131 Hartwell Avenue
Lexington, Massachusetts
02421-3126
USA
Tel: +1 781 761-2288
www.aer.com

FINAL REPORT

Data Analysis Meteorology and Air Quality Analytical Support

TCEQ Contract No. 582-19-90498
Work Order No. 582-22-32005-014
Revision 2.0

Prepared by:
Jennifer Hegarty, John Henderson and Matthew Alvarado
Atmospheric and Environmental Research, Inc. (AER)
131 Hartwell Ave.
Lexington, MA 02466

Correspondence to: malvarad@aer.com

Prepared for:
Erik Gribbin
Texas Commission on Environmental Quality
Air Quality Division
Building E, Room 342S
Austin, TX 78711-3087

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1.5	**29 April 2022**	**Internal Version for Review**
2.0	**30 April 2021**	**Final Version Submitted to TCEQ**

TABLE OF CONTENTS

List of Figures

List of Tables

List of Acronyms

AER – Atmospheric and Environmental Research

agl – above ground level

AHPS - Advanced Hydrologic Prediction Service

ARL – Air Resources Laboratory

DOC – Department of Commerce

GAM – General Additive Model

GFS – Global Forecast System

METAR – METeorological Aerodrome Report

NAAQS – National Ambient Air Quality Standards

NAM12 – 12 km North American Mesoscale Forecast System

NCEP – National Center for Environmental Prediction

NESDIS - National Environmental Satellite Data and Information Service

NOAA – National Oceanic and Atmospheric Administration

NWS – National Weather Service

OSPO - Office of Satellite and Product Operations

PBL – Planetary Boundary Layer

PBLH – Planetary Boundary Layer Height

$PM_{2.5}$ - Fine particulate matter with less than 2.5 microns in diameter.

SO_2 – Sulfur Dioxide

TOEM – Tapered Element Oscillating Microbalances

Executive Summary

The purpose of this project was to provide the TCEQ with focused analytical support for meteorology on air quality projects on a short-term basis. The motivation for the project was that over the past few years TCEQ has been replacing non-regulatory TEOM monitors with regulatory Beta-Gauges and some of the new monitors have unexpectedly high daily averages for pollutant concentrations. The high readings are of concern because the US Environmental Protection Agency is currently reviewing the National Ambient Air Quality Standards (NAAQS) for fine particulate matter ($PM_{2.5}$). The Work Order was written so that the Contractor's personnel could provide technical assistance for analysis of high particulate matter (PM) and sulfur dioxide (SO_2) events. However, after a preliminary analysis was conducted by the TCEQ it was determined that the focus of the project would be on $PM_{2.5}$ events only.

The TCEQ identified three monitor locations for detailed study. These are North Wayside and Westhollow in the Houston area and Karnack in northeastern Texas just west of the Louisiana state line. Through a preliminary analysis of the data for 2021 TCEQ has selected ten days for study during which the daily average $PM_{2.5}$ concentration was above the current annual NAAQS standard of 12.0 $\mu g/m^3$ but were well below the daily average NAAQS of 35.0 $\mu g/m^3$. There were five days selected for the North wayside and Weshollow locations in the Houston area, and five days selected for Karnack.

In Task 3 of this project, AER examined the meteorology for the ten days selected by the TCEQ in which $PM_{2.5}$ concentrations measured at three location in eastern Texas were high. The findings of this analysis were provided in technical memos. The Work Order stated that there would be ten technical memos, one for each day. However, because three of the days were part of the same episode and another of the days involved all three locations it was decided that the memos for these cases could be combined into a single memo. In the end there were seven technical memos written and delivered to TCEQ as a single package to satisfy Deliverable 3.1.

During the study period daily average $PM_{2.5}$ concentrations ranged from a low of 12.0 $\mu g/m^3$ at Westhollow on 19 June to a high of 28.09 $\mu g/m^3$ at North Wayside on 7 October. Daily maximum hourly $PM_{2.5}$ concentrations ranged from 16.9 $\mu g/m^3$ on 7 October at Westhollow to 53 $\mu g/m^3$ at Karnack on 5 September. For most of the cases the synoptic circulation influencing eastern Texas was governed by a nearby anticyclone. This synoptic condition restricted venting of the planetary boundary layer and precipitation and produced light winds. These stagnant conditions lead to the build-up of local pollutants and produced a repeatable diurnal cycle of morning and early evening twin peaks in $PM_{2.5}$ concentrations. For two cases the anticyclonic pattern was disrupted by low-pressure troughs leading to rapid declines in $PM_{2.5}$ concentrations. Smoke from fires in the US was present over Texas for six of the ten days; however, there was no clear evidence that it was mixed down to the surface to significantly influence $PM_{2.5}$ concentrations at the ground level monitors.

It is recommended that future studies focus on improving the understanding of the interaction between local sources and very fine scale meteorological features and include a greater variety of meteorological conditions. Since smoke is often observed over Texas more information

is required on the influence of the smoke on ground-level $PM_{2.5}$ concentrations. Future work could examine the vertical layering of the smoke and mechanisms to mix smoke down to the surface.

1. Introduction

1.1 Project Objectives

The purpose of this project is to provide the TCEQ with focused analytical support for meteorology on air quality projects on a short-term basis. The Contractor's personnel shall provide technical assistance for analysis of high particulate matter (PM) and sulfur dioxide (SO_2) events.

In Task 3 of this project, AER examined the meteorology for ten days selected by the TCEQ in which $PM_{2.5}$ concentrations measured at three location in eastern Texas were high. The findings of this analysis were provided in technical memos. The Work Order stated that there would be ten technical memos, one for each day. However, because three of the days were part of the same episode and another of the days involved all three locations it was decided that the memos for these cases could be combined into a single memo. In the end there are seven technical memos.

The schedule of deliverables for this project is given in Table 1.

Table 1. Projected Schedule for TCEQ Work Order No. 582-22-32005-014

Milestones	Planned Date
Task 1 – Work Plan	
1.1: TCEQ-approved Work Plan	January 27, 2022
1.2: TCEQ-approved QAPP	January 27, 2022
Task 2 – Progress Reports	
2.1: Monthly Progress Reports	Monthly with invoice
Task 3 – Meteorological Analysis of High PM and SO_2 Events	
3.1: Ten technical memos as described above submitted as a single package	April 30, 2022
Task 4 – Draft and Final Reports	
4.1: Draft Report	April 15, 2022
4.2: Final Report	April 30, 2022

1.2 Background

Over the last few years, the TCEQ has been replacing non-regulatory TEOM monitors with regulatory Beta-Gauges. Some of these monitors have unexpectedly high daily averages for pollutant concentrations. These high readings are of concern because the US Environmental Protection Agency is currently reviewing the National Ambient Air Quality Standards (NAAQS) for fine particulate matter ($PM_{2.5}$).

The TCEQ has identified three monitor locations for detailed study. These are North Wayside and Westhollow in the Houston area and Karnack in northeastern Texas just west of the Louisiana state line. Through a preliminary analysis of the data for 2021 TCEQ has selected daily cases for study during which the daily average $PM_{2.5}$ concentration was above the current annual NAAQS standard of 12.0 $\mu g/m^3$ but were well below the daily average NAAQS of 35.0 $\mu g/m^3$. These include a 3-day episode 17 – 19 June that included all three locations on 17 June 17 and the

two Houston stations on 18 and 19 June. The other days in Houston are 7 October and 13 December. For Karnack the remaining four days are 25 July, 6 and 22 August and 5 September.

AER conducted an analysis of the meteorological conditions for these days and locations. The analysis was conducted on different scales ranging from the synoptic scale using archived weather maps and analyses to the local scale using weather data collected at the specific monitoring stations. The analysis identified common meteorological factors that may have influenced the $PM_{2.5}$ concentrations on those case days.

1.3 Report Outline

This Final Report highlights major activities and key findings. The Final Report provides pertinent analysis, describe encountered problems and associated corrective actions. This Final Report satisfies Deliverable 4.2 of the Work Plan for Work Order No. 582-22-32005-014:

Deliverable 4.2: Final Report
Deliverable 4.2 Due Date: April 30, 2022

Section 2 of this report contains brief description of the technical memos describing the meteorological analysis for the ten days identified by TCEQ as having high $PM_{2.5}$ readings. Section 3 describes our quality assurance process. Section 4 summarizes the overall conclusions and Section 5 provides our recommendations for future work.

2 Meteorological Analysis of High PM and SO_2 Events

2.1 Preliminary Analysis and Case Selection

The TCEQ conducted a preliminary analysis of the pollutant concentrations at monitoring locations with the new TEOM monitors. From this analysis the TCEQ determined that $PM_{2.5}$ concentrations were of concern and that $PM_{2.5}$ events would be the focus of this project. Ten one-day events were selected. Five of the events or cases days were in the Houston area using data from the Westhollow and North Wayside monitoring locations and five were in northeastern Texas using the Karnack monitoring location. Each of these case days, shown as red boxes in Figures 1 and 2, had daily average $PM_{2.5}$ concentrations above the current annual NAAQS value of 12.0 $\mu g/m^3$ (Table 2) but were well below the daily average NAAQS of 35.0 $\mu g/m^3$. For the Houston area the concentrations at North Wayside were generally higher than at Westhollow. North Wayside is an area that has more urban build-up than Westhollow and that could partly explain the differences, but there could have also been local meteorological factors at play.

To better understand the possible influence of the meteorological factors on the $PM_{2.5}$ concentrations an in-depth analysis of the meteorology for these ten cases was conducted on a variety of scales from synoptic to local. It included the use of synoptic maps, back trajectory analysis, estimates of planetary boundary layer height (PBLH) or mixing height, and time series of local meteorological variables. For the Houston area it also included inputs to General Additive Models (GAMs) that were determined in previous studies to be reliable predictors of pollutant

concentrations (AER, 2015). The PBLHs were generated from the Air resources Laboratory HYSPLIT VMIXING program (https://www.ready.noaa.gov/HYSPLIT_vmixing.php) using 12 km data from North American Mesoscale Forecast System (NAM12, DOC). The analysis also considered the influence of precipitation and smoke plumes from fires both nearby and distant. The precipitation data was primarily from daily analyses of observed accumulated precipitation from the National Weather Service Advanced Hydrologic Prediction Service (AHPS) at https://water.weather.gov/precip/. The smoke analysis primarily used the satellite smoke analysis product from the NOAA Office of Satellite and Product Operations (OSPO) of the National Environmental Satellite Data and Information Service (NESDIS) available at https://www.ospo.noaa.gov/Products/land/hms.html#0. Some of the key factors for all the cases are summarized in Table 2. The cases are described in seven memos in separate documents. Cases 1-4 were of a three-day continuous episode that involved the Houston area monitors for all three days and Karnack for the first day. Therefore, these four cases are described in a single memo. The memos and brief case descriptions are provided in Section 2.2. The memos were delivered to TCEQ as a single package to satisfy Deliverable 3.1.

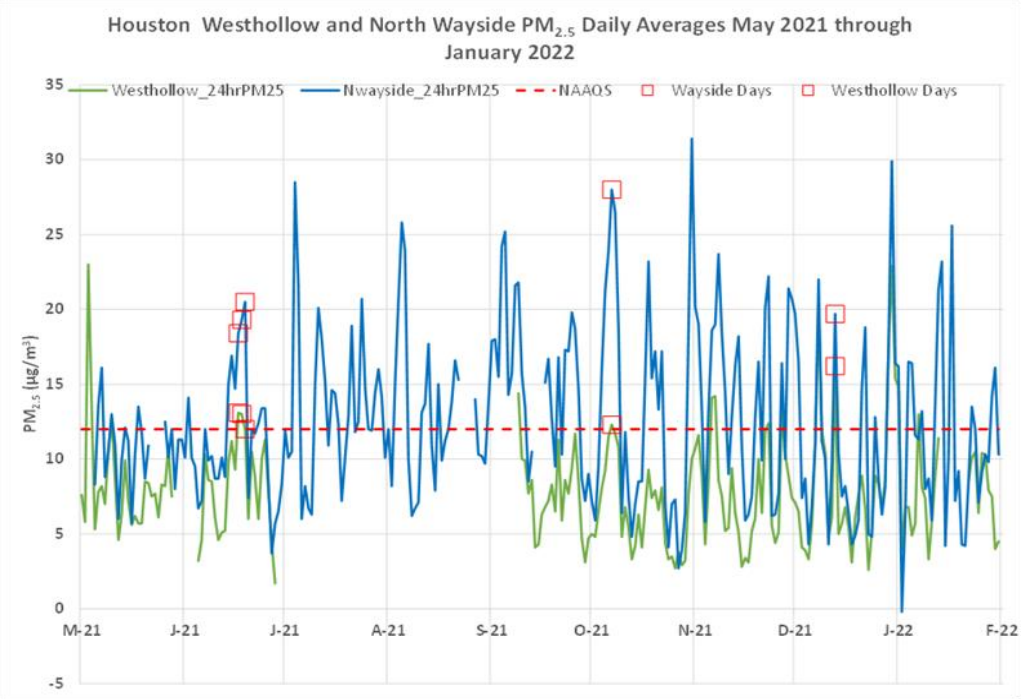

Figure 1: Daily average $PM_{2.5}$ concentration at North Wayside (blue) and Westhollow (green) in Houston for May 2021 – February 2022. The red boxes indicate the case days for each location. The red dotted line is the current annual NAAQS concentration. The figure was provided by the TCEQ project manager during the kick-off meeting.

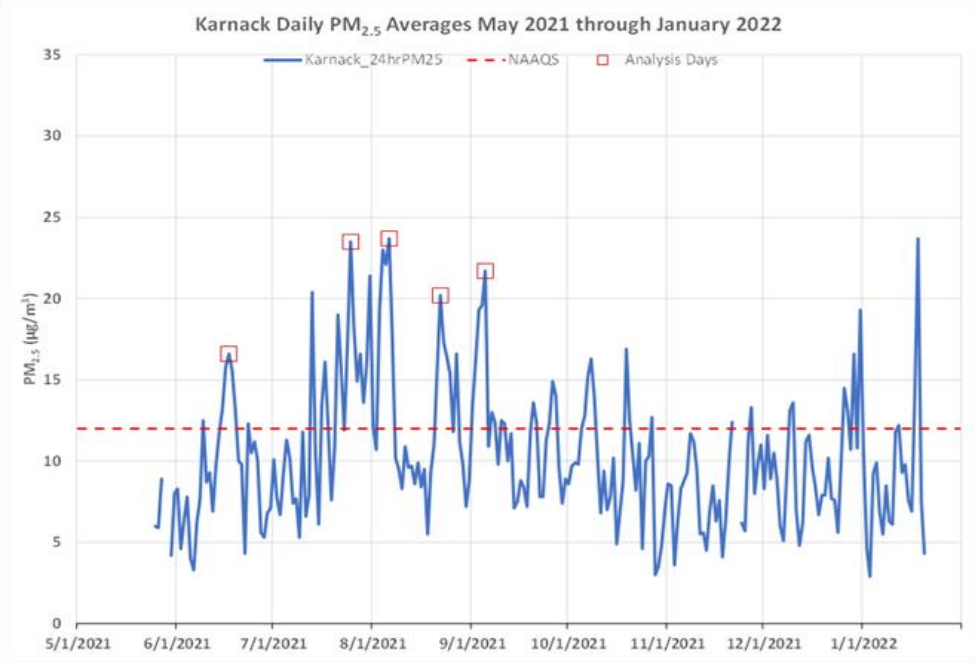

Figure 2: Same as Figure 1 but for Karnack.

Table 2: Summary of cases with $PM_{2.5}$ concentration and important meteorological parameters. NA signifies parameter not available for that case or location. T_diff_950mb is the 925 mb – surface temperature difference at 1200 UTC. T_dev_850mb is deviation of the 1200 UTC 850 mb temperature from the 10-year monthly mean.

Case	**Date**	**Location**	**Avg. $PM_{2.5}$** ($\mu g/m^3$)	**Max $PM_{2.5}$** ($\mu g/m^3$)	**Max PBLH** (m)	**T_diff_ 925mb** (K)	**T_dev_ 850mb** (K)	**Rain**	**Smoke**
1	6/17	North Wayside	18.46	27.0	3004	-0.8	-0.72	Lgt Sct.	Medium
1	6/17	Westhollow	13.14	19.7	3248	-0.8	-0.72	Lgt. Sct	Medium
2	6/17	Karnack	16.65	23.7	2045	NA	NA	None	Medium
3	6/18	North Wayside	19.39	26.0	2159	-0.6	-0.22	None	Light
3	6/18	Westhollow	13.02	20.9	2466	-0.6	-0.22	None	Light
4	6/19	North Wayside	20.58	40.0	2286	-1.1	1.08	Lgt. Sct.	Medium
4	6/19	Westhollow	12.00	23.5	2294	-1.1	1.08	None	Medium
5	7/25	Karnack	23.59	34.4	1669	NA	NA	None	Light
6	8/6	Karnack	23.75	36.0	2069	NA	NA	None	Medium
7	8/22	Karnack	20.20	42.0	2085	NA	NA	None	None
8	9/5	Karnack	21.77	53.0	2466	NA	NA	Mod. Sct.	None
9	10/7	North Wayside	28.09	42.0	2327*	0.3	-1.34	None	None
9	10/7	Westhollow	12.31	16.9	2257*	0.3	-1.34	None	None
10	12/13	North Wayside	19.71	35.0	847	4.7	3.28	None	None
10	12/13	Westhollow	16.26	23.3	868	4.7	3.28	Lgt. Sct.	None

*NAM12 PBLH missing for that day, value calculated by applying bias correction to GFS PBLH.

2.2 Memos and Cases

Memo 1 *Cases 1-4: 17 - 19 June 2021 Episode in Houston and Karnack*

This three-day episode featured anticyclonic conditions 17 - 18 June that were disrupted by Tropical Storm Claudette that made landfall in Louisiana early on 19 June. There were local stagnant conditions with smoke plumes aloft and long-range transport from the northeast on 17 – 18 June and from the Gulf of Mexico on 19 June.

Memo 2 Case 5: 25 July 2021 at Karnack

This case featured an anticyclone centered just east of Texas and produced a general south to north subsiding flow. The anticyclone suppressed planetary boundary layer (PBL) venting and rainfall. Karnack was on the western edge of a light smoke plume.

Memo 3 Case 6: 6 August 2021 at Karnack

The synoptic circulation in the lower troposphere was governed by an anticyclone that had a center near Texarkana. The flow around the anticyclone as it moved into its position on 6 August produced transport into Karnack originating from the north and east that remained close to the surface. No rainfall was observed and there was a medium smoke plume over the region.

Memo 4 Case 7: 22 August 2021 at Karnack

The synoptic circulation in the lower troposphere was governed by an anticyclone that had a center at 850 mb southern Louisiana at 1200 UTC 22 August 2021 elongated along a northwest to southeast axis. Steadily subsiding flow from the southeast arrived at Karnack after passing over the Gulf of Mexico. No rainfall or smoke were observed on this day.

Memo 5 Case 8: 5 September 2021 at Karnack

This case featured a trough associated with a cold front extending from a cyclone in the Midwest. Ahead of the trough were moderate rain showers that would eventually impact Karnack. The flow pattern featured transport from the southeast then turning toward the southeast before reaching Karnack. The trajectory analysis hints at some grid-scale upward motion late in the period.

Memo 6 Case 9: 7 October 2021 at North Wayside and Westhollow

This case featured a low centered in Missouri that produced rainfall to the east and a high-pressure center building behind it in eastern Texas. The trajectory flow pattern was confined to eastern Texas and features several directional changes reflecting the passage of the low center and the building in of the high pressure behind.

Memo 7 Case 10: 13 December 2021 at North Wayside and Westhollow

The synoptic situation for this case was changeable and more complicated than the other cases. A strong anticyclone was centered to the east of Texas and a trough developed along the Gulf coast of Texas that would eventually produce rainfall to the area.

3 Quality Assurance

3.1 Quality Assurance Project Plan

The Quality Assurance Project Plan (QAPP) was provided as a separate document along with the Work Plan and described the QA/QC program. AER developed the QAPP in accordance with the U.S EPA's National Risk Management Research Laboratory (NRMRL) guidelines. This

Work Order falls under QAPP Category IV as a Research Model Development or Application project.

3.2 Quality Control of Original Analysis Code and Models

This project relied heavily on data and products that are available to the public and maintained by the US DOC's NOAA and its sub-branches including NCEP and NWS. These data and products are continually being updated and checked for errors by these government agencies to ensure quality. We carefully reviewed all this data and checked it for consistency and accuracy by cross-comparing different data types for each case.

The original AER code for this project was developed to read local meteorological and air quality data provided to us by the TCEQ and create time-series plots. The code was reviewed for errors by two AER employees to ensure that the information displayed on the final plots provided to TCEQ was accurate and consistent with the raw data provided.

The only model used to generate original data for this data was the NOAA ARL HYSPLIT model. The model was run through a web-based application program interface (API) maintained by NOAA ARL. This API runs the latest version of HYSPLIT and produces output files and plots for the users. The components of this API including HYSPLIT are continually updated and checked for errors. In addition, back-trajectory analyses are continually being verified against meteorological modeling results for reasonableness. The performance of HYSPLIT driven with many different types of meteorological fields has been evaluated with tracer release studies by Hegarty et al. (2013) and shown to be reliable.

4 Conclusions

The meteorological conditions for ten cases in 2021 with high (> 12.0 $\mu g/m^3$) daily average concentrations in eastern Texas were analyzed. Cases 1-4 involved a 3-day episode in June which impacted $PM_{2.5}$ concentrations at the Karnack monitoring location in northeastern Texas and the North Wayside and Westhollow monitoring locations in the Houston area for all three days. Cases 5 – 8 were one-day episodes in Karnack occurring from July – September and Cases 9 and 10 were one-day episodes at both the North Wayside and Westhollow Houston locations In October and December. From this analysis several common factors emerged.

Each case was influenced for at least part of the time by an anticyclone or weak anticyclonic flow ahead of a frontal trough. The anticyclone suppressed venting of the PBL and organized rainfall and produced light winds (< 2 m/s) leading to stagnant conditions conducive to the build-up of pollutants. If persistent throughout the day, these conditions lead to a repeatable diurnal cycle in the $PM_{2.5}$ concentrations with peaks in the morning, followed by declines in the afternoon partly due to dilutions from greater turbulent mixing depth, followed by a second peak in the evening. The two peak diurnal cycle is common for most locations in the North America (Manning et al., 2018).

When the synoptic pattern changed from one dominated by an anticyclone to one with other features such as an approaching frontal trough from the northwest (Case 8) or trough developing in the Gulf of Mexico (Case 10), $PM_{2.5}$ concentrations decreased rapidly. These other

synoptic features are more conducive to large-scale planetary boundary layer (PBL) venting and produce precipitation. On these case days the $PM_{2.5}$ concentration could still build up to high levels, but the typical diurnal cycle with a morning and evening peak would be replaced by a single peak.

Long-range transport diagnosed from HYSPLIT three-day back trajectories was from the north, northeast, east, southeast, or south. For these cases there was no long-range transport from locations to the west though winds at the monitoring locations occasionally had a westerly component for brief periods. Three-day transport ranged from being confined over eastern Texas to as far away as the northern Great Plains and eastern Gulf of Mexico. The trajectories were generally confined to the PBL with a few extending to the lower free troposphere ~ 2000 m agl. The trajectories in most cases featured a steady descent to the initiation point at 100 m agl.

Smoke plumes were present over the monitor locations for six out of the ten cases. However, because of a lack of vertical information in the satellite smoke product it could not be determined to what extent these smoke plumes influenced ground-level $PM_{2.5}$ concentrations. A few METAR observations from airports in Houston and western Louisiana indicated smoke aloft during the 3-day episode of 17 – 19 June at 3000 – 15000 feet agl, but there were no reports of reduced ground-level visibility. The METAR observations are included in the Appendix.

5 Recommendations for Further Study

There are several recommendations for future work that emerged from this study.

1. A more in-depth study could focus on possible local sources and how very fine scale (sub-kilometer to kilometer) meteorological features interact with these sources.
2. In this study most of the cases were strongly influenced by anticyclonic conditions and future studies could include cases with greater meteorological variability.
3. More information is required on the influence of the smoke plumes that were present over the monitoring locations for many of the cases in this study. In particular, the vertical layering of the smoke and mechanisms to mix smoke down to the surface could be explored.

6 References

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Appendix

METAR observations from selected airports in Houston and western Louisiana

16-19 June 2021: Typical summer weather with mostly diurnal thunderstorms, though fairly limited in extent. Very brief mention of smoke aloft (10,000-15000 ft) for both sites on the 18th. Tropical Storm Claudette passed well to the east with perhaps some subsidence distant from it. Some drier air advected in from the northeast.

George Bush Houston International Airport:

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KIAH 170053Z 22003KT 10SM FEW055 SCT250 32/21 A2995 RMK AO2 LTG DSNT E-SW SLP141 CB DSNT NE-SE
AND SW MOV SW T03170211
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MOV SW T03000222
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53013
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56007 $
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KIAH 190653Z 00000KT 10SM FEW065 26/21 A2986
KIAH 190753Z 00000KT 10SM FEW060 25/22 A2984
KIAH 190853Z 36004KT 10SM FEW060 26/21 A2983
KIAH 190953Z 36003KT 10SM CLR 24/21 A2983
KIAH 191053Z 00000KT 10SM CLR 24/21 A2984
KIAH 191153Z 35003KT 10SM CLR 25/22 A2986 RMK T02500217 10283 20233
KIAH 191253Z 00000KT 10SM FEW250 27/22 A2989
KIAH 191353Z 00000KT 10SM FEW250 28/22 A2991
KIAH 191453Z 00000KT 10SM FEW250 30/22 A2991
KIAH 191553Z 05003KT 10SM FEW036 FEW250 33/22 A2990
KIAH 191653Z 05004KT 10SM FEW039 SCT250 34/22 A2990
KIAH 191753Z 00000KT 10SM SCT046 SCT070 BKN250 34/21 A2988 RMK T03390211 10344 20250
KIAH 191853Z 12007KT 10SM SCT050 SCT070 BKN250 34/21 A2986 RMK AO2 SLP109 T03440211 $
KIAH 191953Z VRB03KT 10SM SCT055 SCT075 BKN250 34/21 A2984 RMK AO2 SLP103 T03390211 $
KIAH 192053Z 12006KT 10SM BKN055 34/21 A2983 RMK AO2 SLP099 T03440206 56017 $
KIAH 192153Z 13012G19KT 10SM SCT060 34/22 A2982 RMK AO2 SLP095 MDT CU SW-W T03390217
KIAH 192210Z 14010KT 10SM SCT060 34/22 A2981 RMK AO2 MOD CU SW-NW T03440217
KIAH 192253Z 12011KT 10SM SCT060TCU 34/21 A2981 RMK AO2 SLP094 TCU W-NW T03390211
KIAH 192347Z 16013KT 10SM TS SCT060CB SCT250 33/22 A2981 RMK AO2 TSB46 VCSH SE-S OCNL LTGCG S TS S MOV N
KIAH 192353Z 15017G23KT 10SM TS FEW043 SCT060CB SCT250 33/22 A2982 RMK AO2 TSB46 SLP096 VCSH SE-SW OCNL LTGCG S-SW TS S-SW MOV N T03280222 10361 20328 53001

Houston Hobby:

KHOU 170053Z 16006KT 10SM FEW050 BKN250 32/22 A2995 RMK AO2 LTG DSNT NE AND W SLP147 CB DSNT NE MOV W T03220217
KHOU 170153Z 20004KT 10SM FEW045 BKN250 31/22 A2995 RMK AO2 SLP147 T03110217
KHOU 170253Z 11003KT 10SM FEW110 BKN250 31/23 A2997 RMK AO2 SLP152 T03110228 53010
KHOU 170353Z 21003KT 10SM FEW090 29/23 A2998 RMK AO2 SLP155 T02940228
KHOU 170453Z 19004KT 10SM SCT250 29/22 A2997 RMK AO2 SLP153 T02890222
KHOU 170553Z 29003KT 10SM FEW250 28/22 A2996 RMK AO2 SLP150 T02780222 10333 20278 403610233 58003
KHOU 170653Z 00000KT 10SM CLR 28/21 A2996 RMK AO2 SLP147 T02780211
KHOU 170753Z 00000KT 10SM CLR 27/21 A2995 RMK AO2 SLP146 T02720211
KHOU 170853Z 00000KT 10SM FEW200 27/22 A2995 RMK AO2 SLP147 T02720217 55003
KHOU 170953Z 35003KT 10SM FEW200 27/22 A2996 RMK AO2 SLP149 T02670217
KHOU 171053Z 36007KT 10SM FEW060 FEW200 27/21 A2996 RMK AO2 SLP149 T02670211
KHOU 171153Z 01008KT 10SM FEW140 FEW200 27/22 A2997 RMK AO2 SLP153 70002 T02720222 10283 20261 53006
KHOU 171253Z 01010KT 10SM FEW250 29/22 A2998 RMK AO2 SLP156 T02890217
KHOU 171353Z 05009KT 10SM FEW250 31/22 A2999 RMK AO2 SLP159 T03060217
KHOU 171453Z 07012KT 10SM FEW150 FEW250 32/21 A2999 RMK AO2 SLP159 T03220206 50006
KHOU 171553Z 08007KT 10SM FEW040 SCT250 33/18 A2998 RMK AO2 SLP157 T03280178
KHOU 171653Z 09007KT 10SM SCT250 34/17 A2998 RMK AO2 SLP156 T03390172
KHOU 171753Z 13007KT 10SM FEW060 FEW250 34/19 A2996 RMK AO2 SLP150 T03440189 10344 20272 58009
KHOU 171853Z 08005G15KT 10SM SCT065 SCT250 34/19 A2995 RMK AO2 SLP145 T03440189
KHOU 171953Z 09007KT 050V120 10SM BKN060 BKN250 34/19 A2994 RMK AO2 SLP142 T03440189
KHOU 172053Z 10010KT 10SM BKN055 BKN250 34/19 A2993 RMK AO2 SLP139 T03440194 56010
KHOU 172153Z 11011KT 10SM BKN055 BKN250 34/19 A2992 RMK AO2 SLP136 T03390194
KHOU 172253Z 11009KT 10SM SCT060 BKN250 33/20 A2992 RMK AO2 SLP135 T03280200
KHOU 172353Z 12008KT 10SM SCT055 SCT250 33/20 A2991 RMK AO2 SLP133 T03280200 10350 20322 56006
KHOU 180053Z 13010KT 10SM SCT055 SCT250 31/19 A2992 RMK AO2 SLP136 T03060189
KHOU 180153Z 13009KT 10SM FEW045 SCT250 29/18 A2994 RMK AO2 SLP143 T02940183
KHOU 180253Z 12007KT 10SM FEW040 FEW060 SCT250 28/18 A2995 RMK AO2 SLP147 T02830183 53014

KHOU 180353Z 09005KT 10SM CLR 28/19 A2996 RMK AO2 SLP148 T02830189
KHOU 180453Z 13003KT 10SM CLR 28/19 A2995 RMK AO2 SLP146 T02780189
KHOU 180553Z 00000KT 10SM FEW250 27/19 A2994 RMK AO2 SLP142 T02720189 10322 20267 403500261 58005
KHOU 180653Z 34003KT 10SM FEW250 26/19 A2993 RMK AO2 SLP138 T02560194
KHOU 180753Z 00000KT 10SM CLR 27/19 A2992 RMK AO2 SLP135 T02670189
KHOU 180853Z 34005KT 10SM CLR 24/19 A2992 RMK AO2 SLP134 T02440189 56008
KHOU 180953Z 35005KT 10SM CLR 24/19 A2991 RMK AO2 SLP133 T02440194
KHOU 181053Z 35004KT 10SM CLR 24/19 A2991 RMK AO2 SLP133 T02390194
KHOU 181153Z 01006KT 10SM FEW100 25/19 A2993 RMK AO2 SLP137 FU FEW100 T02500189 10278 20233 53003
KHOU 181253Z 01005KT 10SM FEW200 27/19 A2993 RMK AO2 SLP137 T02720194
KHOU 181353Z 03010KT 10SM FEW200 29/18 A2994 RMK AO2 SLP141 T02890178
KHOU 181453Z 06006KT 10SM FEW200 31/17 A2994 RMK AO2 SLP142 T03110167 53005
KHOU 181553Z 06011KT 10SM FEW050 32/16 A2993 RMK AO2 SLP140 T03220156
KHOU 181653Z 07008G15KT 10SM FEW050 FEW250 33/16 A2992 RMK AO2 SLP137 T03280161
KHOU 181753Z VRB06KT 10SM FEW060 33/16 A2991 RMK AO2 SLP130 T03330161 10339 20250 58012
KHOU 181853Z 12008KT 10SM FEW060 34/17 A2989 RMK AO2 SLP125 T03390172
KHOU 181953Z 10010KT 10SM FEW060 34/17 A2988 RMK AO2 SLP122 T03440167
KHOU 182053Z 08005KT 10SM FEW060 34/17 A2986 RMK AO2 SLP115 T03440172 58015
KHOU 182153Z 11005KT 10SM SCT065 34/18 A2985 RMK AO2 SLP110 T03440183
KHOU 182253Z 12008KT 10SM SCT060 34/19 A2983 RMK AO2 SLP105 T03390189
KHOU 182353Z 11009KT 10SM FEW055 SCT080 33/20 A2983 RMK AO2 SLP106 T03330200 10350 20333 55009
KHOU 190053Z 13003KT 10SM SCT080 33/20 A2983 RMK AO2 SLP106 T03280200
KHOU 190153Z 12003KT 10SM FEW060 FEW080 32/20 A2984 RMK AO2 SLP109 T03220200
KHOU 190253Z 35005KT 10SM BKN050 31/20 A2985 RMK AO2 SLP113 T03110200 53007
KHOU 190353Z 20005KT 10SM BKN050 BKN065 30/22 A2986 RMK AO2 SLP116 T03000217
KHOU 190453Z 22005KT 10SM FEW050 28/22 A2987 RMK AO2 SLP119 T02830222
KHOU 190553Z 25005KT 10SM SCT050 BKN250 28/22 A2987 RMK AO2 SLP117 T02830217 10328 20278
403500233 50004
KHOU 190653Z 25004KT 10SM SCT055 BKN250 28/22 A2985 RMK AO2 SLP113 T02830217
KHOU 190753Z 21005KT 10SM FEW250 27/22 A2984 RMK AO2 SLP109 T02670222
KHOU 190853Z 23008KT 10SM FEW250 27/22 A2983 RMK AO2 SLP105 T02720217 58012
KHOU 190953Z 25007KT 10SM CLR 27/22 A2982 RMK AO2 SLP102 T02670217
KHOU 191053Z 27004KT 10SM FEW250 26/22 A2983 RMK AO2 SLP106 T02610217
KHOU 191153Z 28004KT 10SM CLR 26/22 A2986 RMK AO2 SLP116 T02610222 10289 20256 53011
KHOU 191253Z 28005KT 10SM CLR 28/22 A2988 RMK AO2 SLP121 T02780222
KHOU 191353Z 27005KT 10SM CLR 29/20 A2990 RMK AO2 SLP129 T02890200
KHOU 191453Z 29004KT 10SM FEW250 31/19 A2991 RMK AO2 SLP131 T03110194 51015
KHOU 191553Z 00000KT 10SM FEW030 FEW250 32/19 A2990 RMK AO2 SLP128 T03220189
KHOU 191653Z 16003KT 10SM FEW035 SCT250 34/19 A2989 RMK AO2 SLP124 T03390194
KHOU 191753Z VRB03KT 10SM SCT038 BKN250 34/19 A2987 RMK AO2 SLP119 T03440194 10350 20261 58012
KHOU 191853Z 13005KT 10SM SCT050 BKN250 36/19 A2985 RMK AO2 SLP112 T03560189
KHOU 191953Z 19005KT 10SM SCT055 BKN250 34/19 A2984 RMK AO2 SLP107 T03440189
KHOU 192053Z 16003KT 10SM SCT055 SCT250 36/19 A2982 RMK AO2 SLP102 T03560189 56017
KHOU 192153Z 14011KT 10SM SCT055 SCT250 36/21 A2982 RMK AO2 SLP100 T03560211
KHOU 192253Z 18015G19KT 10SM SCT045 SCT060 SCT250 34/23 A2982 RMK AO2 SLP100 T03440228
KHOU 192353Z 17014G19KT 10SM FEW042 FEW070 SCT250 33/22 A2982 RMK AO2 LTG DSNT N AND NW SLP101 CB
DSNT N MOV N T03280217 10367 20328 55001

Karnack region in E TX:

17 June 2021: Quiescient conditions with brief mention of smoke at ~3000 ft late near Shreveport, but with no surface visibility restrictions.

KSHV Shreveport. LA:

KSHV 170056Z 18005KT 10SM FEW050 31/22 A2997 RMK AO2 SLP146 T03110222
KSHV 170156Z 00000KT 10SM FEW045 29/23 A2998 RMK AO2 SLP147 T02940228
KSHV 170256Z 00000KT 10SM FEW045 28/23 A3000 RMK AO2 SLP155 T02830228 53012
KSHV 170356Z 00000KT 10SM FEW045 27/22 A3001 RMK AO2 SLP158 T02720222
KSHV 170456Z 16003KT 10SM CLR 27/22 A3000 RMK AO2 SLP155 T02720217
KSHV 170556Z 13004KT 10SM CLR 26/21 A2999 RMK AO2 SLP151 T02610206 10328 20261 403560228 58003
KSHV 170656Z 15004KT 10SM CLR 26/21 A2999 RMK AO2 SLP151 T02560206
KSHV 170756Z 00000KT 10SM CLR 25/20 A2999 RMK AO2 SLP150 T02500200
KSHV 170856Z 00000KT 10SM FEW080 24/20 A2999 RMK AO2 SLP151 T02440200 55001
KSHV 170956Z 00000KT 10SM CLR 24/19 A3000 RMK AO2 SLP154 T02440194
KSHV 171056Z 12003KT 10SM FEW080 24/19 A3001 RMK AO2 SLP157 T02390194
KSHV 171156Z 13003KT 10SM CLR 24/18 A3002 RMK AO2 SLP161 T02390183 10261 20233 53010
KSHV 171256Z 15005KT 10SM BKN280 25/19 A3002 RMK AO2 SLP161 TCU DSNT NE-E T02500189
KSHV 171356Z 14009KT 10SM FEW065 BKN085 27/17 A3004 RMK AO2 SLP168 T02670172
KSHV 171456Z 18005KT 10SM SCT060 BKN080 BKN095 28/18 A3005 RMK AO2 SLP170 T02780178 53009
KSHV 171556Z 23005KT 10SM FEW070 BKN095 29/18 A3004 RMK AO2 SLP167 T02940178
KSHV 171656Z 14009KT 10SM BKN049 BKN065 BKN270 31/14 A3004 RMK AO2 SLP168 T03060144

KSHV 171756Z 19007KT 10SM BKN047 BKN095 BKN270 32/13 A3002 RMK AO2 SLP160 T03170133 10317 20239 58009
KSHV 171856Z 14005KT 10SM SCT060 BKN270 31/16 A3001 RMK AO2 SLP157 T03110161
KSHV 171956Z VRB06KT 10SM SCT160 BKN270 32/17 A2999 RMK AO2 SLP151 T03220172
KSHV 172056Z 11005KT 10SM SCT060 SCT170 BKN270 33/18 A2998 RMK AO2 SLP146 T03330183 58015
KSHV 172156Z 13005KT 10SM FEW055 SCT170 33/19 A2997 RMK AO2 SLP144 T03280189
KSHV 172256Z 13005KT 10SM SCT050 SCT170 32/19 A2996 RMK AO2 SLP141 T03220194
KSHV 172356Z 13005KT 10SM FEW030 FEW050 32/19 A2995 RMK AO2 SLP139 FU FEW030 NE T03170194 10333 20311 58007

25 July 2021: Warm conditions with high pressure and some patchy mist.

KSHV 250056Z 19003KT 8SM FEW044 32/23 A2998 RMK AO2 SLP147 T03170233 $
KSHV 250156Z 20003KT 8SM CLR 29/23 A2998 RMK AO2 SLP148 T02890233 $
KSHV 250256Z 00000KT 10SM CLR 28/23 A2999 RMK AO2 SLP151 T02830233 53006 $
KSHV 250356Z 20003KT 10SM CLR 28/23 A2999 RMK AO2 SLP152 T02830233 $
KSHV 250456Z 00000KT 10SM FEW280 27/23 A2999 RMK AO2 SLP151 T02720233 $
KSHV 250556Z 24004KT 10SM FEW280 27/23 A2998 RMK AO2 SLP148 T02720233 10333 20272 403440256 58003 $
KSHV 250656Z 23003KT 10SM FEW280 27/23 A2998 RMK AO2 SLP147 T02720228 $
KSHV 250756Z 24003KT 10SM FEW280 27/23 A2998 RMK AO2 SLP146 T02720228 $
KSHV 250856Z 23003KT 10SM FEW280 27/23 A2998 RMK AO2 SLP147 T02670228 55001 $
KSHV 250956Z 00000KT 10SM FEW280 26/22 A2999 RMK AO2 SLP150 T02610222 $
KSHV 251056Z 00000KT 10SM FEW280 25/22 A2999 RMK AO2 SLP151 T02500222 $
KSHV 251156Z 00000KT 10SM FEW200 FEW280 26/23 A3000 RMK AO2 SLP153 T02560228 10278 20250 51006 $
KSHV 251256Z 23003KT 10SM FEW280 27/23 A3001 RMK AO2 SLP157 T02670228 $
KSHV 251356Z 23004KT 6SM HZ BKN110 28/23 A3002 RMK AO2 SLP162 T02830233 $
KSHV 251456Z 27005KT 7SM SCT110 31/23 A3003 RMK AO2 SLP165 T03060233 51013 $
KSHV 251556Z 26004KT 7SM FEW028 FEW110 32/24 A3003 RMK AO2 SLP166 T03220239 $
KSHV 251656Z 22006KT 7SM FEW030 33/23 A3002 RMK AO2 SLP162 T03280228 $
KSHV 251756Z VRB04KT 7SM SCT034 33/23 A3000 RMK AO2 SLP155 T03330228 10339 20256 58010 $
KSHV 251856Z 18005KT 7SM SCT043 SCT055 35/21 A2997 RMK AO2 SLP146 T03500206 $
KSHV 251956Z 11004KT 7SM SCT044 SCT052 34/22 A2996 RMK AO2 SLP140 T03440217 $
KSHV 252056Z 20003KT 7SM FEW045 34/22 A2994 RMK AO2 SLP133 T03440222 56022 $
KSHV 252156Z 24003KT 7SM FEW048 34/22 A2992 RMK AO2 SLP128 T03440217 $
KSHV 252256Z 20007KT 7SM FEW048 34/21 A2991 RMK AO2 SLP124 T03440206 $
KSHV 252356Z 23004KT 10SM CLR 33/21 A2989 RMK AO2 SLP116 T03330206 10356 20333 58017 $

6 August 2021: Some haze but quiet conditions under high pressure.

KSHV 060056Z 08006KT 10SM FEW180 FEW250 BKN300 28/17 A3005 RMK AO2 SLP171 T02780172
KSHV 060156Z 09006KT 10SM FEW180 SCT250 BKN300 26/18 A3005 RMK AO2 SLP171 T02610178
KSHV 060256Z 11004KT 10SM SCT250 OVC300 26/19 A3006 RMK AO2 SLP175 T02610189 53006
KSHV 060356Z 00000KT 10SM SCT250 OVC300 26/19 A3007 RMK AO2 SLP177 T02610194
KSHV 060456Z 17003KT 10SM OVC250 26/19 A3005 RMK AO2 SLP172 T02560194
KSHV 060556Z 00000KT 10SM OVC260 26/19 A3004 RMK AO2 SLP169 T02560194 10300 20244 403220200 58005
KSHV 060656Z 00000KT 10SM OVC240 24/20 A3003 RMK AO2 SLP167 T02440200
KSHV 060756Z 09003KT 10SM BKN240 24/19 A3003 RMK AO2 SLP166 T02440194
KSHV 060856Z 00000KT 9SM FEW120 BKN240 24/20 A3004 RMK AO2 SLP168 T02390200 55002
KSHV 060956Z 00000KT 10SM FEW130 BKN200 24/19 A3005 RMK AO2 SLP172 T02440194
KSHV 061056Z 00000KT 8SM SCT140 BKN200 23/20 A3006 RMK AO2 SLP175 T02280200
KSHV 061156Z 00000KT 10SM BKN120 BKN190 24/19 A3007 RMK AO2 SLP180 T02390194 10250 20228 53012
KSHV 061256Z 00000KT 8SM SCT120 BKN200 24/21 A3008 RMK AO2 SLP182 T02440206
KSHV 061356Z 00000KT 8SM FEW120 BKN180 BKN250 26/20 A3010 RMK AO2 SLP189 T02610200
KSHV 061456Z 15004KT 10SM FEW016 SCT180 BKN250 28/18 A3009 RMK AO2 SLP186 T02830183 50006
KSHV 061556Z VRB03KT 10SM CLR 31/18 A3010 RMK AO2 SLP187 T03060178
KSHV 061656Z 7SM FEW040 BKN230 31/18 A3009 RMK AO2 SLP185 T03110178
KSHV 061756Z VRB05KT 7SM FEW035 SCT150 SCT270 32/18 A3008 RMK AO2 SLP180 T03220178 10322 20239 58005
KSHV 061856Z 17007KT 7SM FEW040 SCT280 33/18 A3005 RMK AO2 SLP171 T03330183
KSHV 061956Z VRB06KT 10SM CLR 33/18 A3003 RMK AO2 SLP166 T03330178
KSHV 062056Z 22004KT 7SM SCT050 SCT280 33/18 A3002 RMK AO2 SLP162 T03280183 56018
KSHV 062156Z VRB03KT 7SM SCT050 33/17 A3001 RMK AO2 SLP157 T03280172
KSHV 062256Z 14008KT 7SM FEW060 33/18 A3000 RMK AO2 SLP154 T03280178
KSHV 062356Z 16006KT 9SM FEW060 32/18 A2999 RMK AO2 SLP152 T03170183 10339 20317 56011