probable cause when recreational use is now legal in some states and illegal at the federal level. Previous research has been conducted, identifying the volatile organic compounds (VOC) present in the headspace of marijuana. The major components of total VOC in headspace of the plant material has been reported to consist of limonene [1–5], α-pinene [1, 3, 4, 6], β-pinene [1, 3, 4, 6], β-myrcene [1, 3–5], β-ocimene [2, 4], β-caryophyllene [2, 4–6], α-caryophyllene [4, 6], α-phellandrene [4], 3-carene [4], α–terpinene [4], terpinolene [4], terpineol [5], linalool [4, 5], α-cadinene [4]. With improved analytical techniques, the list of identified compounds is increasing, starting from 20 compounds in 1973 [1] with an addition of 10 new compounds since [1–6]. Even though more compounds have been identified, it has not increased understanding of forensic *odor*. To date, a total of approximately 31 compounds are known to be emitted from marijuana [1–6].

Solid phase microextraction (SPME) was used as a non-destructive, non-invasive, sampling device to collect volatiles permeated through packaging and responsible for 'characteristic' aroma of marijuana. The use of micro-sampling techniques in forensic science has been reviewed in Kabir (2013) [7]. SPME is favored due to a smaller requirement on sample size, eliminated use of organic solvents, portability, and lends itself to automation [7]. SPME is also best at reducing matrix effects inherent in forensic work with blood, plasma, and urine [8]. Headspace (HS) sampling using SPME for characterization of volatile organic compounds (VOC) has been used to characterize explosives [9], confiscated 3, 4-methylenedioxy-N-methylamphetamine (MDMA a.k.a. Ecstasy), amphetamine [10], and cocaine [11]. The upsurge in the use of SPME as an all-in-one sample preparation, cleanup, and pre-concentration of volatiles in forensics highlights its importance to the field.

There are some clear favorites in instrumentation being used for analysis of headspace VOC emitted from marijuana. Gas-chromatography (GC) was used to try and distinguish marijuana of different geographic origins, with unsuccessful results for classification [12]. GC tandem mass-spectrometry (MS) was used to characterize volatile oil composition of dried and fresh marijuana buds [13], and to discern differences between volatile compounds found in male and female marijuana plants of Northern Lights and Hawaiian Indica [14]. Volatile composition of entire inflorescences of hemp have been analyzed by GC-MS [15], even with ultrasound-assisted extraction [4].

Dogs trained for specific odor detection (e.g. narcotics, explosives, cadavers) are the current benchmark used in the law enforcement community [16–18]. A study by Macias, *et al*. in 2008 [17] showed that a mixture of α-pinene, β-pinene, myrcene, limonene, and β-caryophyllene associated with marijuana showed low alert responses when field tested on narcotic detection dogs. None of the dogs alerted to Sigma Pseudo Marijuana scent [17] (Sigma Aldrich, St. Louis, MO, USA). In a separate study by Jezierski (2014) [18] comparing dogs trained and tested with illicit drugs, (i.e., 68 Labrador retrievers, 61 German shepherds, 25 terriers and 10 English cocker spaniels), it was found that German shepherds were superior scent dogs and terriers were inferior at detecting drugs. The researchers tested 5 types of illicit drugs and found that marijuana was the easiest for all dogs to detect, followed by hashish, amphetamine, cocaine, and lastly heroin. In over 1000 trials, the dogs found the hidden drugs within 64 sec and an 87.7% accuracy rate (5.3% false positive) [17]. It has also been shown that the dog handler may also affect alert responses, with a failure rate of 85% false positives during search of a clean room [19]. With such a large range of variability, research is warranted on discovering what triggers an alert from the dogs. Rice (2015) [20] and Rice and Koziel (2015) [21] have reported on the usefulness of using OAV to characterize forensic odor from drugs, and offer an explanation on why current surrogate scent training tools may not be effective for canines [21].

Is human sense of smell any better? In a situational based study by Dotty in 2004, subjects were asked to smell a garbage bag containing 5 pounds of marijuana, and a garbage bag of crushed newspapers [22]. All human subjects could identify the bag containing marijuana. Could these same people detect marijuana smell sitting in the driver's compartment, with the marijuana in a garbage bag inside the car trunk? False positives (9.36%) was the same as true positives (12.97%), with $p > 0.20$, meaning there were no significant difference in detecting the marijuana bag versus the newspaper bag. Next, the researchers wanted to know if budding and non-budding marijuana plants produce similar odors (i.e. mature versus non-mature plants, respectively)? A tomato plant was used as the negative control. All participants found mature (budding) plant volatiles more intense ($p< 0.025$) suggesting the buds hold the odorous compounds. Intensities of immature cannabis did not differ significantly from the tomato plant. Lastly, the researchers wanted to test if the smell of marijuana can be distinguished when it is mixed with diesel exhaust. The rates of detection when combined with diesel exhaust were not significant [22].

Limited work has been published on canine and human detection of marijuana odor, yielding mixed results and high variability. A thorough, analytical approach to the investigation of marijuana odor detected by humans is warranted, if and when more states seek to legalize recreational use. The objectives of this study were to (1) identify odorous compounds emitted from marijuana using multidimensional gas chromatography (MDGC) tandem mass spectrometry coupled with simultaneous *human olfaction* and (2) show an application and novelty of odor activity values (OAV) to better understand the 'characteristic' aromas of marijuana (3) explore aromatic compounds that are emitted through packaging typical in illicit distribution of marijuana. The working hypothesis is that simultaneous chemical and sensory analysis can indicate the identity of aromatic compounds that are responsible for the characteristic smell of marijuana. This information is needed to (a) better understand which compounds are really responsible for the "characteristic" aroma of marijuana, (b) provide additional insight into aroma perception by applying a method (i.e., OAV) established in food and beverage field in a new setting (i.e., forensic sciences), and (c) investigate how marijuana packaged for illicit distribution can smell differently according to these OAV.

Odor activity value

Odor perception is multi-faceted and this laboratory has highlighted this complexity, showing the role of highly odorous compounds present at extremely low concentrations [23]. There are two big hurdles when using GC for characterization of odorous compounds, sufficient resolution between aromatic compounds, and co-elution of two or more of these compounds. A GC using a non-polar column connected in series to a polar analytical column can account for such occurrences [24, 25]. The use of state-of-the-art *simultaneous* MDGC-MS-O allows researchers to separate, at high resolution, odors that may not be separated on a single column, and to detect compounds [24] based on their OAV. This report is the first instance of using MDGC-MS-O to characterize the odor of marijuana.

Since the introduction of GC—olfactometry (GC-O), intensity and odor character of an individual compound has been better described [26]. Patton and Josephson originally presented the concept of the OAV [27]. A caveat is offered for equating high chemical concentration to high odor impact. The quantitative measurements of chemical concentration have been the primary data collected to date, while qualitative measurements of odor character has been largely ignored in analysis of marijuana odor.

$$OAV = [Concentration]/ODT \tag{1}$$

where ODT is odor detection threshold and defined as the concentration a compound is detected by 50% of the population [28]

OAV has been used extensively in the food and beverage industry to characterize aroma of bread, beef, coffee, beer [29] and wines [30, 31] and more recently odor emissions from animal buildings [32]. This report is the first application of OAV to characterize marijuana. This paradigm shift from concentration based (i.e., high concentration equates to potent odor) to OAV based aroma detection of marijuana and associated odor perception can help extend the knowledge of marijuana odor and its role in forensic science.

Materials and Methods

The marijuana samples were obtained from Iowa Division of Criminal Investigation (Iowa DCI), Drug Identification Section. Marijuana was available in various states of seizure and included: 1) a US military-style duffel bag filled with marijuana weighing ~ 50 kg; 2) 1 gram air-dried marijuana (*loose*); 3) 1 gram of the same air-dried marijuana placed in a plastic zip-top sandwich bag (*bagged*).

Carboxen/Polydimethylsiloxane (PDMS), 85 μm Stableflex, 24 gauge solid-phase microextraction (SPME) fibers were used (Sigma-Aldrich, St. Louis, MO, USA). Briefly, experimental conditions were as follows: the drugs were placed in separate, pre-cleaned and baked 16 ounce (473 mL) mason jars with modified lids. The Carboxen/PDMS fibers were exposed to the headspace and volatiles were collected. Marijuana samples were placed in the sample jars and sealed, with the exception of the marijuana in a duffel bag

(S1 and S2 Figs). Immediately, SPME fibers were inserted into the sample port and exposed for 5 min, 1 h, and 68 h at ambient temperature. When the extraction step was completed, the SPME fiber was retracted, wrapped in pre-baked aluminum foil, placed in a pre-cleaned mason jar, and transported back to the laboratory in a cooler on ice. In the laboratory, fibers loaded with VOC were stored in a 4°C refrigerator until analysis, wrapped in the foil and sealed in a clean mason jar. SPME fibers were exposed to the heated injection port of the MDGC-MS-O for thermal desorption and analysis.

MDGC-MS-O analysis was performed on an Agilent 6890 GC, with a restrictor guard column, non-polar capillary column (BP-5, 56 m x 530 μm inner diameter x 1.00 μm thickness, SGE, Austin, TX, USA) and polar capillary column (BP-20, 25 m x 530 μm inner diameter x 1.00 μm thickness, SGE, Austin, TX, USA) connected in series. Outflow from analytical column was held at 7.0 mL/min. Sample flow was split 3:1 via open split interface to the sniff port and mass spectrometer, respectively, as determined by restrictor column inner diameter. Desorption time was 2 min in splitless mode at 270°C under flow of helium carrier gas (99.995% purity). Subsequent analysis of the same fiber immediately afterward, revealed no carry over. The oven temperature was programmed as follows: 40°C for 3.00 min, then increased to 220°C at a rate of 7.00°C per min, and held for 11.29 min (40 min total run time). The carrier gas was set at constant pressure at the midpoint (junction point of the non-polar and polar column) at 5.8 psi (0.395 atm). Restricted transfer line to the MS was set at 240°C; restricted transfer line to the sniff port was set at 240°C with humidified air flow. MS heated zones were 150°C for the quadrupole and 230°C for the source. The MS source was electron ionization mode with ionization energy set at 70 eV. Mass acquisition range m/z 33.0–280.0 u.

Tentative identification of VOC was performed using the Automatic Mass Spectral Deconvolution and Identification System (AMDIS) (National Institute of Standards and Technology, Gaithersburg, MD) and six specialty mass spectral libraries provided derived from the NIST05/EPA/NIH mass spectral database. It was not appropriate to use retention indexes (Kovats RI) for identification due to the configuration of the capillary columns, but known retention times of standards previously analyzed on this system were also used for identification.

One panelist was trained using odorous chemical standards on MDGCMS-O. Sample availability and time allotted at the crime lab allowed for limited fibers (i.e., limited replicates). A single panelist analyzed all sample fibers in the open experiments. A maximum of 6 sample fibers was analyzed per day. There were three parameters recorded for perception of odorants during olfactometry work outlined in this study. The first parameter was detectability, defined here as the minimum concentration of the odorant needed to be recognized. Secondly, intensity for each aroma note was recorded, and defined here as the perceived strength of the aroma event. Guidelines for a unitless, relative intensity scale were as follows: not present = 0, faint = 25, distinct = 50, strong = 75, intense = 100. The last parameter measured was character, or aroma descriptor, as described by the trained panelist. A descriptor of “characteristic” was used when an odor was distinguished to represent the overall aroma of the sample. Area under the peak of each aroma event in the aromagram is calculated as Aroma Area = Width x Intensity x 100, where width is the length of time in min that an aroma persisted.

Results

The instrument was tuned daily and column blanks were performed and did not show any contaminating compounds. Final analysis of blank trip fibers (an unloaded SPME fiber taken to the site and back, exposed to a clean jar with no sample, and stored with sampled fibers to be analyzed) did not show any contaminating compounds. Deconvolution resolution in AMDIS was medium, and signal to noise ratio ranged from 5 to 937 (not shown). In this study, a total of 233 compounds were tentatively identified as volatiles in headspace emitted from marijuana at room temperature (Table 1). This list was compiled from analysis of lab-stored, desiccated marijuana (S1 Fig) in packaged and unpackaged form, and newly seized, fresh marijuana (S2 Fig). Over 200 new compounds were added to the list of volatiles known to be emitted from marijuana. Newly reported compounds, represent an addition of 95% of the total compounds reported in Table 1. In this research, the authors are not differentiating between VOC emitted from marijuana samples and VOC emitted from packaging. Due to the legal nature of the samples from active cases, the authors were not able to disturb the evidenced samples or obtain true “blank” plastic bags or duffel bags. Also, from the context of total forensic odor from OAV and not concentration in HS, differentiating between such VOC may not be not be useful if the differences in odor impact of the compounds are small. Full details including CAS number, retention times, significant ions, % spectral match, aroma descriptors, published ODT, relative abundance (given as peak area counts), and calculated OAV for each compound are given in S2 and S3 Tables.

	(-)-Aristolene	(-)-Globulol	(+)-4-Carene	(+)-calarene	(+)-nerolidol	
	(+)-sativene	(1R)-(+)-trans-isolimonene	1-(3-methylphenyl)-ethanone	1-(3-methylphenyl)-ethanone	1,1-dimethylhydrazine	
	1,2,3,4-tetramethylbenzene	1,2-diethylbenzene	1,3,5-triazine-2,4,6-triamine	1,3-dichlorobenzene	1,4-diethylbenzene	
	1-butanol	1-butoxy-2-propanol	1-hexadecanol	1-hexanol	1-undecanol	
	2,2,5-trimethylhexane	2,3,4-trimethylpentane	2,4,6-trimethylphenol	2,4-di-tert-butylphenol	2,6-diethylpyrazine	
	2,6-dimethylquinoline	2-butanone	2-butoxyethanol	2-chloroacetophenone	2-ethenyl-1,3-dimethylbenzene	
	2-ethoxyethanol	2-ethylhexanol	2-ethyltoluene	2-heptanone	2-hydroxyacetophenone	
	2-isopropenyl-3-methylpyrazine	2-methyl naphthalene	2-methyl-1H-indazole	2-methyl-2-propanamine	2-methylaziridine	
	2-methylpentane	2-nitropropane	2-phenoxyethanol	3,4,5-trimethyl-1-hexene	3,4,5-trimethylphenol	
	3-ethyl-o-xylene	3-ethyltoluene	3-isopropylbenzaldehyde	3-methyl-2-cyclopenten-1-one	3-methylheptane	
	3-methylpentane	3-pentanol	4-ethoxy-3-anisaldehyde	4-methyl guaiacol	4-methylidecane	
	4-methylphenylhydrazine	4-methylpyridine	4-pyridinamine	5-ethenyl-2-methylpyridine	5-methylfuran	
	5-octanolide	7-methoxycoumarin	Acetaldehyde	Acetamide	Acetic acid	
	Acetone	Acetophenone	Acrolein	Allyisothiocyanate	Anethole	
	Anthracene	Benzaldehyde	Benzonitrile	Benzophenone	Benzothiazole	
	Benzyl acetate	Benzyl Alcohol	Benzyl formate	Benzyl nitrile	Bisabolene	
This Study (a)	Betazole	Butane	Butyl formate	**Camphener**	Carbofuran	
	Carvacrol	**Caryophyllene oxide**	Cedryl acetate	cis-2-pinanol	Citronellylformate	
	Citronellyl acetate	Cumene	Cuminaldehyde	Decanal	Diacetone alcohol	
	Dibutyl phthalate	Diethyl Phthalate	Dimethylbenzylcarbinyl acetate	Dimethylpyrazine	Dimethylsulfide	
	Dimethylsulfone	DL-carvone	Dodecane	Durene	Dyclozoline	
	Estragole	Ethanol	Ethylacetate	Ethylene oxide	Ethylenediamine	
	Ethylenimine	Eugenol	Eugenyl acetate	**Fenchyl alcohol**	Formic acid	
	Furfural	Furfurylmethylsulphide	Heptanal	Hexadecane	Hexanal	
	Hexanoic acid, methyl ester	Hexanoic acid, propyl ester	Hexanol	Hordenine	Hydrazine	
	Isoamyl alcohol	Isobornyl acetate	Isobornyl thiocyanoacetate	Isobutane	Isobutylaldehyde	
	Isobutylnophenone	Isocyanatomethane	Isobutene	Isoeugenol	Isoprene	
	Isoquinoline	**Limonene**	Limonene dioxide	**Linalool**	Linalyl acetate	
	Longifolene	m-cymene	Methacrolein	Methacrylic anhydride	Methyl acetate	
	Methyl acetylsalicylate	Methyl anthranilate	Methyl benzoate	Methyl hepadienone	Methyl heptenone	
	Methyl isoeugenol	Methyl mercaptan	Methyl salicylate	Methyl valerate	Methylene chloride	
	methylhydrazine	Methylisoheexyl ketone	m-tert-butylphenol	Myrcene	Nerol	
	Nerolidol	Nitrobenzene	Nonanal	Nonene	Octanal	
	o-cymene	o-dimethyl hydroquinone	o-guaiacol	o-methylacetophenone	o-xylene	
	p-acetanisole	p-aminotoluene	**p-cymene**	Pentadecane	Pentamethylbenzene	
	Pentanal	Perillaldehyde	p-ethyltoluene	Phenol	Phenylethyl alcohol	
	Piperidine	Piperonal	p-methylacetophenone	Propanal	Propanoic acid, anhydride	
	Propofol	Propylamine	Propylene glycol	p-tert-butylphenol	p-xylene	
	Sabinene	Salicylaldehyde	Styrene	**Terpinolene**	tert-butanol	
	tert-butyl-benzene	Tetrahydrocodine	Thymol	Toluene	Trideceane	
	Tyramine	Undecane	**Valencene**	Verbenone	α-bisabolol	
	α-bulnesene	**α-cadinene**	α-cedrene	α-copaene	α-cubebene	
	α-guaiene	α-gurjunene	**α-humulene**	α-ionol	α-longipinene	
	α-methylcinnamaldehyde	**α-phellandrene**	**α-pinene**	**α-terpinene**	α-terpineol	
	β-caryophyllene	β-cedrene	β-ionne	**β-pinene**	**β-selinene**	
	γ-gurjunene	γ-heoxlactone	**γ-terpinene**	**δ-3-carene**	δ-cadinene	
	3-(1-methylethyl)-phenol methylcarbamate	3-(3-hydroxyphenyl)-2-propenoic acid, methyl ester	3-methyl-5-(1-methylethyl)-Phenol methylcarbamate	1-Propanamine,3-dibenzo[b,e]thepin-11(6H)-ylidene-N,N-dimethyl-, 5-oxide		
Previously reported (b)						
Da Porto (2014) [1]	(E)-ocimene	**Limonene**	**Linalool**	**Terpinolene**	**α-cadinene**	
	α-humulene	**α-phellandrene**	**α-pinene**	**α-terpinene**	**β-caryophyllene**	
	β-myrcene	**β-pinene**	**δ-3-carene**			
	1,8-Cineole	3-Hexen-1-ol-acetate	**Camphene**	Cis-Hex-3-en-1-ol	Eucalyptol (5,7(11)-Bene	
Ruthar (2011) [11]	Guaiol	**Limonene**	**Valencene**	**α-humulene**	**α-pinene**	
	β-caryophyllene	β-chamigrene	β-maaliene	β-ocimene	**β-pinene**	
	β-selinene					
Lai (2008) [2–3]	**Limonene**	**α-pinene**	**β-caryophyllene**	β-myrcene	β-ocimene	
	β-pinene					
Osman (1985) [5]	**β-caryophyllene**					
Hood (1975) [12]	**Camphene**	**Caryophyllene oxide**	**Fenchyl alcohol**	**Limonene**	**Linalool**	
	Methyl heptenone	**p-cymene**	**Terpinolene**	α-Bergamotene	**α-humulene**	
	α-pinene	**α-terpinene**	**β-caryophyllene**	β-Farnesene	β-myrcene	
	β-ocimene	β-phellandrene	**β-pinene**	**γ-terpinene**	**δ-3-carene**	

Bolded= compounds indicate concurrent identification with this study and previously reported studies. Underlined = compounds indicate compounds previously reported but not found in this study. No true "blank" package sample type was available for comparison of the same material and manufacturing lot of the seized thick marijuana. Therefore, this report is conveying all compounds found in headspace of marijuana, regardless of packaging type and presence.

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Table 1. Comparison of (a) 233 volatiles found in this study emitted from marijuana, including those emitted through-packaging with (b) volatiles previously reported as 'signature' compounds of marijuana in headspace.
https://doi.org/10.1371/journal.pone.0144160.t001

Permeation of marijuana volatiles through packaging

Lai, et al. (2008) reported 1–2 min sampling times were enough for detection of selected volatile markers in marijuana and cocaine. The target VOC were limonene and α/β- pinene, and β-myrcene [2]. The purpose of selecting short sampling time (i.e., 5 min) and long sampling time (i.e., 68 h) was to capture the full aroma profile of marijuana while taking into consideration the limitations of the Carboxen/PDMS SPME coating. Short sampling time allows for the adsorption of lower molecular weight (MW) VOC. Longer sampling time allows for adsorption of higher MW VOC, at the expense of lowered selectivity for the more volatile, lower MW VOC. Exploration of the effects of packaging and dwell time of marijuana in packaging (i.e. sampling time and storage/equilibrium time in the package were identical) revealed an increase in the number of chromatographic peaks detected, with increased headspace sampling time, in both the loose and bagged marijuana. Fig 1 shows an overlay of the total ion chromatogram (TIC) generated by the MS showcasing detected VOC emitted from in loose marijuana in a sealed glass jar and detected VOC emitted *through* a plastic zip-top sandwich bag in a sealed glass jar.

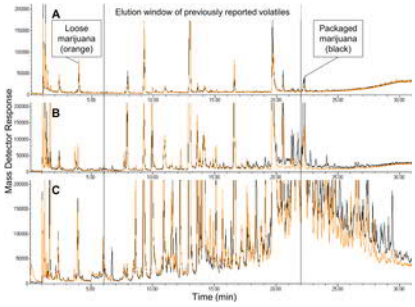

Fig 1. Effects of sampling time, as total ion chromatograms (TICs), of volatiles emitted from marijuana.
Orange signal represents volatiles emitted from 1 g desiccated marijuana, loose in a 473 mL glass jar. Black signal represents volatiles emitted from 1 g desiccated marijuana, in a plastic zip-top bag, in a 473 mL glass jar. The boxed retention time widow highlights where volatiles, from previously published articles, would elute from the analytical column of the MDGC-MS-

O. The set of 3 TICs represent volatiles extracted over (A) 5 min, (B) 1 h, and (C) 68 h resulting 20, 54, and 101 chromatographic peaks (orange signal), and 25, 39, 108 chromatographic peaks (black signal), respectively. See S2 and S3 Tables for the complete summary of identified compounds.
https://doi.org/10.1371/journal.pone.0144160.g001

Across all 3 sampling times, 134 total volatiles were identified from headspace emitted from marijuana, through a plastic zip-top sandwich bag (S2 Table) and loose (S3 Table) with a net match of 65% or higher from AMDIS. Data analysis using all 6 specialty libraries provided in AMDIS resulted in 20, 54, and 101 chromatographic peaks identified in the loose marijuana and 25, 39 and 108 chromatographic peaks identified in the bagged for sampling times of 5 min, 1 h, and 68 h, respectively (Fig 1A–1C). Previously reported volatiles (bolded in Table 1) are known to elute between 6 min and 22 min on the MDGC-MS-O system used in this study (boxed in Fig 1). Please see S2 and S3 Tables for full details regarding the identification, odor character, and OAV of these 134 compounds. Results indicate that the number of unique VOC emitted into HS of marijuana stored at room temperature increased with time, whether packaged in a plastic sandwich bag or loose.

There was not a statistically significant effect of packaging on surrogate concentration of the 134 total VOC emitted from marijuana ($p > 0.05$). Surrogate concentration is defined as MS response to each separated compound, in peak area counts (PAC). There was statistical significant effect of sampling time on surrogate concentration for 34% of the VOC emitted from marijuana ($p < 0.05$). See S4 Table for full summary of F-statistics and p-values from statistical analysis. Compounds previously reported as key components of marijuana odor (α-humulene [4, 6] and β- caryophyllene [2, 4–6] did not permeate through packaging after 5 min. β-Caryophyllene [2, 4–6] did not permeate through packaging after 1 h. After 68 h of storage, 51 of 53 total compounds permeated through plastic packaging. Preliminary results show that packaging of marijuana in plastic zip-top sandwich bags does not have a significant effect on VOC emitted (i.e. odorous VOC), but storage time has a significant effect on the surrogate concentration of VOC emitted (i.e. more time allowed for more odorous VOC to be emitted). This suggests that diffusion of 134 volatiles through packaging was random ($p > 0.05$) but the amount (i.e. surrogate concentration) of these volatiles was affected by time. Specifically, by 68 h, the surrogate concentrations of volatiles emitted were significantly higher than 5 min, regardless of packaging. Marijuana recently stored in a plastic sandwich bag (i.e. 5 min) may have a different odor profile than marijuana stored in a plastic bag for 68 h, due to concentration differences that impact OAV.

Application of OAV to marijuana volatiles

There were 124 chemical peaks tentatively identified using MDGC-MS, thought to be compounds emitted from marijuana through plastic zip-top sandwich bag regardless of sampling time (S2 Table). Only 8%, 19%, and 58% of the total compounds detected by MS after 5 min, 1 h, 68 h sampling time had published odor descriptors. Eight %, 11%, and 41% of the total compounds detected by MS after 5 min, 1 h, 68 h sampling time had published ODT. Similarly, a total of 121 chemical peaks were tentatively identified by MDGC-MS directly emitted from marijuana (a.k.a., loose) regardless of sampling time (S3 Table). Only 9%, 31%, and 59% of the total compounds detected by MS after 5 min, 1 h, 68 h sampling time had published odor descriptors. Seven %, 20% and 38% of the total compounds detected by MS after 5 min, 1 h, 68 h sampling time had published ODT. These numbers point out researchers only know as much as 59% of the information in terms of odor description, and 41% of the information in terms of ODT. Further research to reveal this missing information is warranted.

A Wilcoxon signed rank test of paired samples was performed (S5 Table) for each combination of time and packaging. This test compared the number of times when surrogate concentration is greater than calculated OAV, to the number of times when calculated OAV is greater than surrogate concentration, taking into account the size difference within the pairs. The null hypothesis is there is no difference in number of oppositions in each direction. Results indicated there is a significant difference between surrogate concentration and calculated OAV (using (Eq 1) and listed in S2 and S3 Tables) for loose marijuana at 1 h and 68 h extraction ($p = 0.014$ and $p < 0.0001$, respectively) and marijuana in a plastic zip-top bag at 68 h extraction ($p < 0.0001$). VOC were ranked by surrogate concentration (smallest surrogate concentration = 1) for bagged marijuana, shown in S6 Table. This illustrates how high chemical abundance does not equate to high odor intensity as perceived by human nose. Most importantly, compounds that have previously been reported as important volatile markers of marijuana based on high concentration and found in this study actually rank lower when using OAV (S3–S5 Figs) and vice versa. In other words, surrogate concentration of VOC and calculated OAV are not highly correlated ($R2 < 0.638$; See S7 Table). A general trend, based on available published human ODT, is that lower concentrated compounds could have more impact on odor, and therefore should be more responsible for the overall characteristic odor than the most concentrated compounds.

Simultaneous chemical and sensory analysis of fresh marijuana

There were 179 compounds identified by MDGC-MS using AMDIS and 53 odor events associated with simultaneous olfactometry during a 68 h extraction of volatiles emitted from fresh marijuana through a cloth duffel bag (S2 Fig). Only 29% of the chemicals present in headspace of this marijuana sample registered an odor response by human nose. Only 31% of the total 179 compounds had published ODT in order to calculate OAV. Using Flavornet [33] and The Good Scents Company (TGSC) [34] aroma databases, 62% of the 179 compounds had a description of aroma perceived by human nose. This data highlights how almost 70% of the data presented in this study is missing crucial information (i.e. published ODT) needed to calculate OAV (1). See S8 Table for full details of all 179 compounds and 53 aroma events, associated aromas, ODT and calculated OAV for volatiles emitted from fresh evidence marijuana and emitted through a cloth duffel bag over 68 h.

A comparison of the total ion chromatogram generated by MS and aromagram generated by human olfaction is shown in Fig 2, illustrating simultaneous chemical and sensory detection of extracted volatiles in headspace emitted through a duffel bag.

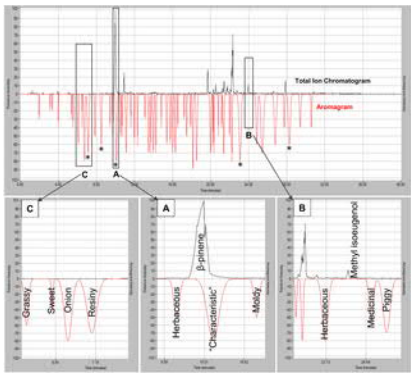

Fig 2. Simultaneous chemical and sensory analysis of volatiles emitted into headspace, through a duffel bag, and captured by SPME over 68 h. Total ion chromatogram (black) and aromagram, (red, inverted) of VOC emitted from marijuana in a duffel bag. An 85 μm Carboxen/PDMS SPME fiber was exposed to headspace over the duffel bag, within an overturned glass jar to capture emitted volatiles for 68 h (see S2 Fig). A total of 53 aroma events and 178 compounds were recorded (S8 Table). Aroma events # 12, 15, 46, and 51 were recorded as a 'characteristic' smell (i.e. (*) the aromas that most represent the overall aroma of marijuana). Outlined boxes signify (A) big chemical peak detected, smell detected; (B) chemical peak detected, no smell detected; (C) Small or no chemical peak detected, smell detected. Zoomed boxes A, B, and C identify chemical peaks and aromas.
https://doi.org/10.1371/journal.pone.0144160.g002

- Box A illustrates the current understanding of compounds responsible for aroma of marijuana, showing a large chemical signal with a large olfactory intensity. There were 20 instances (9% of the identified peaks) of box A.
- Box B (black-outlined box) illustrates where a chemical present in the headspace has no perceived aroma by human nose. There were 159 instances (75% of identified peaks) of box B.
- Box C (black-outlined box) illustrates the paradigm shift of odor perception that is the main focus of this report. Chemicals having small surrogate concentration (i.e. sub-threshold detection by mass spectrometer), can register high odor impact due to OAV (1). There were 34 instances (16%) of box C.

Note the 5 "characteristic" aromas detected by human nose, with the exception of box A (identified by AMDIS as β-pinene), were not the most chemically abundant in headspace, and perceived to represent the overall aroma of marijuana. Full identification and odor characteristics of volatiles belonging to these 3 boxes are shown in S8 Table. This suggests that compounds having very small concentration in headspace of marijuana are the "needles in the haystack" of compounds responsible for overall odor of marijuana, not the most concentrated compounds as previously reported. The effects of synergistic or antagonistic effects of interactions between the components of the mixture were investigated in this study.

There were 53 aroma events identified by human panelist (S8 Table) found in the fresh marijuana sample in a duffel bag, emitted over 68 h (S2 Fig). Aroma event 36 was rated the most intense but with relatively small chemical signal from the mass detector, described as moldy, burnt, and burnt food by the panelist. The 5 "characteristic" aromas had intensities of 80, 80, 70, 60, and 60. The aroma events were ranked by aroma area (assumed to be equivalent to mass detector response); the "characteristic" aromas are within the top 15 most intense aromas. When these volatiles were ordered by surrogate concentration and compared to the OAV, we observed the same trend in rank shift (Fig 3), also observed in S3–S5 Figs, indicating that concentration and odor impact are not highly correlated ($R2 < 0.1047$, S7 Table).

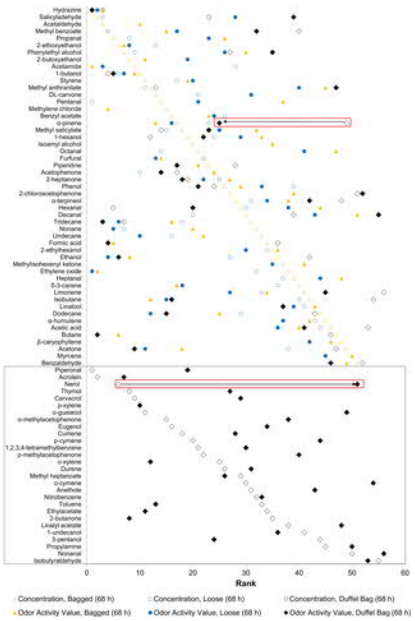

Fig 3. Dot plot reporting shift in rank of volatiles emitted from marijuana by surrogate concentration vs. calculated OAV.
Markers represent VOC emitted from all marijuana samples and extracted from headspace by SPME over 68 h at room temperature. Compounds are ranked by surrogate concentration vs. calculated OAV using standardized ODT in air from Devos, et al. (1990) [35]. Data representing bagged and loose marijuana sampled for 68 h are similar to S5 Fig. Rank value (horizontal-axis) of 1 indicates low surrogate concentration or low OAV; rank of 60 indicates high surrogate concentration or high OAV. The general trend is a shift in rank between surrogate concentration and odor activity value. Nerol has a rank of 6 by surrogate concentration and has a rank of 51 by OAV (bottom red box); α-pinene has a rank of 49 by surrogate concentration and has a rank of 25 by OAV (top red box). Values of rank for each VOC are given in S6 Table. Compounds in the black box highlight VOC that were detected in fresh marijuana and permeated through a duffel bag, not detected or permeated in desiccated marijuana.
https://doi.org/10.1371/journal.pone.0144160.g003

A two-way analysis of variance (ANOVA) was performed without replication and assuming no interaction, followed by a multiple comparisons test. Normal distribution and equal variance is assumed for the analysis. The two-way ANOVA without repetition was conducted to compare the effect of packaging on VOC emitted from marijuana at 5 min, 1h, and 68 h extraction times using static headspace SPME extraction at room temperature. Just one single measurement was taken at each combination of factors; therefore, it is assumed that there were no interactions between the independent variables of sampling time and packaging. The post hoc Tukey HSD is conservative and attempts to control the overall alpha level, and is less sensitive than the ANOVA, so this could account for the 5 VOC showing no significant difference in the pairwise comparison, but indicated as significant in the ANOVA.

Fig 3 shows 79 compounds with published ODT, emitted from all marijuana samples presented thus far. It is pointed out that with missing published ODT for some compounds; this ranking by OAV is only showing information representing less than 47% of the total compounds detected by MS. Only 56 out of 178 volatiles emitted from marijuana through a cloth duffel bag, over 68 h, have published ODT. More research is warranted to establish these missing ODT. Some compounds with unpublished ODT could have extremely high or low ODT, and would alter the current rank. Shown in Fig 3, 3.7% of these 81 compounds were unique to dry marijuana in a plastic zip-top sandwich bag, 2.4% were unique to loose, dry marijuana, 34.5% were unique to fresh marijuana in a duffel bag. Highlighted Fig 3 is α-pinene, ranked 49th (high) in surrogate concentration in headspace of fresh marijuana emitted through a duffel bag, but is ranked 25th (low to mid-range) in OAV. Nerol is ranked 6th (low) in surrogate concentration in headspace of fresh marijuana emitted through duffel bag, but is ranked 51st (high) in OAV. Current research is missing the target when only the highly concentrated compounds are looked at when trying to understand odor. This data also suggests that the complete odor profile of the fresh marijuana emitted through a duffel bag is caused by a mix of compounds different from the dry marijuana (loose) or dry marijuana in a plastic zip-top sandwich bag.

Odor impact based on OAV

Fig 4 illustrates that the most odorous compounds with published ODT, the further the distance on the vertical axis from zero, the more odor impact of the compound. The compounds found to be responsible for the overall aroma of dry marijuana investigated in this research, both loose and emitted through a plastic zip-top bag over 68 h are 1) Benzaldehyde, 2) Myrcene, 3) Decanal, 4) Heptanal, 5) Methyl anthranilate, 6) Octanal, 7) Hexanal, 8) Methylisohexenyl ketone, 9) Linalool, 10) β-Caryophyllene, 11) α-Humelene, and 12) Acetic acid. Highly odorous compounds with published ODT emitted from fresh marijuana through a duffel bag over 68 h are A) Nonanal, B) Decanol, C) o-Cymene, D) Isobutyraldehyde, E) 1-Chloroacetophenone, F) Nerol, G) Propylamine, H) o-Guaiacol, I) Linalyl acetate, J) Methyl anthranilate, K) Benzaldehyde, L) Limonene. Top ranked volatiles (by OAV) do not agree with what is currently known as key odorous compounds responsible for the smell of marijuana [1–6]. Also, results of this research indicate the key odorous compounds responsible for the smell of marijuana are different between old, desiccated marijuana and fresh marijuana.

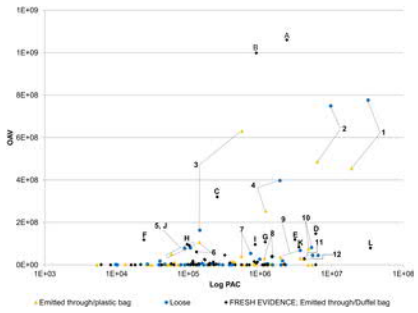

Fig 4. Compounds with high odor impact are not always the most abundant in concentration.
Horizontal axis is peak area counts (PAC) of mass detector response on logarithmic scale, assuming equal response for all compounds. Vertical axis is calculated OAV (Eq 1) for each compound. Highly odorous compounds emitted from *loose* marijuana (blue circles) and *through packaging* (yellow triangles) over 68 h at room temperature are 1) Benzaldehyde, 2) Myrcene, 3) Decanal, 4) Heptanal, 5) Methyl anthranilate, 6) Octanal, 7) Hexanal, 8) Methylisohexenyl ketone, 9) Linalool, 10) β-caryophyllene, 11) α-humelene, 12) Acetic acid. Highly odorous compounds emitted from fresh evidence of marijuana *through a duffel bag* (black diamonds) over 68 h at room temperature are A) Nonanal, B) Decanol, C) o-cymene, D) Isobutyraldehyde, E) 1-chloroacetophenone, F) Nerol, G) Propylamine, H) o-guaiacol, I) Linalyl acetate, J) Methyl anthranilate, K) Benzaldehyde, L) Limonene.
https://doi.org/10.1371/journal.pone.0144160.g004

Conclusions

Odorous compounds emitted from marijuana were identified using MDGC-MS coupled with simultaneous human olfaction. Over 200 compounds are being added to the list of what is currently known to be emitted from illicitly packaged marijuana. It is suggested that newly packaged marijuana (i.e. packaged or sitting in a room for 5 min) would have a different aroma profile than marijuana that has been stored for a longer period (i.e. packaged or sitting in a room for 68 h) due to the increased number of chemical peaks detected by MDGCMS-O (~20 compounds to ~100 compounds, respectively). Overall odor of marijuana due to compounds emitted is time dependent, but effects of plastic zip-top sandwich bag or cloth duffel bag packaging on compound surrogate concentration were not significant ($p < 0.05$). When simultaneous chemical and sensory analysis was used to analyze headspace volatiles of marijuana emitted through a duffel bag, 9% of the chemicals detected by MS had an associated aroma, 75% of the chemicals detected did not have an aroma detected, and 16% registered low or no chemical signal but an aroma was detected. This phenomenon can be explained by taking into account OAV. The application of OAV to forensic odor is being proposed as a novel approach to investigating forensic odor. More work is needed to establish ~55% of missing ODT and ~41% missing odor description. This reports suggests that highly odorous compounds are not necessarily the most concentrated compounds in headspace. This is the first reported instance of using MDGC-MS tandem simultaneous olfactometry by human nose to characterize the volatiles in the total aroma profile emitted from marijuana in the context of non-destructive, through-packaging analysis of evidence. Shifting the focus to using OAV to evaluate total odor, instead of analyzing the most concentrated compounds, can help forensic investigators understand cadaver odor, drug odor, explosives odor, etc. This draws attention to how training a drug detection dog, handlers, and other law enforcement officers to a handful of compounds does not cover the gamut of VOC found in different conditions of marijuana for illicit distribution.

Supporting Information

S1 Fig. Static headspace sampling of VOC emitted at room temperature from illegal street drugs.
(Samples from left to right). The SPME fiber is exposed and sampling in between the evidence bag and original packaging of cocaine. ~1 gram of air-dried marijuana in a zip-top plastic sandwich bag. ~1 gram of air-dried marijuana, loose in the jar. Methamphetamine in a beaker. Holes were predrilled into the metal mason jar lids, and fitted with a half-hole septa as the SPME sampling port. All jars, lids, rings, and septa were pre-cleaned and baked out in 110°C oven overnight to desorb interfering VOC. Pre-conditioned SPME fibers were pre-cleaned prior to sampling by desorbing in a 270°C GC injection port under flow of nitrogen, retracted, and wrapped in aluminum foil for transport. Sample loaded fibers were transported back to the lab wrapped in clean foil, placed in a clean jar with intact metal lid, and kept in a cooler with reusable ice packs.
https://doi.org/10.1371/journal.pone.0144160.s001
(PDF)

S2 Fig. Static headspace sampling of VOC at room temperature from marijuana emitted though a duffel bag.
A US military-style duffel bag containg ~50 kg of marijuana was siezed and tagged as evidence. The SPME fiber was exposed and propped up by a metal binder clip, inside an over-turned, pre-cleaned 16 oz glass mason jar. This ad hoc apparatus created a headspace sampling chamber to collect VOC emitted from the marijuana and through the duffel bag over a period of 68 h. The fiber was transported back to the lab for analysis as described in the caption of S1 Fig.
https://doi.org/10.1371/journal.pone.0144160.s002
(PDF)

S3 Fig. Dot plot illustrating hierarchy of volatiles emitted from marijuana using surrogate concentration and calculated OAV from published ODT at 5 min.

Open markers represent the rank of the volatile based on surrogate concentration. Closed markers represent the rank of the volatile based on OAV. Horizontal axis reads from left to right, indicating least to most concentrated/odor active rank. Rank number is provided above and below markers for ease of reading. The general inference is a shift in rank based on OAV. Compounds with low detection thresholds tend to rank higher in OAV than rank of surrogate concentration in headspace, a relationship shown by Eq 1. Blue box-outlined markers indicate volatiles detected in unpackaged marijuana and not detected by through-package sampling.
https://doi.org/10.1371/journal.pone.0144160.s003
(PDF)

S4 Fig. Dot plot illustrating hierarchy of volatiles emitted from marijuana using surrogate concentration and calculated OAV from published ODT at 1 h.
Open markers represent the rank of the volatile based on surrogate concentration. Closed markers represent the rank of the volatile based on OAV. Horizontal axis reads from left to right, indicating least to most concentrated/odor active rank. Rank number is provided above and below markers for ease of reading. The general inference is a shift in rank based on OAV. Compounds with low detection thresholds tend to rank higher in OAV than rank of surrogate concentration in headspace, a relationship shown by Eq 1. Blue box-outlined markers indicate volatiles detected in unpackaged marijuana and not detected by through-package sampling.
https://doi.org/10.1371/journal.pone.0144160.s004
(PDF)

S5 Fig. Dot plot illustrating hierarchy of volatiles emitted from marijuana using surrogate concentration and calculated OAV from published ODT at 68 h.
Open markers represent the rank of the volatile based on surrogate concentration. Closed markers represent the rank of the volatile based on OAV. Horizontal axis reads from left to right, indicating least to most concentrated/odor active rank. Rank number is provided above and below markers for ease of reading. The general inference is a shift in rank based on OAV. Compounds with low detection thresholds tend to rank higher in OAV than rank of surrogate concentration in headspace, a relationship shown by Eq 1. Blue box-outlined markers indicate volatiles detected in unpackaged marijuana and not detected by through-package sampling.
https://doi.org/10.1371/journal.pone.0144160.s005
(PDF)

S1 Table. Legal cases based on probable cause for search and seizure.
https://doi.org/10.1371/journal.pone.0144160.s006
(PDF)

S2 Table. Summary of VOC emitted from marijuana though packaging into headspace and captured by SPME during 5 min, 1h, 68 h static sampling at room temperature.
https://doi.org/10.1371/journal.pone.0144160.s007
(PDF)

S3 Table. Summary of VOC emitted from unpackaged marijuana into headspace and captured by SPME during 5 min, 1h, 68 h static sampling at room temperature.
https://doi.org/10.1371/journal.pone.0144160.s008
(PDF)

S4 Table. Summary of F-statistics and p-values from two-way analysis of variance comparing the effect of packaging on VOC emitted from marijuana at 5 min, 1 h, and 68 h extraction times.
https://doi.org/10.1371/journal.pone.0144160.s009
(PDF)

S5 Table. Wilcoxon signed rank test of paired samples.
https://doi.org/10.1371/journal.pone.0144160.s010
(PDF)

S6 Table. Hierarchy of volatile compounds with published ODT, emitted from marijuana, through packaging over 68 h.
https://doi.org/10.1371/journal.pone.0144160.s011
(PDF)

S7 Table. Correlation coefficients between surrogate concentration and odor impact of volatile compounds emitted from marijuana.
https://doi.org/10.1371/journal.pone.0144160.s012
(PDF)

S8 Table. Identification of VOC emitted though cloth duffel bag in headspace of marijuana sample, and captured by SPME over 68 h.
https://doi.org/10.1371/journal.pone.0144160.s013
(PDF)

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Author Contributions

Conceived and designed the experiments: SR JK. Performed the experiments: SR. Analyzed the data: SR JK. Contributed reagents/materials/analysis tools: JK. Wrote the paper: SR JK.

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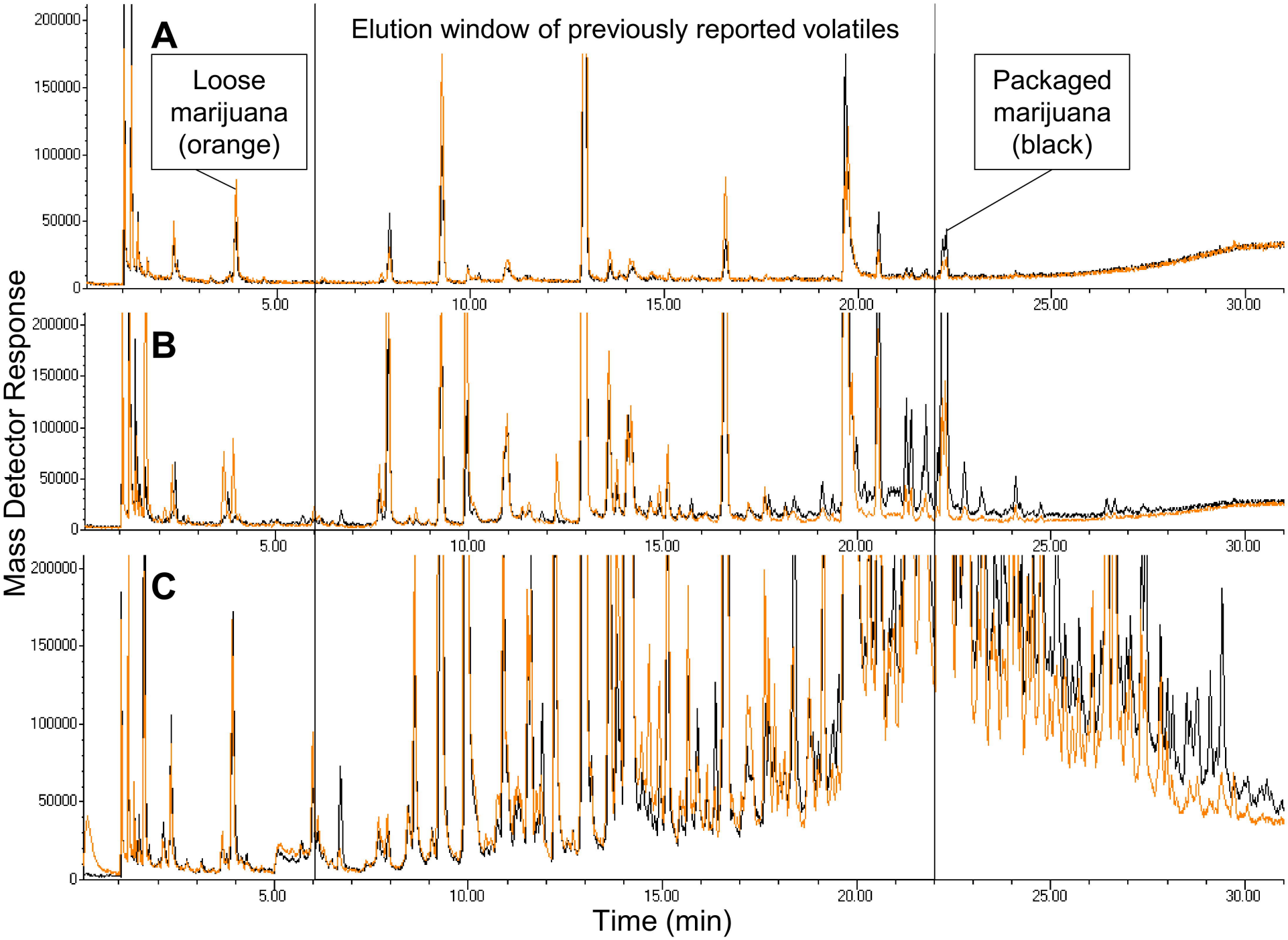
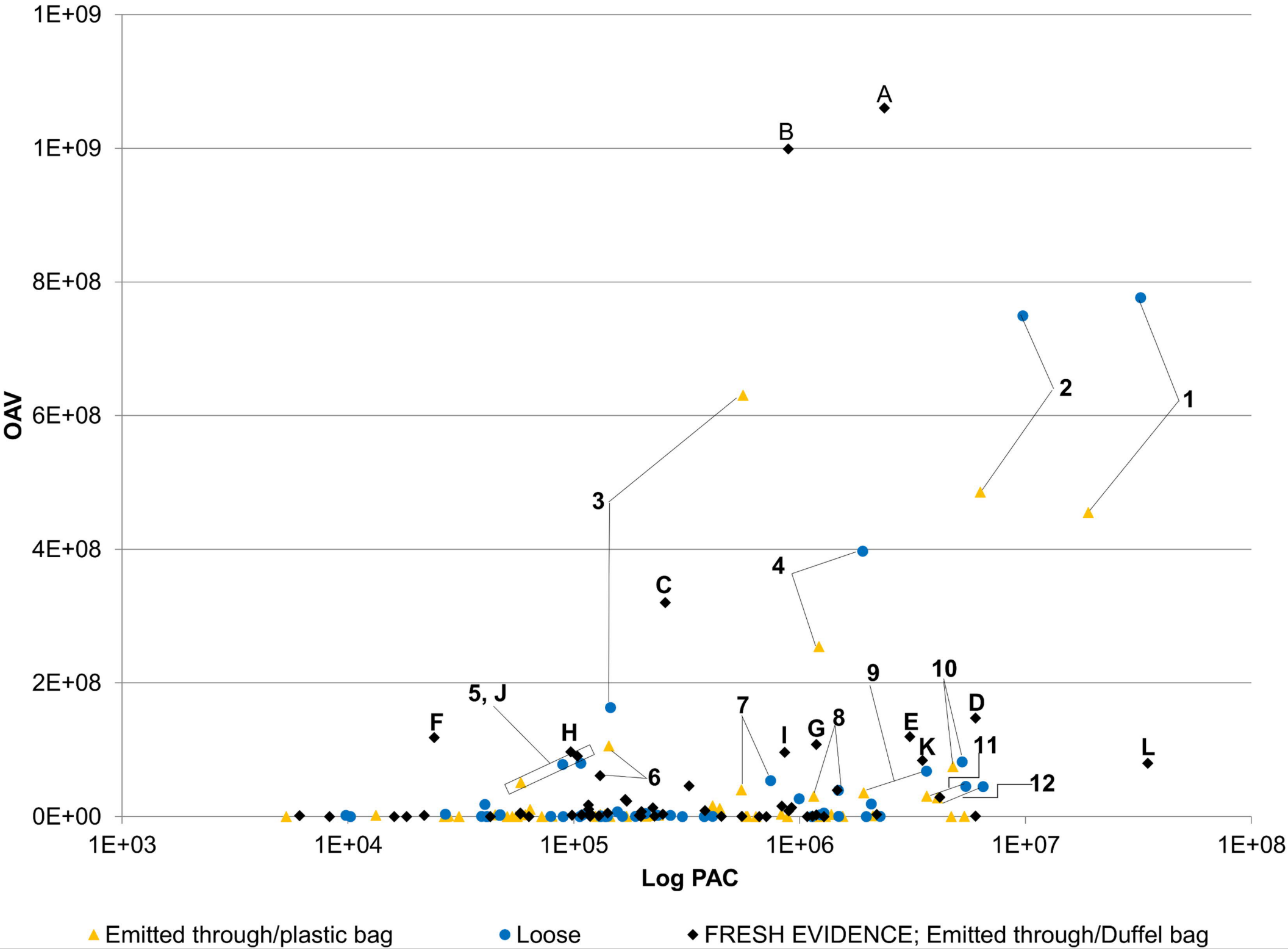
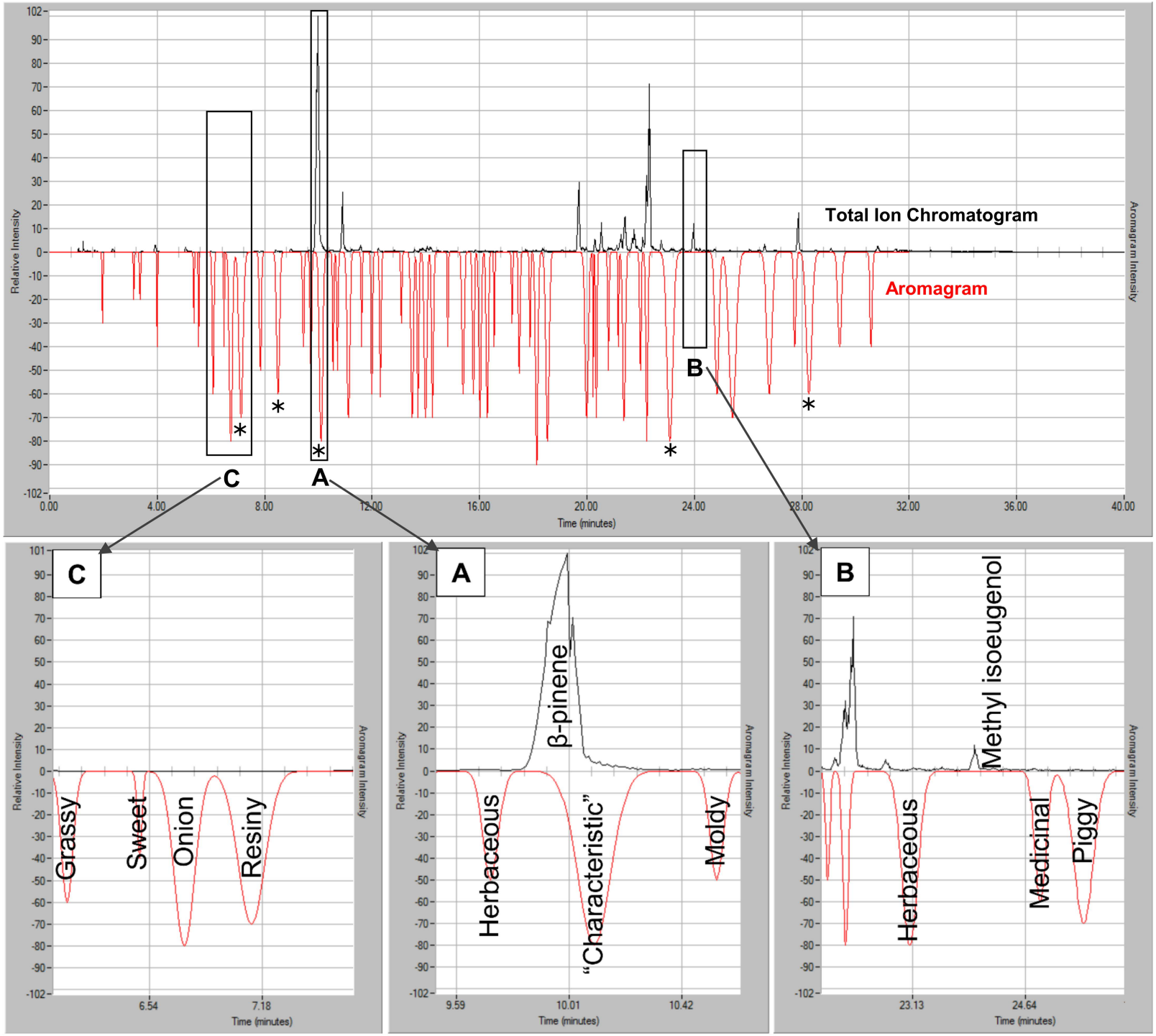
	(-)-Aristolene	(-)-Globulol	(+)-4-Carene	(+)-calarene	(+)-nerolidol
	(+)-sativene	(1R)-(+)-trans-isolimonene	1-(3-methylphenyl)-ethanone	1-(3-methylphenyl)-ethanone	1,1-dimethyl-hydrazine
	1,2,3,4-tetramethylbenzene	1,2-diethylbenzene	1,3,5-triazine-2,4,6-triamine	1,3-dichlorobenzene	1,4-diethylbenzene
	1-butanol	1-butoxy-2-propanol	1-hexadecanol	1-hexanol	1-undecanol
	2,2,5-trimethylhexane	2,3,4-trimethylpentane	2,4,6-trimethylphenol	2,4-di-tert-butylphenol	2,6-diethylpyrazine
	2,6-dimethylquinoline	2-butanone	2-butoxyethanol	2-chloroacetophenone	2-ethenyl-1,3-dimethylbenzene
	2-ethoxyethanol	2-ethylhexanol	2-ethyltoluene	2-heptanone	2-hydroxyacetophenone
	2-isopropenyl-3-methylpyrazine	2-methyl naphthalene	2-methyl-1H-imidazole	2-methyl-2-propanamine	2-methylaziridine
	2-methylpentane	2-nitropropane	2-phenoxyethanol	3,4,5-trimethyl-1-hexene	3,4,5-trimethylphenol
	3-ethyl-o-xylene	3-ethyltoluene	3-isopropylbenzaldehyde	3-methyl-2-cyclopenten-1-one	3-methylheptane
	3-methylpentane	3-pentanol	4-ethoxy-3-anisaldehyde	4-methyl guaiacol	4-methyldecane
	4-methylphenethylamine	4-methylpyrimidine	4-pyridinamine	5-ethenyl-2-methylpyridine	5-methylindane
	5-octanolide	7-methoxycoumarin	Acetaldehyde	Acetamide	Acetic acid
	Acetone	Acetophenone	Acrolein	Alloaromadendrene	Anethole
	Aromadendrene	Benzaldehyde	Benzonitrile	Benzophenone	Benzphentamine
	Benzyl acetate	Benzyl Alcohol	Benzyl formate	Benzyl nitrile	Betahistine
This Study (a)	Betazole	Butane	Butyl formate	**Camphene•**	Carbofuran
	Carvacrol	**Caryophyllene oxide•**	Cedryl acetate	cis-2-pinanol	Citronellolformate
	Citronellyl acetate	Cumene	Cuminaldehyde	Decanal	Diacetone alcohol
	Dibutyl phthalate	Diethyl Phthalate	Dimethylbenzylcarbinyl acetate	Dimethylpyrazine	Dimethylsulfide
	Dimethylsulfone	DL-carvone	Dodecane	Durene	Dyclocaine
	Estragole	Ethanol	Ethylacetate	Ethylene oxide	Ethylenediamine
	Ethylenimine	Eugenol	Eugenyl acetate	**Fenchyl alcohol•**	Formic acid
	Furfural	Furfurylmethylamphetamine	Heptanal	Hexadecane	Hexanal
	Hexanoic acid, methyl ester	Hexanoic acid, propyl ester	Hexestrol	Hordenine	Hydrazine
	Isoamyl alcohol	Isobornyl acetate	Isobornyl thiocyanoacetate	Isobutane	Isobutyraldehyde
	Isobutyrophenone	Isocyanatomethane	Isodurene	Isoeugenol	Isoprene
	Isoquinoline	**Limonene•**	Limonene dioxide	**Linalool•**	Linalyl acetate
	Longifolene	m-cymene	Methacrolein	Methacrylic anhydride	Methyl acetate
	Methyl acetylsalicylate	Methyl anthranilate	Methyl benzoate	Methyl heptadienone	Methyl heptanoate
	Methyl isoeugenol	Methyl mercaptan	Methyl salicylate	Methyl valerate	Methylene chloride
	methylhydrazine	Methylisohexenyl ketone	m-tert-butylphenol	Myrcene	Nerol
	Nerolidol	Nitrobenzene	Nonanal	Nonane	Octanal
	o-cymene	o-dimethyl hydroquinone	o-guaiacol	o-methylacetophenone	o-xylene
	p-acetanisole	p-aminotoluene	**p-cymene•**	Pentadecane	Pentamethylbenzene
	Pentanal	Perillaldehyde	p-ethyltoluene	Phenol	Phenylethyl alcohol
	Piperidine	Piperonal	p-methylacetophenone	Propanal	Propanoic acid, anhydride
	Propofol	Propylamine	Propylene glycol	p-tert-butylphenol	p-xylene
	Sabinene	Salicyladehyde	Styrene	**Terpinolene•**	tert-butanol
	tert-butyl-benzene	Tetrahydrozoline	Thymol	Toluene	Tridecane
	Tyramine	Undecane	**Valencene•**	Verbenone	α-bisabolol
	α-bulnescene	**α-cadinene•**	α-cedrene	α-copaene	α-cubebene
	α-guaiene	α-gurjunene	**α-humulene•**	α-ionol	α-longipinene
	α-methylcinnamaldehyde	**α-phellandrene•**	**α-pinene•**	**α-terpinene•**	α-terpineol
	β-caryophyllene•	β-cedrene	β-irone	**β-pinene•**	**β-selinene•**
	γ-gurjunene	γ-hexalactone	**γ-terpinene•**	**δ-3-carene•**	δ-cadinene
	3-(1-methylethyl)-phenol methylcarbamate	3-(3-hydroxyphenyl)-2-propenoic acid, methyl ester	3-methyl-5-(1-methylethyl)-Phenol methylcarbamate	1-Propanamine,3-dibenzo [b,e]thiepin-11(6H)-ylidene-N,N-dimethyl-, S-oxide	
Previously reported (b)					
	(E)-ocimene⊥	**Limonene•**	**Linalool•**	**Terpinolene•**	**α-cadinene•**
Da Porto (2014) [4]	**α-humulene•**	**α-phellandrene•**	**α-pinene•**	**α-terpinene•**	**β-caryophyllene•**
	β-myrcene⊥	**β-pinene•**	**δ-3-carene•**		
	1,8-Cineole⊥	3-Hexen-1-ol-acetate⊥	**Camphene•**	Cis-Hex-3-en-1-ol⊥	Eudesma-3,7(11)-diene⊥
Rather (2011) [6]	Guaiol	**Limonene•**	**Valencene•**	**α-humulene•**	**α-pinene•**
	β-caryophyllene•	β-chamigrene⊥	β-maaliene⊥	β-ocimene⊥	**β-pinene•**
	β-selinene•				
Lai (2008) [2–3]	**Limonene•**	**α-pinene•**	**β-caryophyllene•**	β-myrcene⊥	β-ocimene⊥
	β-pinene•				
Osman (1985) [5]	**β-caryophyllene•**				
	Camphene•	**Caryophyllene oxide•**	**Fenchyl alcohol•**	**Limonene•**	**Linalool•**
Hood (1973) [1]	Methyl heptenone⊥	**p-cymene•**	**Terpinolene•**	α-Bergamotene⊥	**α-humulene•**
	α-pinene•	**α-terpinene•**	**β-caryophyllene•**	β-Farnesene⊥	β-myrcene⊥
	β-ocimene⊥	β-phellandrene⊥	**β-pinene•**	**γ-terpinene•**	**δ-3-carene•**

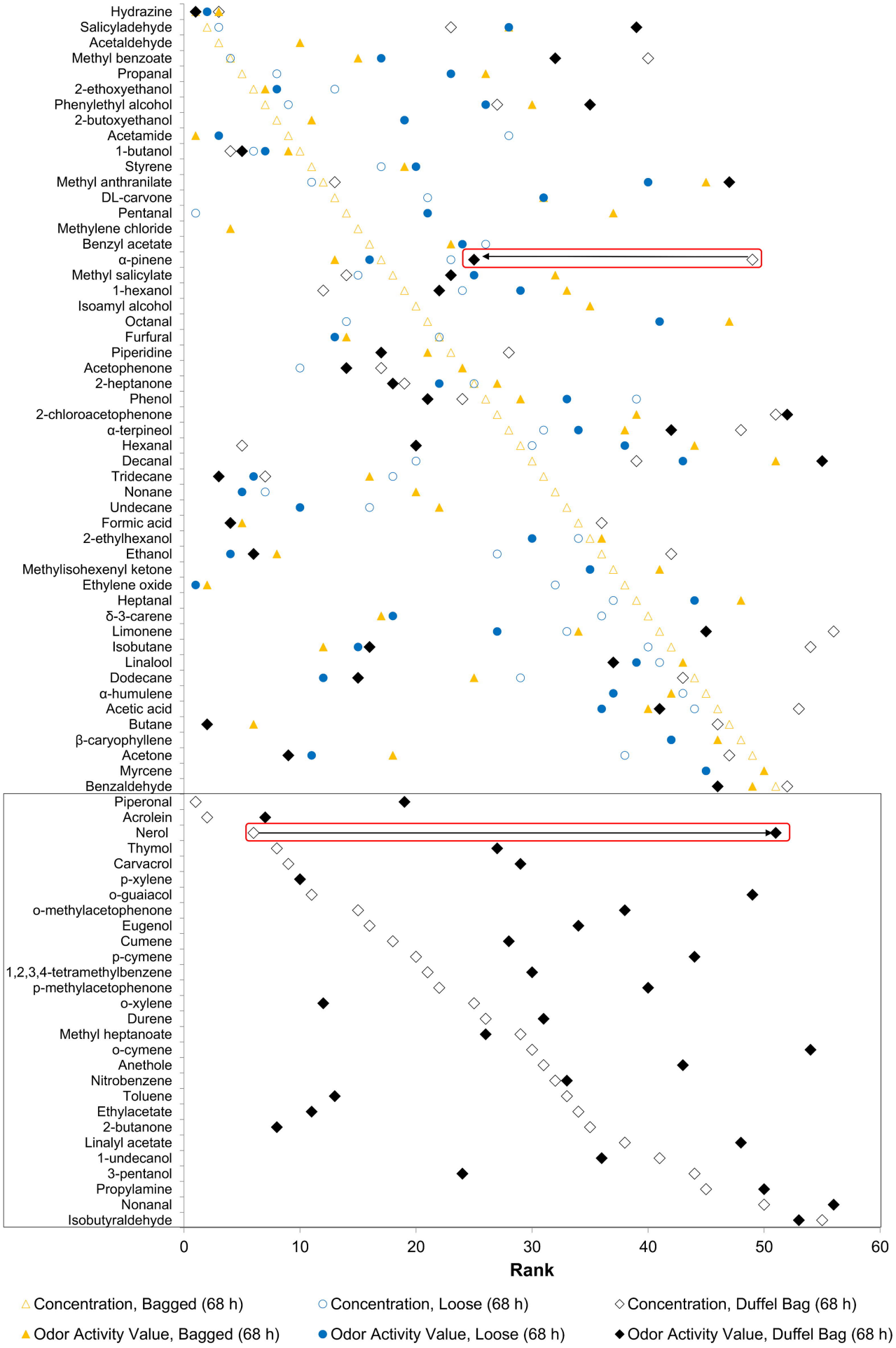
Bolded• compounds indicate concurrent identification with this study and previously reported studies. Underlined⊥ compounds indicate compounds previously reported but not found in this study. No true "blank" package sample type was available for comparison of the same material and manufacturing lot of the seized illicit marijuana. Therefore, this report is conveying all compounds found in headspace of marijuana, regardless of packaging type and presence.

doi:10.1371/journal.pone.0144160.t001


A
B
C
Elution window of previously reported volatiles
Loose marijuana (orange)
Packaged marijuana (black)
Mass Detector Response
Time (min)
0
50000
100000
150000
200000
5.00
10.00
15.00
20.00
25.00
30.00


1E+09
1E+09
8E+08
6E+08
4E+08
2E+08
0E+00
OAV
1E+03
1E+04
1E+05
1E+06
1E+07
1E+08
Log PAC
A
B
C
D
E
F
G
H
I
J
K
L
1
2
3
4
5, J
6
7
8
9
10
11
12
Emitted through/plastic bag
Loose
FRESH EVIDENCE; Emitted through/Duffel bag


Total Ion Chromatogram
Aromagram
Relative Intensity
Aromagram Intensity
Time (minutes)
A
B
C
Grassy
Sweet
Onion
Resiny
β-pinene
Herbaceous
"Characteristic"
Moldy
Methyl isoeugenol
Herbaceous
Medicinal
Piggy


Hydrazine
Salicyladehyde
Acetaldehyde
Methyl benzoate
Propanal
2-ethoxyethanol
Phenylethyl alcohol
2-butoxyethanol
Acetamide
1-butanol
Styrene
Methyl anthranilate
DL-carvone
Pentanal
Methylene chloride
Benzyl acetate
α-pinene
Methyl salicylate
1-hexanol
Isoamyl alcohol
Octanal
Furfural
Piperidine
Acetophenone
2-heptanone
Phenol
2-chloroacetophenone
α-terpineol
Hexanal
Decanal
Tridecane
Nonane
Undecane
Formic acid
2-ethylhexanol
Ethanol
Methylisohexenyl ketone
Ethylene oxide
Heptanal
δ-3-carene
Limonene
Isobutane
Linalool
Dodecane
α-humulene
Acetic acid
Butane
β-caryophyllene
Acetone
Myrcene
Benzaldehyde
Piperonal
Acrolein
Nerol
Thymol
Carvacrol
p-xylene
o-guaiacol
o-methylacetophenone
Eugenol
Cumene
p-cymene
1,2,3,4-tetramethylbenzene
p-methylacetophenone
o-xylene
Durene
Methyl heptanoate
o-cymene
Anethole
Nitrobenzene
Toluene
Ethylacetate
2-butanone
Linalyl acetate
1-undecanol
3-pentanol
Propylamine
Nonanal
Isobutyraldehyde
0
10
20
30
40
50
60
Rank
Concentration, Bagged (68 h)
Concentration, Loose (68 h)
Concentration, Duffel Bag (68 h)
Odor Activity Value, Bagged (68 h)
Odor Activity Value, Loose (68 h)
Odor Activity Value, Duffel Bag (68 h)

Appendix B

Skinny Pineapple Case Study

CASE STUDY

ELEMENT AIR™ SOLUTION REDUCES MICROBIALS, PARTICULATES, AND VOCs FOR CANNABIS CULTIVATION FACILITY

urban-gro®

Element Air™
A Division of RGF Environmental Group, Inc.

SUMMARY

In March 2019, Skinny Pineapple installed Element Air's PHI + Tower, RGF's Hepa Filter and Element Air's Carbon Filter systems. The research project goal was to significantly reduce odors associated with late flower terpene production and volatile organic compounds (VOCs). Within 24 hours of equipment installation, the facility experienced a dramatic reduction in unwanted airborne VOCs, microbials, and particulates. Third-party labs confirmed an 85% reduction in total VOCs and a 99.97% particulate filtration to remove microbials and particulates.

SKINNY PINEAPPLE

THE FACILITY

Skinny Pineapple is a commercial cannabis cultivation facility located in Lafayette, Colorado. Known in the cannabis world as The Farm, a well-regarded craft cannabis brand in production since 2015, Skinny Pineapple employs sustainable growing practices, including the use of biologicals. In order to maintain an optimal growing environment, Skinny Pineapple has implemented a comprehensive sanitation and integrated pest management (IPM) strategy to ensure clean, homogeneous environmental conditions.

Because the cultivation facility is located within an office and industrial park, the ownership and management are keenly aware of any odors generated during the cultivation process and how they could trigger complaints from surrounding businesses. As such, odor control is a top priority.

As an innovator in cannabis cultivation, Skinny Pineapple regularly tests and deploys new service and product offerings aimed at improving the health of the facility, employee safety, and maintaining goodwill with local businesses. Both the ownership and the head cultivator are engaged in product evaluation with the goal of providing a consistently high-quality, safe product for both medical patients and adult-use customers.

THE TEST

TESTING FOR MICROBIALS, PARTICULATES, AND VOLATILE ORGANIC COMPOUNDS (VOCs)

In March 2019 at the recommendation of urban-gro, Inc., Skinny Pineapple installed a combination Element Air PHI + Wall Mount Tower + RGF HEPA Filter + Element Air Carbon Filter system. This combined solution—dubbed the "Trifecta of Microbial and VOC/Odor Purification"—helps mitigate microbials and VOCs and promotes odor control.

Prior to installation, the urban-gro and Element Air team established a baseline of VOCs present in the test room measuring 26 feet by 32 feet by 22 Feet. The test room includes 130 plants / 25 1000 watt lights and utilizes a five-ton HVAC Roof unit feeding directly into room.

Element Air and RGF utilized three core technologies (Advanced Oxidation, HEPA, and Activated Carbon) in tandem to achieve the best results possible. The Element Air Tower provided advanced oxidation as the primary defense against VOCs, microbials, and pathogens.

THE RESULTS

THIRD-PARTY LABORATORY RESULTS

In April 2019, testing of the air purification and odor control protocols commenced at Skinny Pineapple. As a result of using the Element Air and RGF technologies, Skinny Pineapple experienced a dramatic lowering of unwanted airborne VOCs.

Confirmed by a third-party laboratory via air sampling and testing, the report reflected an 85% reduction in total volatile organic compounds over a 20-hour period. Specifically, these common cannabis terpenes were systematically reduced: Alpha-Pinene was reduced 100%; beta-Myrcene was reduced 82%; and D-Limonene was reduced 87% over the same 20-hour period.

Additionally, the Element Air HEPA provided 99.97% particulate filtration to remove microbials and particulates. The Element Air Carbon provided additional protection, filtering out even more VOCs from the air.

SAMPLE	TIME AFTER RGF UNITS STARTUP (hr)	ALPHA-PINENE (ug/m3)	BETA-MYRCENE (ug/m3)	D-LIMONENE (ug/m3)	TOTAL VOCs FROM LIBRARY SEARCH (ug/m3)
1	0	16	370	120	590
2	1	15	370	120	590
3	2	14	310	100	490
4	19	5.8	78	0	110
5	20	0	66	16	87
	Percent Reduction	**100%**	**82%**	**87%**	**85%**

All air samples were collected using stainless-steel canisters under a vacuum. The cannisters were then analyzed by a nationally accredited lab with Gas Chromatography/Mass Spectrometry (GC/MS).

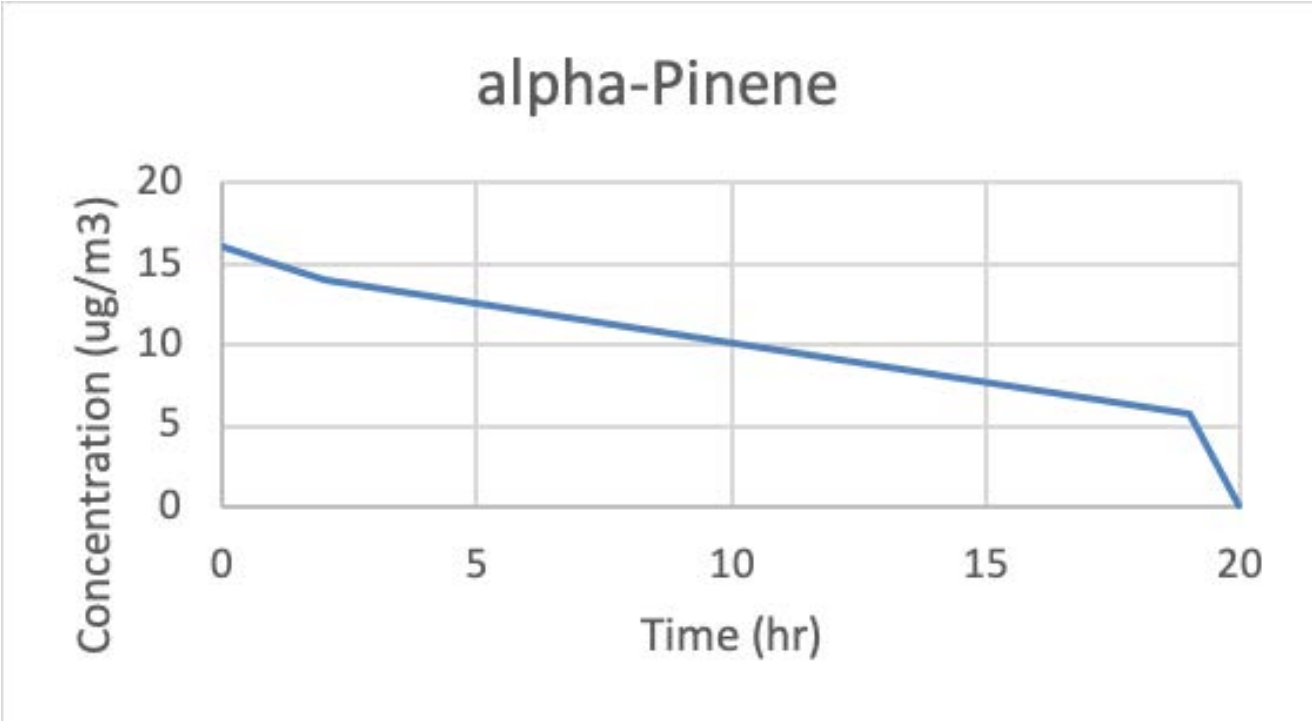
CONCLUSION

STUDY CONCLUSION

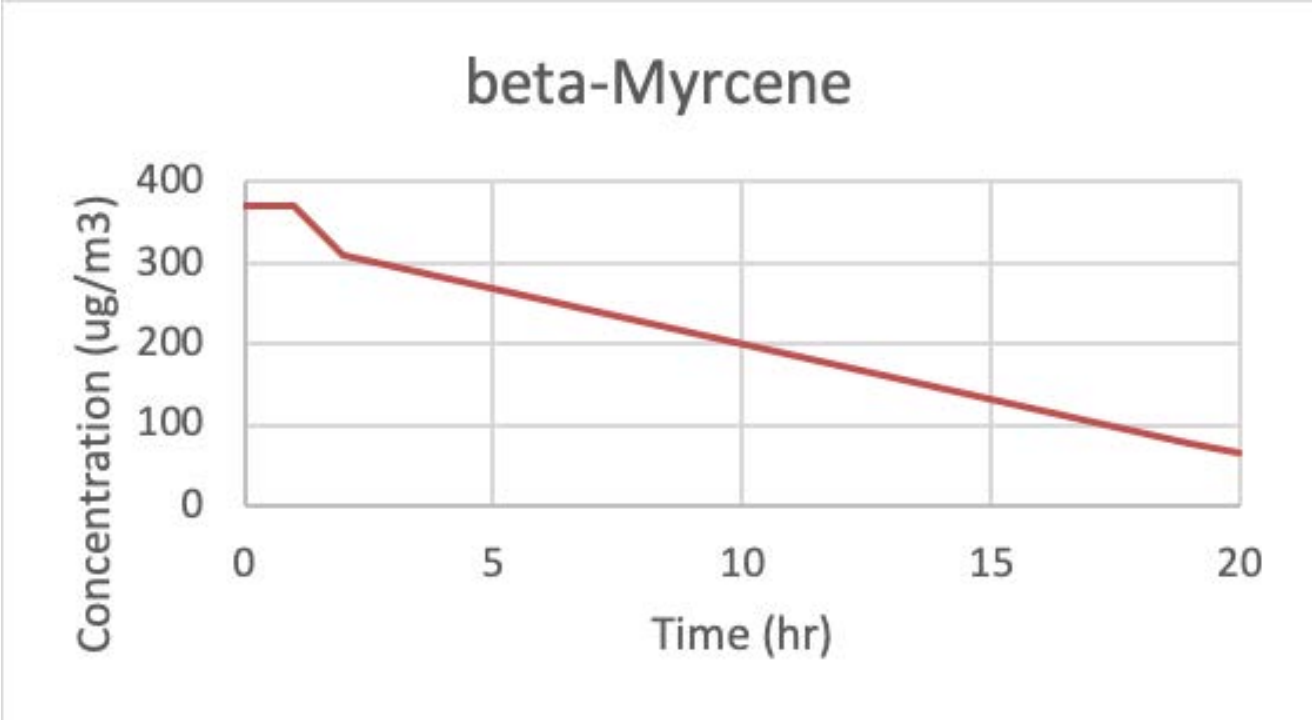
As confirmed by the test results, Skinny Pineapple successfully reduced airborne VOCs, microbials, particulates, and odor. According to head cultivator, John Billings, "using the Element Air solution as a part of my overall integrated pest management (IPM) program has been effective in optimizing my grow environment. urban-gro's IPM program evolves over time to keep up with changing regulations and pest practices, ensuring effective and compliant pest mitigation."

For more information on Element Air, urban-gro, or to request a copy of the test results, please email marketing@urban-gro.com.

THE DATA

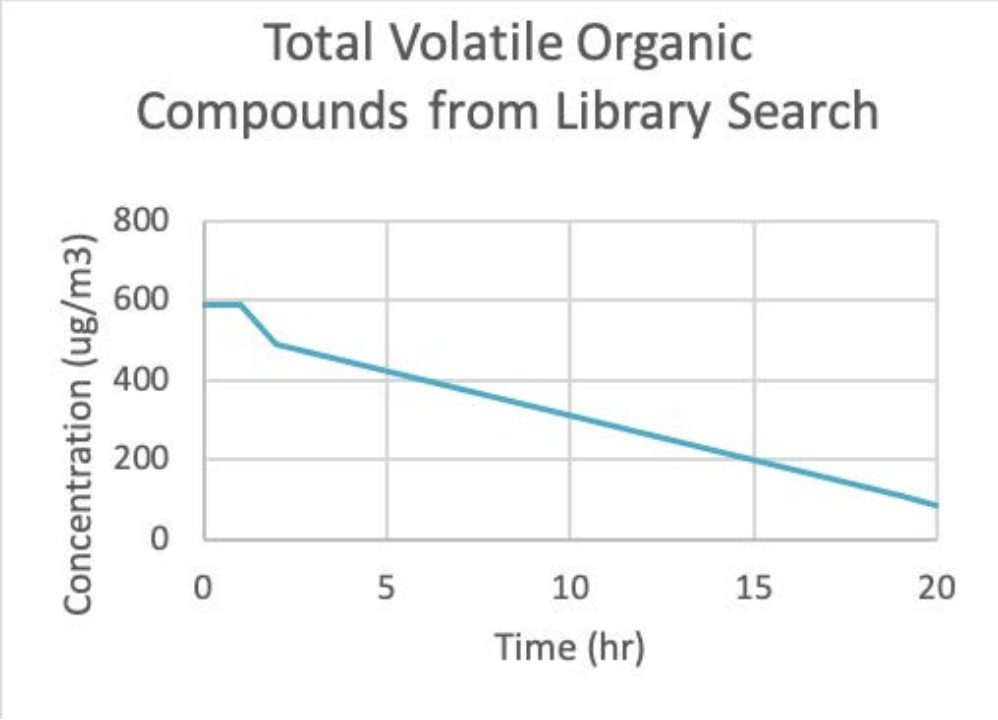


Alpha-Pinene was reduced 100%

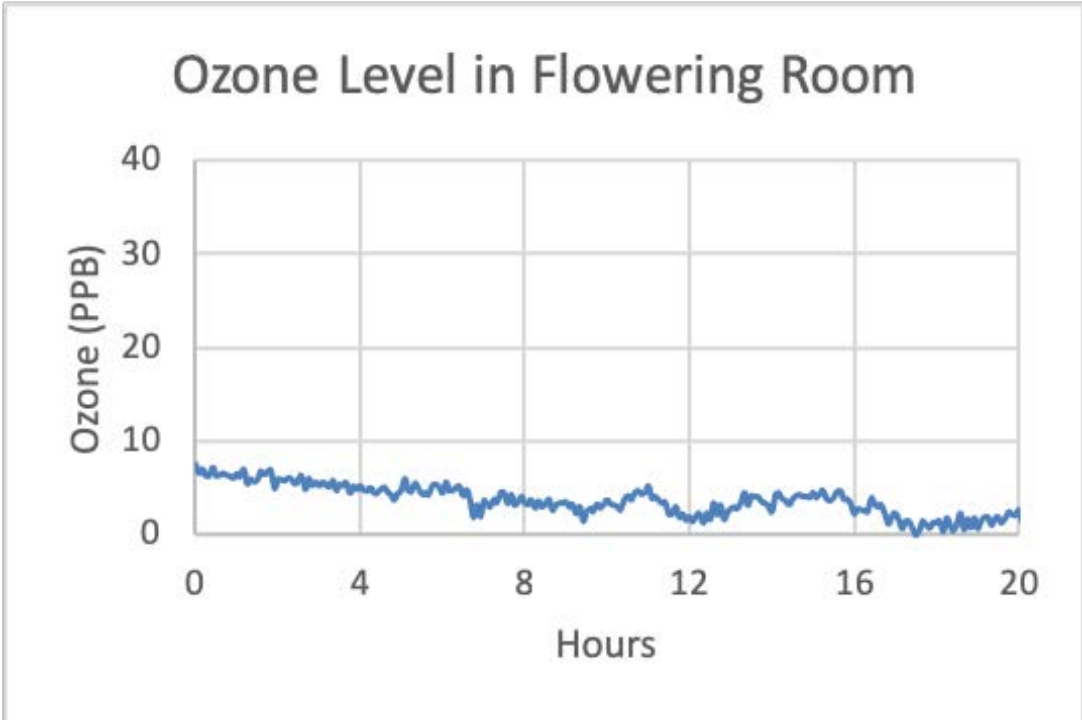


Beta-Myrcene was reduced 82%

THE DATA

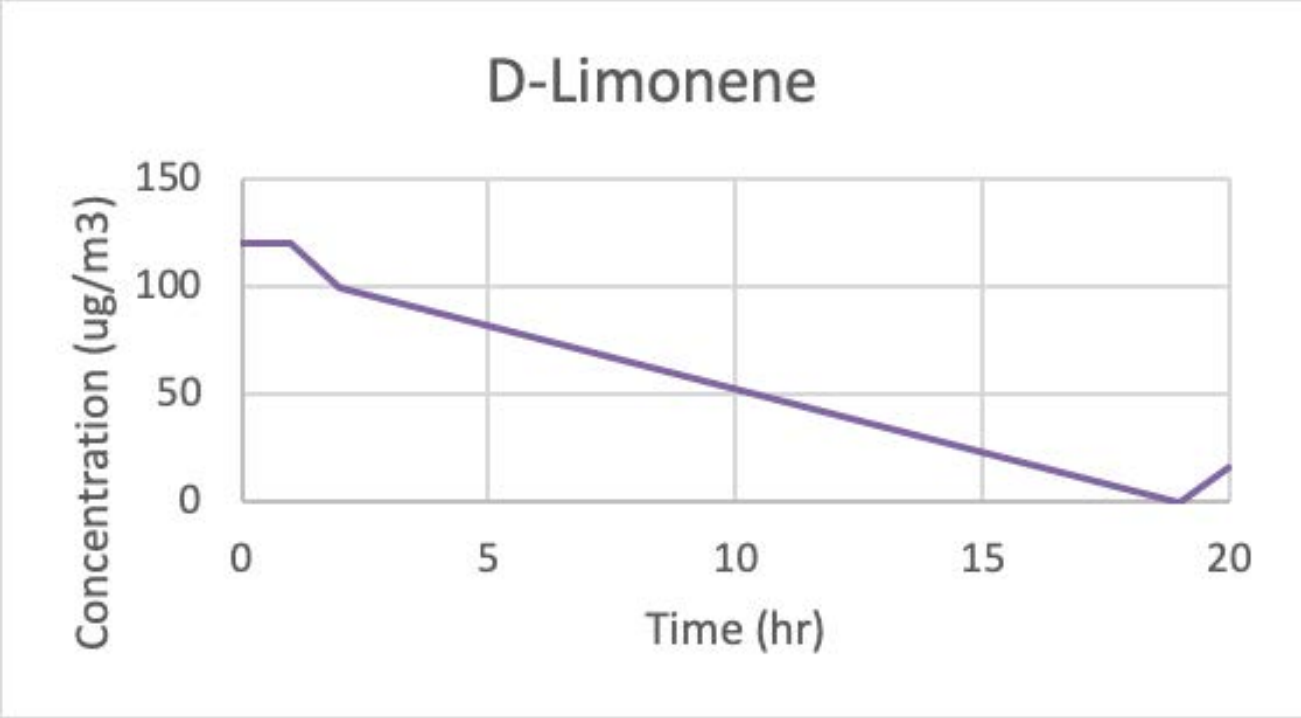


85% reduction in total VOCs over a 20-hour period



Ozone levels remained below 5 ppb over most of the 20 hrs which equates to statistically negligible.

THE DATA



D-Limonene was reduced 87%

TESTING INFORMATION

THIRD-PARTY SAMPLING LOCATION

Skinny Pineapple
1265 Rock Creek Circle, Unit A
Lafayette, CO 80026
Samples taken within Flowering Room

THIRD-PARTY SAMPLING VERIFICATION

urban-gro, Inc.

THIRD-PARTY LAB SERVICE

EMSL Analytical, Inc.

THIRD-PARTY LAB

LA Testing
5431 Industrial Drive, Huntington Beach, CA 92649

RGF UNITS

1 Whole Home Hepa
1 Floor Mounted Tower
1 Carbon Drum

METHOD REFERENCE

USEPA: Compendium Method TO-15, "Determination of Volatile Organic Compounds (VOCs) in Air…" Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/ Mass Spectrometry (GC/MS), January 1999, (EPA/625/R-96/010b) Includes Library Search

TESTING PROTOCOL

- Prior to air treatment by RGF, collect initial air sample using the lab supplied stainless steel canister.
- Position Hepa, Tower, and Carbon Drum into Flowering Room and turn on units. Take several air samples over the next day with the units running continually.

urban-gro®

Element Air™

A Division of RGF Environmental Group, Inc.

Appendix C

Measures Researched but not chosen for initial installation. Future possibilities

1. Bi-Polar Ionization
   - Disinfects air by producing and distributing a controlled amount of positive and negative air ions, which interact with oppositely charged elements.
   - Bi-polar ionization process allows for air cleaning to occur within the desired space treating a larger volume of air within the breathing range.
   - Does not produce harmful chemicals or products such as ultraviolet (UV) and ozone.
   - Effective against bacteria, spores, VOC compounds and particles.
   - Treats the source of contamination.
   - Can be incorporated into central HVAC systems or used as stand alone units.
   - Will not restrict airflow when incorporated into central systems.
   - Requires maintenance each year to replace worn tubes.

2. Needlepoint Ionization
   - Needlepoint ionizers are ionization needles that produce positive and negative ions.
   - Can be incorporated into central HVAC systems or used as stand alone units.
   - Some effect on particulate removal.
   - Some effect on odor removal.
   - Some effect on mold spores, bacteria and viruses.
   - Ions quickly recombine in occupied space.

3. UV (Ultra-Violet light) Purification
   - Disinfects by passing air through ultra-violet light.
   - Can be incorporated into central HVAC systems or used as stand alone units.
   - UV light can only treat contaminants that pass directly through the light field. Ambient air that does not enter through the light field will not be affected.
   - UV is dependent on contaminants being exposed to the light field for a time period long enough for the contaminant to be treated.
   - Is not effective on VOC's, gasses and odors.
   - Is not effective in reducing particulate levels.
   - Will not restrict airflow when incorporated into central systems.
   - Requires maintenance each year to replace worn bulbs.

4. Electronic Air Cleaners
   - Charges particles by generating single polarity ions to pass through the unit to attract to an oppositely charged collector cell.
   - Uses high energy (up to 25,000 volts) to produce ions.

- Mostly ineffective against bacteria, spores, odors and VOC compounds.
- Requires maintenance (sometimes monthly) to clean collector cells.
- Can only treat air which passes through the collector cell.
- Can be incorporated into central HVAC systems.

5. Scent Generators
   - Disperse various chemicals into the air to mask odors.
   - Typically used in casino and hospitality environments to mask odors.
   - Reduces lifespan of HVAC equipment.
   - Coats the inside of HVAC equipment with particles and oil –like substance.
   - Not sustainable.

6. Plant-based odor removers
   - Natural, safe, effective, and complete removal of industrial odors.
   - Tackles tough smells without dangerous side effects.
   - Delivery systems fully integrate with existing equipment and processes.
   - Can be added to supplement existing odor mitigation

7. Wx based monitoring for air flow patterns

Appendix D

South Coast AQMD PM Sensor Evaluations with high ratings for Air Quality Egg

air quality sensor summary reports

aqmd.gov/aq-spec/evaluations/summary-pm

AQ-SPEC

Air Quality Sensor Performance Evaluation Center

Share:

Summary Tables & Reports

Summary PM

PM Sensor Evaluations

South Coast AQMD's AQ-SPEC program aims at being the testing center for low cost air monitoring sensors to establish performance standards by which sensors are evaluated. The program evaluates sensors in both controlled laboratory conditions and in the field. In the field, sensors are tested alongside one or more of South Coast AQMD's existing air monitoring stations using traditional federal reference/equivalent method instruments to gauge overall performance. Sensors demonstrating acceptable performance in the field are then brought to the AQ-SPEC laboratory for more detailed testing in an environmental chamber under controlled conditions alongside traditional federal reference/equivalent method and/or best available technology instruments.

PM Sensors

Sensor Image	**Make** (Model)	**Est. Cost** (USD)	**Pollutant(s)**	***Field R^2**	***Lab R^2**	**Summary Report**

	Aeroqual (AQY) Ver. 0.5	$3,000	$PM_{2.5}$	0.84 to 0.87	0.99	PDF (1,178 KB)
	AethLabs (microAeth)	$6,500	BC (Black Carbon)	0.79 to 0.94		
	Air Quality Egg (2018 Model)	$249	$PM_{1.0}$	0.86 to 0.88	0.99	PDF (771 KB)
			$PM_{2.5}$	0.84 to 0.85	0.99	
			PM_{10}	0.12 to 0.13		
	Air Quality Egg (Version 1)	$200	PM	~ 0.0		
	Air Quality Egg (Version 2)		$PM_{2.5}$	0.79 to 0.85		
			PM_{10}	0.31 to 0.40		
	AirThinx (IAQ)	$1000	$PM_{1.0}$	0.68 to 0.70		
			$PM_{2.5}$	0.54 to 0.57		
			PM_{10}	0.03 to 0.05		

	Airviz Inc. (Speck)	$150	$PM_{2.5}$	0.32		
	Alphasense (OPC-N2)	$310	$PM_{1.0}$	0.63 to 0.82	0.99	PDF (1,291 KB)
			$PM_{2.5}$	0.65 to 0.80	0.99	
			PM_{10}	0.45 to 0.57	0.99	
	Alphasense (OPC-N3)	$338	$PM_{1.0}$	0.78 to 0.82		
			$PM_{2.5}$	0.52 to 0.67		
			PM_{10}	0.45 to 0.52		
	AS-LUNG (Air Quality Station)	$2000	$PM_{1.0}$	0.42 to 0.88		
			$PM_{2.5}$	0.59 to 0.81		
			PM_{10}	0.15 to 0.23		
	AS-LUNG (Portable)	$1000	$PM_{1.0}$	0.86	0.99	PDF (875 KB)
			$PM_{2.5}$	0.78	0.99	

			PM_{10}	0.11 to 0.14		
	Cair	$200	$PM_{(1-2)}$	0.43 to 0.51		
			$PM_{(3-10)}$	0.39 to 0.51		
	Clarity (Node)	$1300	$PM_{2.5}$	0.73 to 0.76	0.99	PDF (1,030 KB)
	Dylos (DC1100 Pro)	$300	$PM_{(0.5-2.5)}$	0.65 to 0.85	0.89	PDF (1,384 KB)
	Dylos (DC1700-PM)	$475	$PM_{2.5}$	0.58 to 0.68		
			PM_{10}	0.15 to 0.18		
	Ecowitt (WH415B)	$100	$PM_{2.5}$	0.39		
	Edimax (AirBox)	$249	$PM_{2.5}$	0.85		

	Edimax (Edigreen Home)	$299	$PM_{2.5}$	0.82		
	FabLab (Smart Citizen Kit V2.1)	$119	$PM_{1.0}$	0.94		
			$PM_{2.5}$	0.77		
			PM_{10}	0.06 to 0.10		
	Foobot	$200	$PM_{2.5}$	0.55		
	HabitatMap (AirBeam)	$200	$PM_{2.5}$	0.65 to 0.70	0.87	PDF (1,144 KB)
	HabitatMap (AirBeam2)	$250	PM_1	0.71 to 0.74		
			$PM_{2.5}$	0.63 to 0.75		
			PM_{10}	~ 0.0		
	Hanvon (Hanvon N1)	$200	$PM_{2.5}$	0.52 to 0.79		

	IQAir (AirVisual Pro)	$270	$PM_{2.5}$	0.69 to 0.73	0.99	PDF (1,461 KB)
			PM_{10}	0.24 to 0.41	-	
	IQAir (AirVisual Pro FW1.1683)	$270	$PM_{2.5}$	0.63 to 0.81		
	Kaiterra (Laser Egg 2+)	$199	$PM_{2.5}$	0.81 to 0.85		
			PM_{10}	0.17 to 0.25		
	Kunak (Air A10)	$3000	$PM_{2.5}$	0.73		
			PM_{10}	0.64		
	Lunar Outpost (Canary-S)	$1070	$PM_{2.5}$	0.83		
			PM_{10}	0.14		
	Magnasci SRL (uRADMonitor A3 HW105)	~$500	PM_1	~ 0.82		
			$PM_{2.5}$	0.72 to 0.81		
			PM_{10}	0.15 to 0.38		
	Magnasci SRL (uRADMonitor INDUSTRIAL HW103)	~$1300	PM_1	~ 0.78		

			$PM_{2.5}$	0.70 to 0.78
			PM_{10}	0.13 to 0.34
	Met One (E-Sampler)	$5,500	$PM_{1.0}$	-
			$PM_{2.5}$	0.55 to 0.62
			PM_{10}	-
			TSP	-
	Met One (Neighborhood Monitor)	$1,900	$PM_{2.5}$	0.53 to 0.67
	Moji China (Airnut)	$150	$PM_{2.5}$	0.81 to 0.88
	Naneos (Partector)	$7,000	PM (LDSA: Lung-Deposited Surface Area)	$PM_{1.0}$: R^2 ~ 0.1 $PM_{2.5}$: R^2 ~ 0.2
	Origins (Laser Egg)	$200	$PM_{2.5}$	0.58
			PM_{10}	~ 0.0

	Perkin Elmer (ELM)	$5,200	PM	~ 0.0		
	PurpleAir (PA-I)	$150	$PM_{1.0}$	0.93 to 0.95	0.95	PDF (1,072 KB)
			$PM_{2.5}$	0.90 to 0.92	0.99	
			PM_{10}	0.32 to 0.44	0.97	
	PurpleAir (PA-I-Indoor)	$180	$PM_{1.0}$	-		
			$PM_{2.5}$	0.75		
			PM_{10}	0.36 to 0.46		
	PurpleAir (PA-II)	$200	$PM_{1.0}$	0.96 to 0.98	0.99	PDF (1,328 KB)
			$PM_{2.5}$	0.93 to 0.97	0.99	
			PM_{10}	0.66 to 0.70	0.95	
	RTI (MicroPEM)	$2,000	$PM_{2.5}$	0.65 to 0.90	0.99	PDF (1,087 KB)

	SainSmart (Pure Morning P3)	$170	$PM_{2.5}$	0.73	0.99	PDF (1,186 KB)
	Samyoung S&C (SY-DS-DK3)	$100	$PM_{2.5}$	0.62		
	Sensirion (SPS30)	$100	$PM_{1.0}$	0.91		
			$PM_{2.5}$	0.80		
			PM_{10}	0.07		
	Shinyei (PM Evaluation Kit)	$1,000	$PM_{2.5}$	0.80 to 0.89	0.93	PDF (1,156 KB)
	TSI (AirAssure)	$1,500	$PM_{2.5}$	0.82	0.99	PDF (5,647 KB)
	uHoo	$300	$PM_{2.5}$	~ 0.0		

*The coefficient of determination (R^2) is a statistical parameter measuring the degree of relation between two variables. Here, it measures the linear relationship between the sensor and the Federal Reference Method (FRM), or Federal Equivalent Method (FEM), or Best Available Technology (BAT) reference instrument. An R^2 approaching the value of 1 reflects a near perfect correlation, whereas a value of 0 indicates a complete lack of correlation. All R^2 values reported in these reports are based either on 5-min or 1-hr average data. The Lab R^2 values are based on experiments conducted in the chamber, under average ambient conditions (20 degrees C and 40% RH). If a sensor has not demonstrated a good performance in the field, it may not advance to the laboratory chamber test. An ad-hoc rating system will be developed to summarize the overall performance of these sensors.

Disclaimer

All documents, reports, data, and other information provided on this website are for informational use only. The majority of sensors evaluated as part of the Air Quality-Sensor Performance Evaluation Center (AQ-SPEC) program were field-tested inside a custom-made aluminum enclosure to protect the sensors from windblown rain, harsh sunlight, and animals. The field evaluations reports included on this website contain data collected at our monitoring station during a specific 30- to 60-day period and may not be duplicated at the same or different location, season, time period, or weather conditions (e.g. temperature, relative humidity, pressure, wind speed/direction). As the overall sensor performance may be affected by the specific environmental conditions experienced at our location during the time of testing, replication and/or duplication may not possible to achieve. The laboratory evaluation was conducted in the AQ-SPEC's environmental chamber with simulated pollutant and interferent concentrations that were generated from nebulizer solutions, dust dispensers, and gas dilution calibrators. Generated environments may not be able to fully replicate the conditions that may be experienced under ambient settings. The sensor assembly, installation, and use can also impact the reliability of the products evaluated by the AQ-SPEC program. South Coast Air Quality Management District (South Coast AQMD) makes no claim, warranty, or guarantee that these devices will or will not work when operated by other users for their specific applications.

The South Coast AQMD AQ-SPEC program in the Quality Assurance division of the Science and Technology Advancement office aims at providing information to and for the benefit of the public to make informed purchasing decisions on commercially available "low cost" air quality sensor devices. In accordance with this mission, the general policy of the Board of the Agency is to exclude from the AQ-SPEC website all commercial advertising and promotional material, including links which provide exclusive private or financial benefit to commercial, non-public enterprises and which do not promote or enhance a public benefit to the general public. As a government agency, the South Coast AQMD neither endorses nor supports individual private commercial enterprises through display of their products on the AQ-SPEC website or through providing links to the sites of such commercial enterprises.

Newsletter Sign Up

Periodic newsletter updates via Email on a variety of air quality-related topics

Submit

Appendix E

Initial Benchmarked Test Standard

PA/625/R-96/010b January 1999 Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air - Second Edition

Method TO-15: 15-1 through 15-62 Determination of Volatile Organic Compounds (VOCs) In Air Collected In

Specially-Prepared Canisters And Analyzed By Gas Chromatography Mass Spectrometry (GC/MS)

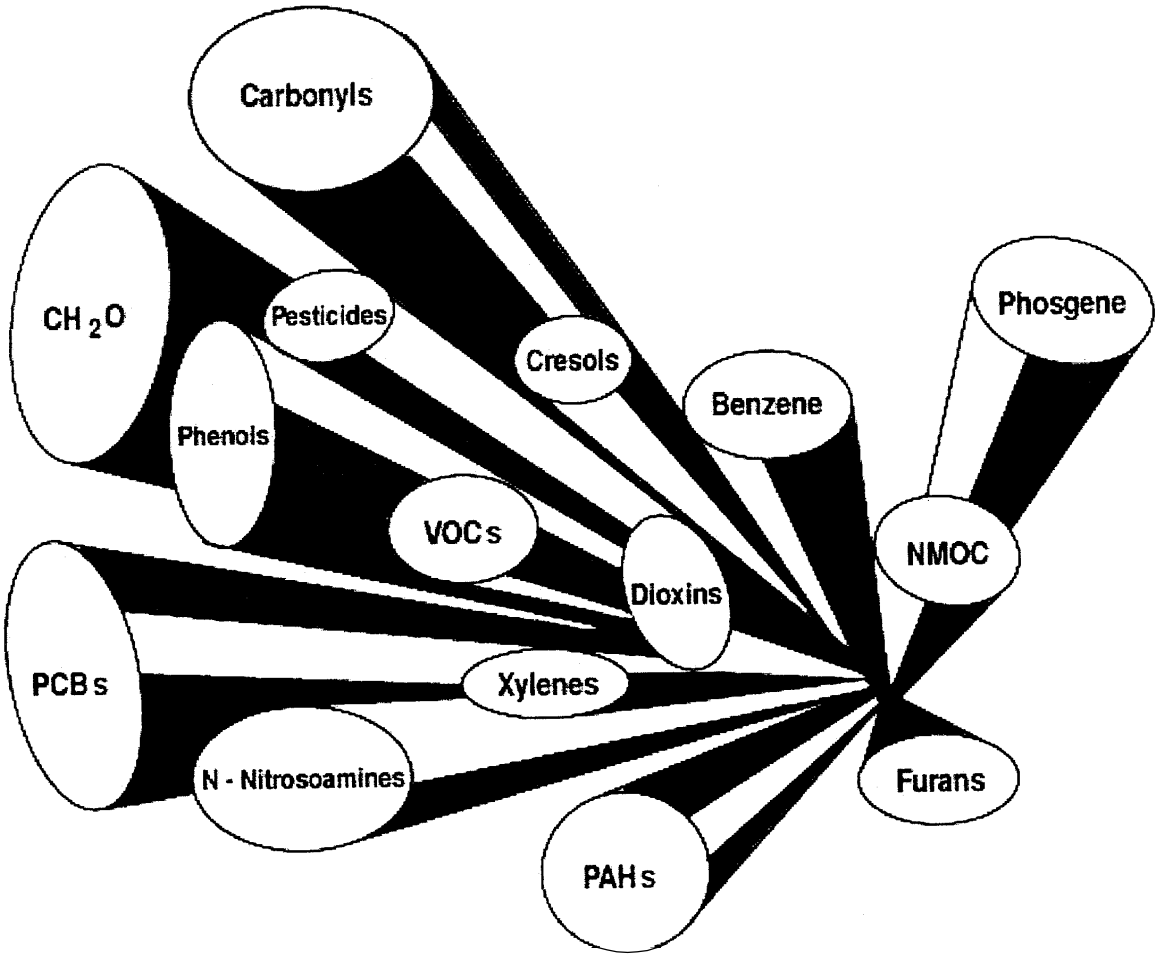
United States
Enivronmental Protection
Agency

Center for Environmental
Research Information

EPA/625/R-96/010b
January 1999

Research and Development

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air - Second Edition



Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

U. S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory
Center for Environmental Research Information
Cincinnati, Ohio 45268

January 1999

Disclaimer

The information in this document has been compiled wholly or in part by the United States Environmental Protection Agency under contract No. 68-C3-0315, W.A. 3-10 to Eastern Research Group (ERG). The work was performed by Midwest Research Institute (MRI) under subcontract to ERG. It has been subjected to Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

It is further noted that the test methods compiled here are working compilations subject to on-going review and update. It is recommended that the reader refer to the "AMTIC, Air Toxics" section of EPA's OAQPS Technology Transfer Network web site at http://www.epa.gov/ttn/amtic/airtox.html to obtain the latest updates, corrections, and/or comments to these test methods.

FOREWORD

The U. S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and ground water; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

Measurement of organic pollutants in ambient air is often difficult, in part because of the variety of organic substances of potential concern, the variety of potential techniques for sampling and analysis, and the lack of standardized and documented methods. Consequently, NRMRL has developed a Second Edition of the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air* to assist Federal, State, and local regulatory personnel in developing and maintaining necessary expertise and up-to-date monitoring technology for characterizing organic pollutants in the ambient air. The Compendium contains a set of 17 peer reviewed, standardized methods for the determination of volatile, semi-volatile, and selected toxic organic pollutants in the air. The 17 methods in the Second Edition have been compiled from the best elements of methods developed or used by various research or monitoring organizations and of which EPA has experience in use of the methodology during various field monitoring programs over the last several years. As with the previous Compendia of methods, these methods are provided only for consideration by the user for whatever potential applications for which they may be deemed appropriate. In particular, these methods are not intended to be associated with any specific regulatory monitoring purpose and are specifically offered with no endorsement for fitness or recommendation for any particular application.

This publication has been prepared in support of NRMRL's goal to provide technical support and information transfer. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-1

Method for the Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Tenax® Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)

Summary of Method

Compendium Method TO-1 involves drawing ambient air through a cartridge containing ~1-2 grams of Tenax®. Selected VOCs are trapped on the resin, while highly volatile organic compounds and most inorganic atmospheric constituents pass through the cartridge. The cartridge is then transferred to the laboratory and analyzed.

For analysis, the cartridge is placed in a heated chamber and purged with an inert gas, which transfers the VOCs from the cartridge onto a cold trap and subsequently onto the front of the GC column. The column is first held at low temperature (e.g., -70°C), then the column temperature is uniformly increased (temperature programmed). The components eluting from the column are identified and quantified by mass spectrometry. Component identification is normally accomplished using a library search routine on the basis of the GC retention time and mass spectral characteristics. Less sophisticated detectors (e.g., electron capture or flame ionization) may be used for certain applications, but their suitability for a given application must be verified by the user. Due to the complexity of ambient air samples, only high resolution (i.e., capillary) GC techniques are considered to be acceptable in this method.

Sources of Methodology

Method TO-1 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-1 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

Electronic versions of the individual unrevised Compendium (TO-) Methods are available for downloading from the "AMTIC, Air Toxics" section of EPA's OAQPS Technology Transfer Network via the Internet at the “AMTIC, Air Toxics” section of the TTNWeb:

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Methods TO-1 to TO-13 are now posted in the portable document format (PDF). The downloaded files can be read using an Acrobat Reader. Acrobat readers are available from Adobe®, free of charge, at:

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-2

Method for the Determination of Volatile Organic Compounds (VOCs) in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)

Summary of Method

Compendium Method TO-2 is similar to Compendium Method TO-1 except the adsorbent is a carbon molecular sieve (CMS) rather than Tenax®. The use of CMS allows some of the more volatile organics (i.e., vinyl chloride) to be captured and analyzed.

Method TO-2 is suitable for the determination of certain nonpolar VOCs having boiling points in the range of -15°C to 120°C. The analytical detection limit varies with the analyte. Detection limits of 0.01 to 1 ppbv are achievable using a 20-liter sample.

Sampling involves drawing ambient air through a cartridge containing ~0.4 g of a CMS adsorbent. Volatile organic compounds are captured on the adsorbent while major inorganic atmospheric constituents pass through (or are only partially retained). After sampling, the cartridge is returned to the laboratory for analysis. Prior to analysis the cartridge is purged with 2 to 3 liters of pure, dry air (in the same direction as sample flow) to remove adsorbed moisture.

Similar to Compendium Method TO-1, the cartridge is heated to 350° to 400°C, under helium purge, and the desorbed organic compounds are collected in a specially designed cryogenic trap. The collected organics are then flash evaporated onto a capillary column GC/MS system (held at -70°C). The individual components are identified and quantified during a temperature programmed chromatographic run.

Similar to Compendium Method TO-1, contamination of the CMS, breakthrough, and antifact formation are potential weaknesses of the methodology. Method TO-2 also involves a single analysis.

Sources of Methodology

Method TO-2 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-2 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-3

Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection

Summary of Method

Compendium Method TO-3 involves the *in situ* collection of VOCs having boiling points in the range of -10° to 200°C in a cryogenic trap constructed of copper tubing packed with glass beads. The collection trap is submerged in either liquid nitrogen or liquid argon. Liquid argon is highly recommended because of the safety hazard associated with liquid oxygen. With the sampling valve in the fill position, an air sample is admitted into the trap by a volume measuring apparatus. In the meantime, a GC column oven is cooled to a subambient temperature (-50°C) for sample analysis. Once sample collection is completed, the value is switched so that the carrier gas sweeps the VOCs in the trap onto the head of the cooled GC column. Simultaneously, the liquid cryogen is removed, and the trap is heated to assist the sample transfer process. The GC column is temperature programmed, and the component peaks eluting from the columns are identified and quantified using flame ionization and/or electron capture detection. Alternative detectors (e.g., photoionization) can be used as appropriate. An automated system incorporating these various operations as well as the data processing function is described in the method. Due to the complexity of ambient air samples, high resolution (capillary column) GC techniques are recommended. However, when highly selective detectors (such as the electron capture detector) are employed, packed column technology without cryogenic temperature programming can be effectively used in some cases.

Sources of Methodology

Method TO-3 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-3 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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EPA/625/R-96/010b

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-5

Determination of Aldehydes and Ketones in Ambient Air Using High Performance Liquid Chromatography (HPLC)

Summary of Method

Compendium Method TO-5 involves drawing ambient air through a midget impinger containing 10 mL of 2N HCl/0.05% 2,4-dinitrophenylhydrazine (DNPH reagent) and 10 mL of isooctane. Aldehydes and ketones readily form stable 2,4-dinitrophenylhydrazones (DNPH derivatives).

After sampling, the impinger solution is placed in a screw-capped vial having a Teflon®-lined cap and returned to the laboratory for analysis. The DNPH derivatives are recovered by removing the isooctane layer, extracting the aqueous layer with 10 mL of 70/30 hexane/methylene chloride, and combining the organic layers.

The combined organic layers are evaporated to dryness under a steam of nitrogen and the residue dissolved in methanol. The DNPH derivatives are determined using reversed phase HPLC with an ultraviolet (UV) adsorption detector operated at 370 nm.

Sources of Methodology

Method TO-5 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-5 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-6

Determination of Phosgene in Ambient Air Using High Performance Liquid Chromatography (HPLC)

Summary of Method

Compendium Method TO-6 involves drawing an air sample through a midget impinger containing 10 mL of 2% aniline/toluene (2/98 by volume). Phosgene readily reacts with aniline to form carbanilide (1,3-diphenylurea), which is stable indefinitely. After sampling, the impinger contents are transferred to a screw-capped vial having a Teflon-lined cap and returned to the laboratory for analysis. The solution is taken to dryness by heating to 60°C on an aluminum heating block under a gentle stream of pure nitrogen gas. The residue is dissolved in 1 mL of acetonitrile. Carbanilide is determined in the acetonitrile solution using reverse-phase HPLC with an ultraviolet (UV) absorbance detector operating at 254 nm. Precision for phosgene spiked into a clean air stream is ±15-20% relative standard deviation. Recovery is quantitative within that precision, down to less than 3 ppbv.

Sources of Methodology

Method TO-6 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-6 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-7

Method for the Determination of N-nitrosodimethylamine (NDMA) in Ambient Air Using Gas Chromatography

Summary of Method

Compendium Method TO-7 involves drawing ambient air through a Thermosorb/N adsorbent cartridge at a rate of approximately 2 L per minute for an appropriate period of time. Breakthrough has been shown not to be a problem with total sampling volumes of 300 L (i.e., 150 minutes at 2 L per minute) or less. The selection of Thermosorb/N adsorbent over Tenax® GC, was due, in part, to recent laboratory studies indicating artifact formation on Tenax® from the presence of oxides of nitrogen in the sample matrix.

After sampling, the cartridge is plugged and returned to the laboratory for analysis. In the laboratory, the cartridge is pre-eluted with 5 mL of methylene chloride (in the same direction as sample flow) to remove interferences. Residual methylene chloride is removed by purging the cartridge with air in the same direction. The cartridge is then eluted, in the reverse direction, with 2 mL of acetone. This eluate is collected in a screw-capped vial and refrigerated until analysis. NDMA is determined by GC/MS using a Carbowax 20M capillary column. NDMA is quantified from the response of the m/e 74 molecular ion using an external standard calibration method.

Sources of Methodology

Method TO-7 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-7 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-8

Method for the Determination of Phenol and Methylphenols (Cresols) in Ambient Air Using High Performance Liquid Chromatography

Summary of Method

Compendium Method TO-8 involves drawing ambient air through two midget impingers, each containing 15 mL of 0.1 N NaOH. The phenols are trapped as phenolates. The impinger solutions are placed in a vial with a Teflon®-lined screw cap and returned to the laboratory for analysis. The solution is cooled in an ice bath and adjusted to a pH <4 by addition of 1 mL of 5% sulfuric acid (V/V). The sample is adjusted to a final volume of 25 mL with distilled water. The phenols are determined using reverse-phase HPLC with either ultraviolet (UV) absorption detection at 274 nm, electrochemical detection, or fluorescence detection. In general, the UV detection approach should be used for relatively clean samples.

Sources of Methodology

Method TO-8 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-8 is contained in the original *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

Second Edition

Compendium Method TO-12

Method for the Determination of Non-Methane Organic Compounds (NMOC) in Ambient Air Using Cryogenic Preconcentration and Direct Flame Ionization Detection (PDFID)

Summary of Method

Compendium Method TO-12 combines a cryogenic concentration technique for trapping organics in the ambient air (similar to Compendium Method TO-3) coupled to a highly sensitive and simple flame ionization detector (FID) to determine non-speciated total NMOC concentrations in the ambient air.

In Compendium Method TO-12, a whole air sample is either extracted directly from the ambient air and analyzed on-site by the GC system or collected into a precleaned specially-treated canister and analyzed off-site.

The analysis requires drawing a fixed-volume portion of the extracted sample air, at a low flow rate, through a glass-bead filled trap that is cooled to approximately -186°C with liquid argon. The cryogenic trap simultaneously collects and concentrates the NMOC (either via condensation or adsorption) while allowing the methane, nitrogen, oxygen, etc. to pass through the trap without retention. The system is dynamically calibrated so that the volume of sample passing through the trap does not have to be quantitatively measured, but must be precisely repeatable between the calibration and the analytical phases.

After the fixed-volume air sample has been drawn through the trap, a helium carrier gas flow is diverted to pass through the trap, in the opposite direction to the sample flow, and into an FID. When the residual air and methane have been flushed from the trap and the FID baseline restabilizes, the cryogen is removed and the temperature of the trap is raised to approximately 90°C.

The NMOC previously collected in the trap revolatilize due to the increase in temperature and are carried into the FID, resulting in a response peak or peaks from the FID. The area of the peak or peaks is integrated, and the integrated value is translated to concentration units via a previously obtained calibration curve relating integrated peak areas with known concentrations of propane.

By convention, concentrations of NMOC are reported in units of parts per million carbon (ppmC), which, for a specific compound, is the concentration by volume (ppmv) multiplied by the number of carbon atoms in the compound.

Sources of Methodology

Method TO-12 has not been revised. Therefore, the original method is not repeated in the Second Edition of the *Compendium*. Method TO-12 is contained in the original supplement of *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, EPA-600/4-89-017, which may be purchased in hard copy from: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Telephone: 703-487-4650; Fax: 703-321-8547; E-Mail: info@ntis.fedworld.gov; Internet: www.ntis.gov. Order number: **PB90-116989**. The TO-methods may also be available from various commercial sources.

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United States
Environmental Protection
Agency

Center for Environmental
Research Information

Research and Development EPA-625/SR-96/010b January 1999

EPA Project Summary[1]

Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air--Second Edition

This Project Summary is the announcement of the availability of the Second Edition of the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. This Second Edition of the Compendium has been prepared to provide regional, state and local environmental regulatory agencies with step-by-step sampling and analysis procedures for the determination of selected toxic organic pollutants in ambient air. It is designed to assist those persons responsible for sampling and analysis of hazardous air pollutants (HAPs) in complying with the requirements of Title III of the Clean Air Act.

Determination of pollutants in ambient air is a complex task, primarily because of the wide variety of compounds of interest coupled with the lack of standardized sampling and analysis procedures. Many toxic organics can be sampled and analyzed by several techniques, often with different interferences and detection limitations. This revised Compendium presents a set of 17 methods in a standardized format with a variety of applicable sampling methods, as well as several analytical techniques, for specific classes of organic pollutants, as appropriate to the specific pollutant compound, its level, and potential interferences. Consequently, this treatment allows the user flexibility in selecting alternatives to complement his or her background and laboratory capability. These methods may be modified from time to time as advancements are made.

This Project Summary was developed jointly by the U. S. Environmental Protection Agency (EPA) Center for Environmental Research Information (CERI), National Risk Management Research Laboratory (NRMRL), Office of Research and Development (ORD), Cincinnati, OH and ORD's National Exposure Research Laboratory (NERL) at Research Triangle Park, NC to alert potential users of the availability of the updated Compendium that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The Clean Air Act Amendments of 1990 (CAAA of 1990) have significantly increased the responsibilities of both federal and state agency programs for evaluating and maintaining air emissions compliance. In turn, this increased responsibility has generated a need for more

1

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personnel trained to interpret, enforce, and respond to regulatory initiatives. Consequently, the Agency has restructured its technology transfer program to more effectively provide technical assistance in the form of publication of technical documents, presentations and workshops, and development of tools to assist Agency personnel in keeping their skills up-to-date so that they may efficiently cope with the many changes evolving in new programs, equipment, sampling and analytical methodology, and available enforcement tools.

Limited guidance has been available to state and local agencies or to other organizations concerned with the determination of toxic organic compounds in ambient air. As a result, state and local agencies and others responding to air pollution problems have had to develop their own monitoring strategies, including selection of monitoring methods, sampling plan design, and specific procedures for sampling, analysis, logistics, calibration and quality control. For the most part, these procedures were based on professional judgments rather than adherence to any documented uniform guidelines. Many governmental agencies and professional or research organizations have developed ambient air monitoring methods and procedures, mostly to respond to specialized needs. But these methods and procedures have, *in general,* been neither standardized nor readily available to other agencies involved with ambient air monitoring for organic hazardous air pollutants (HAPs).

To meet these needs, EPA's ORD, through CERI and NERL has supported technology transfer programs involving standardized, peer reviewed monitoring methods for regulatory and industrial personnel via publications of Compendia methods. Other recent or upcoming documents in this series are:

- *Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air,* EPA 625/R-96/010a, January 1999. (This publication is scheduled for release during the first half of 1999).
- *Compendium of Methods for the Determination of Air Pollutants in Indoor Air,* EPA 600/4-90-010, April 1990.

These Compendia have historically assisted Federal, State, and local regulatory personnel in developing and maintaining necessary expertise and up-to-date technology involving sampling and analysis of both inorganic and organic HAPs. However, since the publication of these documents, new technology has been introduced to cope with the monitoring requirements identified in the Amendments, thus creating the need for updating many of the methods in the existing Organic Compendium.

The methods in the Second Edition have been compiled from the best elements of methods developed or used by various research or monitoring organizations. They are presented in a standardized format, and each one has been extensively reviewed by several technical experts having expertise in the methodology presented.

Structure of the Second Edition of the Compendium

This Second Edition has been prepared to provide regional, state and local environmental regulatory agencies, as well as other interested parties, with specific guidance on the determination of selected toxic organic compounds in ambient air. A visual guide to the organization of the Compendium for specific methods covering a variety of organic compounds is illustrated in Figure 1.

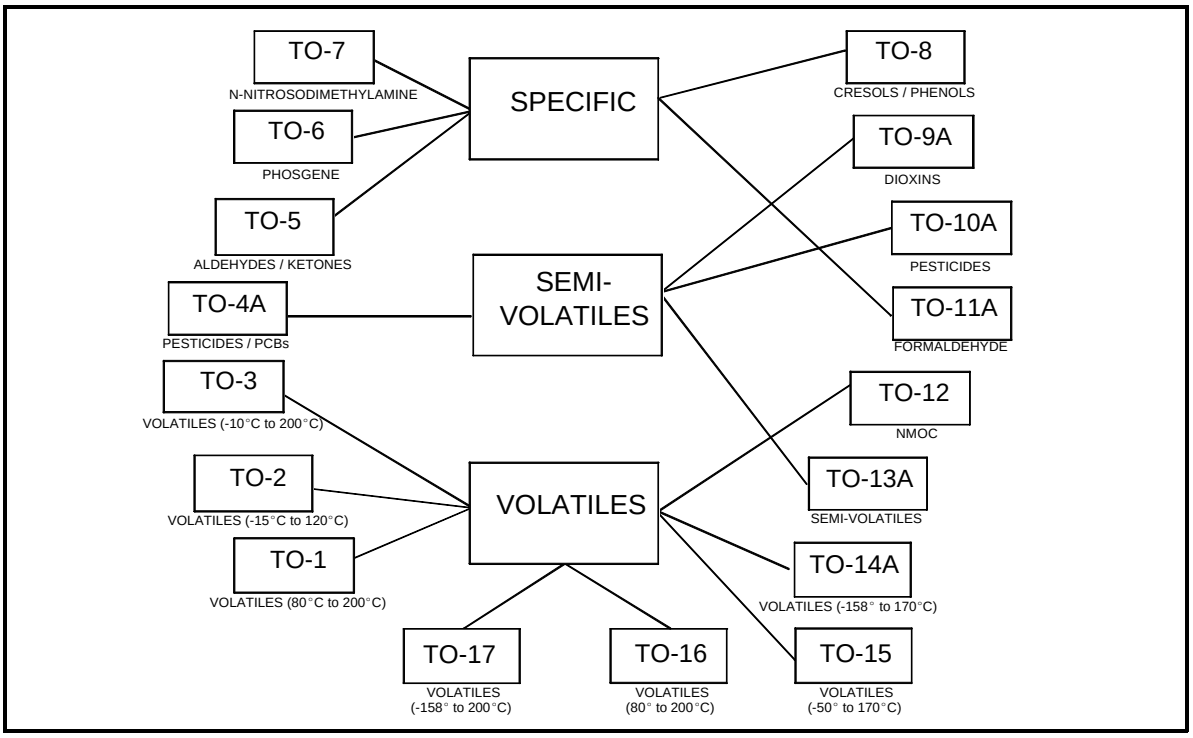

Figure 1. A visual guide to the organization of the Second Edition of the Organic Compendium.

Those methods assigned the "A" notation are methods which were published in the First Edition (Compendium Methods TO-1 through TO-14) of the Compendium and have now been updated due to technological advances in either the sampling or analysis methodology. In addition, three new methods (Compendium Methods TO-15 through TO-17) have been added to make the complete Second Edition of the Compendium. These methods were added due to their advanced technology application involving specially treated canisters (Compendium Method TO-15), long-path (open-path) fourier transform infrared spectroscopy (Compendium Method TO-16), and multibed sorbent techniques (Compendium Method TO-17). The methods which are neither new or modified are not reproduced in the Second Edition in order to save space. This decision was based on the fact that they are not as likely to be used as the revised or new methods.

A list of methods contained in the Second Edition of the Compendium is presented in Table 1. This listing provides a brief indication of the type of compounds to which the method is applicable, the type of sample collection device used, and the type of analytical methodology for which the sample collection system was designed for compatibility. Finally, a listing of the advantages and disadvantages of the methods in the Second Edition of the Compendium are documented in Table 2.

TABLE 1. LIST OF METHODS IN SECOND EDITION OF THE COMPENDIUM

Compendium Method No.	Type of Compounds Determined	Sample Collection Device	Analytical Methodology[1]
TO-1[2]	Volatile organic compounds	Tenax® solid sorbent	GC/MS
TO-2[2]	Volatile organic compounds	Molecular sieve sorbent	GC/MS
TO-3[2]	Volatile organic compounds	Cryotrap	GC/FID
TO-4A	Pesticides/PCBs	Polyurethane foam	GC/MD
TO-5[2]	Aldehydes/Ketones	Impinger	HPLC
TO-6[2]	Phosgene	Impinger	HPLC
TO-7[2]	Anilines	Adsorbent	GC/MS
TO-8[2]	Phenols	Impinger	HPLC
TO-9A	Dioxins	Polyurethane foam	HRGC/HRMS
TO-10A	Pesticides/PCBs	Polyurethane foam	GC/MD
TO-11A	Aldehydes/ketones	Adsorbent	HPLC
TO-12[2]	Non-methane organic compounds (NMOC)	Canister or on-line	FID
TO-13A	Polycyclic aromatic hydrocarbons	Polyurethane foam	GC/MS
TO-14A	Volatile organic compounds (nonpolar)	Specially-treated canister	GC/MS and GC/MD
TO-15	Volatile organic compounds (polar/nonpolar)	Specially-treated canister	GC/MS
TO-16	Volatile organic compounds	Open path monitoring	FTIR
TO-17	Volatile organic compounds	Single/multi-bed adsorbent	GC/MS, FID, etc.

[1] GC/MS = Gas chromatography/mass spectrometry.
GC/FID = Gas chromatography/flame ionization detector.
HPLC = High performance liquid chromatography.
GC/MD = Gas chromatography/multi-detector.
GC/IT = Gas chromatography/ion trap detector.
FTIR = Fourier transform infrared spectroscopy.
HRGC/HRMS = High resolution gas chromatography/high resolution mass spectrometry.

[2] Methods denoted by "2" have not been changed since their publication in the First Edition of the Compendium, so the full content of these methods is not repeated in this Second Edition. Therefore, the full content of these methods must be obtained from the original Compendium (EPA 600/4-89-017).

TABLE 2. COMPENDIUM METHODS CHARACTERISTICS

Method Desig.	Types of Compounds Determined[1]	Sampling and Analysis Approach	Detection Limit	Advantages	Disadvantages
TO-1 (See also Methods TO-14A, TO-15, and TO-17)	VOCs (80° to 200°C) [e.g., benzene, toluene, xylenes]	**TENAX-GC ADSORPTION AND GC/MS OR GC/FID ANALYSIS** Ambient air is drawn through organic polymer sorbent where certain compounds are trapped. The cartridge is transferred to the laboratory, thermally desorbed and analyzed using GC/MS or GC/FID.	0.01-100 ppbv	• Good data base. • Large volume of air can be sampled. • Water vapor is not collected. • Wide variety of compounds collected. • Low detection limits. • Standard procedures available. • Practical for field use.	• Highly volatile compounds and certain polar compounds are not collected. • Rigorous clean-up of adsorbent required. • No possibility of multiple analysis. • Low breakthrough volumes for some compounds. • Desorption of some compounds difficult. • Structural isomers are the most common interferences. • Contamination of adsorbent and blank contaminants may be a problem. • Artifact formation.
TO-2 (See also Methods TO-14A, TO-15, and TO-17)	Highly volatile VOCs (-15° to +120°C) [e.g., vinyl chloride, chloroform, chlorobenzene]	**CARBON MOLECULAR SIEVE ADSORPTION AND GC/MS OR GC/FID ANALYSIS** Selected volatile organic compounds are captured on carbon molecular sieve adsorbents. Compounds are thermally desorbed and analyzed by GC/MS or GC/FID techniques.	0.1-200 ppbv	• Trace levels of volatile organic compounds are collected and concentrated on sorbent material. • Efficient collection of polar compounds. • Wide range of application. • Highly volatile compounds are adsorbed. • Easy to use in field.	• Some trace levels of organic species are difficult to recover from the sorbent. • Structural isomers are common interferences. • Water is collected and can de-activate adsorption sites. • Thermal desorption of some compounds may be difficult.
TO-3 (See also Methods TO-14A, TO-15, and TO-17)	VOCs nonpolar (-10° to +200°C) [e.g., vinyl chloride, methylene chloride, acrylonitrile]	**CRYOGENIC PRECONCENTRATION AND GC/FID/ECD ANALYSIS** Vapor phase organics are condensed in a cryogenic trap. Carrier gas transfers the condensed sample to a GC column. Adsorbed compounds are eluted from the GC column and measured by FID or ECD.	0.1-200 ppbv	• Collects wide variety of volatile organic compounds. • Standard procedures are available. • Contaminants common to adsorbent materials are avoided. • Low blanks. • Consistent recoveries. • Large data base.	• Moisture levels in air can cause freezing problems with cryogenic trap. • Difficult to use in field. • Expensive. • Integrated sampling is difficult. • Compounds with similar retention times will interfere.
TO-4 (See also Method TO-10A)	Pesticides/PCBs [e.g., PCBs, 4,4-DDE, DDT, DDD]	**HIGH VOL FILTER AND PUF ADSORBENT FOLLOWED BY GC/FID/ECD OR GC/MS DETECTION** Pesticides/PCBs trap on filter and PUF adsorbent trap. Trap returned to lab, solvent extracted and analyzed by GC/FID/ECD or GC/MS.	0.2pg/m^3 - 200 ng/m^3	• Low detection limits. • Effective for broad range of pesticides/PCBs • PUF reusable. • Low blanks. • Excellent collection and retention efficiencies for common pesticides and PCBs.	• Breakdown of PUF adsorbent may occur with polar extraction solvents. • Contamination of glassware may limit detection limits. • Loss of some semi-volatile organics during storage. • Extraneous organics may interfere. • Difficulty in identifying individual pesticides and PCBs if using ECD.

TABLE 2. (CONTINUED)

Method Desig.	Types of Compounds Determined[1]	Sampling and Analysis Approach	Detection Limit	Advantages	Disadvantages
TO-5 (See also Method TO-11A)	Aldehydes and ketones [e.g., formaldehyde, acetaldehyde, acrolein]	**DNPH LIQUID IMPINGER AND HPLC/UV ANALYSIS** Air sample is drawn through dinitrophenylhydrazine (DNPH) impinger solution using a low volume pump. The solution is analyzed using HPLC with a UV detector.	1-50 ppbv	• Specific for aldehydes and ketones. • Good stability for derivative compounds formed in the impingers. • Low detection limits.	• Sensitivity limited by reagent purity. • Potential for evaporation of liquid over long term sampling. • Isomeric aldehydes and ketones may be unresolved by the HPLC system.
TO-6	Phosgene	**ANILINE/TOLUENE LIQUID IMPINGER AND HPLC/UV ANALYSIS** Ambient air is drawn through a midget impinger containing 10 mL of 2/98 aniline/toluene (v/v). The phosgene reacts with aniline to form 1,3-diphenylurea and is analyzed using reverse-phase HPLC with a UV absorbance detector operating at 254 nm.	1-50 ppbv	• Good specificity. • Good stability for derivative compounds formed in the impingers. • Low detection limits.	• Chloroformates and acidic materials may interfere. • Contamination of aniline reagents may be a source of interference. • Use of midget impingers in field application may not be practical.
TO-7	N-Nitroso dimethylamine	**THERMOSORB/N CARTRIDGE WITH GC/MS ANALYSIS** Ambient air is drawn through a cartridge containing Thermosorb/N adsorbent to trap N-nitrosodimethylamine. The cartridge is returned to the lab and eluted with 5 mL of dichloromethane. The cartridge is then eluted in reverse direction with 2 mL of acetone. The N-nitrosodimethylamine is then determined by GC/MS.	1-50 ppbv	• Good specificity. • Good stability for derivative compounds formed on the cartridge. • Low detection limit for n-nitrosodimethylamine. • Placement of sorbent as first component in sample train minimizes contamination. • Sampling system portable and lightweight.	• Compounds with similar GC retention times and detectable MS ions may interfere. • Specificity is a limiting factor if looking for other organic amines.
TO-8	Cresol/phenol	**SODIUM HYDROXIDE LIQUID IMPINGER AND HPLC/UV DETECTION** Ambient air is drawn through two midget impingers. Phenols are trapped as phenolates in NaOH solution which is returned to the lab and analyzed by HPLC.	1-250 ppb	• 4,6-dinitro-2-methylphenol specific to class of compounds. • Good stability. • Detects non-volatile as well as volatile phenol compounds.	• Compounds having the same HPLC retention times will interfere with this method. • Phenolic compounds of interest may be oxidized during sampling. • Limited sensitivity.

TABLE 2. (CONTINUED)

Method Desig.	Types of Compounds Determined[1]	Sampling and Analysis Approach	Detection Limit	Advantages	Disadvantages
TO-9A	Dioxin/Furan/PCBs	**PUF ADSORBENT CARTRIDGE AND HRGC/ HRMS ANALYSIS** Ambient air is drawn through a glass fiber filter and a polyurethane foam (PUF) adsorbent cartridge by means of a high volume sampler. The filter and PUF cartridge are returned to the laboratory and extracted using toluene. The extract is concentrated using the Kuderna-Danish technique, diluted with hexane, and cleaned up using column chromatography. The cleaned extract is then analyzed by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS).	0.25-5000 pg/m^3	• Cartridge is reusable. • Excellent detection limits. • Easy to preclean and extract. • Excellent collection and retention efficiencies. • Broad database. • Proven methodology.	• Analytical interferences may occur from PCBs, methoxybiphenyls, chlorinated hydroxydiphenylethers, naphthalenes, DDE, and DDT with similar retention times and mass fractions. • Inaccurate measurement Ds/Fs are retained on particulate matter and may chemically change during sampling and storage. • Analytical equipment required (HRGC/HRMS) is expensive and not readily available. • Operator skill level important. • Complex preparation and analysis process. • Can't separate particles from gaseous phase.
TO-10A	Pesticides [e.g., heptachlor, chlordane, dieldrin, aldrin]	**PUF ADSORBENT CARTRIDGE AND GC/ECD/PID/FID ANALYSIS** A low-volume sample (1-5 L/min) is pulled through a polyurethane foam (PUF) plug to trap organochlorine pesticides. After sampling, the plug is returned to the laboratory, extracted and analyzed by GC coupled to multi-detectors (ECD, PID, FID, etc.).	1-100 ng/m^3	• Easy field use. • Proven methodology. • Easy to clean. • Effective for broad range of compounds. • Portability. • Good retention of compounds.	• ECD and other detectors (except the MS) are subject to responses from a variety of compounds other than target analytes. • PCBs, dioxins and furans may interfere. • Certain organochlorine pesticides (e.g., chlordane) are complex mixtures and can make accurate quantitation difficult. • May not be sensitive enough for all target analytes in ambient air.

TABLE 2. (CONTINUED)

Method Desig.	Types of Compounds Determined[1]	Sampling and Analysis Approach	Detection Limit	Advantages	Disadvantages
TO-11A	Formaldehyde (other aldehydes/ ketones) [e.g., formaldehyde, acetaldehyde, acrolein]	**DNPH-CARTRIDGE AND HPLC/UV DETECTION** An ambient air sample is drawn through a commercially-coated DNPH cartridge at a rate of 500-1200 mL/minute. The cartridges are returned to the laboratory in screw-cap glass vials. The cartridges are then removed from the vials and washed with acetonitrile by gravity feed elution. The eluate is diluted volumetrically and an aliquot is removed for determination of the DNPH-formaldehyde derivative by isocratic reverse phase HPLC with UV detection at 350 nm.	0.5-100 ppbv	• Placement of sorbent as first element in the sampling train minimizes contamination. • Large database. • Proven technology. • Sampling system is portable and light weight.	• Isometric aldehydes and ketones and other compounds with the same HPLC retention time as formaldehyde may interfere. • Carbonyls on the DNPH cartridge may degade if an ozone denuder is not employed. • Liquid water captured on the DNPH cartridge during sampling may interfere. • O_3 and UV light deteriorates trapped carbonyls on cartridge.
TO-12	NMOC (non-methane organic compounds)	**CANISTER SAMPLING--CRYOGENIC PRECONCEN-TRATION AND FID DETECTION** Ambient air is drawn into a cryogenic trap where the non-methane organic compounds (NMOCs) are concentrated. The trap is heated to move the NMOCs to the FID. Concentration of NMOCs is determined by integrating under the broad peak. Water correction is necessary.	0.1-200 ppmvC	• Standard procedures are available. • Contaminants common to adsorbent materials are avoided. • Low blanks. • Consistent recoveries. • Large data base. • Good sensitivity. • Useful for screening areas or samples. • Analysis much faster than GC.	• Moisture levels in air can cause freezing problems. • Non-speciated measurement. • Precision is limited.

TABLE 2. (CONTINUED)

Method Desig.	Types of Compounds Determined[1]	Sampling and Analysis Approach	Detection Limit	Advantages	Disadvantages
TO-13A	PAHs [e.g., benzo(a)pyrene, naphthalene, fluorene]	**PUF OR XAD-2 ADSORBENT CARTRIDGE AND GC/MS ANALYSIS** Ambient air is drawn through a glass fiber filter and a polyurethane foam (PUF) or XAD-2 adsorbent cartridge by means of a high volume sampler. The filter and PUF cartridge are extracted using 10% diethyl ether. The extract is concentrated using Kuderna-Danish technique, diluted, and cleaned up using column chromatography. The cleaned extract is then analyzed by gas chromatography/mass spectrometry (GC/MS).	0.5-500 ng/m^3	• Allows for sample dilution if concentration is too high during analysis. • Repeated analysis is possible. • High-volume sampling provides for lower detection limits. • Filter and PUF are low cost.	• Method has interferences due to contamination of solvents, reagents, glassware, and sampling hardware. • Coeluting contaminants may cause interference with target analytes. • Heat, ozone, NO_2, and ultraviolet light may cause sample degradation.
TO-14A	VOCs (non-polar) [e.g., toluene, benzene, chlorobenzene]	**SPECIALLY-PREPARED CANISTER AND GC/FID/ECD OR GC/MS DETECTION** Whole air samples are collected in an evacuated stainless steel canister. VOCs are concentrated in the laboratory with cryogen trap. VOCs are revolatilized, separated on a GC column, and passed to one or more detectors for identification and quantitation.	0.2-25 ppbv	• Best method for broad speciation of unknown trace volatile organics. • Simple sampling approach. • Good QA/QC database. • Proven field and analytical technology.	• Limited to non-polar compounds due to use of permeation type dryer. • Sample components may be adsorbed or decompose through interaction with container walls. • Water condensation at high humidity may be a problem at high concentrations (ppm). • Complex equipment preparation required. • Expensive analytical equipment.
TO-15	VOCs (polar/non-polar) [e.g., methanol, benzene, xylene, nitrobenzene]	**SPECIALLY-PREPARED CANISTER AND GC/MS ANALYSIS** Whole air samples are collected in a specially-prepared canister. VOCs are concentrated on a solid sorent trap or other arrangement, refocused on a second trap, separated on a GC column, and passed to an MS detector for identification and quantification.	0.2-25 ppbv	• Incorporates a multisorbent/ dry purge technique or equivalent for water management thereby addressing a more extensive set of compounds. • Establishes method performance criteria for acceptance of data. • Provides enhanced provisions for quality control. • Unique water management approach allows analysis for polar VOCs.	• Expensive analytical equipment. • Operator skill level important.

TABLE 2. (CONTINUED)

Method Desig.	Types of Compounds Determined[1]	Sampling and Analysis Approach	Detection Limit	Advantages	Disadvantages
TO-16	VOCs (polar/non-polar) [e.g., alcohols, ketones, benzene, toluene, o-xylene, chlorobenzene]	**FTIR OPEN PATH SPECTRO-SCOPY** VOCs are monitored using real-time long-path open-path fourier transform infrared spectroscopy (FTIR).	25-500 ppbv	• Open path analysis maintains integrity of samples. • Multi-gas analysis saves money and time. • Path-integrated pollutant concentration measurement minimizes possible sample contamination, and provides real-time pollutant concentration.. • Applicability for special survey monitoring. • Monitoring at inaccessible areas possible using open-path FTIR.	• High level of operator skill level required. • Requires spectra interpretation. • Limited spectra library available. • Higher detection limits than most alternatives. • Must be skilled in computer operation. • Substantial limitations from ambient CO_2 and humidity levels associated with spectral analysis.
TO-17	VOCs (polar/non-polar) [e.g., alcohols, ketones, benzene, toluene, o-xylene, chlorobenzene]	**MULTI-BED ADSORBENT TUBE FOLLOWED BY GC/MS** Ambient air is drawn through a multi-bed sorbent tube where VOCs are trapped. The cartridge is returned to the laboratory, thermally desorbed and analyzed by GC/MS or other methods.	0.2-25 ppbv	• Placement of the sorbent as the first element minimizes contamination from other sample train components. • Large selection of sorbents to match with target analyte list. • Includes polar VOCs. • Better water management using hydrophobic sorbents than Compendium Method TO-14A. • Large database, proven technology. • Size and cost advantages in sampling equipment.	• Distributed volume pairs required for quality assurance. • Rigorous clean-up of sorbent required. • No possibility of multiple analysis. • Must purchase thermal desorption unit for analysis. • Desorption of some VOCs is difficult. • Contamination of adsorbent can be a problem.

[1]Number in parenthesis is the boiling point range of the organics applicable to that Compendium Method.

The following is a brief overview of important technical changes/additions that have been made to those methods which have been updated or added to comprise the Second Edition of the Organic Compendium.

Compendium Method TO-4A
(Pesticides/PCBs)

- Incorporates an extensive update of quality assurance (QA) requirements involving the sampling mechanism.
- Allows a multi-detector approach for quantifying analytes on the target compound list (TCL).
- Establishes method performance criteria for acceptance of data, allowing the use of alternative but equivalent sampling and analytical equipment.
- Provides specific procedures for sample clean-up, employing solid phase extraction using silica, alumina or florisil.
- A detailed discussion associated with method performance criteria involving surrogate recoveries, laboratory method blanks, GC column performance and minimum detection limits is provided.

Compendium Method TO-9A
(Dioxins/Furans)

- Includes guidance associated with the use of benzene or toluene as the extraction solvent.
- Provides extensive guidance associated with field operation and quality assurance checks involving the high-volume sampler.
- Presents extracted ion current profiles (EICP) for selected dioxins and furans.
- Discusses method performance criteria involving surrogate recoveries, laboratory method blanks, GC column performance, laboratory control spikes, matrix spikes, and minimum detection limits determination.
- Provides specific procedures for sample clean-up employing solid phase extraction using silica, alumina, and carbon adsorbents.

Compendium Method TO-10A
(Pesticides/PCBs)

- Provides guidance on determining sampling efficiency (SE), retention efficiency (RE), and dynamic retention efficiency (RE_d).
- Recommends specific detectors for common pesticides and PCBs.
- Gives construction specifications for both PUF and PUF/XAD-2 adsorbent cartridges.
- Includes recent laboratory evaluation of sampling efficiencies for organochlorine pesticides, PCBs, ureas, triazines and pyethrins.
- Describes generator used in determining sampling efficiencies.

Compendium Method TO-11A
(Formaldehyde)

- Includes new material from EPA's Technical Assistance Document (TAD) on enhanced ozone monitoring.
- Adds design and construction specifications for an ozone denuder and scrubber.
- Reviews commercially-prepared low pressure drop adsorbent cartridges.
- Discusses sampler design for sequential sampling and heated inlet.

- Provides guidance on sorbent selection (C_{18} vs. silica gel).
- Illustrates the application of ozone denuder or scrubber to the field sampling system.
- Updates of HPLC procedures for column alternatives to quantitate up to 14 carbonyl compounds.

Compendium Method TO-13A
(Semi-volatiles)

- Incorporates an extensive update of quality assurance (QA) requirements involving sampling mechanism.
- Allows only gas chromatography/mass spectrometry (GC/MS) approach specified for quantifying analytes on the target compound list (TCL).
- Establishes method performance criteria for acceptance of data, allowing the use of alternative but equivalent sampling and analytical equipment.
- Provides specific procedures for sample clean-up, employing solid phase extraction.
- Provides detailed discussion of method performance evaluation (PE) standard and recoveries, laboratory method blanks, GC column performance and minimum detection limits requirements.

Compendium Method TO-14A
(VOCs - non-polar)

- Excludes alternative "water management" technique in lieu of permeation dryers.
- Expands canister requirements to include specially-prepared canisters.
- Provides for gas chromatography coupled to an ion trap detector.

Compendium Method TO-15
(VOCs - polar/non-polar)

- Addresses a more extensive set of compounds (the VOCs mentioned in Title III of the CAAA of 1990).
- The analytical methodology emphasizes GC/MS as the means to identify and quantitate target compounds.
- Establishes method performance criteria for acceptance of data, allowing the use of alternate but equivalent sampling and analytical equipment.
- Uses a multisorbent/dry purge technique or equivalent for water management.

Compendium Method TO-16
(VOCs - polar/non-polar)

- Describes the use of an FT-IR system to measure pollutants using a long, open air path.
- Provides measurement of the path-average atmospheric concentrations of various organic gases.
- Methodology discussed in Compendium Method TO-16 provides the following advantages for field application:
  - -- The integrity of the sample is assured, since no sampling actually occurs.
  - -- Multi-gas analysis is possible with a single field spectrum.
  - -- Path-integrated pollutant concentrations are obtained.
  - -- Spatial survey monitoring of industrial facilities is possible if scanning optics are used.

-- Coadding of spectra to improve detection capabilities is easily performed.
-- Rapid temporal scanning of line-of-site or multiple lines-of-sight is possible.
-- Monitoring of otherwise inaccessible areas is possible.

Compendium Method TO-17
(VOCs - polar/non-polar)

- The use of solid adsorbents in multisorbent tubes for concentrating VOCs from the ambient air is presented as part of EPA's program for methods development of automated gas chromatographs.
- Uses sorbent tubes with single or multisorbent packings.
- Compendium Method TO-17, collection of VOCs in ambient air samples by passage through solid sorbent packings, provides numerous advantages, including:

  -- The small size and light weight of the sorbent packing and attendant equipment allows for field application.
  -- The placement of the sorbent packing as the first element (with the possible exception of a filter or chemical scrubber for ozone) in the sampling train reduces the possibility of contamination from upstream elements.
  -- The availability of a large selection of sorbents enables matching sorbents with a target set of compounds, including polar VOC.
  -- The method provides for the possibility of water management using a combination of hydrophobic sorbents (to cause water breakthrough while sampling), dry gas purge of water from the sorbent after sampling, and splitting of the sample during analysis.
  -- Technology is based on a large amount of literature associated with the use of sorbent sampling and thermal desorption for monitoring of workplace air, particularly from the Health and Safety Executive in the United Kingdom.

Ordering Information

The First Edition of the Compendium was published over a period of four years in four separate EPA documents. They are:

- Original Compendium (Methods TO-1 through TO-5), EPA 600/4-84-041, April 1984.
- First Supplement (Methods TO-6 through TO-9), EPA 600/4-87-006, September 1986.
- Second Supplement (Methods TO-10 through TO-14), EPA 600/4-89-018, June 1988.
- Full Compendium (Methods TO-1 through TO-14), EPA 600/4-89-017, June 1988.

Please Note: The Second Edition of the Compendium does not contain Methods TO-1, 2, 3, 5, 6, 7, 8, and 12. These methods, which were not updated because there were no significant technological advances made in them, can be found in their entirety in the First Edition only. The Second Edition contains only: a) the updated methods (methods assigned with an "A" in Table 1 from the First Edition which includes Compendium Methods TO-4A, TO-9A, TO-10A, TO-11A, TO-13A, and TO-14A); and b) the three new methods, Compendium Methods TO-15, TO-16, and TO-17.

These documents, including the Second Edition, may be purchased in hard copy from:

National Technical Information Service (NTIS)
5285 Port Royal Road, Springfield, VA 22161
Telephone: 703-487-4650; FAX: 703-321-8547
E-mail:Info @ NTIS.FEDWORLD.GOV
INTERNET: http://www.ntis.gov.

U.S. EPA: Office of Air Quality Planning and Standards (OAQPS)

Electronic versions of the individual unrevised Compendium (TO-) Methods are available for downloading from the "AMTIC, Air Toxics" section of EPA's OAQPS Technology Transfer Network via the Internet at the “AMTIC, Air Toxics” section of the TTNWeb:

http://www.epa.gov/ttn/amtic/airtox.html

Methods TO-1 to TO-17 are now posted in the portable document format (PDF). The downloaded files can be read using an Acrobat Reader. Acrobat readers are available from Adobe®, free of charge, at:

http://www.adobe.com/prodindex/acrobat/readstep.html

and are required to read Acrobat (PDF) files. Readers are available for Windows, MacIntosh, and DOS.

U.S. EPA: Office of Research and Development (ORD),
Center for Environmental Research Information (CERI)

New technology transfer documents may be ordered on-line through the CERI Technology Transfer web site - “http://www.epa.gov/ttbnrmrl/”. Once the web site has been accessed, click on the publication list and follow the menu-driven ordering instructions.

Acknowledgements

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OLWX1 LED
LED Wall Luminaire

Catalog Number

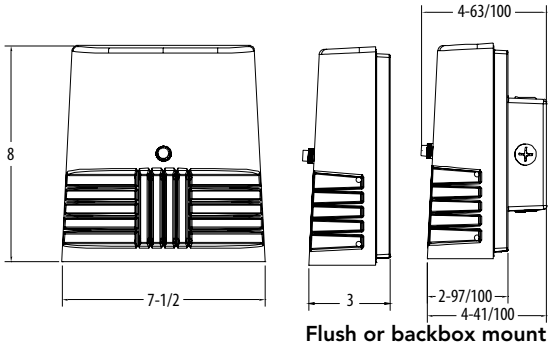
Notes

Type

Hit the Tab key or mouse over the page to see all interactive elements.

Specifications

Width:	7-1/2" (19 cm)
Height:	8" (20.3 cm)
Depth:	3" (7.62 cm)
Weight:	5 lbs (2.27kg)



Flush or backbox mount

Introduction

The OLWX1 is versatile and energy efficient. It is designed to replace up to 250W metal halide while saving over 87% in energy costs. Whether you are mounting it to a recessed junction box, conduit/ through wiring, as an up light, as a down light, or as a flood light – the OLWX1 has all applications covered.

Ordering Information

EXAMPLE: OLWX1 LED 20W 50K

OLWX1 LED					
Series	**Performance Package**	**Color Temperature**	**Voltage**	**Controls**	**Finish**
OLWX1 LED	**13W** 13 watts [1] **20W** 20 watts **40W** 40 watts [1]	**40K** 4000 K **50K** 5000 K [1]	**(blank)** MVOLT [1] **120** 120V	**(blank)** None	**(blank)** Dark bronze

Accessories

Ordered and shipped separately.

OLWX1YK	Yoke for OLWX1
OLWX1THK	Knuckle for OLWX1

NOTES

1 MVOLT driver operates on any line voltage from 120-277V (50/60Hz).

FEATURES & SPECIFICATIONS

INTENDED USE

The versatility of the OLWX1 LED combines a sleek, low-profile wall pack design with energy efficient, low maintenance LEDs for replacing up to 250W metal halide fixtures. Mounting accessories are available to convert the OLWX1 LED into an energy efficient flood light.

OLWX1 LED is ideal for outdoor applications such as building perimeters, loading areas, driveways and sign and building flood lighting.

CONSTRUCTION

Cast-aluminum housing with textured dark bronze polyester powder paint for durability. Integral heat sinks optimize thermal management through conductive and convective cooling. LEDs are protected behind a glass lens. Housing is sealed against moisture and environmental contaminants (IP65 rated). See Lighting Facts label and photometry reports for details.

ELECTRICAL

Light engine consists of 1 high-efficiency Chip On Board (COB) LED with integrated circuit board mounted directly to the housing to maximize heat dissipation and promote long life (L73/100,000 hours at 25°C). Electronic drivers have a power factor >90% and THD <20% and a minimum 2.5kV surge rating. Flood light mounting accessories include an additional 6kV surge protection device. LEDs are available in 4000K and 5000K CCTs.

INSTALLATION

Easily mounts to recessed junction boxes with the included wall mount bracket, or for surface mounting and conduit entry - with the included junction box with five 1/2" threaded conduit entry hubs. Flood light mounting accessories (sold separately) include knuckle, integral slipfitter and yoke mounting options. Each flood mount accessory comes with a top visor and vandal guard. Luminaire may be wall or ground mounted in downward or upward orientation.

LISTINGS

UL Listed to U.S. and Canadian safety standards for wet locations. Rated for -40° C minimum ambient. Tested in accordance with IESNA LM-79 and LM-80 standards. DesignLights Consortium® (DLC) qualified product. Not all versions of this product may be DLC qualified. Please check the DLC Qualified Products List at www.designlights.org to confirm which versions are qualified.

WARRANTY

5-year limited warranty. Complete warranty terms located at:
www.acuitybrands.com/support/customer-support/terms-and-conditions

Note: Actual performance may differ as a result of end-user environment and application. All values are design or typical values, measured under laboratory conditions at 25 °C. Specifications subject to change without notice.

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Performance Data

Lumen Output

Lumen values are from photometric tests performed in accordance with IESNA LM-79-08. Data is considered to be representative of the configurations shown, within the tolerances allowed by Lighting Facts.

Fixture Model Number	CCT	System Watts	Lumens	LPW	B	U	G	CRI
OLWX1 LED 13W 40K	4000 K	14 W	1,271	91	1	0	0	>70
OLWX1 LED 13W 50K	5000 K	14 W	1,289	92	1	0	0	>80
OLWX1 LED 20W 40K	4000 K	20 W	2,697	135	1	0	0	>70
OLWX1 LED 20W 50K	5000 K	19 W	2,663	140	1	0	0	>70
OLWX1 LED 40W 40K	4000 K	39 W	4,027	101	2	0	0	>70
OLWX1 LED 40W 50K	5000 K	37 W	4,079	110	2	0	0	>70

Electrical Load

Fixture Model Number	Rated Power (watts)	Input current at given input voltage (amps)				
		120V	208V	240V	277V	347V
OLWX1 LED 13W 40K	14 W	0.12	0.07	0.06	0.06	0.04
OLWX1 LED 13W 50K	14 W	0.12	0.07	0.06	0.06	0.04
OLWX1 LED 20W 40K	20 W	0.20	0.12	0.10	0.09	0.06
OLWX1 LED 20W 50K	19 W	0.20	0.12	0.10	0.09	0.06
OLWX1 LED 40W 40K	39 W	0.37	0.21	0.19	0.16	0.11
OLWX1 LED 40W 50K	37 W	0.37	0.21	0.19	0.16	0.11

Lumen Ambient Temperature (LAT) Multipliers

Use these factors to determine relative lumen output for average ambient temperatures from 0-40°C (32-104°F).

	0°C	10°C	20°C	25°C	30°C	40°C
13W	1.06	1.03	1.01	1.00	0.99	0.96
20W	1.06	1.04	1.01	1.00	0.99	0.96
40W	1.07	1.04	1.01	1.00	0.99	0.96

Projected LED Lumen Maintenance

Data references the extrapolated performance projections in a **25°C ambient**, based on 10,000 hours of LED testing (tested per IESNA LM-80-08 and projected per IESNA TM-21-11).

To calculate LLF, use the lumen maintenance factor that corresponds to the desired number of operating hours below. For other lumen maintenance values, contact factory.

Operating Hours	0	25,000	50,000	100,000
OLWX1 LED 13W	1.00	0.92	0.85	0.73
OLWX1 LED 20W	1.00	0.92	0.85	0.73
OLWX1 LED 40W	1.00	0.94	0.88	0.79

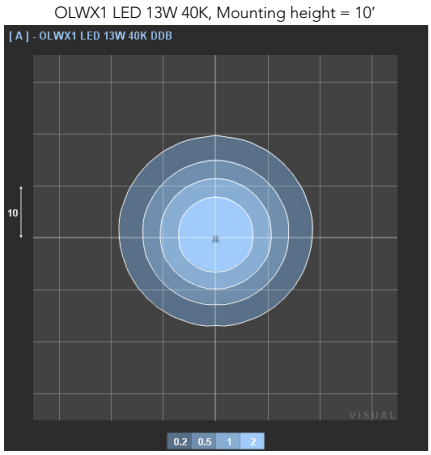
Photometric Diagrams

To see complete photometric reports or download .ies files for this product, visit the Lithonia Lighting OLWX1 LED homepage. Tested in accordance with IESNA LM-79 and LM-80 standards

LEGEND

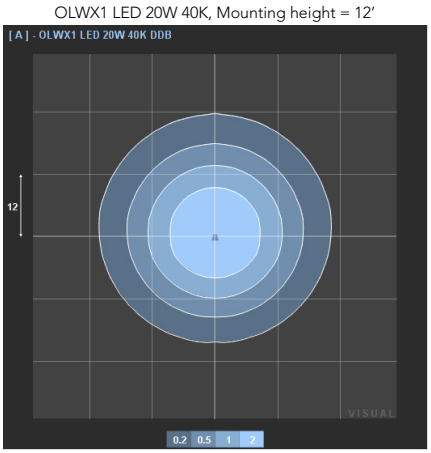
- 0.2 fc
- 0.5 fc
- 1.0 fc
- 2.0 fc

OLWX1 LED 13W 40K, Mounting height = 10'



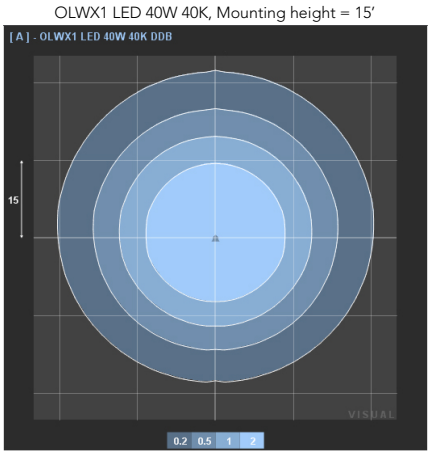
Test No. LTL22697 tested in accordance in IESNA LM-79-08.

OLWX1 LED 20W 40K, Mounting height = 12'



Test No. LTL22696 tested in accordance in IESNA LM-79-08.

OLWX1 LED 40W 40K, Mounting height = 15'



Test No. LTL22695 tested in accordance in IESNA LM-79-08.

Accessories

OLWX1TS
Slipfitter for OLWX1

Standard size tenon is 2 1/8".
The slip fitter has a range of 2" to 2 3/8".

OLWX1YK
Yoke for OLWX1

OLWX1THK
Knuckle for OLWX1

Top Visor and Vandal Guard included with accessories

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cPort
CREDIT UNION

March 5, 2020

Mr. David Hediger
Director of Planning and Code Enforcement
City of Lewiston
27 Pine Street
Lewiston, ME 04240

Dear Mr. Hediger,

On behalf of cPort Credit Union, I am pleased to provide this letter of support for Highbrow Cultivation #2, LLC. Based on our knowledge of Highbrow's past projects, we believe from a fiscal perspective that this firm is well qualified to manage a project such as the renovation to and operation of a cannabis cultivation facility at 16 Bridge Street in Lewiston.

Further, based upon our banking relationships, we believe that the Highbrow team possess the skills, expertise, and capacity to complete the proposed project to your satisfaction.

While this letter is not a commitment to lend, cPort Credit Union welcomes the opportunity to further its banking relationship discussions with Highbrow, as this project is exciting and represents a market in Maine core to our banking business. Please feel free to call me with any questions.

Sincerely,

cPort Credit Union

cPort
CREDIT UNION
NMLS: 409174

399 Western Avenue
Augusta, ME 04330

cportcu.org

Cortney Raymond
Branch Supervisor

craymond@cportcu.org
207-253-4174
fax 207-623-3639
1-800-464-0253

NMLS: 1850023

GENERAL NOTES

1. NO PRE-EXISTING MARIJUANA BUSINESSES EXISTS WITHIN 500-FEET FROM SUBJECT PROPERTY.

2. NO PRE-EXISTING SCHOOLS ARE LOCATED WITH 750-FEET FROM SUBJECT PROPERTY.

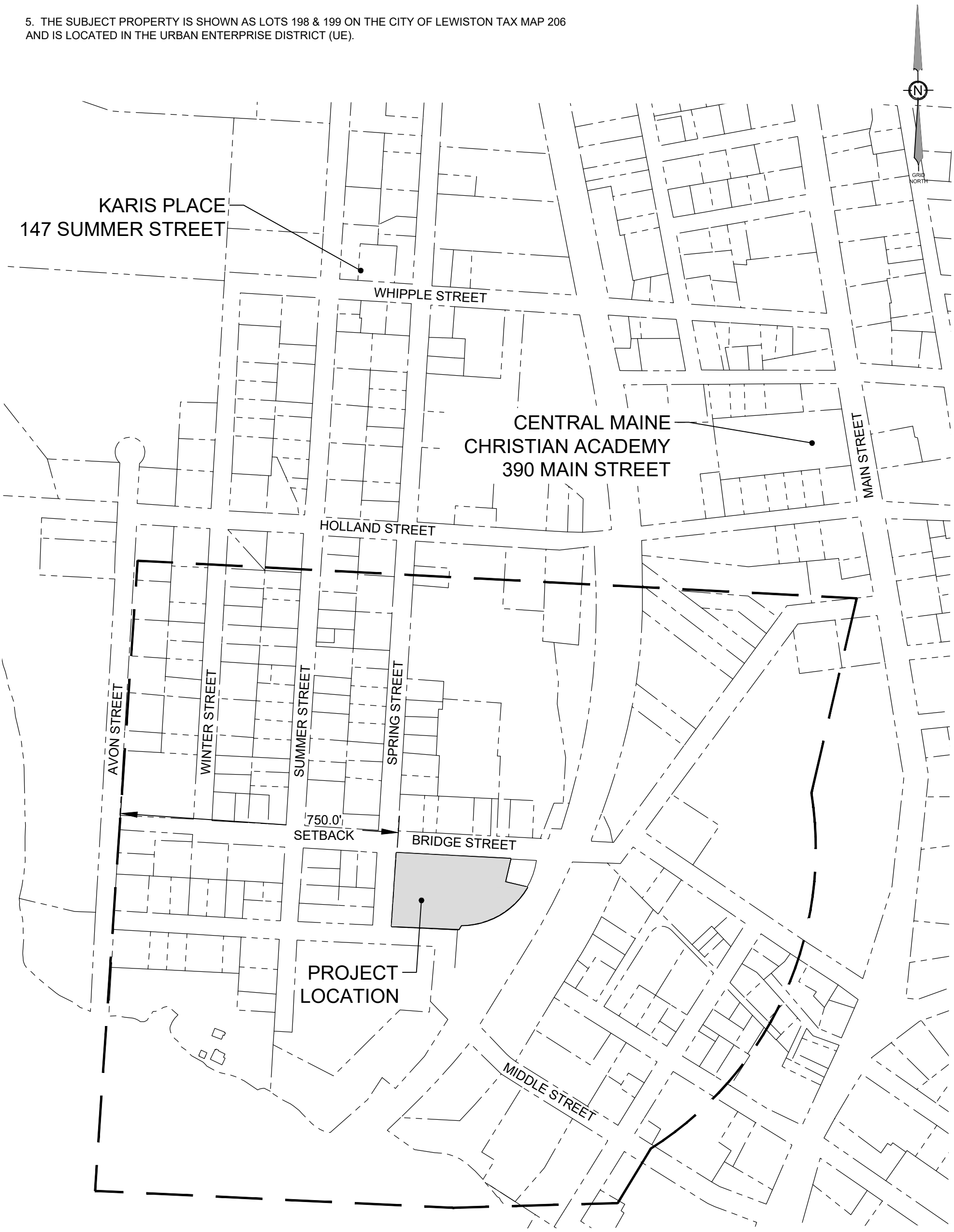
3. NO PRE-EXISTING CHILD CARE FACILITIES ARE LOCATED WITHIN 750-FEET FROM SUBJECT PROPERTY.

4. NO PRE-EXISTING CITY OWNED PUBLIC PARKS, PLAYGROUNDS AND/OR RECREATIONAL FACILITIES ARE LOCATED WITHIN 750- FEET FROM SUBJECT PROPERTY.

5. THE SUBJECT PROPERTY IS SHOWN AS LOTS 198 & 199 ON THE CITY OF LEWISTON TAX MAP 206 AND IS LOCATED IN THE URBAN ENTERPRISE DISTRICT (UE).

LEGEND

EXISTING PROPERTY LINE
PROPOSED PROPERTY LINE
EXISTING BUILDING
PROPOSED SETBACK LINE



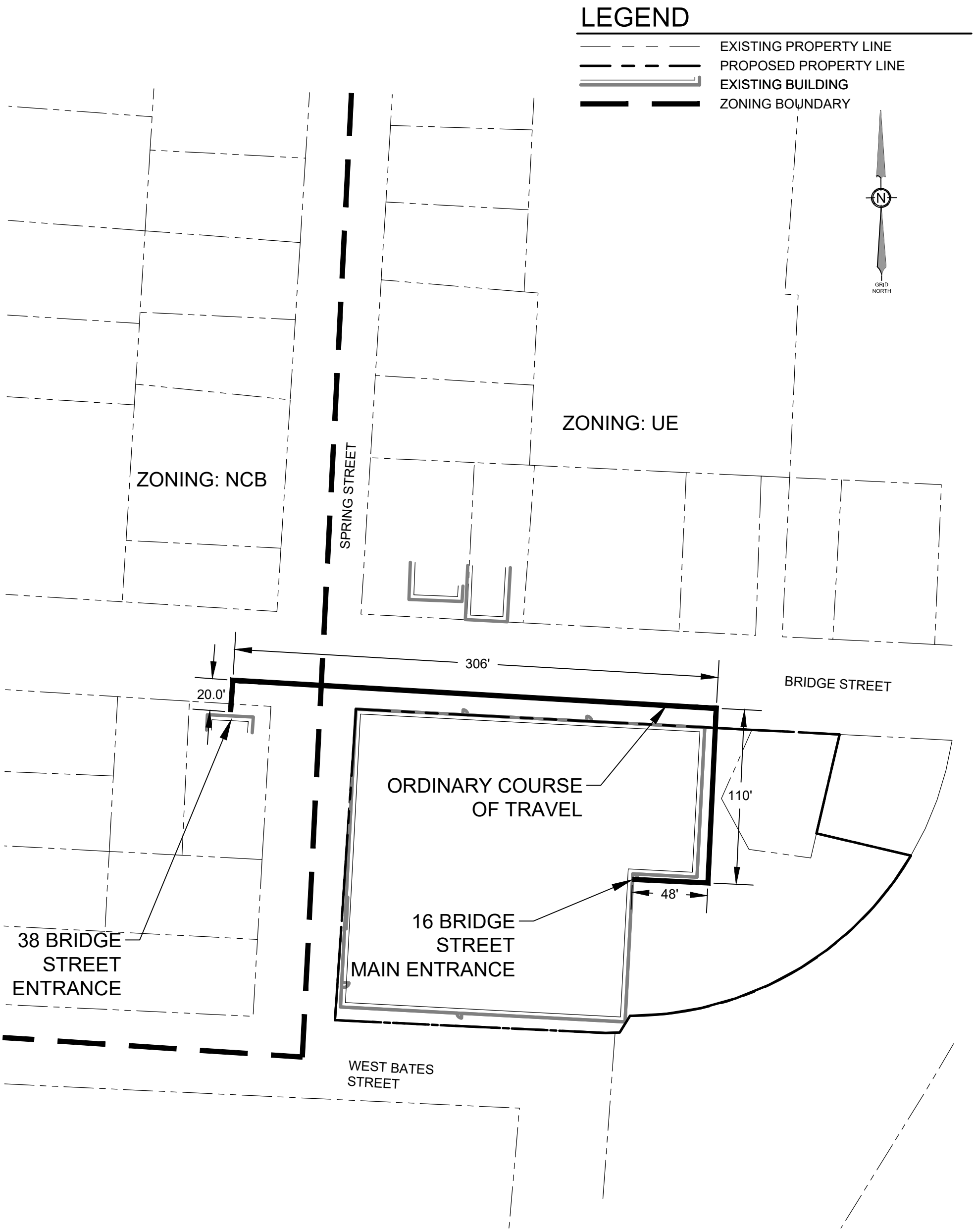
SHEET	FIG -1
SCALE	1"=250'
DATE	3/16/2020
JOB NO.	2012
SHEET DESCRIPTION	SITE SETBACK FIGURE -1 16 BRIDGE STREET
PREPARED FOR	HIGHBROW CULTIVATION #2, LLC 84 MARGINAL WAY, SUITE 600 PORTLAND, ME 04101

TERRADYN CONSULTANTS, LLC

PINELAND
41 CAMPUS DRIVE, SUITE 101
NEW GLOUCESTER, ME 04260

PORTLAND
565 CONGRESS STREET, SUITE 201
PORTLAND, ME 04101

207.926.5111 • info@terradynconsultants.com • www.terradynconsultants.com



GENERAL NOTES

1. ORDINARY COURSE OF TRAVEL BETWEEN PRE-EXISTING DWELLING WITHIN RESIDENTIAL ZONING DISTRICT AND MAIN ENTRANCE OF SUBJECT PROPERTY EXCEEDS 300-FEET.

2. THE SUBJECT PROPERTY IS SHOWN AS LOTS 198 & 199 ON THE CITY OF LEWISTON TAX MAP 206 AND IS LOCATED IN THE URBAN ENTERPRISE DISTRICT (UE).

SHEET: FIG -2	SCALE: 1"=60'	DATE: 3/16/2020	JOB NO.: 2012	SHEET DESCRIPTION: SITE SETBACK FIGURE -2 16 BRIDGE STREET PREPARED FOR: HIGHBROW CULTIVATION #2, LLC 84 MARGINAL WAY, SUITE 600 PORTLAND, ME 04101

TERRADYN CONSULTANTS, LLC
PINELAND
41 CAMPUS DRIVE, SUITE 101
NEW GLOUCESTER, ME 04260
PORTLAND
565 CONGRESS STREET, SUITE 201
PORTLAND, ME 04101
207.926.5111 • info@terradynconsultants.com • www.terradynconsultants.com

THAYER CORPORATION
"Call in the Experts"™
Design/Build/Maintain HVAC&R

March 17, 2020

City of Lewiston

Attn.: David Hediger

27 pine Street

Lewiston, Maine 04240

In reference: Lavertu Growers Extraction Lab

96 Commercial Street

Mr. Hediger,

Thayer Corporation is pleased to provide a site plan, development checklist, and plan package review for the above referenced project. We have included 6 sets of plans and a PDF as requested for 96 Commercial Street map/lot 125/000/046.

Our submission does not change the building type (F-1), increase impervious surfacing, alter the site, or change the exterior presentation with the exception of mandated fire service connection and address signage.

We have met with Fire Inspector and Code Enforcement for general project review, made any suggested changes, and filled out all necessary supporting documentations. The design team has reviewed the project plans for National Fire Protection Code compliance, Life Safety compliance, 2015 International Building Code compliance, and all other applicable codes.

We are happy to meet at your convenience to review this project with your team.

Respectfully,

Greg Marles, CPM, LEED-GA

General Manager

PARID: RE00006553 **96 COMMERCIAL ST**

Parcel

Parcel ID	RE00006553
Map/Lot	125/000/046
Property Location	96 COMMERCIAL ST
Property Class	Warehouse & Distribution Facilities
Land Area (acreage)	1.12

Owners

Owner	LAVERTU HOLDINGS LLC
Address	10 HARMONY DRIVE
City	STANDISH
State	ME
Zip	04084
Book	9745
Page	263

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Development Review Checklist

City of Auburn Planning and Permitting Department
City of Lewiston Department of Planning and Code Enforcement

THE FOLLOWING INFORMATION IS REQUIRED WHERE APPLICABLE TO BE SUBMITTED FOR AN APPLICATION TO BE COMPLETE

PROJECT NAME: Lavertu Growers Extraction Lab

PROPOSED DEVELOPMENT ADDRESS and PARCEL #: 96 Commercial Street 125/000/046

Required Information		Check Submitted		Applicable Ordinance	
Site Plan		**Applicant**	**Staff**	**Lewiston**	**Auburn**
	Owner's Names/Address	x		x	
	Names of Development	N/A		x	
	Professionally Prepared Plan	x		x	
	Tax Map or Street/Parcel Number	x		x	
	Zoning of Property	x		x	
	Distance to Property Lines	x		x	
	Boundaries of Abutting land	x		x	
	Show Setbacks, Yards and Buffers	x		x	
	Airport Area of Influence (Auburn only)	N/a		x	
	Parking Space Calcs	x		x	
	Drive Openings/Locations	N/A		x	
	Subdivision Restrictions	N/A		x	
	Proposed Use	x		x	
	PB/BOA/Other Restrictions	N/A		x	
	Fire Department Review	x		x	
	Open Space/Lot Coverage	N/A		x	
	Lot Layout (Lewiston only)	x		x	
	Existing Building (s)	x		x	
	Existing Streets, etc.	x		x	
	Existing Driveways, etc.	~~N/A~~ X		x	
	Proposed Building(s)	N/A		x	
	Proposed Driveways	N/A		x	
Landscape Plan					
	Greenspace Requirements	N/A		x	
	Setbacks to Parking	N/A		x	
	Buffer Requirements	N/A		x	
	Street Tree Requirements	N/A		x	

	Screened Dumpsters	x		x	
	Additional Design Guidelines	N/A		x	
	Planting Schedule	N/A		x	
Stormwater & Erosion Control Plan					
	Compliance w/ chapter 500	N/A		x	
	Show Existing Surface Drainage	N/A		x	
	Direction of Flow	N/A		x	
	Location of Catch Basins, etc.	N/A		x	
	Drainage Calculations	N/A		x	
	Erosion Control Measures	N/A		x	
	Maine Construction General Permit	N/A		x	
	Bonding and Inspection Fees	N/A		x	
	Post-Construction Stormwater Plan	N/A		x	
	Inspection/monitoring requirements	N/A		x	
	Third Party Inspections (Lewiston only)	N/A		x	
Lighting Plan					
	Full cut-off fixtures	N/A		x	
	Meets Parking Lot Requirements	N/A		x	
Traffic Information					
	Access Management	N/A		x	
	Signage	N/A		x	
	PCE - Trips in Peak Hour	N/A		x	
	Vehicular Movements	N/A		x	
	Safety Concerns	N/A		x	
	Pedestrian Circulation	N/A		x	
	Police Traffic	N/A		x	
	Engineering Traffic	N/A		x	
Utility Plan					
	Water	N/A		x	
	Adequacy of Water Supply	N/A		x	
	Water main extension agreement	N/A		x	
	Sewer	N/A		x	
	Available city capacity	N/A		x	
	Electric			x	
	Natural Gas	N/A		x	
	Cable/Phone	N/A		x	
Natural Resources					
	Shoreland Zone	N/A		x	
	Flood Plain	N/A		x	
	Wetlands or Streams	N/A		x	
	Urban Impaired Stream	N/A		x	
	Phosphorus Check	N/A		x	
	Aquifer/Groundwater Protection	N/A		x	
	Applicable State Permits	N/A		x	

	No Name Pond Watershed (Lewiston only)	N/A		x	
	Lake Auburn Watershed (Auburn only)	N/A		x	
	Taylor Pond Watershed (Auburn only)	N/A		x	
Right Title or Interest					
	Verify	N/A		x	
	Document Existing Easements, Covenants, etc.	N/A		x	
Technical & Financial Capacity					
	Cost Est./Financial Capacity	x		x	
	Performance Guarantee	N/A		x	
State Subdivision Law				x	
	Verify/Check	N/A		x	
	Covenants/Deed Restrictions	N/A		x	
	Offers of Conveyance to City	N/A		x	
	Association Documents	N/A		x	
	Location of Proposed Streets & Sidewalks	N/A		x	
	Proposed Lot Lines, etc.	N/A		x	
	Data to Determine Lots, etc.	N/A		x	
	Subdivision Lots/Blocks	N/A		x	
	Specified Dedication of Land	N/A		x	
Additional Subdivision Standards					
	Single-Family Cluster (Lewiston only)	N/A		x	
	Multi-Unit Residential Development (Lewiston only)	N/A		x	
	Mobile Home Parks	N/A		x	
	Private Commercial or Industrial Subdivisions (Lewiston only)	N/A		x	
	PUD (Auburn only)				
A jpeg or pdf of the proposed site plan		x		x	

Final sets of the approved plans shall be submitted digitally to the City, on a CD or DVD, in AutoCAD format R 14 or greater, along with PDF images of the plans for archiving		6 sets		x	

Development Review Application

City of Auburn Planning and Permitting Department
City of Lewiston Department of Planning and Code Enforcement

PROJECT NAME: Lavertu Grower Extraction Lab_

PROPOSED DEVELOPMENT ADDRESS: 96 Commercial Street

PARCEL ID#: 125/000/046

REVIEW TYPE: Site Plan/Special Exception xx☐ Site Plan Amendment ☐
Subdivision ☐ Subdivision Amendment ☐

PROJECT DESCRIPTION: Renovation of an existing manufacturing space to construct an extraction lab and supporting spaces

CONTACT INFORMATION:

Applicant Thayer Corporation	Property Owner Lavertu Holdings, LLC
Name: Gregory Marles	Name: Mark Lavertu
Address: 1400 Hotel Road, Auburn	Address:10 Harmony drive, Standish
Zip Code 04210	Zip Code04084
Work #: 1-800-649-4197	Work #: 207-572-6372
Cell #: 207-713-2774	Cell #: 207-572-6372
Fax #:	Fax #:
Home #:	Home #:
Email:gmarles@thayercorp.com	Email: Marklavertu@gmail.com)

Project Representative Thayer Corporation	Other professional representatives for the project (surveyors, engineers, etc.),
Name: Gregory Marles	Name: Daniel Thayer
Address: 1400 Hotel Road, Auburn	Address: 1400 Hotel Road, Auburn
Zip Code04210	Zip Code 04210
Work #:1-800-649-4197	Work #:1-800-649-4197
Cell #:1-207-713-2774	Cell #:1-207-576-4197
Fax #:	Fax #:
Home #:	Home #:
Email:gmarles@thayercorp.com	Email:dthayer@thayercorp.com

PROJECT DATA

The following information is required where applicable, in order to complete the application

IMPERVIOUS SURFACE AREA/RATIO

Existing Total Impervious Area	15103	sq. ft.
Proposed Total Paved Area	0	sq. ft.
Proposed Total Impervious Area	15103	sq. ft.
Proposed Impervious Net Change	0	sq. ft.
Impervious surface ratio existing	30	% of lot area
Impervious surface ratio proposed	0	% of lot area

BUILDING AREA/LOT COVERAGE

Existing Building Footprint	27000	sq. ft.
Proposed Building Footprint	0	sq. ft.
Proposed Building Footprint Net change	0	sq. ft.
Existing Total Building Floor Area	27000	sq. ft.
Proposed Total Building Floor Area	0	sq. ft.
Proposed Building Floor Area Net Change	0	sq. ft
New Building	no	(yes or no)
Building Area/Lot coverage existing	55	% of lot area
Building Area/Lot coverage proposed	0	% of lot area

ZONING

Existing	UE	
Proposed, if applicable	UE	

LAND USE

Existing
Manufacturing
Proposed
Manufacturing

RESIDENTIAL, IF APPLICABLE: N/A

Existing Number of Residential Units	
Proposed Number of Residential Units	
Subdivision, Proposed Number of Lots	

PARKING SPACES

Existing Number of Parking Spaces	29	
Proposed Number of Parking Spaces **0**		
Required Number of Parking Spaces **24**		
Number of Handicapped Parking Spaces **0**		

ESTIMATED COST OF PROJECT

$449,114.—

DELEGATED REVIEW AUTHORITY CHECKLIST

SITE LOCATION OF DEVELOPMENT AND STORMWATER MANAGEMENT

Existing Impervious Area		sq. ft.
Proposed Disturbed Area		sq. ft.
Proposed Impervious Area		sq. ft.

1. ***If the proposed disturbance is greater than one acre, then the applicant shall apply for a Maine Construction General Permit (MCGP) with MDEP.***
2. ***If the proposed impervious area is greater than one acre including any impervious area crated since 11/16/05, then the applicant shall apply for a MDEP Stormwater Management Permit, Chapter 500, with the City.***
3. ***If total impervious area (including structures, pavement, etc) is greater than 3 acres since 1971 but less than 7 acres, then the applicant shall apply for a Site Location of Development Permit with the City. If more than 7 acres then the application shall be made to MDEP unless determined otherwise.***
4. ***If the development is a subdivision of more than 20 acres but less than 100 acres then the applicant shall apply for a Site Location of Development Permit with the City. If more than 100 acres then the application shall be made to MDEP unless determined otherwise.***

TRAFFIC ESTIMATE

Total traffic estimated in the peak hour-existing (Since July 1, 1997) _____ passenger car equivalents (PCE)

Total traffic estimated in the peak hour-proposed (Since July 1, 1997) _____ passenger car equivalents (PCE)

If the proposed increase in traffic exceeds 100 one-way trips in the peak hour then a traffic movement permit will be required.

Zoning Summary

1. Property is located in the _____zoning district.
2. Parcel Area: _____acres / _____ square feet(sf).

Regulations	Required/Allowed	Provided
Min Lot Area	_____ /	_____
Street Frontage	_____ /	_____
Min Front Yard	_____ /	_____
Min Rear Yard	_____ /	_____
Min Side Yard	_____ /	_____
Max. Building Height	_____ /	_____
Use Designation	_____ /	_____
Parking Requirement	1 space/ per_____ square feet of floor area	
Total Parking:	_____ /	_____
Overlay zoning districts (if any):	_____ /	_____ / _____
Urban impaired stream watershed?	YES/NO If yes, watershed name_____	

DEVELOPMENT REVIEW APPLICATION SUBMISSION

Submission shall include payment of fee and fifteen (15) complete packets containing the following materials:

1. Full size plans containing the information found in the attached sample plan checklist.
2. Application form that is completed and signed.
3. Cover letter stating the nature of the project.
4. All written submittals including evidence of right, title and interest.
5. Copy of the checklist completed for the proposal listing the material contained in the submitted application.

Refer to the application checklist for a detailed list of submittal requirements.

L/A's development review process and requirements have been made similar for convenience and to encourage development. Each Citys ordinances are available online at their prospective websites:
Auburn: www.auburnmaine.org under City Departments/ Planning and Permitting/Land Use Division/Zoning Ordinance
Lewiston: http://www.ci.lewiston.me.us/clerk/ordinances.htm Refer to Appendix A of the Code of Ordinances

I hereby certify that I am the Owner of record of the named property, or that the owner of record authorizes the proposed work and that I have been authorized by the owner to make this application as his/her authorized agent. I agree to conform to all applicable laws of this jurisdiction. In addition, I certify that the City's authorized representative shall have the authority to enter all areas covered by this permit at any reasonable hour to enforce the provisions of the codes applicable to this permit.

This application is for development review only; a Performance Guarantee, Inspection Fee, Building Permit Application and other associated fees and permits will be required prior to construction.

Signature of Applicant:	Date:
GREGORY MARLEI Thayer Corporation GM/COO	3-17-2020

F-1 Occupancy

Moderate-hazard factory and industrial occupancies not classified as Group F, Division 2, occupancies.

- ☐ See Section 202 for definition of "Story above Grade Plane" and Section 502 for definition of "Building Height."
- ☐ See Section 504.2 for permitted height and story increases in a building protected by an automatic sprinkler system (not applicable for Groups H-1, H-2, H-3, H-5 and
- ☐ I-2 of Types IIB, III, IV and V construction).
- ☐ See Section 505 for buildings containing mezzanines.
- ☐ Area indicated is basic allowable for buildings one story in height per Table 503. See Sections 506.4 and 506.5 for allowable areas of buildings more than one story in height.
- ☐ See Section 506.2 for allowable area increases for adequate frontage.
- ☐ In fully sprinklered buildings, see Section 506.3 for area increases (not applicable for Groups H-1, H-2 and H-3).
- ☐ See Sections 506.4 and 506.5 for allowable area limitations for basements.
- ☐ For allowable area of mixed-occupancy buildings, see Sections 506.5, 508.2.3, 508.3.2 and 508.4.2.
- ☐ Fire walls are to be constructed in accordance with Section 706. See Section 706.1.1 for party walls.
- ☐ Based on Table 602, nonbearing exterior walls having a fire separation distance of at least 30 feet do not require a fire-resistance rating.
- ☐ See Section 705.5 for fire-resistance-rated construction requirements for exterior walls when considering fire separation distance.
- ☐ For protection of projections from exterior walls, see Sections 705.2 and 1406.3. For parapet requirements, see Section 705.11.
- ☐ For exterior wall requirements for buildings on the same lot, see Section 705.3.
- ☐ In Type I buildings, the fire-resistance ratings of the primary structural frame and interior bearing walls are permitted to be reduced by 1-hour when the frame/walls support a roof only (see Note a, Table 601).
- ☐ In other than Type IV construction, interior nonbearing walls and partitions require no fire-resistance rating per Table 601. For interior nonbearing partitions in Type IV construction, see Section 602.4.6.
- ☐ For use of combustible material in Type I and II construction, see Section 603.1.
- ☐ Reductions in the minimum construction types in high-rise buildings are permitted for Type IA and IB buildings (other than Groups F-1, M and S-1) as set forth in Section 403.2.1.1.
- ☐ Heavy timber shall be permitted where I-hour or less fire-resistant construction is required (see Note c, Table 60 I).
- ☐ In Type I and II construction, fire-retardant-treated wood shall be permitted as part of the roof system, except in Type I buildings greater than two stories with the uppermost story less than 20 feet in height (see Section 603.1, #25.3).
- ☐ See Table 1505.1, Note c, for roof coverings of wood shakes or shingles.
- ☐ See Section 708.4 for shaft enclosure fire-resistance requirements. For exceptions to shaft enclosure provisions, see Section 708.2.
- ☐ For buildings not greater than 420 feet in height, the required rating of shaft enclosures in high-rise buildings (other than exit enclosures and elevator hoistways) may be reduced to 1-hour (see Section 403.2.1.2).

- ☐ A shaft enclosure is not required in fully sprinklered buildings at openings for escalators and nonrequired stairways meeting specified conditions (see Section 708.2, Exception 2).
- ☐ In other than Group I-2 and I-3 occupancies, a shaft enclosure is not required for openings that comply with the seven conditions of Exception 7 to Section 708.2.
- ☐ See Table 803.9 for interior wall and ceiling finish requirements. For floor finishes, see Section 804.
- ☐ In buildings fewer than three stories in height, Class B interior finishes are permitted in exit enclosures of nonsprinklered buildings and Class C for sprinklered buildings. (See Table 803.9, Note a)
- ☐ See Table 508.2.5 for separation of incidental accessory occupancies.
- ☐ In mixed-occupancy buildings regulated as nonseparated occupancies, the most restrictive type of construction shall apply to the entire building (see Section 508.3.1).
- ☐ In a mixed-occupancy building where the provisions of Section 508.4 for separated occupancies are utilized, the occupancies shall be separated in accordance with Table 508.4.
- ☐ Where a fire wall also separates occupancies that are required to be separated by a fire barrier, the most restrictive requirements of each separation shall apply (see Section 706.1).
- ☐ See Table 715.4 for opening protective fire-protection ratings.
- ☐ The maximum allowable area of unprotected openings in buildings (other than Group H-1, H-2 and H-3 occupancies) equipped throughout with an automatic sprinkler system ("UP, S") is equivalent to that allowed for protected openings. (See Table 705.8)
- ☐ For the maximum area of unprotected and protect openings located in an exterior wall, use Equation 7-2 from Section 705.8.4.
- ☐ See Section 705.8.1, Exception 2 for permitted unlimited unprotected openings in buildings whose exterior walls and exterior primary structural frame are not required to be fire-resistance rated.
- ☐ Where dividing a building into multiple fire areas so as not to exceed the limits of Section 903.2 for required sprinkler systems, see Sections 707.3.9 and 901.7.
- ☐ The area of one- or two-story Group B, F, M or S occupancies with automatic sprinkler systems may be unlimited where complying open space is provided around the building (see Sections 507.3 and 507.4).
- ☐ For allowances and limitations on Group H-2, H-3 and H-4 fire areas in unlimited area buildings containing Group F or S occupancies, see Section 507.8.
- ☐ See Section 503.1.1 for area and height exemptions for buildings housing special industrial processes that require large areas and unusual heights.
- ☐ A manual fife alarm system shall be provided in Group F occupancies that meet both of the following conditions (see Section 907.2.4 and exception):
- ☐ The occupancy is two or more stories in height.
- ☐ More than 500 occupants are located above or below the lowest level of exit discharge.
- ☐ An automatic sprinkler system shall be provided for Group F-1, M and S-1 occupancies (see Sections 903.2.4, 903.2.7 and 903.2.9) where one of the following conditions exists:
  - The fire area exceeds 12,000 square feet.
  - The sum of all fire areas exceeds 24,000 square feet.
  - The fire area is located more than three stories above grade plane.
- ☐ Group F-1 occupancy fire areas containing woodworking operations in excess of 2,500 square feet that generate finely divided combustible waste or materials shall be provided with an automatic sprinkler system (see Section 903.2.4.1).
- ☐ Where the separated use provisions require a fire barrier between Group S-2 occupancies and other occupancies, the fire rating may be reduced by 1 hour but to no less than I hour where the Group S-2 is limited to the parking of private vehicles (see Note b, Table 508.4).

- ☐ In other than Group R-3 and U occupancies, an automatic sprinkler system shall be provided on windowless stories as set forth in Section 903.2.11.1.
- ☐ An automatic sprinkler system shall be installed in all buildings with a floor level having an occupant load of30 or more located 55 feet or more above the lowest level of fire department vehicle access (See Section 903.2.11.3). See exceptions for airport control towers, open parking garages and Group F-2 occupancies.
- ☐ A manual fire alarm system shall be provided in lumber, wood structural panel and veneer mills. (See Section 907.2.17 and IFC Section 1904.2.1).
- ☐ Shaft rating is generally not applicable due to permitted number of stories. Because a story height increase (see Section 504.2) or a basement (See Sections 506.4 or 506.5) will change the permitted number of stories, the shaft rating may be applicable.

ZONING AND LAND USE CODE APPLICATION FEE SCHEDULE

In accordance with the provisions of the Code of Ordinances of the City of Lewiston, the City Council hereby establishes the following application fees:

Zoning Amendments	
Text Amendment	$400 + PRA
Map Amendment	$400 + PRA
Zoning Board	
Appeal/Interpretation/Variance/Conditional Use Permit: Multiple appeal types ie. administrative/interpretational/variance, etc are $150 per appeal type	$150 + PRA
Site Plan Review	
Minor projects: Interdepartmental/Staff Review	$200
Major Projects and Subdivision of Existing Structures: Planning Board Review/Special Exceptions	$500 + PRA
Site Plan Amendment	
Staff Approved Amendment/De minimis change	$100
Planning Board Approved Amendment	Same as Site Plan Review Major Projects fee above
Subdivision Review	
New lots/structures	$750 for first 3 lots, plus $100 per unit thereafter
Delegated Review (In addition to Site Plan or Subdivision fee when required)	
Includes one or all areas (stormwater, TMP, Site Law, etc.)	$1000 plus applicable site plan review fee
Zoning Conformance/Rebuild Letter	$50

Independent professional review fees

Staff may determine, due to the size and nature of a project, that a peer review is necessary to generate facts sufficient to warrant a finding that certain applicable criteria have been meet. The developer/applicant is responsible for the additional costs of this peer review.

Engineering Inspection Fees

Inspections required by the City Engineer for projects that directly impact municipal infrastructure or for proposed city streets shall be paid for by the developer/applicant.

ZONING AND LAND USE CODE APPLICATION FEE SCHEDULE

PRA: Plus Required Advertising

$100 per required public newspaper notice (see table below)

Request Type	Planning Board(PB) or Zoning Board(ZB)	City Council (CC)	Total Advertising fee
Zoning Ordinance Text or Map Amendment Petitions	2 PB	1 CC	$300
Zoning Board of Appeals	2ZB(Auburn) 0ZB (Lewiston)	0	$200 N/A
Site Plan Review (Major/Special Exception with or without Delegated Review)	2PB	0	$200

NOTES:

Delegated Review - Authority to review (1) large developments that generate 100+ trips in an hour [TMP] for MDOT; (2) development three to seven acres in area for the MDEP;(3) stormwater permits for projects that disturb 1+ acres of area for the MDEP.

MDEP - Maine Department of Environmental Protection

MDOT - Maine Department of Transportation

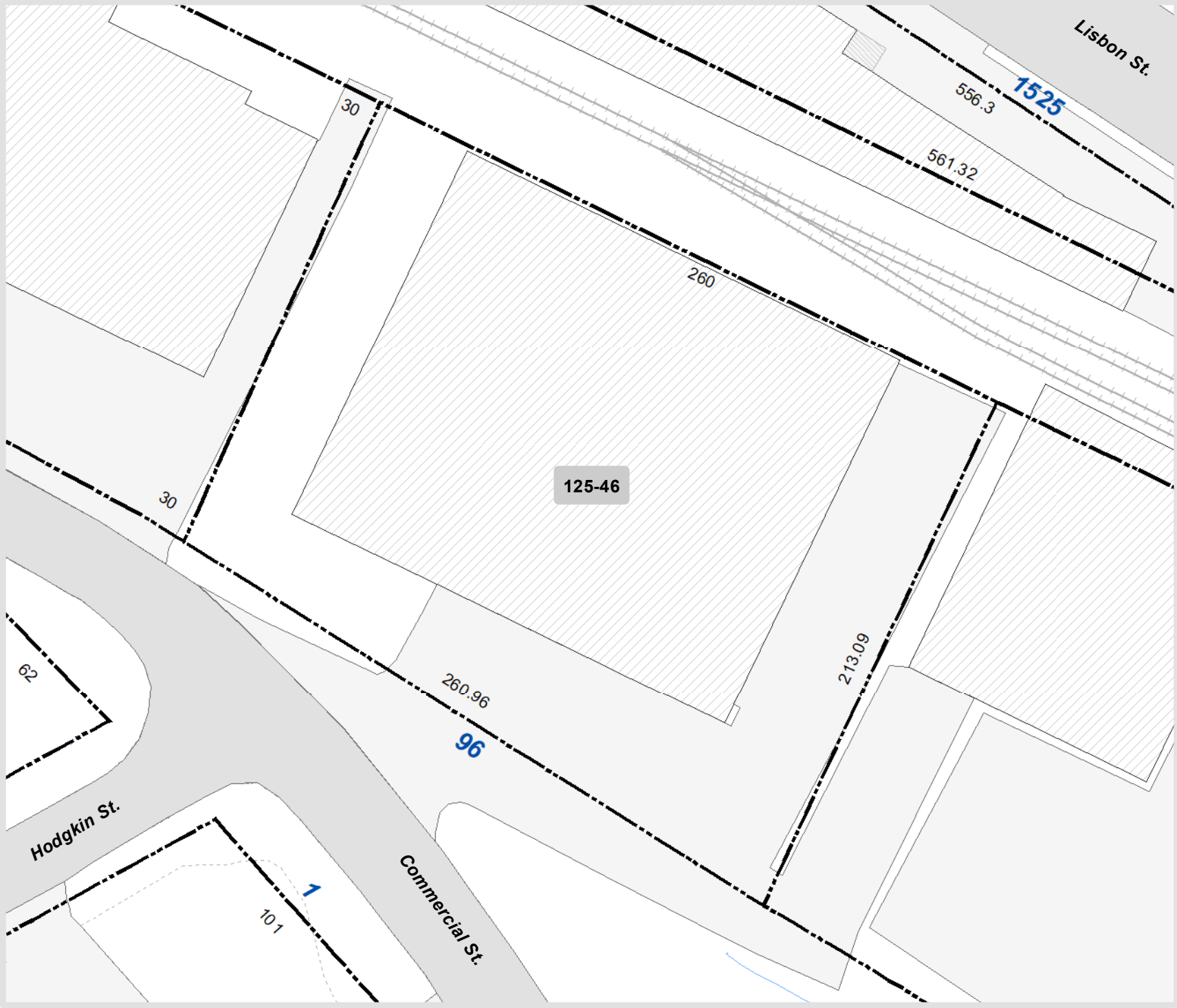
Special Exception/Conditional Use - Permitted uses subject to additional regulations and conditions.

Subdivision of Existing Structures - Any proposal for re-use /redevelopment of existing building(s) that result in the creation of 3 or more dwelling units.

TMP - Traffic Movement Permit

Lavertu Growers

Google Earth view of Lavertu Growers Extraction Lab facility and a 700' circle showing no schools or day care in the set back area.



This Map is provided by the City of Lewiston, ME Mapping shown on is for general reference. The City of Lewiston shall not be held liable for damages due to discrepancies, and makes no warranty of accuracy of map. Field verification is required. This map is not printed to scale.

Aproximate Map Scale:
1 in = 50 ft

Legend

- Parcel Line
- ROW
- Easement
- Mobile Home Lot
- 22 Street Address
- 123-45 Subject Map and Lot
- 100.25 Lot Dimension
- Utility ROW

Planimetric Legend:

- Building, General
- Mobile Home
- Foundation
- Deck
- Patio
- Railroad
- Fence
- Roads, Parking, Walks
- Athletic Courts, Fields
- Swimming Pool
- Lake or Pond; River; Canal
- Swamp or Apparent Wetland
- Stormwater Detention Pond
- Brooks, Streams

Cadastral mapping displayed is intended for assessment purposes only, and shall not be used in place of a boundary survey. Do not use for description delineation, or transfer of property.

Parcel ID

RE00006553

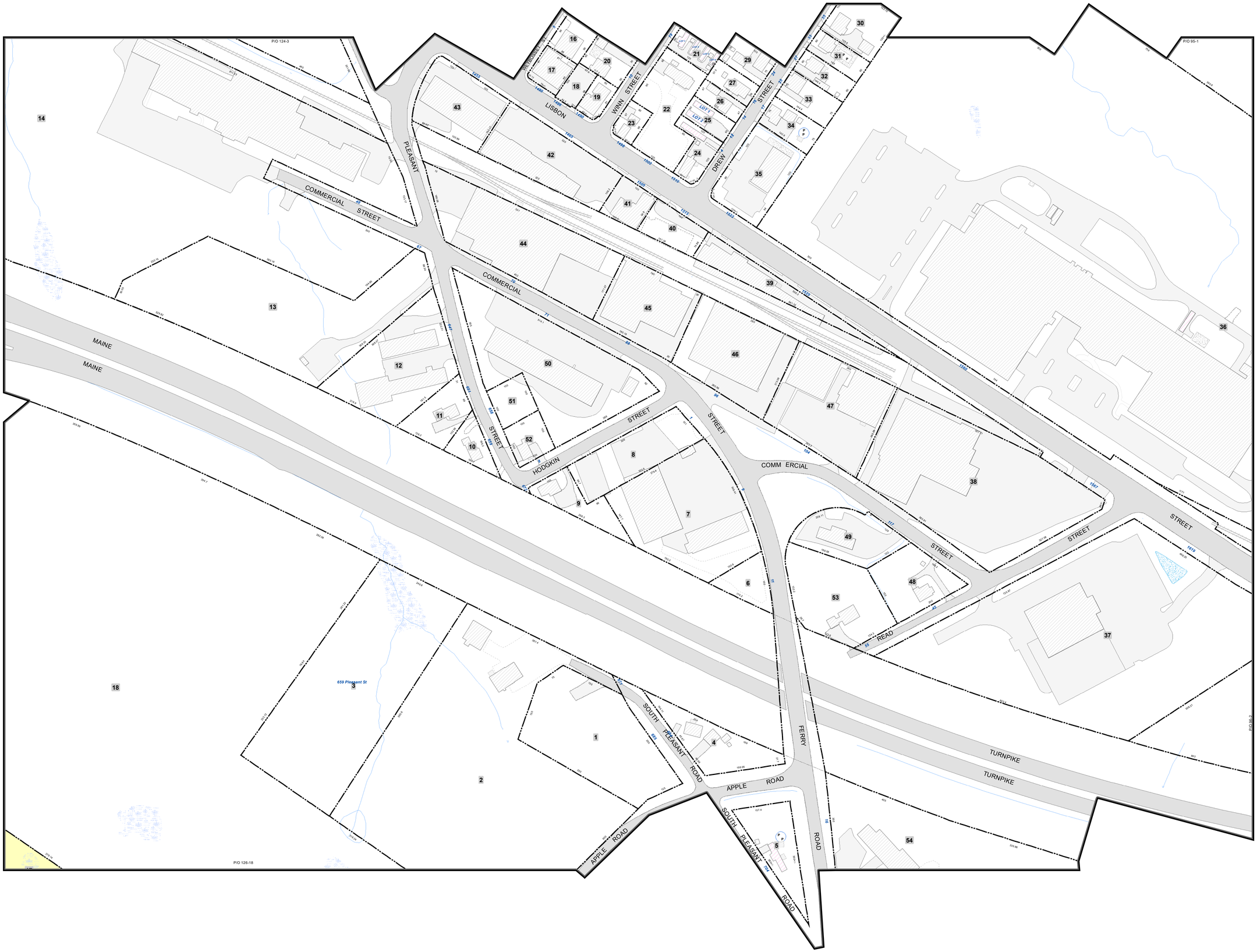
96 COMMERCIAL ST

Tax Map Ref: 125-46

Tax Mapping
Effective April 1, 2019
to March 31, 2020

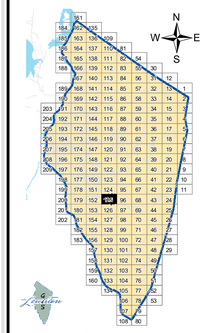
City of Lewiston
Assessing Dept.
27 Pine Street
Lewiston Maine 04240

10/21/2019



CITY OF LEWISTON
LEWISTON INCORPORATED 1795
INDUSTRY
BECAME A CITY 1863

This Map is provided by the City of Lewiston, Maine. Planimetric mapping shown on this map is for general reference and conditions as observed from aerial photography performed April 30, 2013, by Woolpert, Inc of Dayton Ohio. In addition planimetric features are also periodically updated by city staff and may or may not reflect actual field conditions to coincide with the applicable tax year on any given parcel. The City of Lewiston shall not be held liable for damages due to discrepancies, and makes no warranty of accuracy of map. Field verification is required.



Tax Map Index Indicator

Legend

- City Limits
- Parcel Line
- ROW
- Easement
- Misc. or Mobile Home Lot
- Proposed Subdivison
- 22 Street Address
- 48 Tax Map Lot No.
- 160.25 Lot Dimension
- Utility ROW

Planimetric Legend:

- Building, General
- Mobile Home
- Foundation
- Deck
- Patio
- Railroad
- Dam
- Roads, Parking, Walks
- A Athletic Courts, Fields
- P Swimming Pool
- Lake or Pond; River; Canal
- Swamp or Apparent Wetland
- Stormwater Detention Pond
- Brooks, Streams

0 50 100 200

Scale: 1" = 100'

** see note at bottom of page

Cadastral mapping which is displayed here is intended for assessment purposes only. It is not considered a substitution for a proper boundary survey. Do not use for description, delineation, or transfer of property.

Tax Map

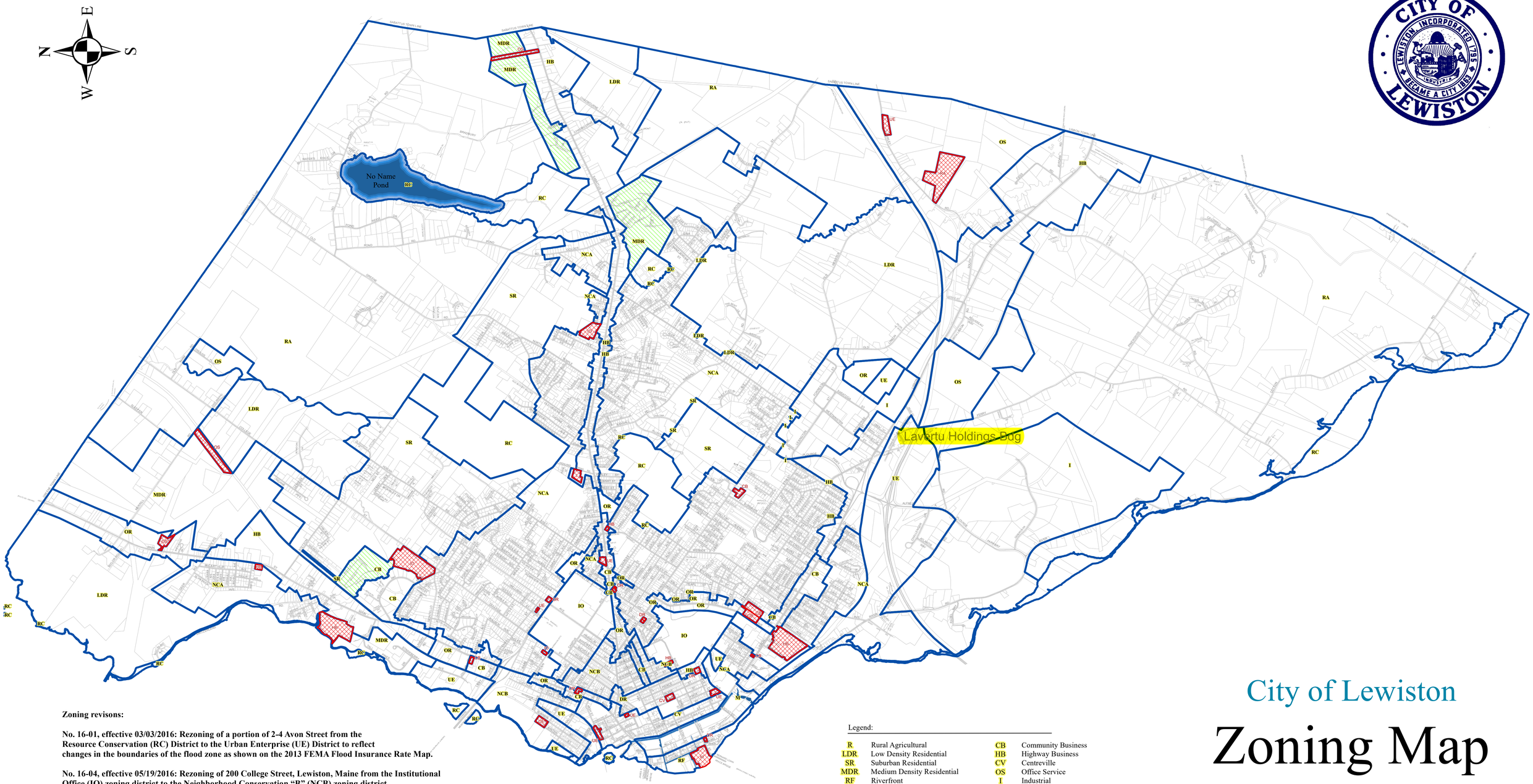
Effective April 1, 2019 to March 31, 2020

151	124	95
152	125	96
153	126	97

City of Lewiston
Assessing Dept.
27 Pine Street
Lewiston Maine 04240

** Scale noted above is approximate assuming the map is printed at full size 25"x36" layout as intended. The black outline title frame immediately above should measure exactly 23"h x 3"w as a hardcopy.

10/8/2019



City of Lewiston

Zoning Map

January 2017

Not to Scale

Zoning revisons:

No. 16-01, effective 03/03/2016: Rezoning of a portion of 2-4 Avon Street from the Resource Conservation (RC) District to the Urban Enterprise (UE) District to reflect changes in the boundaries of the flood zone as shown on the 2013 FEMA Flood Insurance Rate Map.

No. 16-04, effective 05/19/2016: Rezoning of 200 College Street, Lewiston, Maine from the Institutional Office (IO) zoning district to the Neighborhood Conservation "B" (NCB) zoning district.

No. 16-09, effective 10/20/2016: Conditional rezoning of 117 Webster Street, from the Neighborhood Conservation "A" (NCA) zoning district to the Downtown Residential (DR) zoning district.

No. 16-13, effective 12/15/2016: Rezoning of the even-numbered addressed properties on the north side of King Avenue, 10 King Avenue to 108 King Avenue, from the Community Business (CB) district to the Neighborhood Conservation "A" (NCA) district.

Legend:

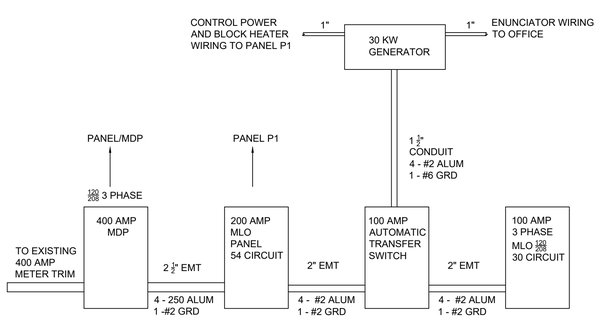
R	Rural Agricultural	CB	Community Business
LDR	Low Density Residential	HB	Highway Business
SR	Suburban Residential	CV	Centreville
MDR	Medium Density Residential	OS	Office Service
RF	Riverfront	I	Industrial
NCA	Neighborhood Conservation "A"	UE	Urban Enterprise
NCB	Neighborhood Conservation "B"	M	Mill
OR	Office Residential	RC	Resource Conservation
DR	Downtown Residential		Zoning Boundary
IO	Institutional Office		Mobile Home Overlay
			Conditional Rezoning

4/18/2017

- Lighting, Three Head Emergency Battery Power
- Lighting, Two Head Emergency Battery Power
- Lighting, One Head Emergency Battery Power
- Lighting, One Head Emergency Battery Power
- Exit sign, wall mounted w/ directional arrows and faces as shown
- Exit sign, ceiling mounted w/ directional arrows and faces as shown
- Control Panel
- Video Camera
- Door Contact
- Key Pad
- Motion Detector
- Network Video Recorder

ITEM #	DESCRIPTION	MANUFACTURER	RESPONSIBLE PARTY	VOLTAGE	AMPACITY	REMARKS
1	C1D1 LED LIGHT	LARSON	LIFESPRING	110V	.05	
2	EXHAUST FAN	COOK	LIFESPRING	220V	10	NEEDS BACK UP POWER
3	AXIAL FAN	CAN-FAN	LIFESPRING	110V	6.3	
4	HYDROCARBON SENSOR	RKI	LIFESPRING	24V	1	NEEDS BACK UP POWER
5	DUCT HEATER, INSIDE	INDEECO	LIFESPRING	220V	42	
6	DUCT HEATER, OUTSIDE	INDEECO	LIFESPRING	220V	42	
7	C1/D1 EXIT SIGN		LIFESPRING	N/A		SELF ILLUMINATING
8	MINI SPLIT INSIDE	DAIKEN	LIFESPRING	220V	1	
9	MINI SPLIT OUTSIDE	DAIKEN	LIFESPRING	220V	20	
10	AUDIBLE/STROBE ALARM	EDWARDS SIGNAL	LIFESPRING	110V	1	NEEDS BACK UP POWER
11	STACK SENSOR	GRAINGER	LIFESPRING	110V	15	
12	UL LISTED CONTROL PANEL	LIFESPRING	LIFESPRING	110V	5	NEEDS BACK UP POWER
13	UTILITY ROOM LED LIGHTS			110V	05	OPTIONAL
14	OUTLET 220V		LAVERTU	QTY 2 FOR CHILLERS	20	OPTIONAL
15	OUTLET 110V		LAVERTU	QTY 3 (2 INSIDE & 1 OUTSIDE)	20	OPTIONAL
16	MAGNAHELIC GAGE	DWYER	LIFESPRING	N/A	20	NO POWER
17	AIR COMPRESSOR		LIFESPRING	240V	10.7	
18						
19						
20						

TOTAL AMPS 184.3



General Notes:

Electrical Systems of Maine Inc.
www.electricalsystemsofmaine.com
1200 Minot Avenue
Auburn Maine 04210
Phone: 207-783-7126
Fax: 207-795-0311

Drawing Status:

Designs For:

Lavertu Extraction Lab

96 Commercial Street
Lewiston, Me

Revision	DATE

Sheet Title:

BUILDING
KEY PLAN

Scale:

Drawn by: SM

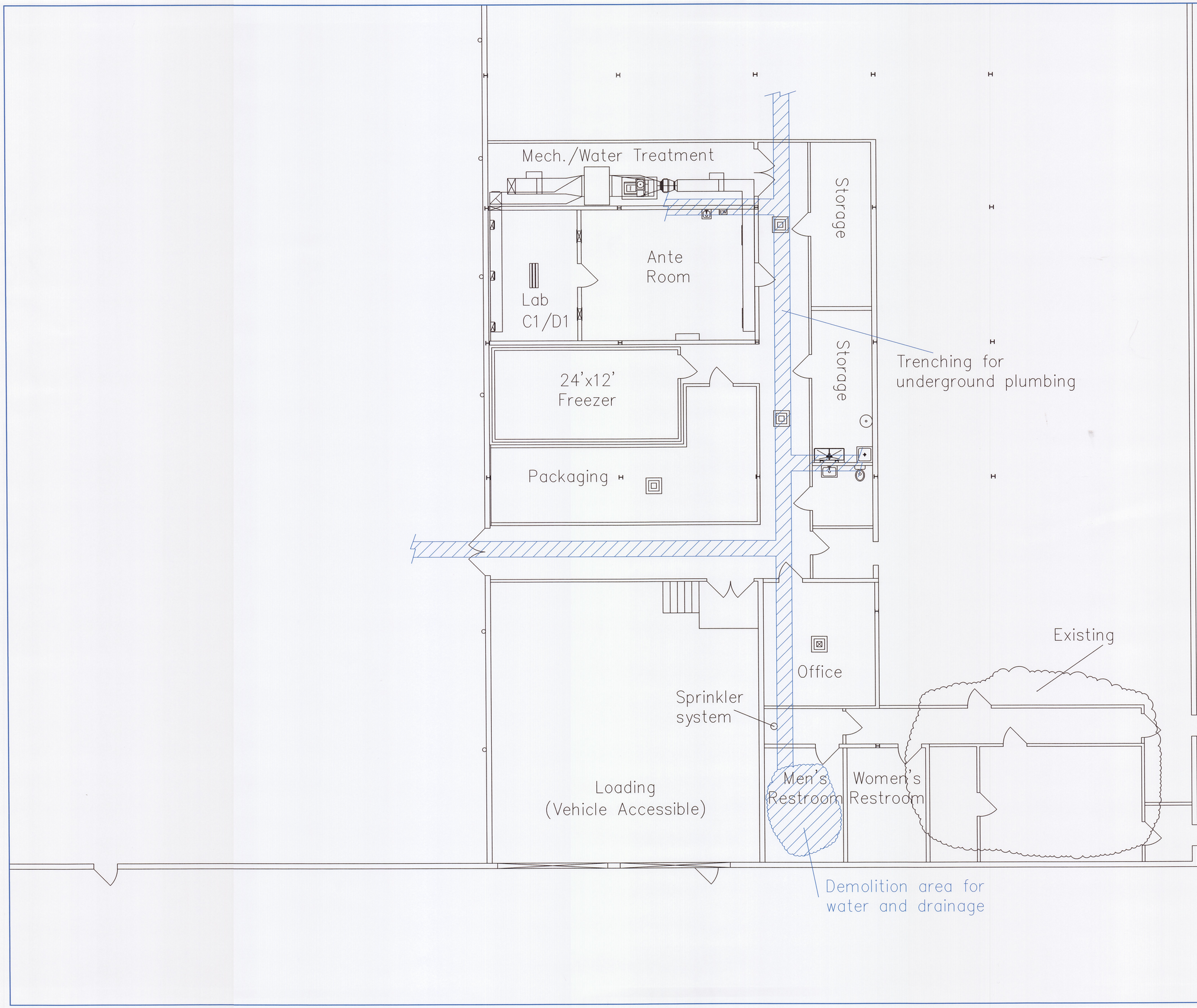
Checked by: SM

Project No: 1

Date: 3/11/2020

Sheet No:

WARNING: THIS DRAWING IS THE PROPERTY OF ELECTRICAL SYSTEMS OF MAINE. ANY REPRODUCTION OR EXTENSION MAY BE MADE TO THIS DRAWING AND AS USE MAY BE MADE OF THIS DRAWING WITHOUT THE EXPRESS WRITTEN PERMISSION OF ELECTRICAL SYSTEMS OF MAINE INCLUDING ANY AND ALL LIABILITY FOR SOLICITOR.



Lifespring MICROCLIMATES
1400 Hotel Road
AUBURN, MAINE 04210
Tel. (207)782-4197

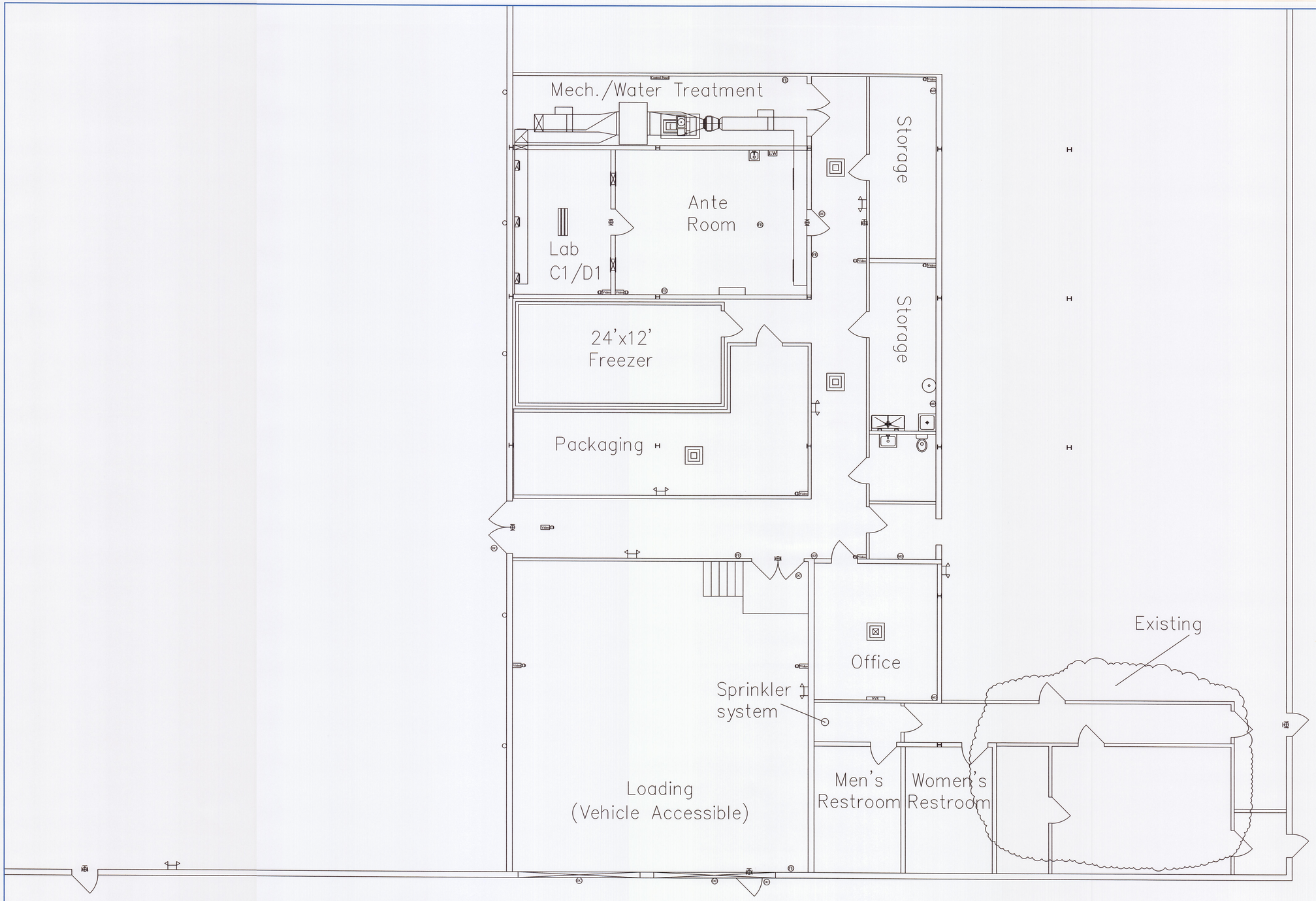
REV.	DESCRIPTION	DATE
1	Permit Copy	
0	Plan with trench for sub-surface evaluation	3/17/20

STATE OF MAINE DANIEL D. THAYER No. 5070 LICENSED PROFESSIONAL ENGINEER

PROJECT: Lavertu Lab
96 Commercial Street
Lewiston, ME 04240

SHEET TITLE: Floor Alteration

SCALE:	NTS	DATE:	12/17/19
PROJECT MANAGER:	MS		
JOB CAP/DRAWN:	MS		
E OF RECORD:	D.THAYER,P.E.	SHEET No.	ALTERATION
THAYER CAD FILE	PL-2		



- Lighting, Three Head Emergency Battery Power
- Lighting, Two Head Emergency Battery Power
- Lighting, One Head Emergency Battery Power
- Lighting, One Head Emergency Battery Power
- Fire Extinguisher, ABC
- Exit sign, wall mounted w/ directional arrows and faces as shown
- Exit sign, ceiling mounted w/ directional arrows and faces as shown
- Control Panel
- Video Camera
- Door Contact
- Key Pad
- Motion Detector
- Network Video Recorder

Lifespring MICROCLIMATES

1400 Hotel Road
AUBURN, MAINE 04210
Tel. (207)782-4197

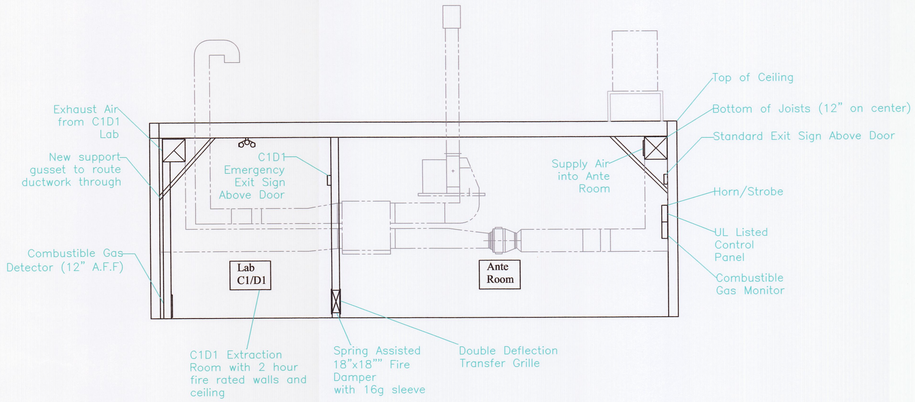
REV.	DESCRIPTION	DATE
1	Permit Copy	
0	Security and safety Plan	3/17/2020

STATE OF MAINE DANIEL D. THAYER No. 6090 LICENSED PROFESSIONAL ENGINEER 3/19/20

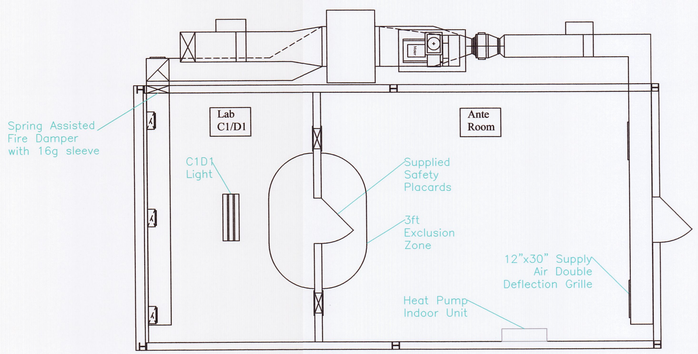
PROJECT: Lavertu Lab
96 Commercial Street
Lewiston, ME 04240

SHEET TITLE: Life/Safety

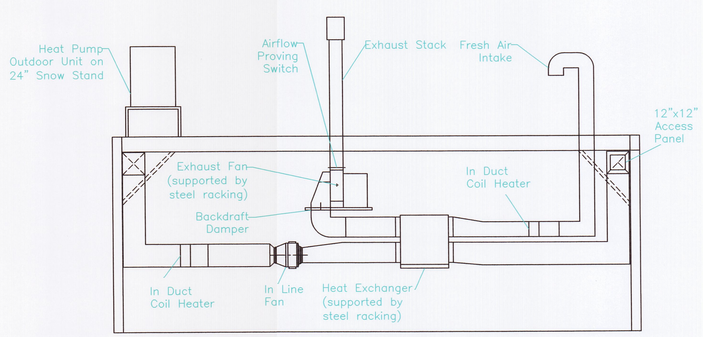
SCALE:	NTS	DATE:	12/17/19
PROJECT MANAGER:	EM		
JOB CAP/DRAWN:	EM		
E OF RECORD:	D.THAYER,P.E.	SHEET No.	L/S
THAYER CAD FILE	PL-1		



Left View



Top View



Right View (Mechanical Room)

1) Drawing Scope:

The drawing is intended to detail a layout and construction details for a closed loop extraction facility utilizing hydrocarbons. The design does not include the production equipment or procedure for its operation outside of the utilization of the facility. Requirements detailed in the following codes were incorporated into the design, other codes that were adopted by reference were also considered.

a) National Fire Protection Association NFPA 1-2018

b) NFPA 101, the Life Safety Code (2009 ed.)

c) The Maine Uniform Building and Energy Code MUBEC (based on the 2015 International Building Code (IBC) with amendments)

d) NFPA 30 Flammable and Combustible Liquids Code, (2018 ed.) (NFPA 30)

e) NFPA 1-2018, Chapter 38

f) NFPA 58 Liquefied Petroleum Gas Code (2014 ed.)

2) Extraction Room General Requirements:

The extraction process shall be performed within a dedicated room that is fully enclosed. Other than equipment that is directly associated with the extraction process, there must be no other equipment in the room (i.e. refrigerators, cooking appliances, electrical panels, computers, cell phones, etc.) except for an approved eyewash station. Smoking, open flames, direct-fired heating devices, etc., shall be prohibited from the extraction room.

Extraction processes using flammable hydrocarbons should be considered inherently dangerous. This plan will define the equipment, methods, and operation of engineering controls that will make the process safe when followed precisely. These plans and specifications are suitable for the use but not limited to Butane, Hexane, Ethanol, and LPG or other hydrocarbons listed as flammable liquids type 1A and 1B according to definitions by NFPA. If hydrocarbons other than those specifically listed are used the maximum allowable quantity (MAQ) of hydrocarbons stored in one or more control sites should be reevaluated.

No appliance and/or any electrical device including battery operated is permitted in the C1/D1 room when any hydrocarbon is present unless labeled as approved for C1/D1 environment.

Openings and penetrations into the extraction room shall be provided for any egress, mechanical, electrical, and plumbing systems serving the extraction room. Penetrations shall be tightly sealed. Non-operable glazing (i.e. windows) is permitted where glazing does not interfere with required exhaust systems. Exit doors from the extraction room shall swing in the direction of egress and be provided with panic hardware where hazardous materials are used in the extraction process. Exit doors and all egress pathways shall remain unobstructed at all times.

3) Extraction Room General Signage:

The NFPA 704 Hazard Rating Diamond sign shall be posted on the exterior of the extraction room door and on the main entrance of the facility.

Smoking shall be prohibited and "NO SMOKING" signs shall be posted at the locations where hazardous materials are stored, dispensed, or used in accordance with IFC 2703.7.1. Additional signage may be required by the state or local code official.

4) General Notes:

1. Perform all work in a neat, workmanlike fashion. Coordinate construction and laydown areas with owner.
2. Install equipment in a manner that is conducive to servicing.
3. All penetrations shall be sealed in accordance to applicable fire codes and local ordinances and shall maintain a weather tight seal.
4. Install and startup equipment in accordance with manufacturers written instructions.
5. Mechanical work shall conform to requirements of applicable NFPA, IBC, SMACNA, and ASHRAE standards.
6. Perform all electrical work in conformance with the NEC.
7. All conductive materials and equipment in extraction room shall be bonded and grounded with resistance less than 1 mega ohm.
8. Locate (2) type ABC fire extinguishers within 30 feet of extraction room door. One of which should be within 10 feet.
9. Provide a separate facility/cage outside of building for the storage of hydrocarbon containers not in use, in accordance with NFPA 30. Limit the quantity of these stored containers per NFPA 30 and NFPA 58.
10. Provide automatic fire suppression system for C1/D1 room per NFPA 1-2018 and installed per NFPA 13.
11. If LPG is used in the hydrocarbon extraction process, extraction room must have suitable standby power for exhaust fan, hydrocarbon sensor, and lighting, at a minimum.

5) Equipment:

1. Fire dampers: 1-1/2HR fire rating with fusible link. Rated in accordance with UL-555
2. Transfer air grilles: Metal construction, double deflection, and standard powder coat finish
3. Exhaust air grilles: Metal construction, balancing, and standard powder coat finish. The grilles should not exceed max static pressure drop of .04" WC at 1400 CFM
4. Differential pressure switch: Low differential air pressure switch to confirm exhaust airflow. Position coordinated with electrical controls. Include manufacturer's optional duct pressure tap kit. Set point range 0.07-0.15" WC
5. Exhaust fan: AMCA type B spark resistant construction. Motor and belt shall be out of air stream. Drive belt shall be conductive with resistance less than 1 mega ohm
6. Audible alarms: Minimum 78 DB @ 10'. Provide ability for alarm acknowledgement and silencing
7. Visual strobe: Color is amber. Not integrated with building fire alarm system
8. Combustible gas detector: Rated for C1/D1 group D environment. Alarming calibrated to 25% LEL/LFL and at 40% LEL/LFL of the most volatile hydrocarbon utilized in the extraction process.

6) Ducting:

1. Seal all seams with duct mastic to reduce leakage on supply duct and exhaust duct outside of C1/D1 space.
2. When possible provide long radius elbows and smooth transitions.
3. Insulate supply air duct outside of conditioned area with 2"thick foil faced fiberglass insulation with all seams taped.
4. All ducting and volume dampers shall be installed minimum 1" clearance from combustible materials.
5. Provide thimbles, sleeves, or other approved means for 1" clearance to combustibles when passing through walls or other barriers.
6. Provide supports at spacing indicated in SMACNA HVAC standards.
7. Install flexible duct connection at exhaust fan inlet/outlet connection. Material shall be silicon-impregnated fiberglass for fire resistance.
8. Exhaust discharge shall be a minimum 10ft from openings into building.

7) Testing, Adjusting, Balancing, and Start Up:

1. Balance all air flows to +/- 5% of specified values. After proper air balancing is achieved, lock all dampers in place. Provide report to owner for records.
   a. Balance each exhaust grille to within to +/-5% of scheduled flow rate by adjusting volume damper serving grille.
   b. Exhaust fan serving the C1/D1 space must operate at a volume sufficient to provide air movement as stated in NFPA 30, 18.6.5. The direction of airflow must be uniform toward exhaust grills.
2. Demonstrate that all normal electrical circuits in the extraction room are interlocked with exhaust fan operation as sensed by differential switch.
3. Demonstrate that exhaust fan, hydrocarbon sensor with audible/visual alarm, and lighting are interlocked.

8) Operation and Electrical Interlocks:

Maximum allowable capacity of all hydrocarbons in C1/D1 space shall be 60 gallons when in operation if containers meet requirements of U.S. D.O.T. Transportation of hazardous materials regulation in 49CFR 100-199. If containers do not meet this standard, the maximum allowable quantity in C1/D1 room shall be no greater than 1.3 gallons. All hydrocarbons must be removed and stored in designated storage area outside of building when not in use.

Hydrocarbon must be stored in lockable enclosure outside of building when not in use. The maximum allowable quantity (MAQ) stored at any time shall be 2200 gallons per NFPA 30 15.1. Storage enclosure must be 10' or greater from any door, penetration to building, electrical device, or thermal device.

The minimum separation distance from outdoor storage locker to property line is 50' and 10' to street, ally, or public way. These separation distances can be reduced by 50% if the (MAQ) is reduced by 50%.

1. All electrical components in C1/D1 extraction room, including non-essential lighting, outlets, and HVAC equipment (normal power) shall be excluded from essential interlock and be disabled at detection of unsafe level of hydrocarbons.
2. Exhaust fan must run continuously when extraction room is in operation.
3. Exhaust fan operation shall be proven by a pressure differential switch in the exhaust stack. On loss of air flow the audible/visual alarm shall alarm and all non-essential normal power circuits in the room shall be de-energized.
4. The combustible gas detector shall be calibrated to activate on 25% of the lower explosive limit/ lower flammable limit (LEL/LFL) of most volatile hydrocarbon used in normal production. Upon sensing 25% LEL/LFL the visual strobe/horn shall be energized allowing operators to take proper action.
5. If LPG is utilized in the processing, provide a suitable backup power system to operate at minimum the lighting, combustable gas detection, and exhaust fan serving the C1/D1 space per NFPA-1 2018 and applicable NEC standards.
6. No combustible gas or liquids shall be stored in C1/D1 lab while not in production.

Disclaimer and Liability Statement

The customer understands and acknowledges that the engineer-of-record and/or the installing contractor make no expressed or implied guarantees to the effectiveness or safety of using hydrocarbon based extraction equipment.

Customer agrees that in no event shall the engineer-of-record and/or installing contractor be liable for and incidental, direct, indirect, special, punitive, or consequential damages to property or life, including but not limited to, product liability, negligence, strict liability or other theory of liability, whatsoever arising out of or connected with the use or misuse of hydrocarbon based extraction systems described in this document. Customer understands the inherent dangers associated with hydrocarbon based extraction systems and assumes all risks.

Lifespring MICROCLIMATES
1400 Hotel Road
AUBURN, MAINE 04210
Tel. (207)782-4197

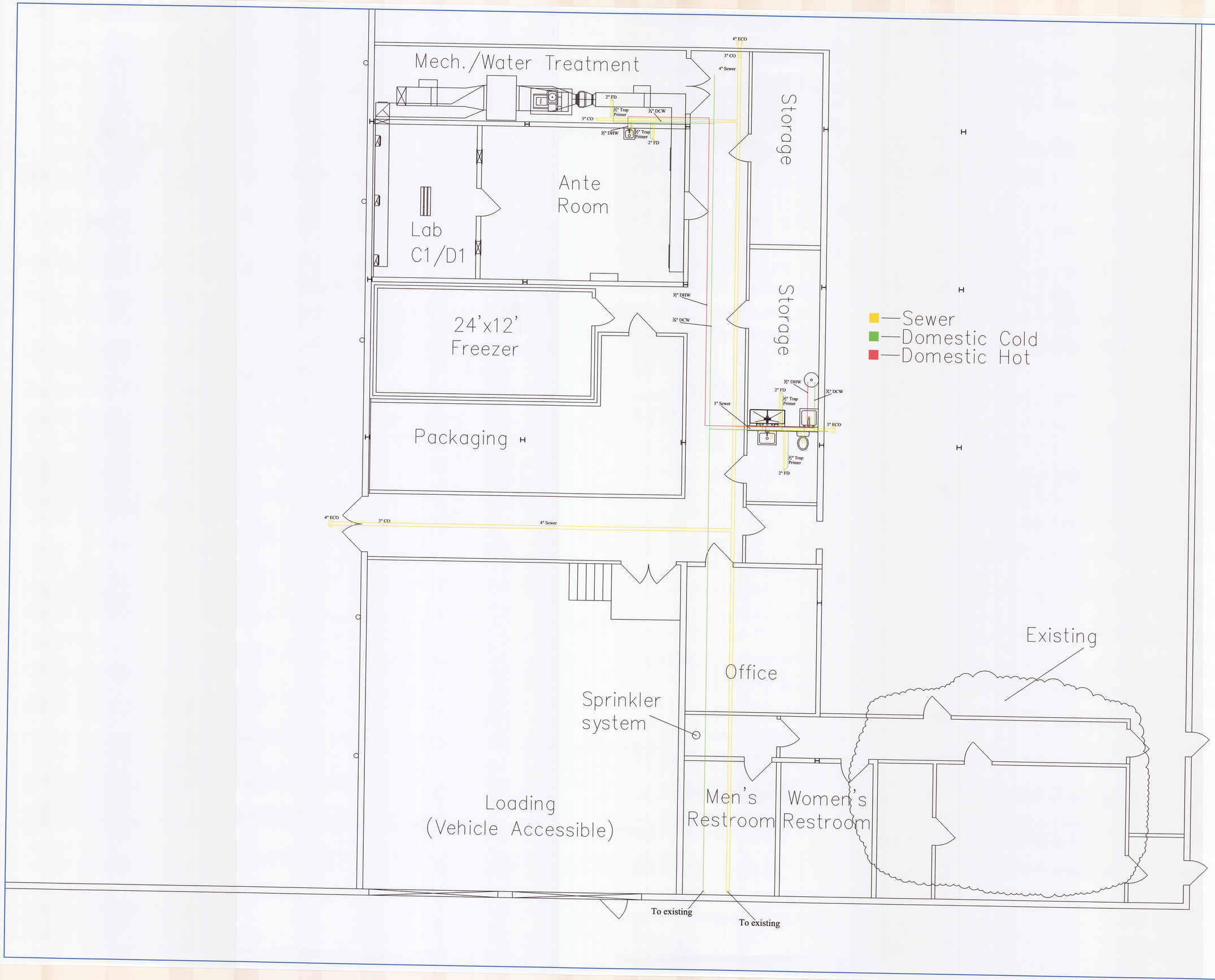
REV.	DESCRIPTION	DATE
1	Permit Copy	
0	Mechanical Plan	12/12/2019

STATE OF MAINE
DANIEL D. THAYER
No. 5070
LICENSED
PROFESSIONAL ENGINEER

PROJECT:
Lavertu Lab
96 Commercial Street
Lewiston, ME 04240

SHEET TITLE:
Lavertu Extraction Lab

SCALE:	NTS	DATE:	12/10/19
PROJECT MANAGER:	EM		
JOB CAP/DRAWN:	EM		
E OF RECORD:	D.THAYER,P.E.	SHEET No.	M1
THAYER CAD FILE	PL-1		



Lifespring MICROCLIMATES

1400 Hotel Road
AUBURN, MAINE 04210
Tel. (207)782-4197

REV.	DESCRIPTION	DATE
1	Permit Copy	
0	Plumbing plan	3/17/20

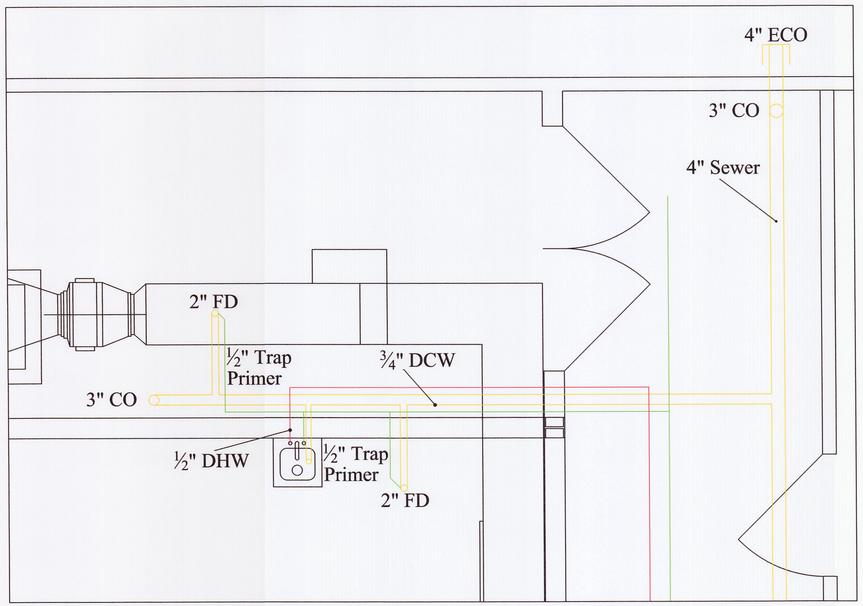
STATE OF MAINE DANIEL D. THAYER NO. 5070 LICENSED PROFESSIONAL ENGINEER 3/17/20

PROJECT:
Lavertu Lab
96 Commercial Street
Lewiston, ME 04240

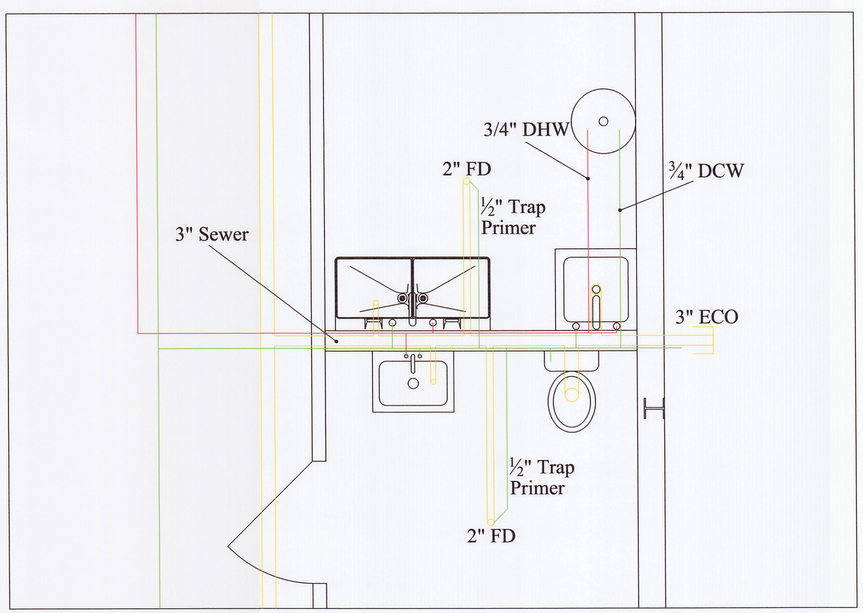
SHEET TITLE:
Plumbing Plan View A

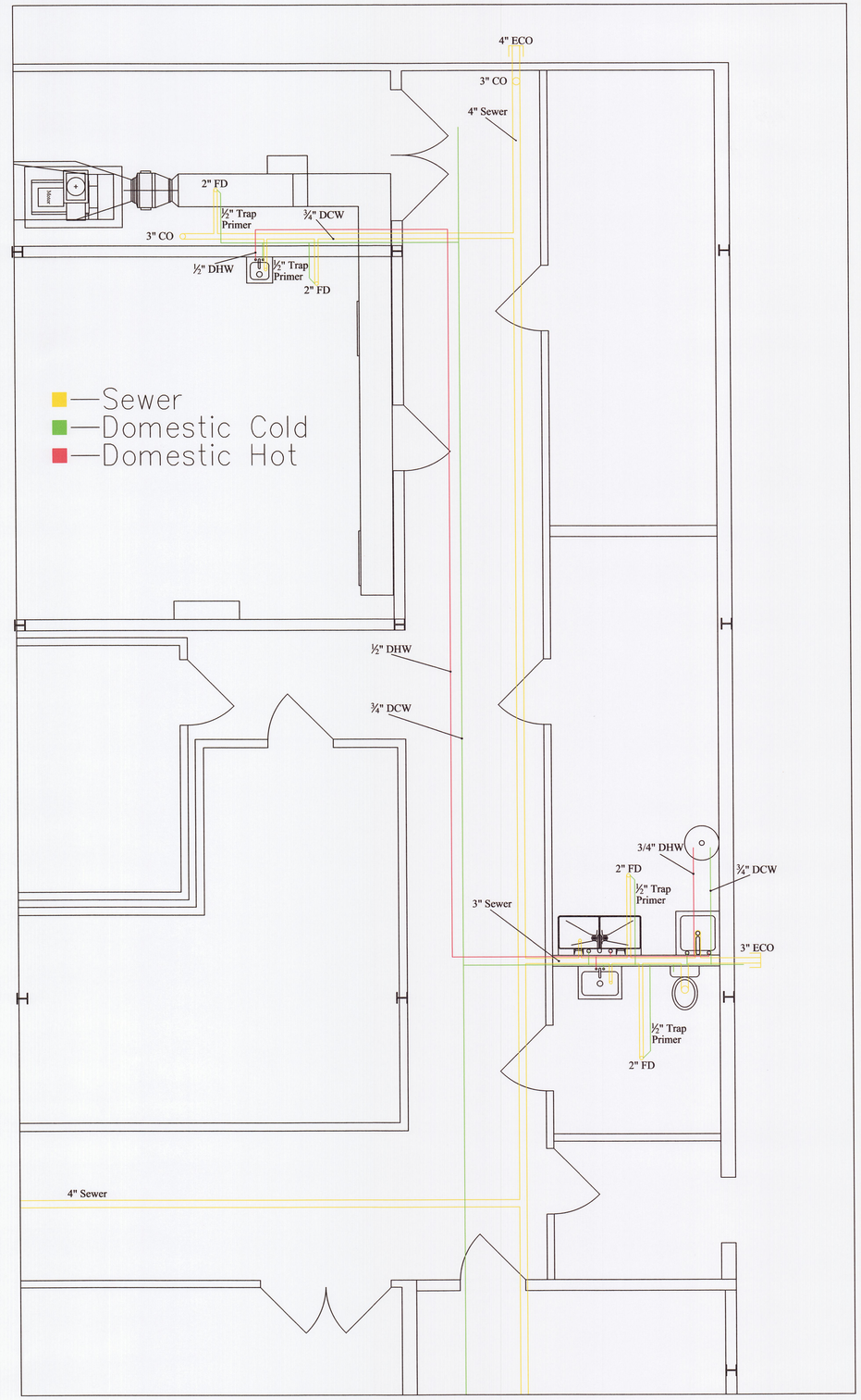
SCALE:	NTS	DATE:	3/17/20
PROJECT MANAGER:	EM		
JOB CAP/DRAWN:	EM		
E OF RECORD:	D.THAYER,P.E.	SHEET No.	
THAYER CAD FILE	PL-2	PLUMBING	

Detail 1



Detail 2





Lifespring MICROCLIMATES

1400 Hotel Road
AUBURN, MAINE 04210
Tel. (207)782-4197

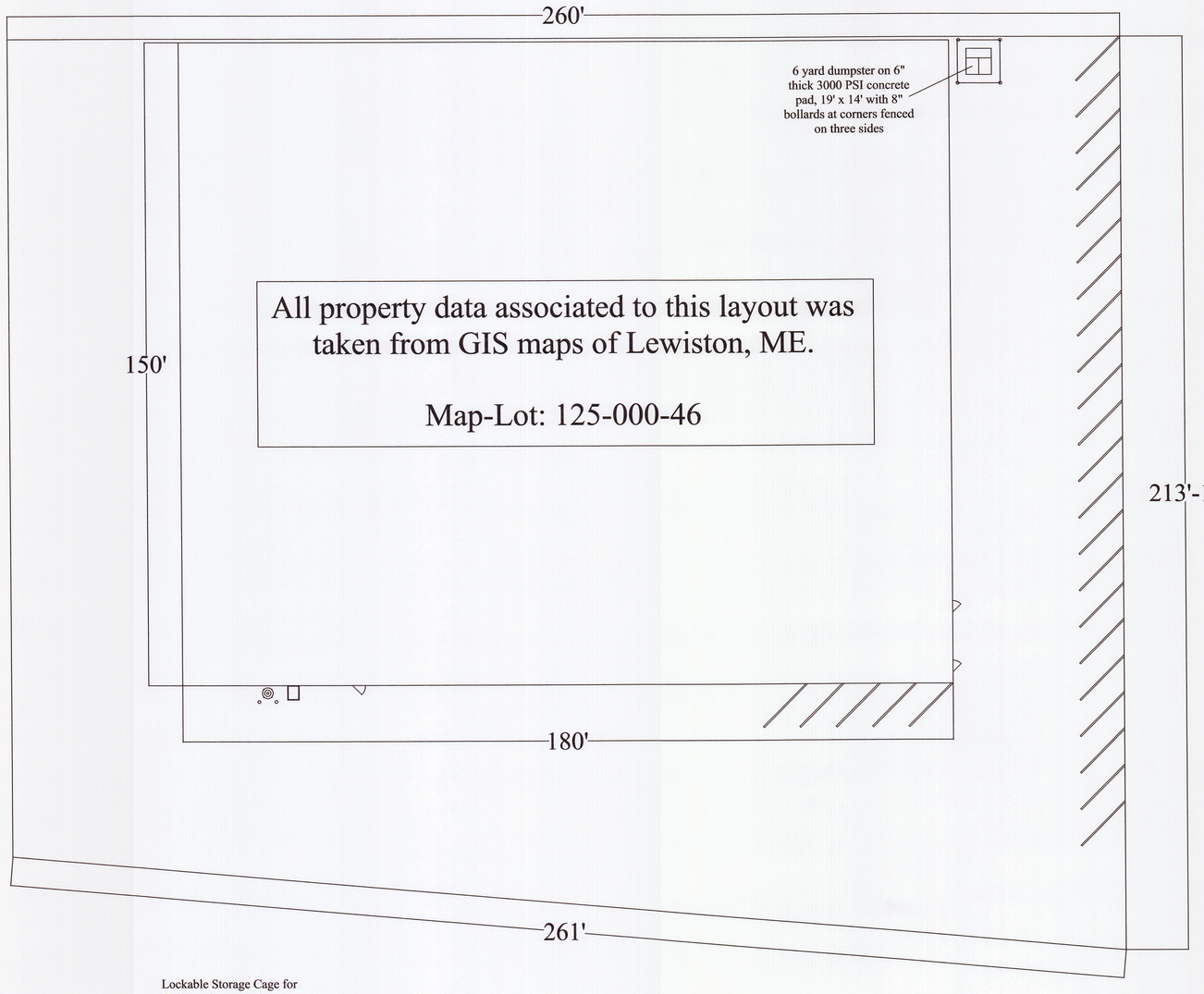
REV.	DESCRIPTION	DATE
1	Permit Copy	
0	Plumbing plan	3/17/20

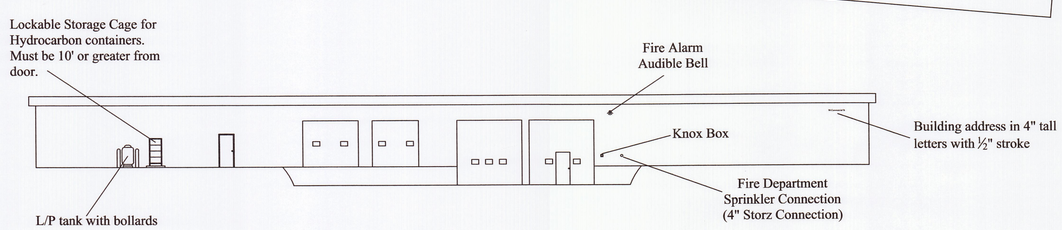
STATE OF MAINE
DANIEL D. THAYER
No. 5470
LICENSED
PROFESSIONAL ENGINEER

PROJECT:
Lavertu Lab
96 Commercial Street
Lewiston, ME 04240

SHEET TITLE:
Plumbing Plan View B

SCALE:	NTS	DATE:	3/17/20
PROJECT MANAGER:	EM		
JOB CAP/DRAWN:	EM		
E OF RECORD:	D.THAYER,P.E.	SHEET No.	
THAYER CAD FILE	PL-2	PLUMBING	





• Construction Type:	III -A
• Occupancy Classification:	F1
• Occupancy Level:	6-12
• General means of egress: Table 1004.1.2 Group F 2015 IBC	
• Maximum Occupancy:	49
• Spaces with one point of egress with sprinkler: Section 903.3.1.2 Table 1006.2.1	100 feet
• Maximum egress distance:	91 feet

Meets but not limited to:

• NFPA	1-2018
• Maine Uniform Building:	2015 IBC
• NFPA	30
• NFPA	1-2018 Ch. 38
• NFPA	58
• NFPA	70 NEC
• NFPA	10
• NFPA	13
• NFPA	731

Lot Plan

• Total square footage of lot:	48,787
• Lot Coverage Exiting:	27,000
• Percentage of Lot Coverage:	55%
• Existing total impervious area:	15,103
• Impervious surface ratio existing:	30%
• Existing number of parking spaces:	29
• Required number of parking spaces:	24

Lifespring MICROCLIMATES

1400 Hotel Road
AUBURN, MAINE 04210
Tel. (207)782-4197

REV.	DESCRIPTION	DATE
1	Permitting Copy	
0	Site Plan	3/17/2020

STATE OF MAINE DANIEL D. THAYER No. 5070 LICENSED PROFESSIONAL ENGINEER

PROJECT: Lavertu Lab
96 Commercial Street
Lewiston, ME 04240

SHEET TITLE: Site Plan

SCALE:	NTS	DATE:	3/17/20
PROJECT MANAGER:	EM		
JOB CAP/DRAWN:	EM		
E OF RECORD:	D.THAYER,P.E.	SHEET No.	SITE
THAYER CAD FILE	PL-1		