Airborne
Spectral
Photometric
Environmental
Collection
Technology

ASPECT Bio-Lab Fire Assessment

Westlake, LA
27 August 2020

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Acronyms and Abbreviations

Alt	Altitude (in feet)
AGL	Above Ground Level
ASPECT	Airborne Spectral Photometric Environmental Collection Technology
cm	centimeter
CST	Central Standard Time
DEM	Digital Elevation Model
Digital	Digital photography file from the Nikon D2X camera
ft	feet
FTIR	Fourier Transform Infrared Spectrometer
FTP	File Transfer Protocol
igm	Spectral data format based on grams format
IR	Infrared
IRLS	Infrared Line Scanner
jpg	JPEG image format
kts	knots
Line #	Specific numbering system that corresponds to specific gps coordinates. Line numbers are assigned before the beginning of the first flight on the first day. Each line number can have multiple source names (e.g. facility names) within the line number—usually when facilities are close in a proximity to each other.
mph	miles per hour
Pass #	Corresponds to the number of "passes" over the designated line. Each line could have multiple passes in order to capture the data. Example of factors affecting data during a run where another pass is warranted include clouds appearing under the plane, turbulence, gust of wind, inclement weather, etc.
Run #	Numbering system for when the plane has flown over a line in chronological order for the day. For each flight the run number starts over with number "1" for each day or when the plane lands. Run numbers can be test flights, the initial run (i.e. Pass #1), or a re-pass of a line (i.e. Pass #2, #3,…,etc.)
m/s	meters per second
MSIC	Digital photography file from the Imperx mapping camera
MSL	Mean Sea Level Altitude (in feet)
ppm	parts per million
UTC	Universal Time Coordinated

Final Report

Executive Summary

On 27 August 2020, Hurricane Laura made landfall near Cameron, LA and rapidly moved northward impacting Lake Charles, LA. Wind speeds in excess of 130 mph caused extensive damage, including a fire at the Bio-Lab facility in Westlake, LA. ASPECT was requested by EPA Region 6 to provide air monitoring on the morning of the 27th and was airborne at 1205 CST, arriving onsite just before 1400 CST. ASPECT conducted a total of 12 data collection runs, both up and downwind of the fire and collected a full set of FTIR, IRLS, and photographic data on each run. The fire generated a white, low altitude plume which moved toward the NE. Data collected flying downwind of the fire showed the presence of ammonia, dichloroethane and tetrachloroethylene at maximum concentrations of 10.10 ppm, 0.70 ppm and 1.58 ppm, respectively. Analysis of IRLS imagery did not show the presence of a chemical plume being generated by the fire.

This report serves as the final complete mission report and should replace all previous draft versions.

ASPECT Bio-Lab Fire Report
Westlake, LA
27 August 2020

Background and Operational Overview

On the early morning of 27 August 2020 Hurricane Laura made landfall near Cameron, LA and moved north with the eye wall passing over Lake Charles. Damage to the area was extensive with the peak wind gust reported as 132 mph. In addition to winds, heavy rain and a storm surge impacted much of the area. At approximately 0930 CST local reports from Region 6 indicated that a fire was present at a chemical facility in Lake Charles immediately south of I-10. Further information indicated that the fire might be chlorine-based from the Bio-Lab facility. The location of the fire was determined from ASPECT IR data to be at 30.2344N and 93.2678W (Figure 1).

U.S. EPA Region VI requested the ASPECT system to be deployed to provide monitoring support on 27 August 2020. The order to launch the aircraft was given at approximately 1138 CST, and the aircraft was airborne at 1205 CST. ASPECT completed the first of 12 runs at 1606 CST. Only one flight was needed for the incident. This report summarizes the findings observed during the mission.

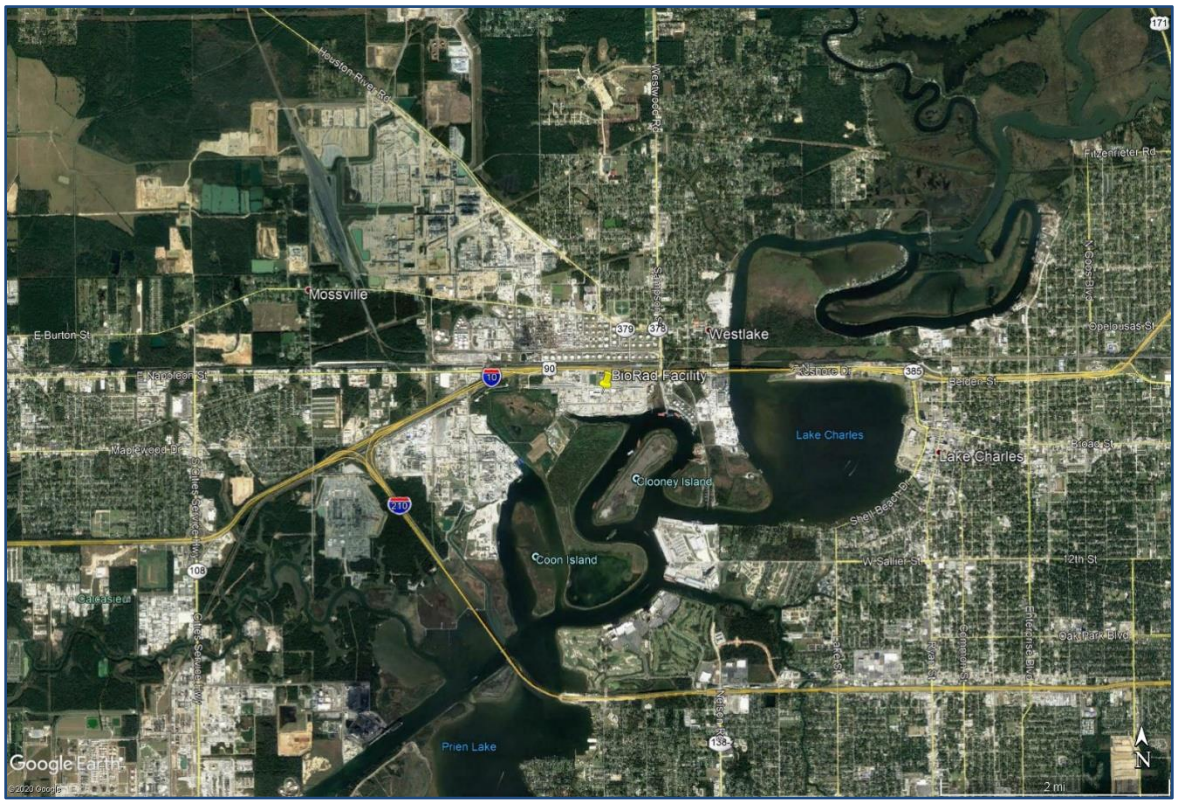

Figure 1: Location of Bio-Lab Facility in Lake Charles, LA

General Mission Objectives

The following general mission objectives are employed in conducting emergency response data collection with ASPECT:

1. To capture an overall, situational awareness of the incident using aerial photography with:
    - Oblique camera—photos taken by hand from the view/position of the co-pilot, and
    - MSIC photos—advanced camera housed underneath the plane for a top-down view of the incident
2. To qualitatively characterize and locate both the visible and non-visible components of the plume, as well as which areas are on fire:
    - Using the Infrared Line Scanner (IRLS)
3. To screen for the presence and location of specific chemicals within ASPECT's chemical library:
    - Using the Fourier Transform Infrared (FTIR) Spectrometer

See Appendix B for a detailed description of ASPECT's instrumentation.

Flight Conditions and Status

Weather and Site Conditions

Before the mission begins status on the weather forecast, site conditions and any potential flight obstacles including radio towers is collected for the health and safety of the crew. A complete timeline of the ground weather conditions during the mission can be found in Table 1.

Table 1. Ground Weather for Poly-America Fire Response

Location (time)	Ground (1200)	Ground (1300)	Ground (1400)	Ground (1500)	Ground (1600)
Wind direction	250 degrees (WSW)	250 degrees (WSW)	250 degrees (WSW)	225 degrees (SW)	200 degrees (SSW)
Wind speed	4.5 m/s (10 mph)	4.0 m/s (9 mph)	2.7 m/s (67 mph)	4.5 m/s (10 mph)	3.2 m/s (7 mph)
Temperature	31ºC	31ºC	31ºC	33ºC	35ºC
Humidity	60%	66%	60%	58%	50%
Dew Point	22ºC	24ºC	24ºC	24ºC	15ºC
Pressure	1008 mb	1008 mb	1008 mb	1008 mb	1008 mb
Ceiling	4200	3600	4000	Clear	Clear

While in flight, the crew reported that winds at 2800 ft AGL were 18.0 m/s (35 kts) from 270 degrees. The crew reported moderate to heavy turbulence. Once on station, the aircraft reported that smoke/vapor emitted from the facility was white in color and

moving toward the NE. It was also reported that the smoke was staying close to the ground.

Data Results

The following data is provided as a summary analysis. All data products are available for the Region to access on a shared FTP site. For a complete list of available products, see Appendix A. The data collected during this mission included a flight path summary, IRLS images, FTIR chemical identification and quantification, high resolution MSIC photos, and oblique photos.

Flight Paths

Wide, slow turns have to be made in between runs in order to keep the instruments stable. Figure 2 shows the various flight paths that the plane had to take to maintain optimal data quality. The blue lines indicate the flight path while the green lines indicate the specific sections of the flight where chemical data was collected and processed.

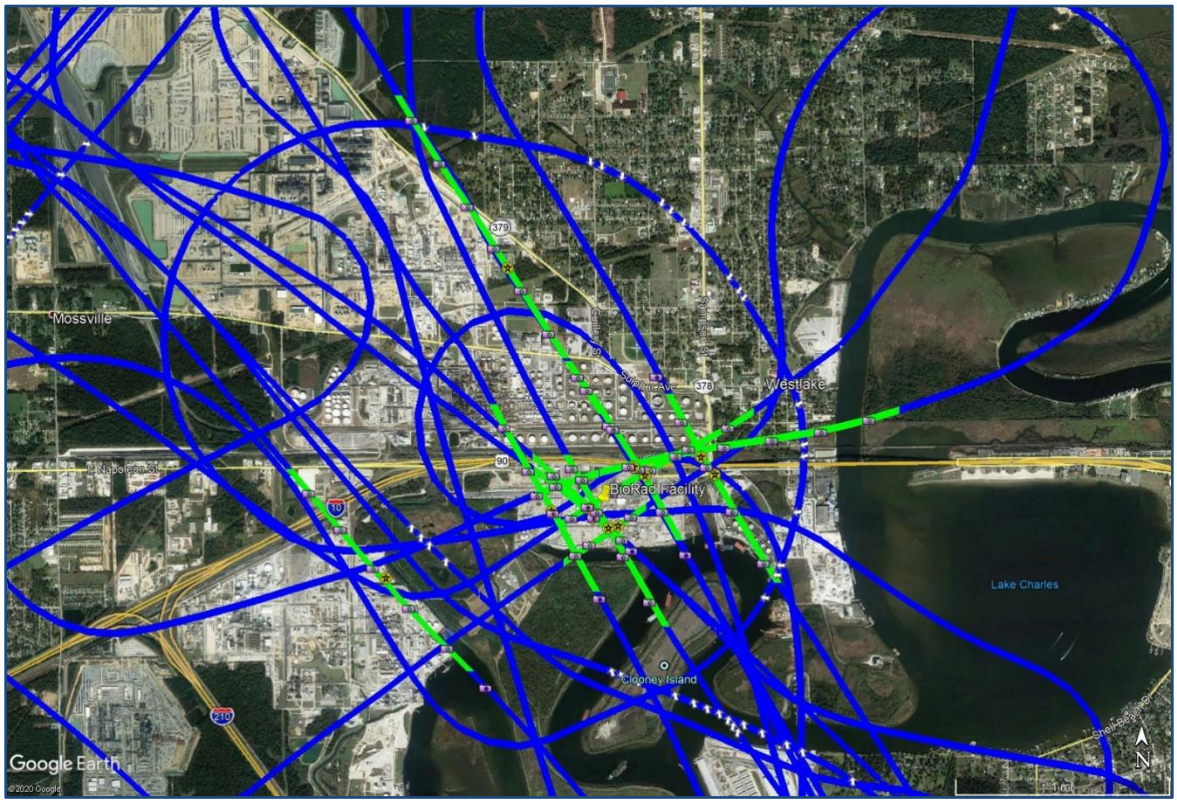

Figure 2. Data collection runs, Bio-Lab Fire, Lake Charles, LA.

Line Scanner Data Results

A total of 12 data collection runs were made in the proximity of the fire and an infrared line scanner image was generated for each run. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 2. This image was generated by flying from the NW toward the SE generally downwind of the facility Based on this imagery, no detectable chemical plume was observed in the image.

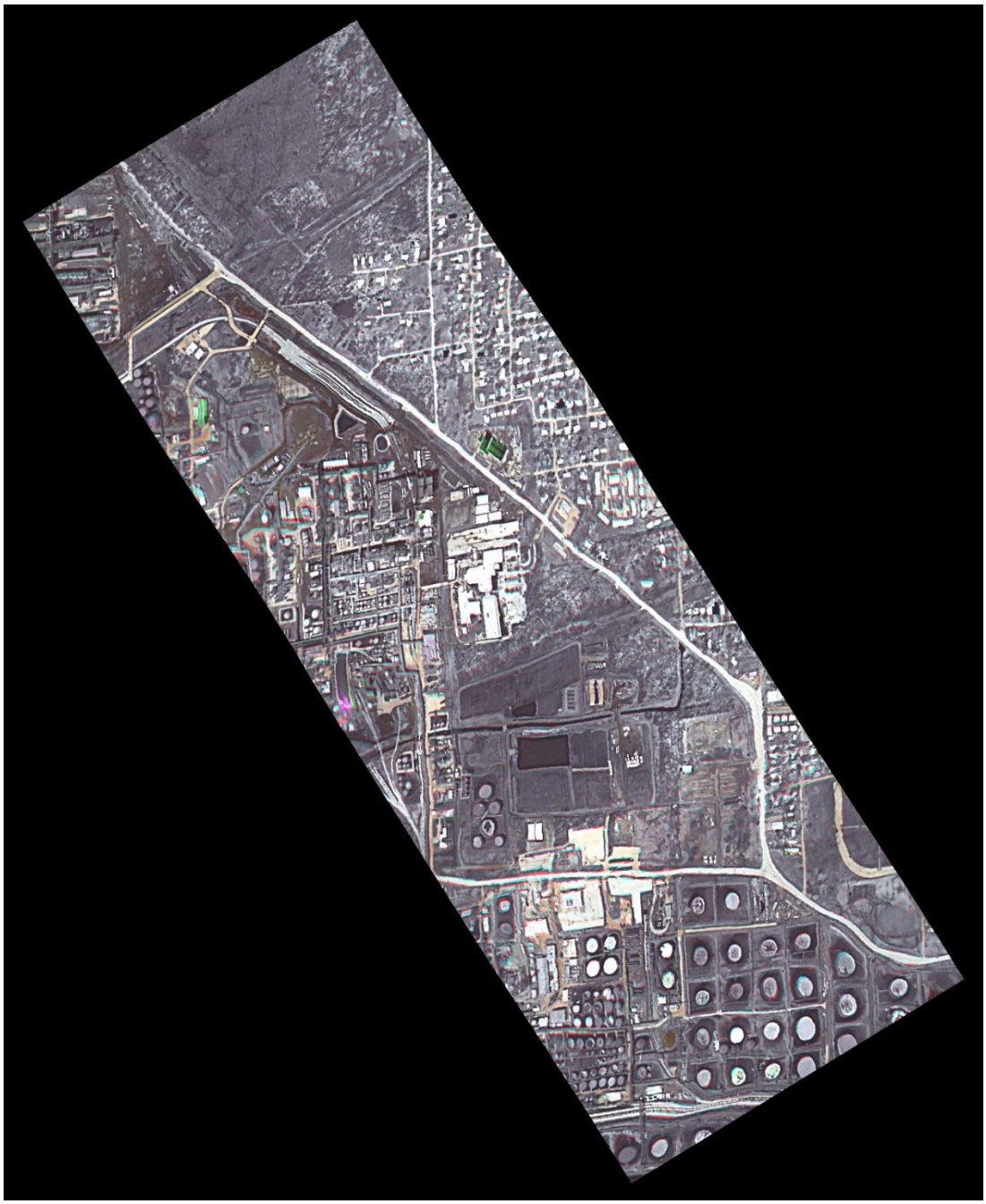

Figure 3. Three band IR image, Run 2, Bio-Lab Fire

FTIR Data Results

FTIR spectral data at a resolution of 16 wavenumbers was collected for each run. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. Seventy-six compounds are included in the airborne algorithm (the list is given in Appendix B, Table 1). In addition, collected data was also manually quality checked against a collection of published library spectra for each chemical detected.

Three chemical detections were observed during the mission: ammonia (CAS 7664-41-7), 1,1-dichloroethane (CAS 107-06-2) and tetrachloroethylene (CAS 127-18-4). Ammonia was detected on two collection runs and the chlorinated compounds were detected on one. All collections were associated with the fire. Figure 4a (the site-collected ammonia spectrum) and 4b (the published library spectra) show a confirmation comparison. For ammonia, at the resolution used by ASPECT, the characteristic peaks are those at 930 and 960 cm^{-1}. Figures 5a and 5b show a similar presentation for the chlorinated compounds. Visual confirmation is more difficult with these compounds because the detection was weak due to the low concentrations present, but two peaks near 800 cm^{-1} and one near 920 cm^{-1} are discernable. It should be noted that the ASPECT spectrum is collected at 16 cm^{-1} resolution while the library spectrum is collected at 0.5 cm^{-1} resolution.

The locations of chemical detections for the overall mission are shown in Figure 6. The variability observed in the locations of the detections is likely due to the variability of the wind direction. Table 2 provides the maximum concentration estimate observed on the respective data collection runs. Detections for ammonia ranged from no detections (ND) up to 10 ppm. Detections of the chlorinated compounds were lower at 0.70 ppm and 1.58 ppm for dichloroethane and tetrachloroethylene, respectively.

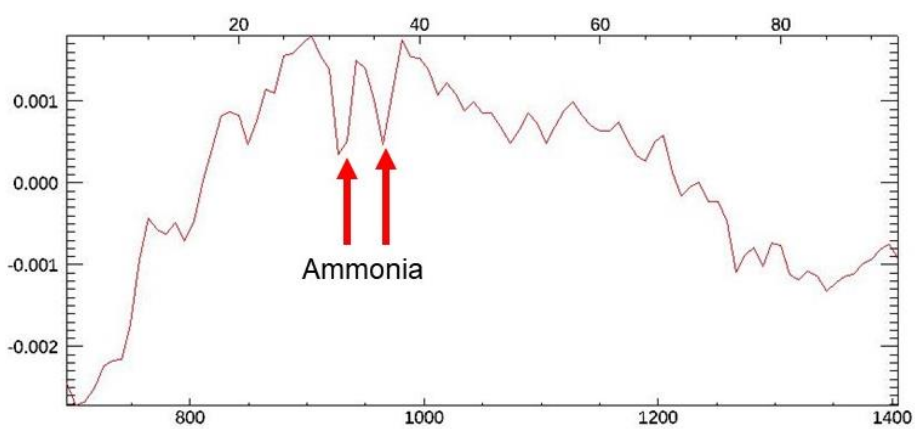

Figure 4a. Field spectrum at 16 cm-1 resolution, showing ammonia absorption peaks at 940 and 960 cm^{-1}

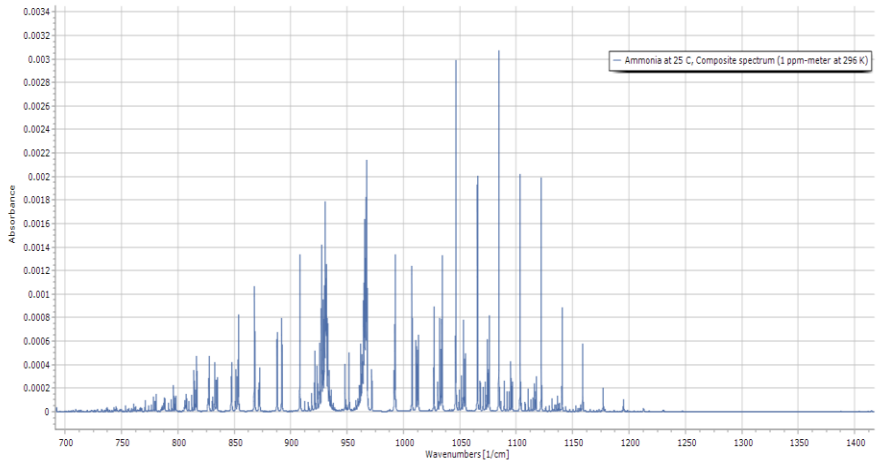

Figure 4b. Library Spectrum, Ammonia

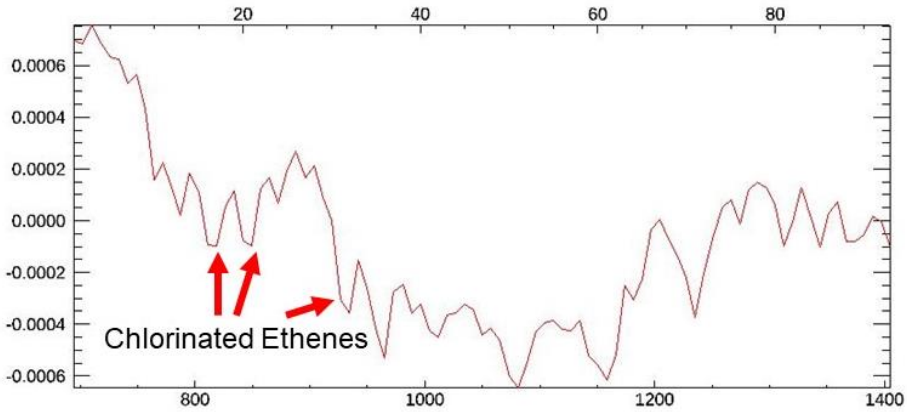

Figure 5a. Field spectrum at 16 cm-1 resolution, chlorinated ethenes

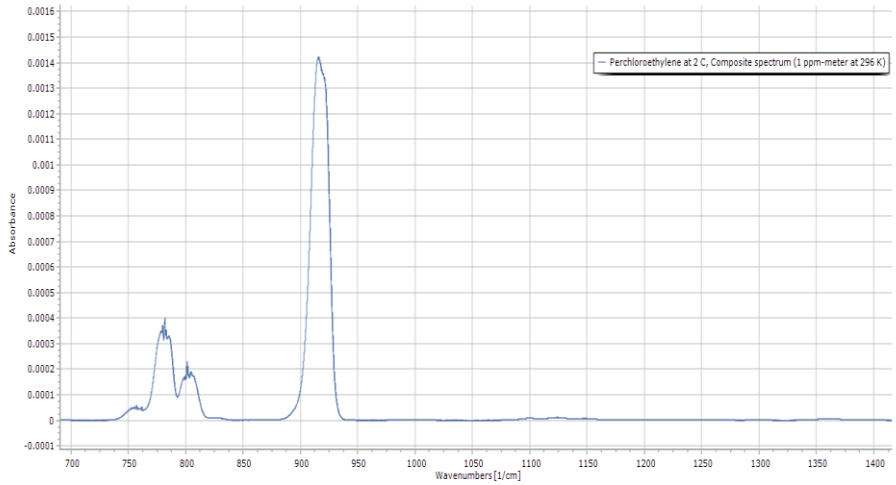

Figure 5b. Library spectrum, tetrachloroethylene

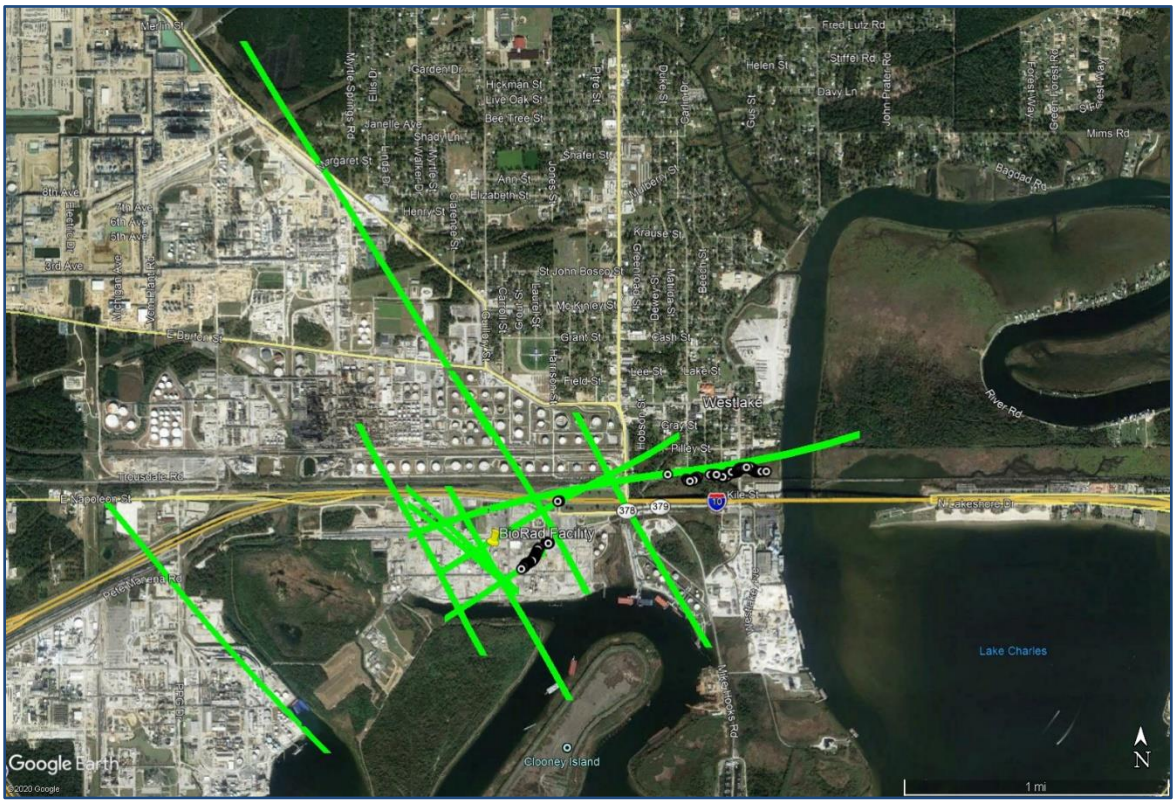

Figure 6. Compound detection locations associated with the Bio-Lab Fire

Table 2. Chemical Results Summary

Run #	Date	Time (UTC)	Chemical	Max Concentration (ppm)
1	27 Aug 2020	18:09:24	Test	Test
2		18:45:24	ND	ND
3		18:55:26	ND	ND
4		19:26:07	ND	ND
5		19:31:59	ND	ND
6		19:40:04	ND	ND
7		19:47:22	ND	ND
8		20:04:28	ND	ND
9		20:11:21	ND	ND
10		20:29:13	Ammonia 1,1-dichloroethane Tetrachloroethylene	10.10 0.70 1.58
11		20:32:14	Ammonia	5.10
12		21:06:20	ND	ND
Note: ND = No Detections				

Aerial Photography Results

A full set of high-resolution aerial digital photography were collected as part of the flight. Figure 7 shows a representative image collected as part of each run. This image was collected using the MSIC camera located underneath the plane on Run 3. As indicated in the crew report, this fire generated a white plume which moved toward the NE. Very little plume rise was reported indicating very little thermal lift present in the fire. Figure 8 shows an oblique image collected northwest of the facility showing the white nature of the plume.

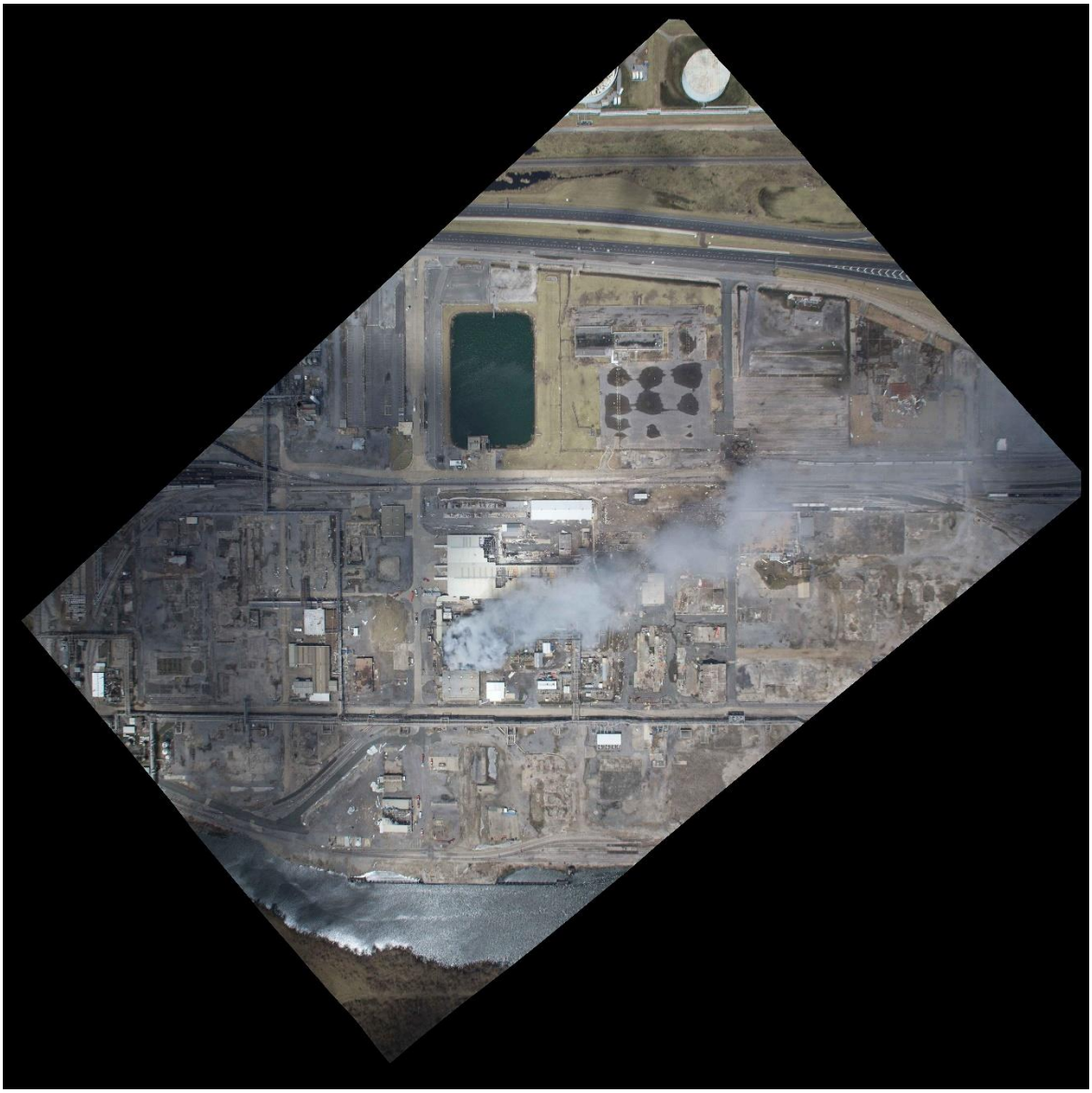

Figure 7. MSIC aerial image of the Bio-Lab Fire

Figure 8. Oblique image of the Bio-Lab Fire

Summary

On 27 August 2020, ASEPCT was requested by EPA Region 6 to provide air monitoring support for the Bio-Lab fire in Lake Charles. This fire, which was a result of Hurricane Laura, was reported to involve chlorine compounds. ASPECT conducted a total of 12 data collection runs, both up and downwind of the fire and collected a full set of FTIR, IRLS, and photographic data on each run. The fire generated a white, low altitude plume which moved toward the NE. Data collected flying downwind of the fire showed the presence of ammonia, dichloroethane and tetrachloroethylene at maximum concentrations of 10.10 ppm, 0.70 ppm and 1.58 ppm, respectively. Analysis of IRLS imagery did not show the presence of a chemical plume being generated by the fire.

Appendix A: File Names of Data Collected During Flight

Run #	Time (UTC)	Altitude (ft MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
Run 1	18:09:24	3712	173	20200827180930443.jpg 20200827180936801.jpg 20200827180943160.jpg	20200827_180926_A.igm	2020_08_27_18_09_28_R_01 TA=26.0;TB=46.4;Gain=3	None
Run 2	18:45:24	3029	109	20200827184530342.jpg 20200827184536692.jpg 20200827184543050.jpg	20200827_184527_A.igm	2020_08_27_18_45_28_R_02 TA=25.2;TB=45.4;Gain=3	None
Run 3	18:55:26	3021	113	20200827185532280.jpg 20200827185538629.jpg 20200827185544978.jpg	20200827_185530_A.igm	2020_08_27_18_55_31_R_03 TA=24.5;TB=44.5;Gain=3	None
Run 4	19:26:07	2997	115	20200827192613499.jpg 20200827192619857.jpg 20200827192626207.jpg 20200827192632571.jpg	20200827_192610_A.igm	2020_08_27_19_26_12_R_04 TA=24.2;TB=44.1;Gain=3	None
Run 5	19:31:59	3015	109	20200827193205766.jpg 20200827193212117.jpg 20200827193218476.jpg 20200827193224840.jpg 20200827193231190.jpg	20200827_193202_A.igm	2020_08_27_19_32_04_R_05 TA=22.8;TB=43.0;Gain=3	None
Run 6	19:40:04	3042	118	20200827194009679.jpg 20200827194016949.jpg 20200827194023298.jpg 20200827194029647.jpg 20200827194036012.jpg	20200827_194007_A.igm	2020_08_27_19_40_09_R_06 TA=23.1;TB=43.1;Gain=3	None
Run 7	19:47:22	3029	104	20200827194728196.jpg 20200827194734556.jpg 20200827194740905.jpg 20200827194747271.jpg 20200827194753620.jpg	20200827_194724_A.igm	2020_08_27_19_47_26_R_07 TA=23.2;TB=43.3;Gain=3	None

Run #	Time (UTC)	Altitude (ft MSL)	Velocity (knots)	MSIC Data Files	FTIR Data Files	IRLS Data Files	Gamma Files
Run 8	20:04:28	2987	112	20200827200435036.jpg 20200827200441395.jpg 20200827200447744.jpg 20200827200454109.jpg 20200827200500458.jpg	20200827_200432_A.igm	2020_08_27_20_04_34_R_08 TA=24.5;TB=44.3;Gain=3	None
Run 9	20:11:21	3016	116	20200827201127224.jpg 20200827201133584.jpg 20200827201139942.jpg 20200827201146291.jpg 20200827201152656.jpg 20200827201159005.jpg 20200827201205354.jpg 20200827201212629.jpg	20200827_201124_A.igm 20200827_201203_A.igm	2020_08_27_20_11_26_R_09 TA=23.8;TB=43.8;Gain=3	None
Run 10	20:29:13	3004	113	20200827202919475.jpg 20200827202925807.jpg 20200827202932168.jpg	20200827_202915_A.igm	2020_08_27_20_29_18_R_10 TA=29.5;TB=49.6;Gain=3	None
Run 11	20:32:14	3002	110	20200827203221050.jpg 20200827203227400.jpg 20200827203233755.jpg 20200827203240104.jpg 20200827203246470.jpg 20200827203252819.jpg 20200827203259184.jpg 20200827203305533.jpg	20200827_203218_A.igm 20200827_203257_A.igm	2020_08_27_20_32_20_R_11 TA=23.5;TB=43.6;Gain=3	None
Run 12	21:06:20	3005	119	20200827210626549.jpg 20200827210632914.jpg 20200827210639263.jpg 20200827210645628.jpg 20200827210651983.jpg 20200827210658332.jpg	20200827_210622_A.igm	2020_08_27_21_06_25_R_12 TA=22.5;TB=42.7;Gain=3	None

Appendix B: ASPECT Systems

The US EPA ASPECT system collects airborne infrared (IR) images and chemical screening data from a safe distance over the site (about 3,000 ft AGL). The system consists of an airborne high-speed Fourier Transform Infra-Red (FTIR) spectrometer coupled with a wide-area IR Line Scanner (IRLS). The ASPECT IR systems can detect chemical compounds in both the 8 to 12 micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. List of chemicals and detection limits are listed in Table 1. The 8 to 12 micron region is typically known as the atmospheric window region since the band is reasonably void of water and carbon dioxide influence. Spectrally, this region is used to detect carbon - non-carbon bonded compounds. The 3 to 5 micron region is also free of water and carbon dioxide but typically does not have sufficient energy for use. This band does show use in high-energy environments such as fires. The carbon - hydrogen stretch is very common in this region.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) is concurrently operated as part of all chemical collections. These images are often digitally processed in lower resolution, so they can be transmitted via satellite communication. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery can be processed while in flight or approximately 600 frames per hour can be processed once the data are downloaded from the aircraft. The high-resolution images (>20 MB each) are pulled from the ASPECT after the sortie and are available at a later time.

All aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the scientific reach back team. In general, this consists of conducting geo-registration using a USGS Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is check by the team (using a Google Earth base map) for proper location and rotation.

Airborne radiological measurements are conducted using three fully integrated multi-crystal sodium iodide (NaI) RSX4 gamma ray spectrometers. Each RSX4 spectrometer contains four 4”x2”x16” doped NaI crystals each having an independent photomultiplier/ spectrometer assembly. One RSX unit is configured with an additional upward NaI crystal utilized to provide real-time cosmic ray correction. Count and energy data from each crystal and pack is combined using a self-calibrating signal processor to generate a virtual detector output. All radiological spectrometer “packs” are further combined using a signal console controlled by the on-board central computer in the aircraft. Altitude correction data is provided by a radar altimeter with internal GPS systems within the packs serving as a backup. It should be noted that no radiological measurements were conducted on this mission.

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT scientific reach back team for QA/QC analysis. Upon landing, preliminary data results are examined and validated by the scientific reach back team.

Table 1. ASPECT Automated Compounds

This table contains ASPECT's library of automated compounds.
Detection limits are for each chemical is found in parenthesis in units of parts per million (ppm)

Acetic Acid (2.0)	**Cumene (23.1)**	**Isoprene (6.5)**	**Phosphine (8.3)**
Acetone (5.6)	**Diborane (5.0)**	**Isopropanol (8.5)**	**Phosphorus Oxychloride (2.0)**
Acrolein (8.8)	**1,1-Dichloroethene (3.7)**	**Isopropyl Acetate (0.7)**	**Propyl Acetate (0.7)**
Acrylonitrile (12.5)	**Dichloromethane (6.0)**	**MAPP (3.7)**	**Propylene (3.7)**
Acrylic Acid (3.3)	**Dichlorodifluoromethane (0.7)**	**Methyl Acetate (1.0)**	**Propylene Oxide (6.8)**
Allyl Alcohol (5.3)	**1,1-Difluoroethane (0.8)**	**Methyl Acrylate (1.0)**	**Silicon Tetrafluoride (0.2)**
Ammonia (2.0)	**Difluoromethane (0.8)**	**Methyl Ethyl Ketone (7.5)**	**Sulfur Dioxide (15)**
Arsine (18.7)	**Ethanol (6.3)**	**Methanol (5.4)**	**Sulfur Hexafluoride (0.07)**
Bis-Chloroethyl Ether (1.7)	**Ethyl Acetate (0.8)**	**Methylbromide (60)**	**Sulfur Mustard (6.0)**
Boron Tribromide (0.2)	**Ethyl Acrylate (0.8)**	**Methylene Chloride (1.1)**	**Sulfuryl Fluoride (1.5)**
Boron Triflouride (5.6)	**Ethyl Formate (1.0)**	**Methyl Methacrylate (3.0)**	**Tetrachloroethylene (10)**
1,3-Butadiene (5.0)	**Ethylene (5.0)**	**MTEB (3.8)**	**1,1,1-Trichloroethane (1.9)**
1-Butene (12.0)	**Formic Acid (5.0)**	**Naphthalene (3.8)**	**Trichloroethylene (2.7)**
2-Butene (18.8)	**Freon 134a (0.8)**	**n-Butyl Acetate (3.8)**	**Trichloromethane (0.7)**
Carbon Tetrachloride (0.2)	**GA (Tabun) (0.7)**	**n-Butyl Alcohol (7.9)**	**Triethylamine (6.2)**
Carbonyl Fluoride (0.8)	**GB (Sarin) (0.5)**	**Nitric Acid (5.0)**	**Triethylphosphate (0.3)**
Carbon Tetraflouride (0.1)	**Germane (1.5)**	**Nitrogen Mustard (2.5)**	**Trimethylamine (9.3)**
Chlorodifluoromethane (0.6)	**Hexafluoroacetone (0.4)**	**Nitrogen Trifluoride (0.7)**	**Trimethyl Phosphite (0.4)**
Chloromethane (12)	**Isobutylene (15)**	**Phosgene (0.5)**	**Vinyl Acetate (0.6)**