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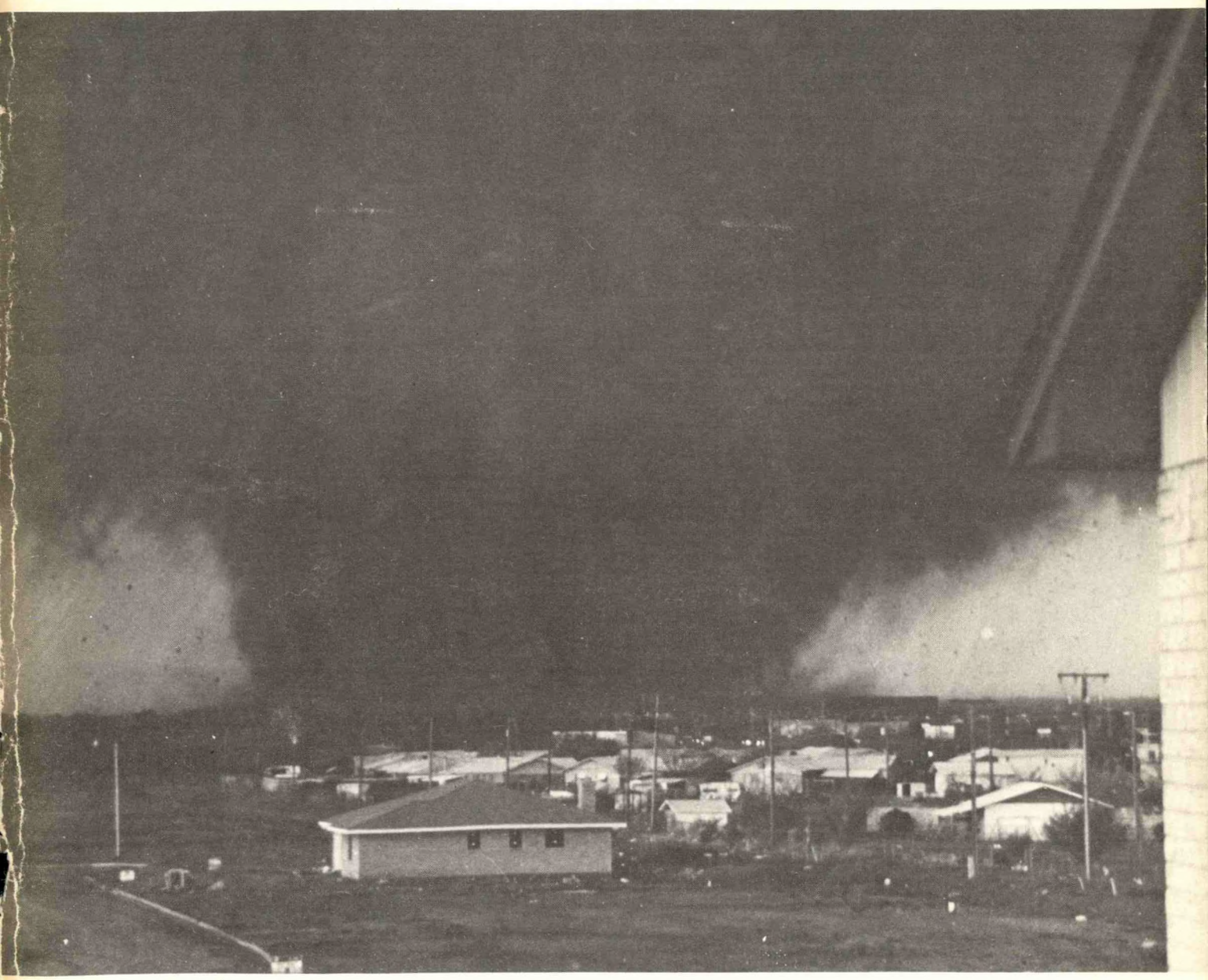
A Report to the Administrator



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md.
January 1980

Natural Disaster Survey Report 80-1

Red River Valley Tornadoes of April 10, 1979

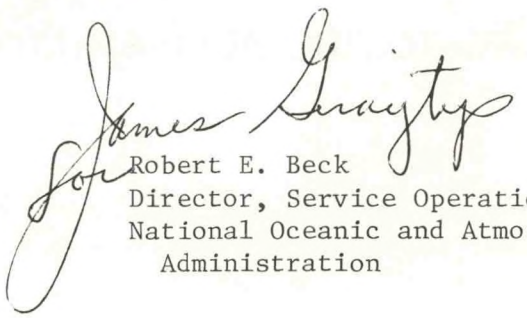
A REPORT TO THE ADMINISTRATOR

Rockville, Md
January 1980

U.S. DEPARTMENT OF COMMERCE
Philip M. Klutznick, Secretary
United States
National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

FOREWORD

Within 24 hours after several devastating tornadoes struck the Red River Valley area on the Texas-Oklahoma border, a NOAA survey team was formed to assess the effectiveness of the warning system. This report presents the findings and recommendations of that team.



Robert E. Beck
Director, Service Operations
National Oceanic and Atmospheric
Administration

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PREFACE

A NOAA disaster survey team was formed on April 11, 1979, to review the performance of the National Weather Service (NWS) and the National Environmental Satellite Service (NESS) during the Red River Valley killer tornadoes of April 10. Members of the team were:

Robert E. Beck, NOAA Headquarters, Team Leader
Walter D. Castle, NOAA Headquarters
Jack Guinan, NOAA, Public Affairs
Karl Johannessen, NWS Headquarters
Melvin McLaughlin, WSFO San Antonio, Tex.
H. Michael Mogil, NWS Headquarters
Jim Purdom, NESS Applications Group
Max White, NWS Southern Region Headquarters

Members of the team visited the communities of Wichita Falls and Vernon, Tex., and Lawton, Okla., on April 12 and 13, 1979. Some members also visited the National Severe Storms Forecast Center in Kansas City, Mo., and the NWS offices at Fort Worth, Wichita Falls, and Oklahoma City. In June 1979, followup discussions were held with some local officials and representatives of the mass media at a conference convened by Texas Tech University to assess research on the Wichita Falls tornado.

Substantive contributions to the report were made by many NWS people, particularly at the NWS Southern Region Headquarters at Fort Worth, Tex., and at the Wichita Falls, Fort Worth, and Oklahoma City NWS offices. Professor T. T. Fujita (University of Chicago) provided detailed storm track analyses based on his aerial photographic missions. First Lt. Wolfgang Lange of the 80th Flying Training Wing, Sheppard AFB, Tex., supplied the sequence of photographs of the tornado as it approached Wichita Falls. Len Hooten of Wichita Falls, Tex., supplied the cover photograph for this report.

The team is indebted to the many people from the States of Texas and Oklahoma; the cities of Vernon and Wichita Falls, Tex., and Lawton, Okla.; and all the representatives of the system. We also thank the people of Wichita Falls, Vernon, and Lawton who shared their experiences with us to help us undertand why people act or don't act in the precious seconds and minutes before the tornado strikes.

As high as the losses were, there was widespread agreement by public officials and the media that loss of life and injuries would have been much higher but for the excellent NWS forecasts and warnings and effective siren systems. A great deal of credit must be given to the strong preparedness programs in the area and to all the participating public officials, civic organizations, media representatives, and the citizens themselves. These were communities prepared through united efforts for cooperative action to save lives. Their model preparedness efforts paid off and point the way for other towns and cities.

Thomas B. Owen

Thomas B. Owen
Assistant Administrator
National Oceanic and Atmospheric
Administration

CHAPTER I

THE RED RIVER VALLEY TORNADOES OF APRIL 10, 1979

To people in the Red River Valley of Texas and Oklahoma, nothing about the weather appeared unusual during the early hours of April 10, 1979: it was business as usual. But before the day's end, three very large, devastating tornadoes swept across the area leaving scores dead and hundreds injured. Most of the deaths were in Wichita Falls and Vernon, Tex., and Lawton, Okla.

Early on April 10, NWS forecasters became aware of the threat of severe weather. During the morning, closely monitored air mass movements, temperatures, dew points, and winds had all been shifting toward the critical values indicative of severe thunderstorms and potential tornadoes. By noon, all doubt was gone. Forecasters at the National Severe Storms Forecast Center in Kansas City had to decide only how soon tornadoes would develop and how large an area would be threatened. Tornado Watch #67 was issued at 1:55 p.m. Central Standard Time (CST)* calling for tornadoes, large hail, and damaging thunderstorm winds in portions of a 30,000-square-mile area of north-central Texas and southwest Oklahoma. Just minutes later all counties included in Watch Area #67 were being alerted through statements issued by the NWS Forecast Offices (WSFO's) at Fort Worth and Oklahoma City. The messages were fanned out by NOAA Weather Wire, NOAA Weather Radio, and by direct phone calls to media outlets for radio and TV broadcasts to the public. In Wichita Falls, an emergency hot line to key local officials, TV, and radio stations assured rapid and complete local dissemination.

Storm spotter networks were alerted. Members of the Wichita Falls Repeater Club Weather Spotters manned their preplanned command post in the NWS Office (WSO) and deployed radio-equipped members to vantage points that assured good observation coverage southwest of the city. Radio and TV stations aired the Tornado Watch so that most people were alerted to the threat and ready for the warning messages and sirens that were to come later.

At Vernon, reports of earlier damage to the southwest of the city had alerted spotters and city officials. For example, the police chief called the city manager out of a meeting with the county commissioners. The police chief and county sheriff conferred and dispatched patrol cars to the southwest edge of town to watch for the approaching storm. Sirens blew as the tornado bore down on Vernon. In slightly more than 10 minutes, the tornado had passed across the southern tip of the city leaving 11 dead, more than 60 injured, and several hundred homes destroyed or damaged. The police chief and the sheriff later said the approaching

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* All times CST.

storm did not look like a normal twister, but appeared as a thick, dark mass of clouds low to the ground and difficult to see because of heavy rain, hail, and low cloud base.

The thunderstorm system that produced the Vernon tornado crossed the Red River and left a 50-mile-long skipping track of tornado damage through Oklahoma. Just after 5:00 p.m., another tornado spawned by the same thunderstorm system crashed into Lawton, Oklahoma. Lawton had been alerted by Tornado Watch #67 and had received a tornado warning issued by WSFO Oklahoma City. Lawton was as ready as a community could be for the tornado. Using spotter and radar reports, Lawton officials sounded the siren system to warn the people of the approaching storm. As a result of the early warning, the casualty list of 3 dead and 109 injured was relatively small despite the destruction of several hundred homes and businesses.

About the time the Vernon tornado was moving across the Red River into Oklahoma, 20 miles to the south, another funnel cloud was dropping out of thunderstorm clouds approaching Harrold, Tex. This thunderstorm spawned a tornado with a continuous ground track of almost 60 miles. Fortunately, its long path on the ground was mostly over open farmland so that it caused relatively few casualties and small total property damage. However, several small communities, among them Harrold, Tex., and Grandfield, Okla., were hit by the storm.

When the giant tornado struck Wichita Falls just before 6:00 p.m., most people were not surprised. Severe weather warnings had been in effect for Wichita County and Wichita Falls for almost an hour. The warnings were being broadcast repeatedly by two local TV stations and three local radio stations which were receiving continuously updated information over the emergency hotline connecting them with the Wichita Falls WSO. The siren system for the city was sounded three times, the last around 5:50 p.m. just as storm spotters reported the tornado approaching Memorial Stadium in the southwestern suburbs of Wichita Falls. The giant tornado was a massive black column extending from the low striated base of the inky clouds to the ground. Huge pieces of debris thrown high in the air were clearly visible from miles away as the storm cut a swath of destruction through the city. Eyewitnesses described details of the storm differently, but they were unanimous on one point -- it was an awesome, terrifying experience beyond anything they had encountered before.

Despite the excellent warning lead-time and multiple sounding of the sirens, some people of Wichita Falls either did not hear the warnings or failed to take prescribed lifesaving actions. More than 40 died, and about 1,700 were injured. As the storm bore down, those who sought the

safest refuge in their immediate surroundings generally fared well. Those who were caught in automobiles and trucks made up a high percentage of the fatalities. People from the shopping center took shelter in refrigerator vaults, in restrooms, and under counters. A number of families used bathtubs, hallways, and closets. Several got extra protection by covering themselves with mattresses and pillows. They survived!

The three main storms in the Red River Valley outbreak were giant tornadoes. Each lasted for an hour or more and left a continuous track of ground damage 35 miles or longer. In addition, the damage path of all three was wider than normal. This was especially true of the Wichita Falls tornado whose more than 1-mile-wide path of damage is one of the biggest on record. T. T. Fujita, noted tornado researcher from the University of Chicago, said, "The damage path was one of the widest I have ever seen, and its intensity was almost equal to that of the giant storm that leveled Xenia, Ohio, in the 1974 tornado outbreak."

When the day had ended, the tornadoes had left in their wake a tragically high toll -- 56 dead and 1,916 injured. According to the American National Red Cross, 7,759 families suffered losses in the storms (table 1). Losses eligible for Federal disaster relief totalled $63 million, but Federal disaster assistance did not cover additional millions in damages.

A

B

C

This is what people on the southwest side of Wichita Falls saw as the tornado-producing thunderstorm approached. (A) Wall cloud at southwestern edge of storm. (B) Tornado touchdown. (C) Tornado grows, picking up dust.

D

E

F

(D) Strong tornado clearly visible against bright sky. (E and F) Tornado moves closer to Wichita Falls. School on left-hand side of all pictures was totally destroyed by the tornado.

Table 1 -- Casualty and Property Losses - Red River Valley Tornadoes*

	TEXAS	OKLAHOMA	TOTAL
Deaths	53	3	56
Injuries	1,807	109	1,916
Hospitalized	240	19	259
Dwellings			
Destroyed	2,784	150	2,934
Major damage	923	97	1,020
Minor damage	1,803	440	2,243
Mobile homes			
Destroyed	103	36	139
Major damage	1	4	5
Apartment/Condominium Family units			
Destroyed	1,124	8	1,132
Major damage	0	4	4
Minor damage	170	0	170
Small businesses Destroyed or with major damage	98	14	112
Families suffering losses	7,006	753	7,759

* These figures include 12 counties. In Texas: Clay, Foard, Wichita, and Wilbarger; and in Oklahoma: Carter, Cleveland, Commanche, Cotton, Jefferson, Pottawatomie, Stephens, and Tillman. Casualty data were supplied by Texas and Oklahoma NWS offices. Other data were supplied by the American National Red Cross.

CHAPTER II

THE TORNADO AND SEVERE LOCAL STORMS WARNING PROGRAM

A. OVERVIEW

The basic forecast program begins at the National Meteorological Center (NMC) near Washington, D.C. NMC computer-processes meteorological observations and produces maps of observed and forecast weather systems. NMC also computes and transmits statistical thunderstorm and severe thunderstorm guidance forecasts, and several forecast and observed stability indices to the National Severe Storms Forecast Center (NSSFC) in Kansas City, Mo., and to NWS field offices.

NSSFC is responsible for issuing Tornado and Severe Thunderstorm Watches and Severe Weather Outlooks. A NESS* field service station is collocated with NSSFC.

NSSFC meteorologists monitor potential severe weather conditions over the North American continent, using surface data from hundreds of locations, radar information, satellite imagery, detailed meteorological upper air profiles and analyses, and special computer-derived fields (not only from NMC, but also several developed and produced at NSSFC). These forecasters also routinely perform detailed mesoscale analyses. From this arsenal of weather information, the forecaster determines the area(s) in which severe local storms are most likely to occur.

NSSFC routinely issues severe weather outlooks at 2:30 a.m., 9 a.m., and 1:30 p.m. daily during the height of the tornado season. These outlooks have information about both severe and nonsevere thunderstorms for periods up to 24 hours in advance. The outlooks are updated as necessary.

Tornado Watches are messages from NSSFC alerting areas potentially threatened by tornadoes. They specify the area covered by the watch, and establish a period of a few hours during which tornado probabilities are expected to be dangerously high. Watches are sent by teletypewriter to NWS offices where they are broadcast on NOAA Weather Radio and to commercial radio and television stations for dissemination to the general public in and near endangered areas. The watches also alert law enforcement and emergency service officials, volunteer storm spotters, and other cooperating personnel. Some of these people "fan out" the watch information to others.

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* NESS, like NWS, is a major program element of NOAA.

Tornado watches are not tornado warnings. They simply tell people that tornadoes are possible in a specified area, for a specified period of time. Until a tornado warning is issued, persons in watch areas are urged to continue their normal routines but to watch for threatening weather and listen for later statements and possible warnings.

The 52 NWS Forecast Offices (WSFO's) are the backbone of the field forecasting operation. These offices have forecast responsibility for States or large portions of States. WSFO's redefine the NSSFC watch areas usually into county and major metropolitan area lists.

The 52 WSFO's and the more than 200 WSO's have important county warning responsibilities. In the contiguous United States, all counties are assigned to specific field offices for warning purposes. County warning areas are assigned on the basis of radar coverage, availability of methods for communicating with the public and public safety officials, station staffing, and other factors. In addition to issuing tornado and severe thunderstorm warnings, these offices issue weather statements to keep people in their areas informed, especially when severe weather is anticipated.

Tornado Warnings are issued when a tornado or funnel cloud has actually been sighted or radar indicates a tornado-bearing storm. In many cases, warnings are made possible through the cooperation of SKYWARN Volunteers (trained storm spotters) and other public-spirited persons who notify the nearest NWS office or community warning center when they see a tornado or funnel cloud or experience large hail or high winds. Warnings usually indicate the location of the tornado at the time of detection, the area through which it is expected to move, and the time (usually within an hour or less) when the tornado is expected to move through the area warned. When a tornado warning is issued, persons in the path of the storm are urged to take immediate safety precautions.

B. EARLY ACTIONS ON APRIL 10

Up to 9 a.m. The large-scale computer forecasts and the special severe weather guidance forecasts based on 6 p.m. (April 9) upper air data indicated severe weather was possible for the Texas-Oklahoma area. The weather situation, however, did not have all the ingredients necessary for a major tornado outbreak.

The key factor was a strong upper level weather disturbance headed southeastward from the western United States. Ahead of it a weaker upper level disturbance was moving northeastward from the Texas Panhandle. A strong 200 millibar (about 40,000 feet) level jet stream existed from the eastern Pacific across northern Mexico into south Texas. Very warm, moist,

and unstable air was poised over southern Texas. Figures 1 - 4 show these features.

The NSSFC forecaster preparing the 2:30 a.m. outlook was faced with several difficult problems. These included: (1) forecasting the movement and intensity of the upper level storm system over the western States, (2) evaluating the effect of a weaker disturbance over the Texas Panhandle, and (3) determining the movement of the low-level moisture into the area. After studying the situation carefully, he concluded that the ingredients for severe weather would be present by afternoon. Thus, he called for a few severe thunderstorms in part of northern Texas, most of Oklahoma, Arkansas, and Louisiana, and part of western Mississippi in his 2:30 a.m. severe weather outlook.

This outlook is routinely given nationwide public distribution weekdays on the NBC and ABC networks and on public television. It can also be incorporated into State, zone, and local forecasts as forecasters in WSFO's adjust the outlook for timing and local factors. The early morning State weather summaries and forecasts for Oklahoma and west Texas mentioned severe or locally heavy thunderstorms. The forecasts prepared by WSFO Fort Worth for north-central Texas did not yet indicate that thunderstorms were expected to reach severe limits.

9 a.m. to 2 p.m. Analyses of 6 a.m. data at NSSFC confirmed the earlier thinking. The upper level disturbance had turned east-southeastward and continued to move slower than the LFM* had forecast. It had also intensified and taken on a classic "negative-tilt." (Most upper level weather systems are oriented northeast to southwest. This was oriented north-northwest to south-southeast. Many historical severe storm outbreaks have been associated with this type of upper level pattern.) At 200 millibars, the jet stream continued from the eastern Pacific across northern Mexico and southern Texas. However, missing upper air data at both Guadalupe Island and Guaymas resulted in a very poor resolution of the upper level wind speed structure. Fortunately, satellite images showed a wind speed maximum moving east-southeastward across northwestern Mexico. At lower levels moisture began to advance northward on strong southerly winds. The 5,000-foot level dew point at Stephenville, Tex., rose 31°F (17°C) during the 12-hour period ending 6 a.m. Surface dew points had begun to rise, too. Instability was rapidly increasing in the north Texas area. Figures 5 - 8 show these weather features.

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* The LFM (Limited-Area Fine Mesh Model) is used by NMC twice daily (6 a.m. and 6 p.m.) to produce surface and selected pressure level prognostic charts for up to 48 hours.

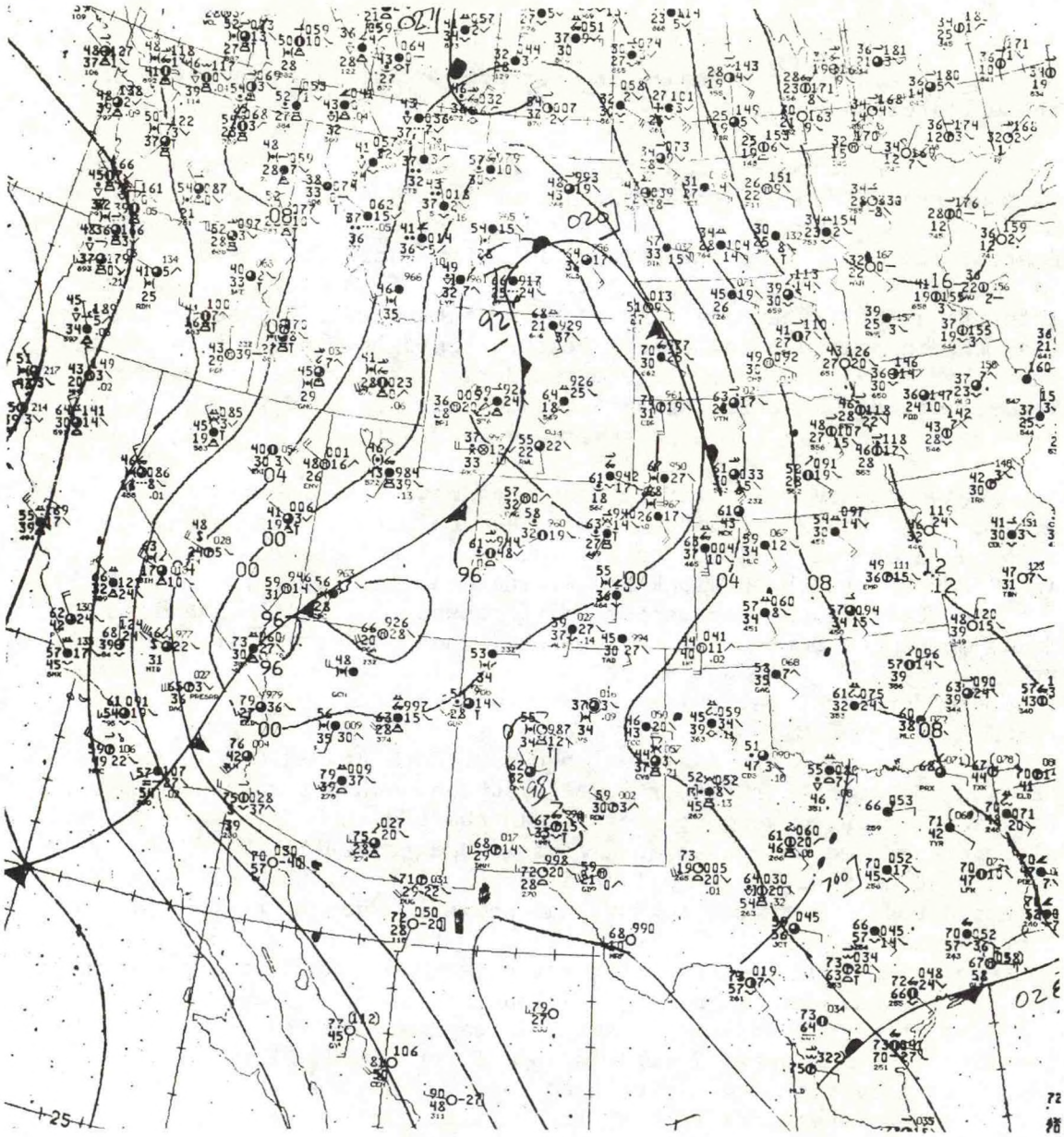

Figure 1 -- Surface Weather Map, 6 p.m., April 9, 1979.

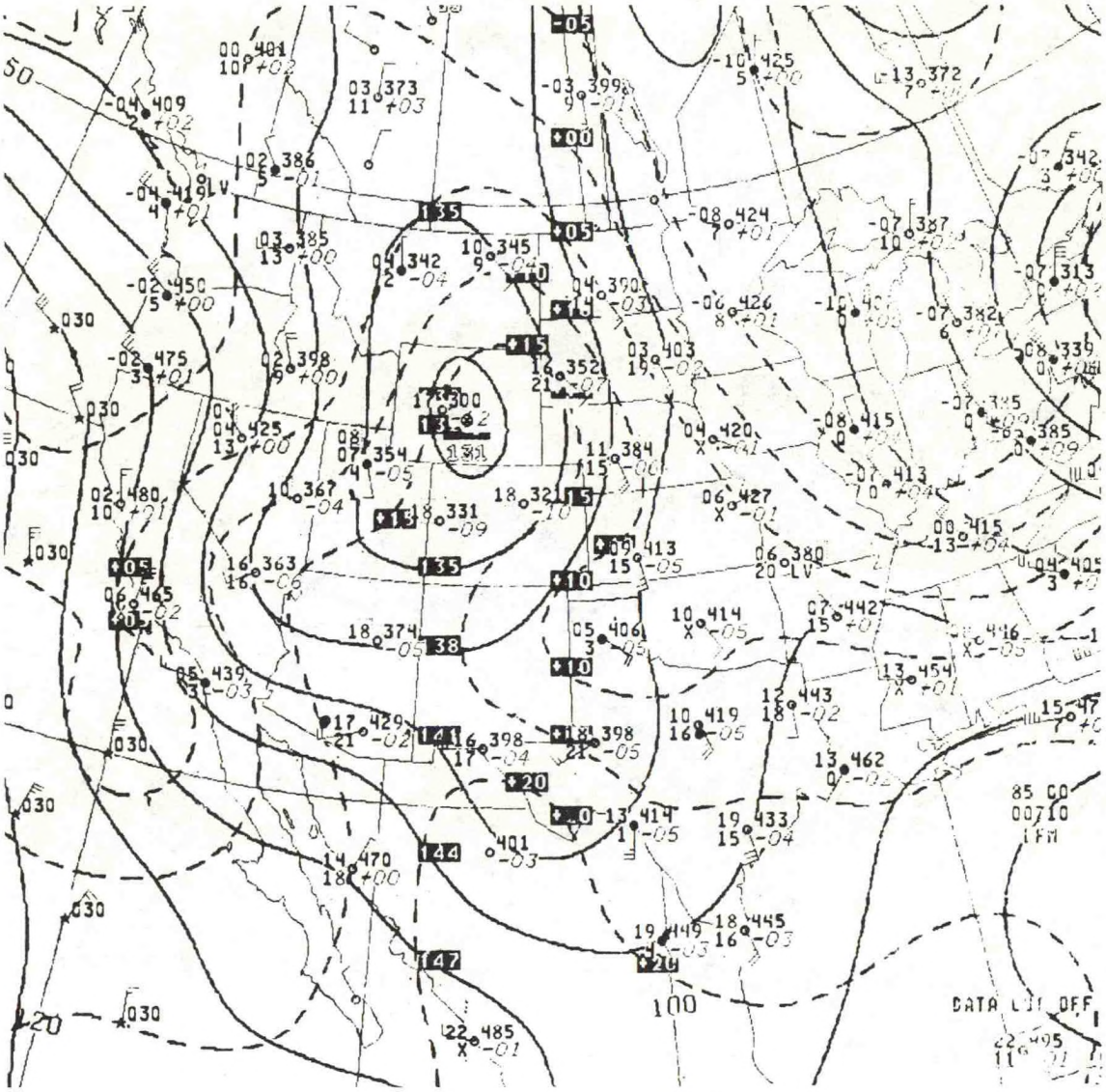

Figure 2 -- 850 Millibar Map, 6 p.m., April 9, 1979.

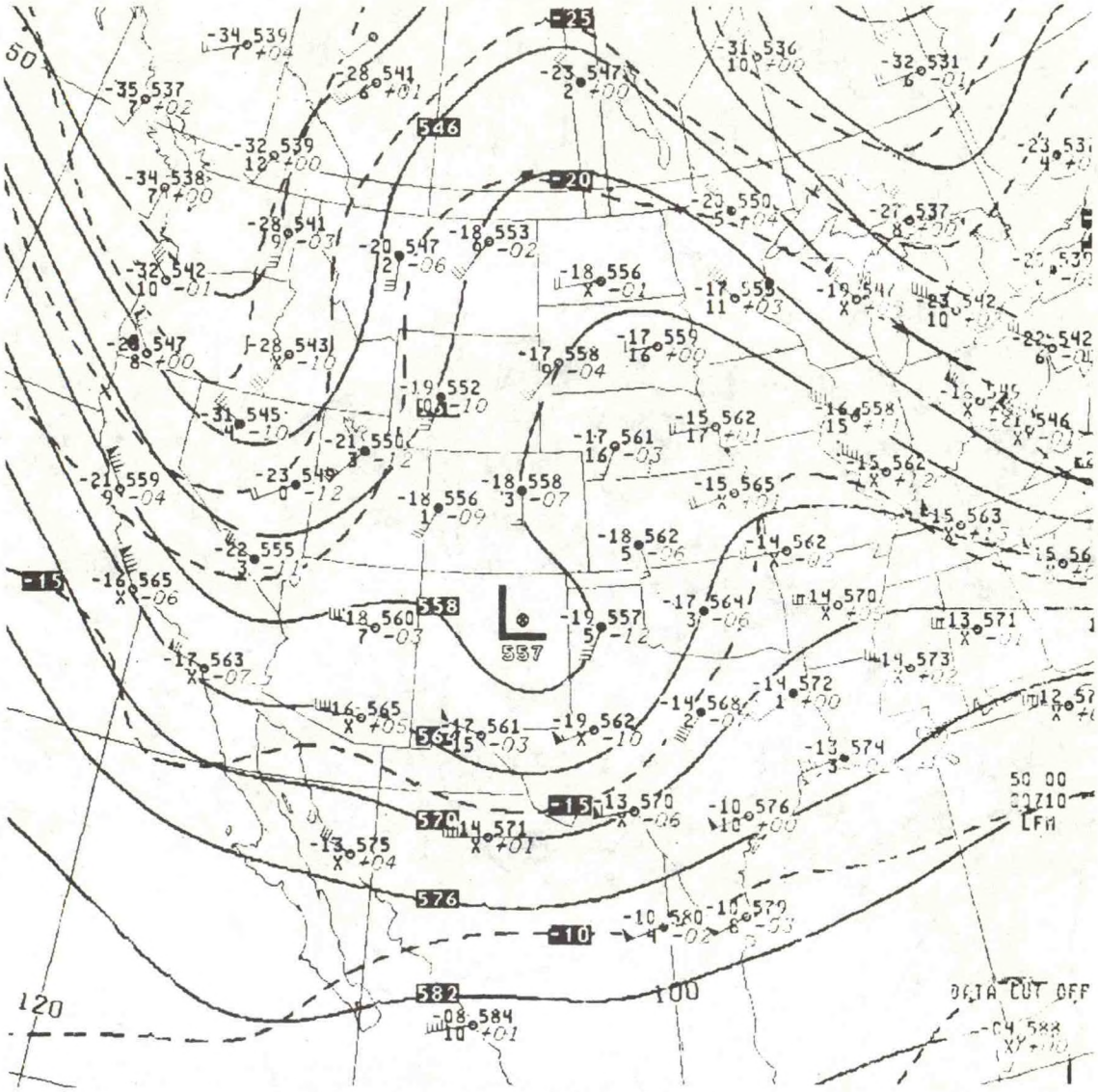

Figure 3 -- 500 Millibar Map, 6 p.m., April 9, 1979.

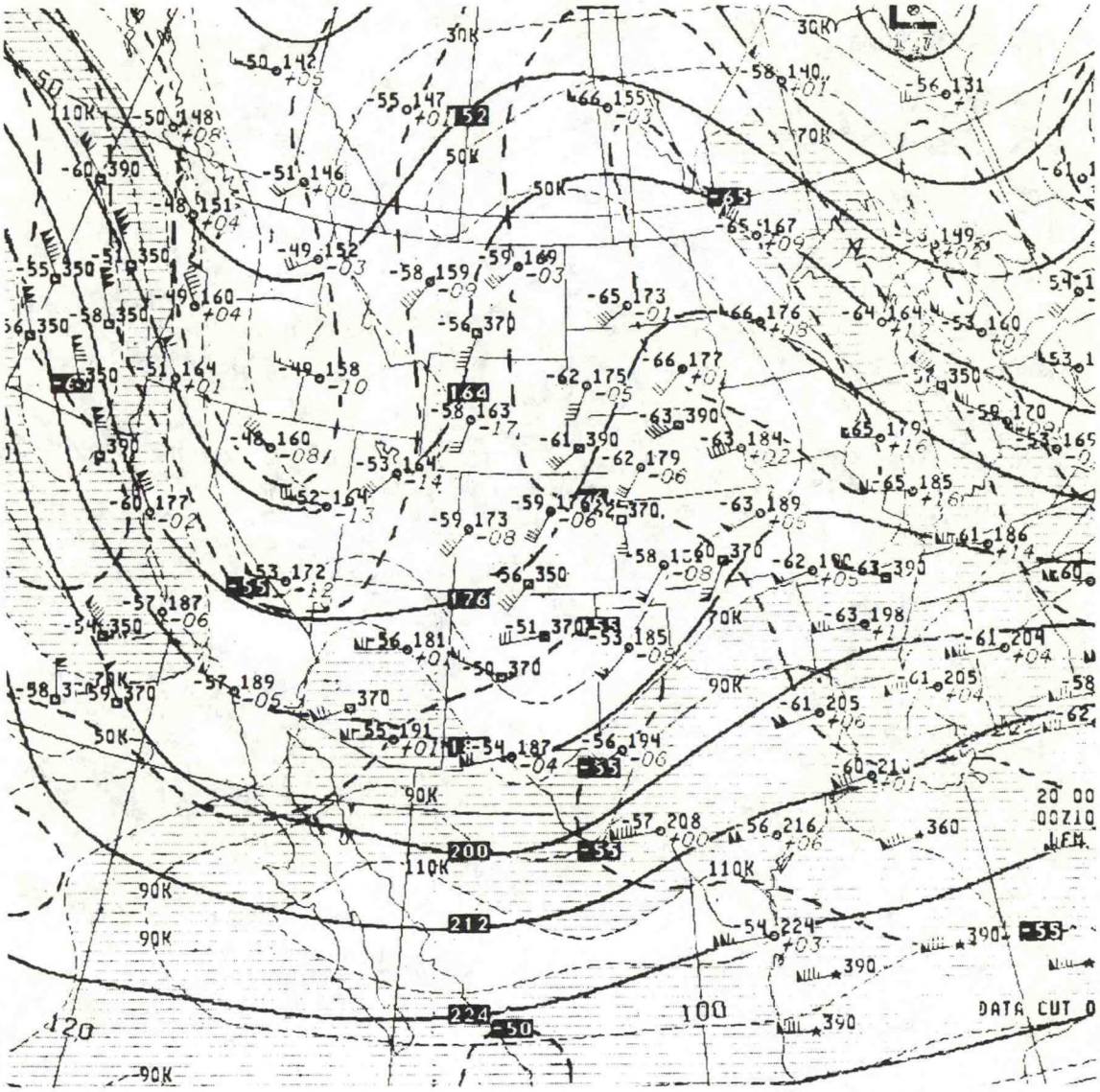

Figure 4 -- 200 Millibar Map, 6 p.m., April 9, 1979.

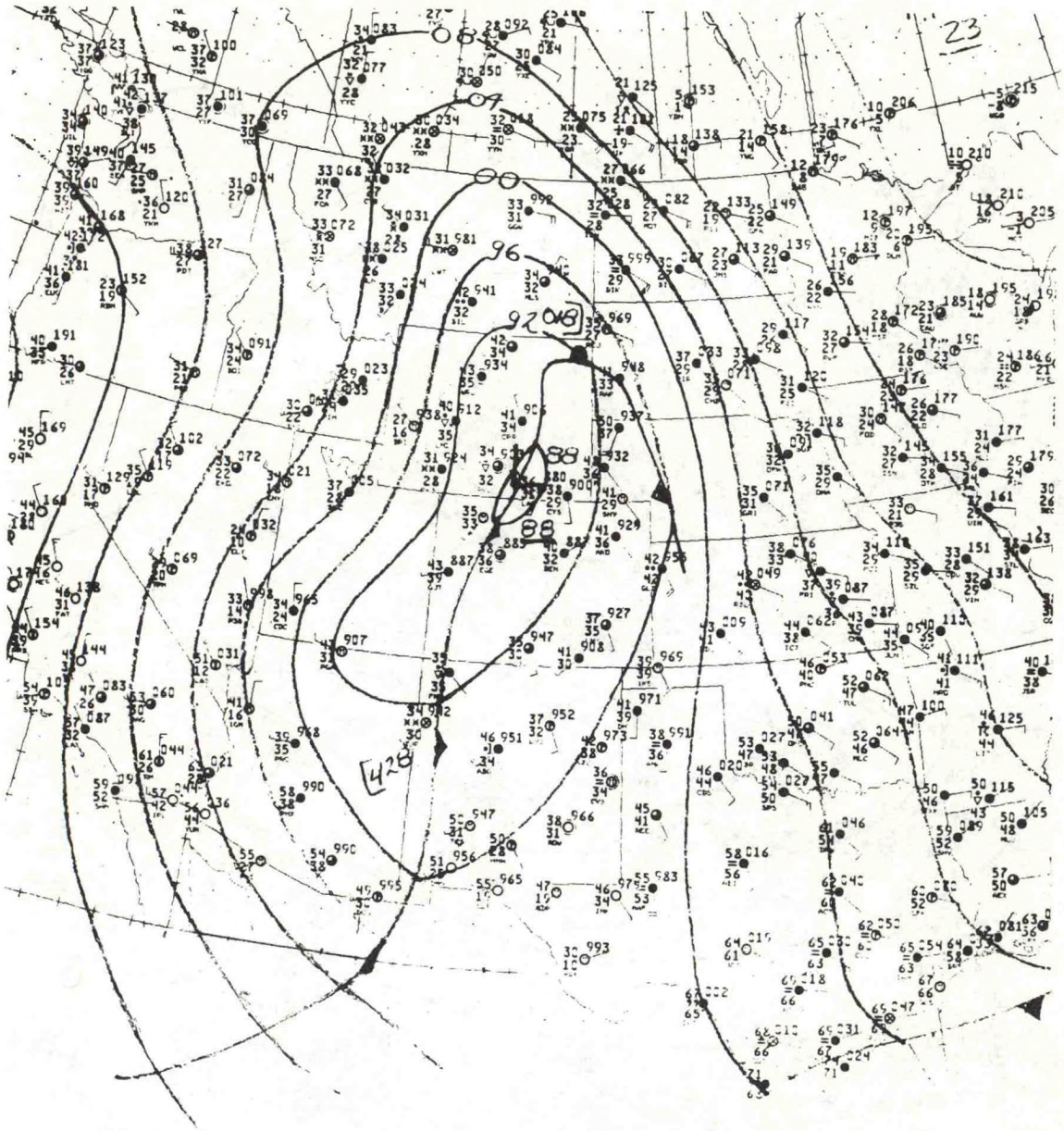

Figure 5 -- Surface Weather Map, 5 a.m., April 10, 1979.

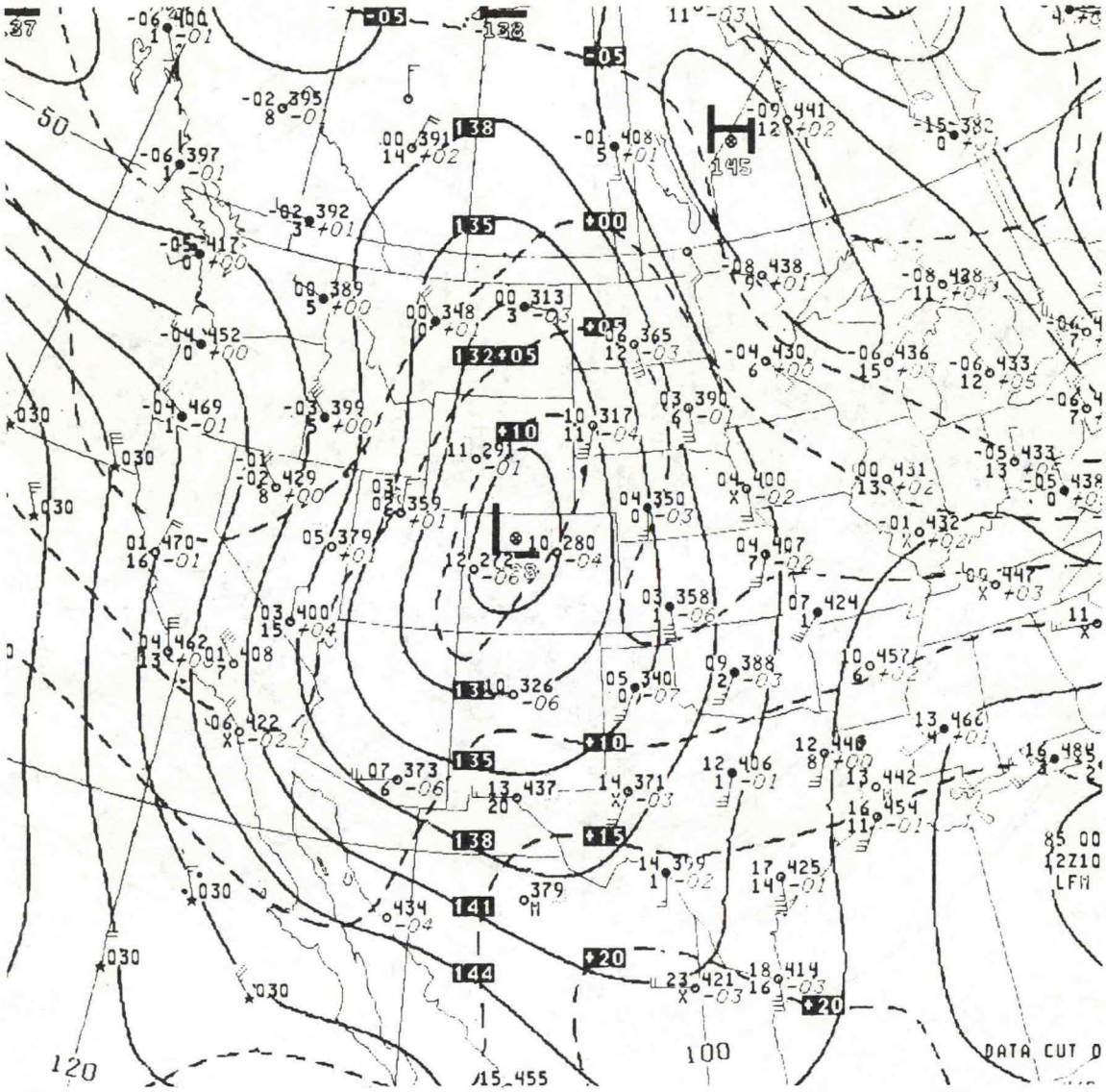

Figure 6 -- 850 Millibar Map, 6 a.m., April 10, 1979.

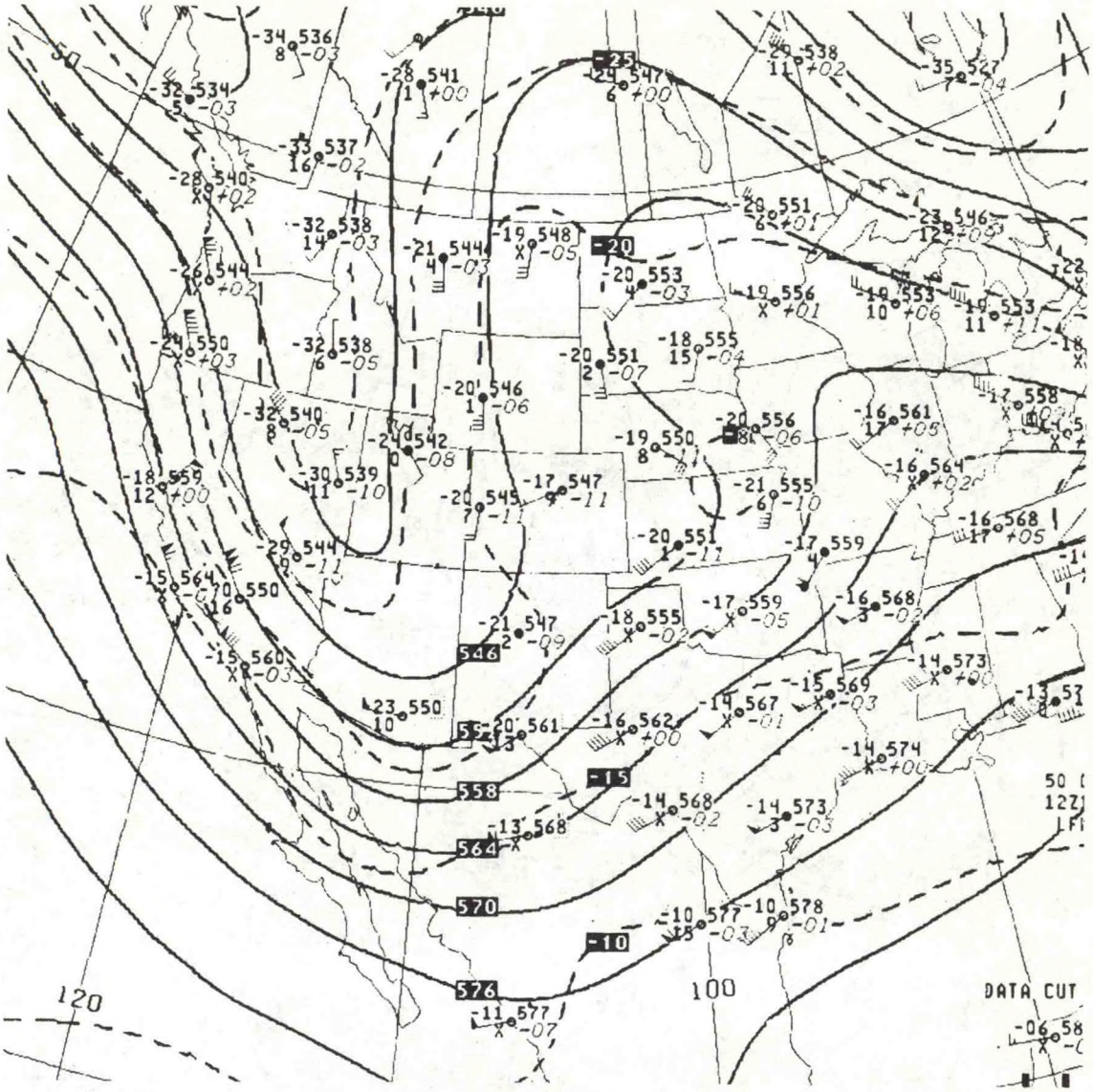

Figure 7 -- 500 Millibar Map, 6 a.m., April 10, 1979.

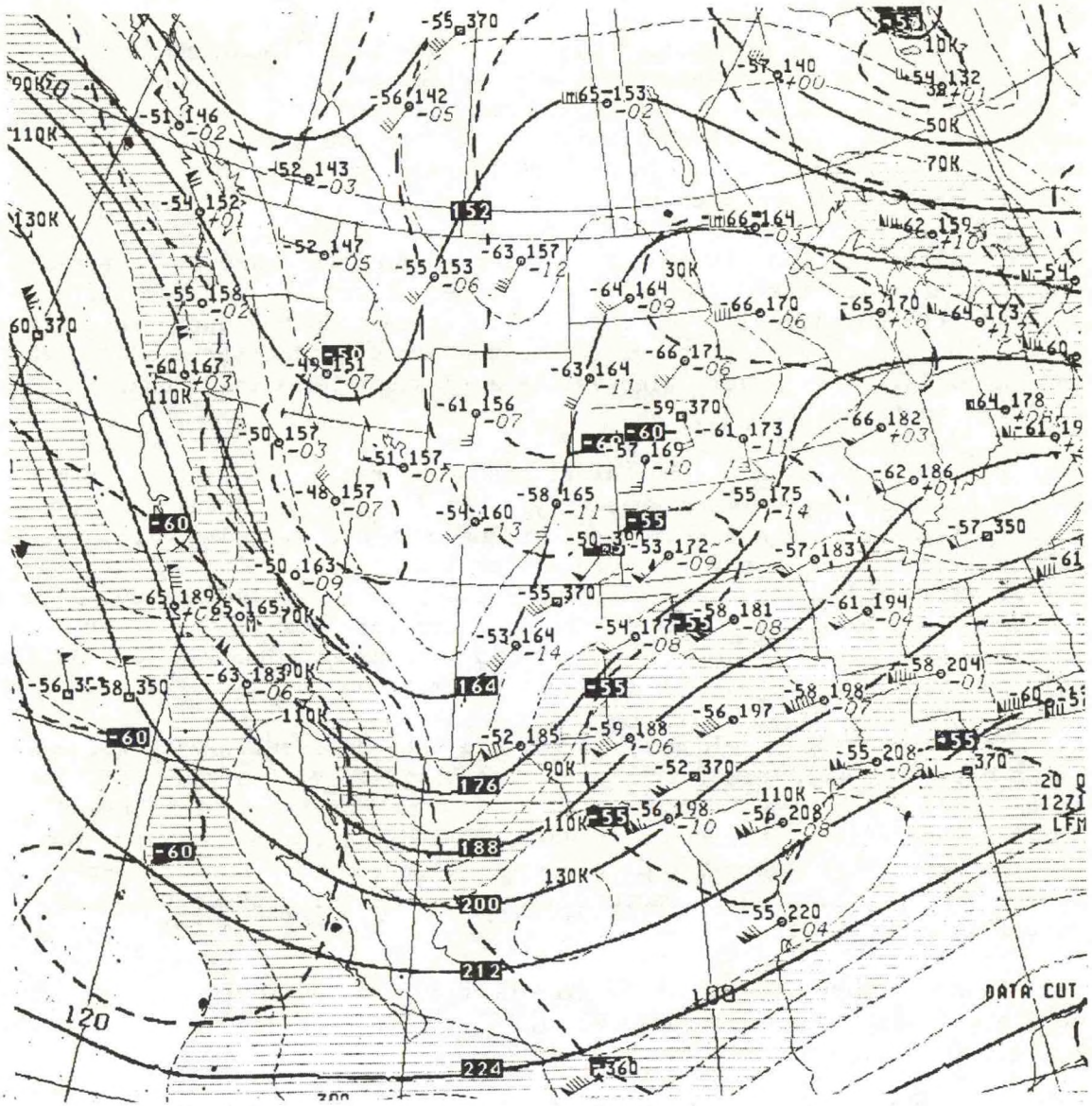

Figure 8 -- 200 Millibar Map, 6 a.m., April 10, 1979.

NSSFC continued to monitor hourly surface data, radar summaries, and satellite images to keep track of the progress of the upper level system to the west, and the northward and westward progress of the moist unstable air mass over south Texas. As the morning wore on, an east-west oriented area of thunderstorms developed rapidly across north Texas. Some of the storms produced small hail.

Satellite images showed a jet stream maximum entering southwest Texas. This "jet-max" appeared to be headed toward the northeast and was expected to intensify convection when it reached the unstable air mass. Short-period statistical severe weather guidance forecasts based on 9 a.m. data showed very high values across north-central Texas, centered near Abilene.

By noon, the wind maximum aloft was being reflected in the surface data. Unusually strong southwesterly surface winds had developed over eastern New Mexico and west Texas, pushing warm and very dry air eastward across west Texas. Numerous surface stations reported blowing dust which was clearly visible in satellite pictures. Meanwhile, surface dew points across north Texas had jumped 10° to 15°F and were now in the upper 50's. Thunderstorms began to develop very rapidly along the leading edge of the drier air in west Texas from just west of Amarillo to near Plainview.

This explosive development was picked up from satellite imagery and radar data. About 1 p.m., the NESS meteorologist briefed the NSSFC forecaster with the composite charts (fig. 9). The analysis chart showed significant weather features seen on satellite imagery around noon to 1 p.m. Expected changes and developments over the next 3 hours were also presented (fig. 9b). Increasing and intensifying thunderstorms were indicated as well.

These factors were discussed in the 1:30 p.m. outlook. And at 1:55 p.m., NSSFC issued Tornado Watch #67, valid from 2:30 p.m. to 7 p.m., for parts of Oklahoma and Texas (fig. 10).

When WSFO's Oklahoma City and Fort Worth received Tornado Watch #67 via the Radar Warning and Coordination (RAWARC)* teletypewriter circuit, they immediately prepared statements identifying counties in the watch area. The statements were distributed on each State's weather wire service. The watch and the statement were read over the Oklahoma NAWAS.** Information about the watch was placed on NOAA Weather Radio by appropriate offices in Texas and Oklahoma. Local forecasts were updated to reflect the watch.

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* RAWARC is an internal NWS teletypewriter distribution system.

** NAWAS is the National Warning System, a hotline telephone system operated by the Federal Emergency Management Agency (FEMA).

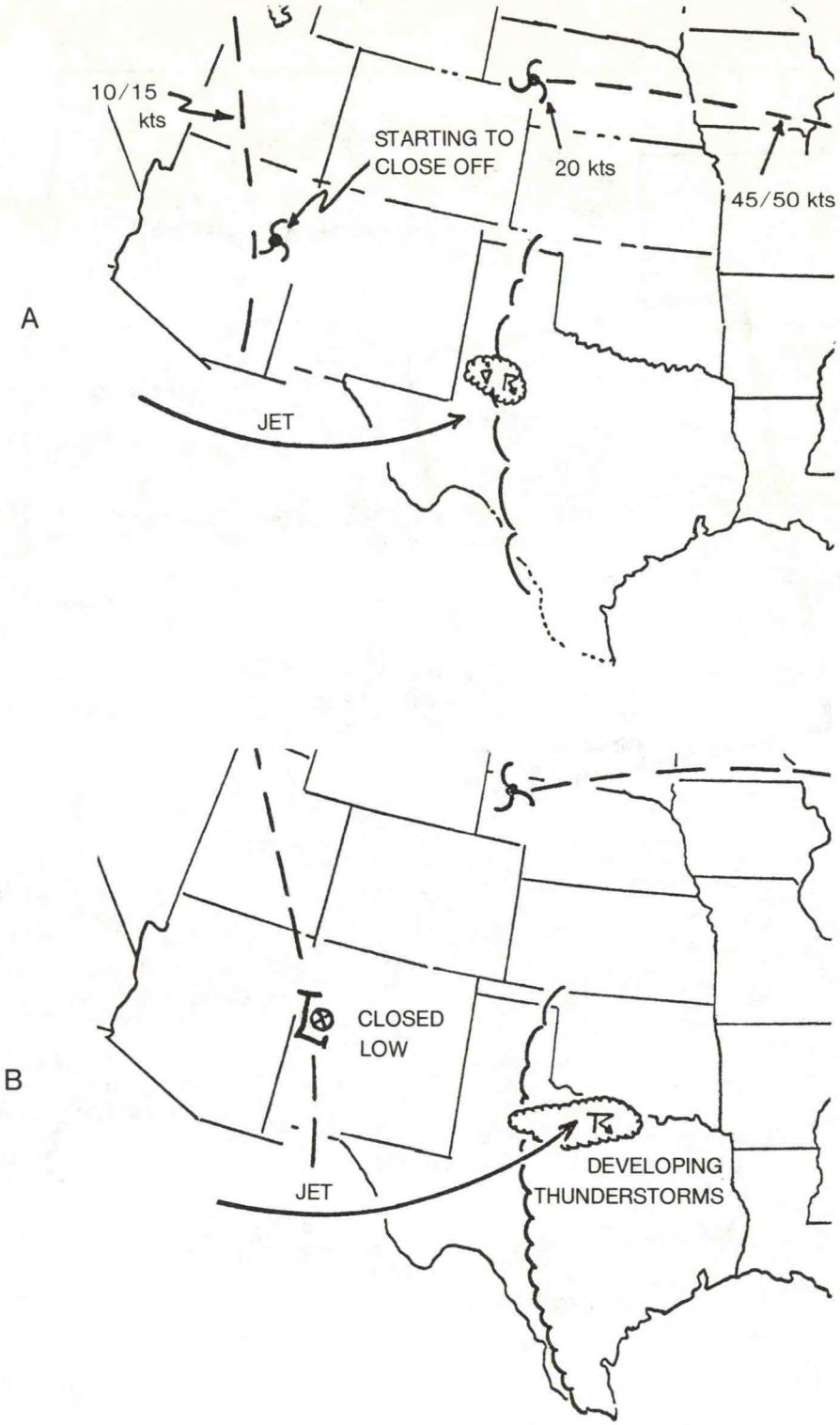

Figure 9 -- (A) Satellite Analysis at noon, April 10, 1979.
(B) Short-period developments expected by 3 p.m., April 10, 1979. Map based on satellite and other data available up to noon.

Figure 10 -- Tornado Watch #67. The towns of Wichita Falls, Vernon, and Lawton are within the watch area.

Watch #67 had activated the "total warning system."

C. THE WARNINGS*

Vernon, Tex. (Wilbarger County) - Population 11,000**

Shortly after tornado Watch #67 was issued, WSO Wichita Falls, Tex., began its battle with severe weather.

At 2:40 p.m., the WSO notified Foard and Knox Counties (just to the west of Wilbarger County) about heavy thunderstorms and activated the Skywarn spotters of the Foard County CB Club. At 2:50 p.m., a severe thunderstorm warning was issued for Knox, Foard, and Hardeman Counties (valid until 3:50 p.m.). Golf-ball size hail was reported at Truscott in Knox County at 2:51 p.m., and golf-ball size hail and high winds were reported at Crowell in Foard County at 2:55 p.m.

At 3:14 p.m., Foard County spotters reported a possible funnel 6 miles east of Crowell. WSO Wichita Falls immediately issued a severe thunderstorm warning for Wilbarger County (valid until 4:15 p.m.).

At 3:18 p.m., WSO Wichita Falls received a damage report from Foard County. A house 3 miles south of Crowell was destroyed around 3 p.m. There was one injury.

At 3:28 p.m., the Texas Highway Department and the Vernon Police Department reported a tornado on the Pease River north of Rayland and west of Lockett -- on the Foard-Wilbarger County line. WSO Wichita Falls immediately issued a tornado warning for Wilbarger County. The warning (see fig. 12) cited both reports and specifically mentioned the city of Vernon in the "call to action" segment. Sirens were blown in Vernon about 3:30 p.m.

The tornado struck Vernon between 3:30 p.m. and 3:40 p.m. Eleven people were killed, and 60 to 70 injured. About 130 homes and 20 businesses were destroyed.

Lawton, Okla. (Comanche County) - Population 75,000

As the thunderstorms continued to move toward Oklahoma, WSFO Oklahoma City issued a severe thunderstorm warning at 3:30 p.m. for Tillman County, Okla., valid until 4 p.m. The warning was based on radar indications of a severe thunderstorm to the southwest of Vernon, Tex. Tillman County

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* Figure 11 shows counties and communities in the April 10, 1979, tornado outbreak area.

** Population figures from 1970 Census.

Figure 11 -- The Red River Valley area of Texas and Oklahoma showing counties and communities affected by the April 10, 1979, tornadoes.

TORNADO WARNING
NATIONAL WEATHER SERVICE WICHITA FALLS TX
328 PM CST TUE APR 10 1979

THE NATIONAL WEATHER SERVICE HAS ISSUED A TORNADO WARNING EFFECTIVE UNTIL 430 PM CST FOR WILBARGER COUNTY OF TEXAS INCLUDING THE CITY OF VERNON.

AT 328 PM CST A TORNADO WAS REPORTED BY BOTH THE TEXAS HIGHWAY DEPT AND THE VERNON POLICE DEPT TO BE LOCATED ALONG THE PEASE RIVER NEAR THE RAYLAND COMMUNITY JUST WEST OF LOCKETT MOVING TOWARD THE NORTHEAST.

DEBRIS WAS REPORTED IN THE RAYLAND AREA ALTHOUGH NO REPORTS OF INJURIES WERE RECEIVED.

PERSONS ALONG THE PEASE RIVER BETWEEN RAYLAND AND THE CITY OF VERNON SHOULD SEEK A PLACE OF SAFETY IMMEDIATELY.

Figure 12 -- Tornado warning for Vernon, Tex.

Damage on eastern edge of Vernon, Tex. (Photo courtesy Vernon Daily Record.)

lies just to the northeast of Wilbarger County, Tex., and just to the southwest of Comanche County, Okla.

At 3:42 p.m., WSFO Oklahoma City called the Davidson (Tillman County) Police Department to advise them that a potential tornado-producing thunderstorm was bearing down on them. Not getting an answer, they called the Davidson mayor. The mayor was not home, but NWS asked his son to activate sirens; the sirens were blown, and people heard them. WSFO Oklahoma City then called Lawton Civil Defense to tell them of the situation. Lawton's Civil Defense said they would try to call Davidson.

At 3:45 p.m., the lead forecaster at WSFO Oklahoma City upgraded the warning for Tillman County to a tornado warning based on radar. The WSFO simultaneously issued a severe weather statement and radar summary. The tornado destroyed several homes in the south and east sections of Davidson shortly before 4 p.m. There were no reported casualties.

At 4:15 p.m., WSFO Oklahoma City issued a tornado warning for eastern Tillman, western Cotton, and southern Comanche Counties (valid until 5 p.m.). The warning was based on radar indications of two possible tornadoes.

The 4:15 p.m. warning was transmitted via weather wire and NOAA Weather Radio directly to Lawton Civil Defense and Lawton news outlets. KCCO radio, KWSO-TV, Lawton cablevision, and NOAA Weather Radio provided extensive warning dissemination to the public. City sirens were sounded well in advance of the storm's striking Lawton. At 5:00 p.m., WSFO Oklahoma City extended the tornado warning for Comanche County (now including the southern two-thirds) and Cotton County (now including the whole county) until 5:45 p.m. About 5:05 p.m., the tornado struck Lawton. The WSFO continued issuing warnings as the storm system moved on to the northeast.

The Lawton tornado killed 3 people and injured 100 others. About 200 dwellings and businesses were destroyed or heavily damaged. The twister also overturned a tanker truck loaded with hazardous chemicals about one block from a Lawton hospital; fortunately, there was no spill or rupture.

Wichita Falls, Tex. (Wichita County) - Population 96,000

While Oklahoma City was warning for Davidson and Lawton, WSO Wichita Falls remained busy. At around 3:50 p.m., radar showed possible new tornado development in Wilbarger County about 15 miles south of Vernon. WSO Wichita Falls advised the Wilbarger County Emergency Operating Center (EOC) that the storm appeared to be headed for the Oklaunion-Harrold area in northeastern Wilbarger County. At 3:55 p.m., the Wichita

County spotter network was activated. At 4 p.m., a tornado warning (valid until 4:30 p.m.) was issued for northwest Wichita County based on radar information and a report from the Texas Department of Public Safety. A member of the Wichita Falls Two-Meter Repeater Club reported to the Wichita Falls WSO within half an hour to staff their base station. Amateur radio-equipped spotters were deployed to the west and southwest of Wichita Falls. Some of these people left their jobs to fulfill their roles as spotters.

At 4:12 p.m., damage was reported at Harrold. At 4:18 p.m., the Texas Department of Public Safety (DPS) dispatcher at Wichita Falls received a report from a private citizen of a funnel near Electra (northwest Wichita County). A DPS unit dispatched to the scene tracked the funnel to the Red River.

Thunderstorms continued to develop southward into Baylor County. At 4:40 p.m., a severe thunderstorm warning was issued for Baylor and Wichita Counties (valid until 5:40 p.m.). At 4:55 p.m., the Baylor County Sheriff's Department reported a tornado touchdown in Seymour (50 miles west-southwest of Wichita Falls) moving toward the northeast. A tornado warning for Baylor County was issued at 4:56 p.m. (valid until 6 p.m.). Moments later a spotter reported a tornado in Wichita County (about 12 miles west-southwest of Iowa Park). This sighting prompted issuance of a tornado warning for Wichita County at 5:08 p.m. (also valid until 6 p.m.). At 5:25 p.m., the fire department blew the Wichita Falls sirens for the first time.

At 5:20 p.m., the Baylor County Sheriff reported a tornado near Mabelle. WSO Wichita Falls issued a tornado warning for Archer County (valid until 6:15 p.m.). This warning, like the 3:30 p.m. warning for Vernon, specifically listed towns in the path of the storm and urged people to take immediate precautions.

At 5:45 p.m., WSO Wichita Falls issued a severe thunderstorm warning for Wichita County based on radar indications of a strong thunderstorm near Holliday (15 miles southwest of Wichita Falls).

At 5:50 p.m., hail as large as baseballs was reported near Holliday. At 5:58 p.m., the local warning radar at WSO Wichita Falls indicated a possible tornado 10 miles southwest of the city.

As the 6 p.m. tornado warning for Wichita County was being written, a spotter reported a tornado just southwest of the Wichita Falls Memorial Stadium. This report was included in the warning message. The warning closed by stating "persons in the city of Wichita Falls should take cover immediately." (See figure 13.)

BULLETIN - EBS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE WICHITA FALLS TX
6 PM CST TUE APR 10 1979

THE NATIONAL WEATHER SERVICE HAS ISSUED A TORNADO WARNING EFFECTIVE UNTIL 7 PM CST FOR WICHITA COUNTY OF TEXAS AND THE CITY OF WICHITA FALLS TEXAS.

AT 558 PM CST RADAR INDICATED A TORNADO TEN MILES SOUTHWEST OF WICHITA FALLS TX.

AT 6 PM A SPOTTER REPORTED A TORNADO FIVE MILES SW OF THE WICHITA FALLS MEMORIAL STADIUM ON SOUTHWEST PARKWAY AND MOVING TO THE NORTHEAST AT 30 MILES AN HOUR.

PERSONS IN THE CITY OF WICHITA FALLS SHOULD TAKE COVER IMMEDIATELY.

Figure 13 -- Tornado warning for Wichita Falls, Tex.

Wichita Falls damage scene. (NOAA photograph)

Mapped by FUJITA & WAKIMOTO
THE UNIVERSITY OF CHICAGO
(Based on data as of May 5, '79)

Mapping for "SESAME", 1979

Red River Valley Tornado Outbreak of APRIL 10, 1979

NO.	Name and Storm Type	Length	F, P, P	Killed/Injured		Based on survey by
1.	Crowell Tornado	23mi	2,3,2	0	1	U of C, NSSL
2.	Vernon Tornado	39	4,4,3	10	70	U of C, NASA, NSSL
3.	Hollister Tornado	8	2,2,1	0	0	U of C, NSSL
4.	Faxon Tornado	7	1,2,1	0	2	U of C, NSSL
5.	Lawton Tornado	4	3,2,2	3	100	U of C, NASA, NSSL
6.	Grandfield Tornado	64	2,4,5	1	5	U of C
7.	Marlow Twg Downburst	18	1,3,6	0	0	U of C
8.	Purcell (west of) High Wind	8	0,2,5	0	0	U of C
9.	Noble Tornado	2	2,1,1	0	0	NSSL
10.	Prague Tornado	3	2,2,2	0	1	NWS-OKC(48E OKC)
11.	Seymour Tornado	11	2,3,3	0	0	NSSL, U of C
12.	Wichita Falls Tornado	47	4,4,4	45	850	U of C, NASA
13.	Pruitt Tornado	27mi	3,3,3	0	0	U of C

0 1 2 4 3 1 2 1 ← Fujita Scale

TORNADO

HIGH WINDS

2,100 aerial photos of damage areas filed at U of C

NORMAN
BLANCHARD
NOBLE
PURCELL
ANADARKO
CHICKASHA
DIBBLE
APACHE
CYRIL
ALEX
LINDSAY
MAYSVILLE
ELGIN
STERLING
RUSH SPRINGS
PAULS VALLEY
CACHE
LAWTON
PUMPKIN CENTER
MARLOW
ELMORE CITY
PERNELL
DUNCAN
ALPERS
RATLIFF CITY
PRUITT
COMANCHE
WALTERS
TIPTON
MANITOU
FREDERICK
CHATTANOOGA
HOLLISTER
FAXON
GERONIMO
GOODLETT
ODELL
QUANAH
CHILLICOTHE
DAVIDSON
TEMPLE
HASTINGS
HEALDTON
RINGLING
WILSON
WAURIKA
GRANDFIELD
RANDLETT
VERNON
LOCKETT
HARROLD
BURKBURNETT
BYERS
ELECTRA
RYAN
PETROLIA
CROWELL
THALIA
IOWA PARK
MARBLE DEAN
WICHITA FALLS
KADANE CORNER
FOARD CITY
HOLLIDAY
HENRIETTA
NOCONA
TRUSCOTT
GILLILAND
RED SPRINGS
MABELLE
SEYMOUR
ARCHER CITY
RED RIVER
OKLAHOMA
TEXAS

Central Standard Time

34°30'
34°00'
35°00'
99°30'
99°00'
98°30'
98°00'
97°30'

0 10 20 30 40 50 60 miles
0 10 20 30 40 50 60 70 80 90 100 km

WSO Wichita Falls issued another strongly worded warning, this time for Clay County, at 6:11 p.m. Commercial power failed at the WSO minutes later. An emergency generator provided power for continued operation of the weather radar, but all long-line communications were lost. However, direct contact was maintained with the EOC by the amateur radio capability of the storm spotters.

The tornado killed more than 40 people and injured about 1,700. About 4,700 family units in Wichita Falls were destroyed by this more than 1-mile-wide tornado.

D. OTHER CONSIDERATIONS

There can be no doubt that the excellent warning service provided by WSO Wichita Falls and WSFO Oklahoma City was the result of skilled and concerned staffs.

WSO Wichita Falls is a small office -- an official in charge, five weather service specialists, and an electronics technician. They run a 24-hour operation, which means that most of the time only one person is on duty. But on the afternoon of April 10, there was ample assistance. After Watch #67 was issued, all but one man voluntarily reported to work. (He had worked the midnight to 8 a.m. shift earlier in the day and was home sleeping.) Because of this support, it was possible for one person to monitor the radar, one person to handle NWR, NWWS, and RAWARC communications, and another person to handle the telephone. After 4 p.m., however, one person was assigned solely to the Wichita Falls Emergency Communications Hotline (ch. IV).

WSFO Oklahoma City had called an extra forecaster to duty during the afternoon of April 10. He was assigned the warning coordination role. The Principal Assistant was available, too. Two people (rather than one) were assigned to the WSR-57 network radar; one person was dedicated to the NOAA Weather Radio. Observation and communication staffs were also on duty. With the activation of Project SESAME,* the

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* Project SESAME (Severe Environmental Storms and Mesoscale Experiment) is a $3.9 million cooperative experiment to improve scientific understanding of small-scale weather. The spring 1979 experiment focused on the Southern Plains -- a square area roughly 1,000 miles on a side centered in Norman, Okla. Special satellite, upper air, and radar observations, along with an intensive aircraft and ground-base observational emphasis, were designed to supply researchers with the data they needed to gain a more complete view of the prestorm environment and the conditions that trigger severe storms. The Experiment is designed to operate in either regional or storm scale mode depending upon data desired. Data for both scales were collected on April 10. Stan Barnes (ERL, RB3, Boulder, Colo., 323-6234) is Project SESAME Manager.

WSFO was taking 3-hourly upper air observations instead of at the normal 12-hour interval. Doppler radar data were also being collected in Oklahoma.

Coordination among offices was excellent. This can best be shown by the manner in which WSO Wichita Falls alerted WSFO Oklahoma City of the several Texas tornadoes that soon would be affecting counties within Oklahoma City's area of responsibility. The prudence of these acts of notification is especially worthy of commendation when one considers that one of the storms had devastated much of the southern part of Wichita Falls.

CHAPTER III

DATA ACQUISITION AND COMMUNICATIONS

Knowledge of current and recent weather is necessary for operational forecasting and warning. NWS routinely receives weather data from a variety of real-time observing stations, substation networks, and other sources. Trained spotter organizations are called upon to provide critical storm information. The continuous collection, transfer, processing, and storage of data require the use of many communication systems. This chapter discusses the major types and sources of data and communication systems available during the Red River Valley tornadoes.

SURFACE DATA

The locations of regular real-time surface reporting stations in Texas and Oklahoma are in figure 14. NWS operates some; FAA or the Department of Defense operates the rest. In addition to taking and reporting hourly observations when specified weather events take place, these stations send "special" reports immediately.

The data network was dense enough for NMC to perform synoptic scale analyses and for NSSFC and WSFO forecasters to perform real-time detailed analyses of the special area of interest. These detailed analyses clearly showed the high-risk severe storm area developing on the Texas-Oklahoma border on April 10.

STORM SPOTTERS

Years ago, NWS and Civil Defense organizations recognized that local communities needed their own storm monitoring capabilities to complement the NWS storm detection radars. Trained storm spotters -- people well-versed in severe weather and the cloud formations that often accompany it -- were the answer. So for many years NWS Warning and Preparedness Meteorologists and others on the staffs of WSO's in Texas and Oklahoma have trained thousands of spotters. Local authorities, law enforcement agencies, civic groups, the mass media, amateur and CB radio organizations, and others have supported the spotter program. Many of these spotters, some of the best trained in the Nation, were "on duty" on April 10.

RADAR DATA

The NWS WSR-57 network radars at Oklahoma City, Okla., and Stephenville, Tex., provide network weather radar coverage for the Red River Valley area. Both radars are staffed and operated for continuous radar surveillance.

Figure 14 -- Texas and Oklahoma Regular Surface Data Reporting Stations.

The two network radars are supplemented by several NWS local warning and military radars (fig. 15).

NWS local warning radars are operated whenever weather echoes are detected or are expected to develop within 125 nautical miles (nmi) of the radar or when the radar office is alerted by a nearby NWS office. They are operated by WSO personnel involved in many different and essential activities while on duty. WSO Wichita Falls, aware of the threat of severe weather, had extra personnel voluntarily on duty to ensure dedicated radar coverage.

Routine duties at the network radar stations include making at least hourly radar observations that are encoded and transmitted on the RAWARC circuit, preparing hourly radar summaries (narrative descriptions of the observed precipitation patterns and intensities) that are disseminated on NOAA Weather Wire and broadcast by nearby NOAA Weather Radio stations, and preparing hourly and intermediate tracings of the radar scope on paper overlays that depict the surrounding geography and jurisdictions. Special observations are also taken as needed.

Both network (WSR-57) radars have remote transmitters to provide echo displays on facsimile recorders at other offices. The radar operator annotates the display by hand at least once an hour. Coded annotations describe echo configurations, precipitation types, areal coverage, intensity, intensity trend, movement (speed and direction), and location and height of maximum echoes. WSFO Fort Worth has a dedicated line to the Stephenville office and can also receive images from the Oklahoma City network radar.

Both the Oklahoma City and Stephenville radars, as well as the local warning radars at WSO's Abilene and Wichita Falls, are equipped with Video Integrator and Processor (VIP) units that automatically contour up to six intensity or reflectivity levels. These levels are used to determine storm intensity, make rainfall rate estimates, evaluate echo tops, and detect storm features suggesting severe weather. This capability is limited to the area within 125 nmi from the radar antenna, because the accuracy of echo intensity measurements decreases significantly beyond that range.

Numerous warnings issued on April 10 were based solely on radar information.

Studies of Doppler radar data as a mean of detecting tornadoes were begun at the National Severe Storms Laboratory (NSSL) in 1971. A Joint Doppler Operational Project (JDOP) involving Air Force, FAA, and NOAA was established in 1976. On April 10, the NSSL Doppler radar was not operating in the JDOP mode, but instead was operating in support of Project SESAME 79

Figure 15 -- Texas and Oklahoma Network and Local Warning Radar Stations.

research experiments. However, mesocyclone circulations normally associated with giant tornadoes were seen by NSSL at various times, and information was passed to WSFO Oklahoma City. A cursory review of the Doppler data strongly suggests that each of the giant tornadoes would have been detected early in their formative stages, about 20 to 30 minutes before tornado touchdown. These data are to be analyzed and evaluated as a part of the JDOP and SESAME programs.

SATELLITE DATA

During the period from 7 a.m. to 6:15 p.m. on April 10, personnel of the NESS Satellite Field Service Station (SFSS) in Kansas City focused their attention on the potential and developing severe weather situation in Texas and Oklahoma.

The satellite images received at the SFSS were of excellent quality. A combination of 3-minute and 15-minute interval, 1-mile resolution visible imagery was received to provide optimum coverage of the area of concern. In addition, 30-minute interval, 4-mile resolution enhanced infrared imagery was received continuously during the entire period.

Imagery at Kansas City was used both as still pictures and in movie loop form. The movies were extremely valuable and were used to track the upper level wind speed maximum from Mexico into Texas and to monitor the development of the severe thunderstorms. Movie loops were updated on a picture-by-picture basis using the SFSS image analysis system.

Main support to NSSFC throughout the morning focused on the upper level wind-speed maximum approaching Texas. Around noon, attention shifted as the first signs of organized convection appeared in west Texas. At around 1 p.m., the SFSS meteorologist gave the NSSFC forecaster a complete briefing, including charts showing current conditions and expected short-period developments (fig. 9).

The Kansas City SFSS's support to the field was mainly through its coded satellite interpretation messages. These messages are transmitted on RAWARC four times each day.

WSFO's Oklahoma City and Fort Worth received visible and infrared imagery, too. The pictures available at each office were of adequate quality and number to be used to confirm and supplement other meteorological data. Appendix A shows some of the satellite imagery available April 10.

UPPER AIR DATA

NWS operates a national network of upper air stations (fig. 16). These stations provide data on the vertical distribution of pressure, temperature, water vapor, and wind in the atmosphere. Observations, taken at 6 a.m. and 6 p.m., provide the basic information used in numerical weather predictions at the National Meteorological Center, Washington, D.C. Special observations can be taken at the request of NSSFC and WSFO's.

Data from all regular NWS upper air reporting stations were received at NSSFC and NMC in time to be used on the evening of April 9 and the morning of April 10. However, key Mexican upper air data at Guadalupe Island and Guaymas were missing the morning of April 10. As discussed previously, absence of these data detracted from analyses and forecasts of the jet stream, but satellite imagery was able to fill this crucial gap. Special upper air observations as part of Project SESAME were taken at numerous sites in and around the affected area of April 10. In accordance with the SESAME plan, the noon upper air observations from NWS sites made for SESAME were available for operational use.

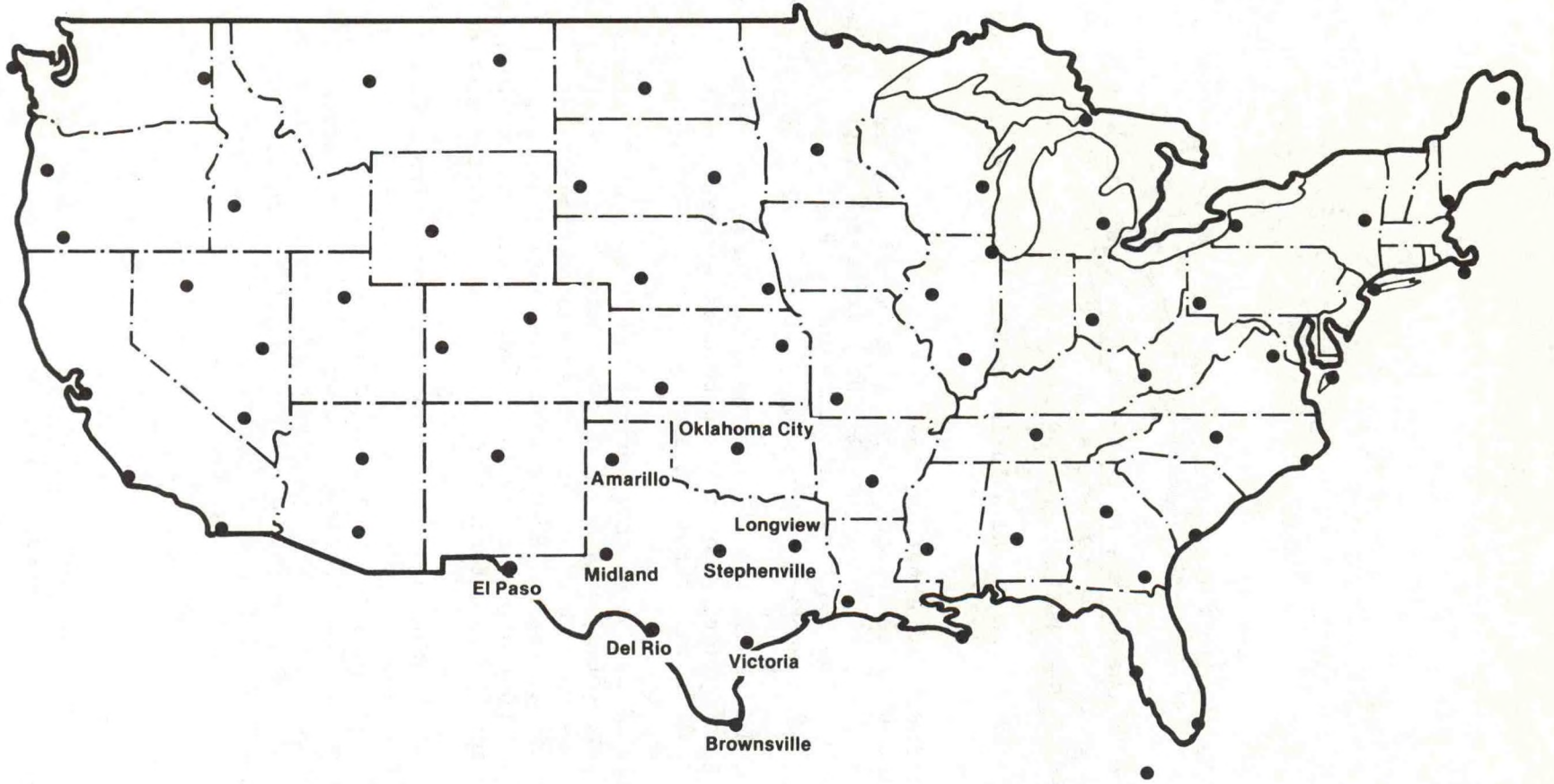

Figure 16 -- Upper Air Reporting Network.

CHAPTER IV

WARNING DISSEMINATION, COMMUNITY DISASTER PREPAREDNESS, AND PUBLIC RESPONSE

"Action by the Wichita Falls office of the National Weather Service saved hundreds, perhaps even thousands of lives...."

That accolade by the Wichita Falls Record News to the Wichita Falls NWS staff as well as to the forecasters at NOAA's National Severe Storms Forecast Center tells only part of the story.

What happened in Vernon, Wichita Falls, and Lawton on April 10 began years earlier.

A major research study of natural hazards* in its evaluation of warning systems in the United States stated that "warning systems must be assessed from an integrated perspective including every stage of the total warning process from the first detection and forecast of a hazard threat through public response."

NWS calls these links in the warning chain its "warning-preparedness" program. It gives top priority to its preparedness work and makes it integral to the complete and "total" warning program.

At the present time, the Weather Service has 19 dedicated Warning and Preparedness Meteorologists stationed at selected WSFO's. It's a modest effort to link up with the radio and television broadcasters; recruit and train tornado spotters; and work with State and local police, civil defense, and a host of others in the community who are involved in disaster warnings and the associated educational/public awareness efforts.

The Warnings and Preparedness Meteorologist, who is also a forecaster at the WSFO, can't possibly do the job alone. At the Wichita Falls WSO, the Official in Charge (OIC) and the entire staff of weather service specialists realized that and carried on an aggressive preparedness program. The program in Wichita Falls' 11-county warning area has been well balanced, consisting primarily of public education, spotter organization and training, school tornado preparedness and drills, and watch/warning dissemination. Over the past few years, 11 new tornado spotter groups have been organized and trained, including groups at Wichita Falls and Vernon.

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* Assessment of Research on Natural Hazards by Gilbert F. White and J. Eugene Haas, 1975, MIT Press, Cambridge, Mass., 487 pp.

During the last 6 months of 1978, OIC or staff members made 29 preparedness trips (for as long as half a day) including visits to all local radio and TV stations in the area of warning responsibility. The office was particularly active during February and March 1979. Ten of the 11 counties in WSO Wichita Falls area were visited at least once, and most trips involved stops at two or three of the larger towns in each county.

A weather service specialist from WSO Wichita Falls visited Vernon on March 20, 1979. He discussed with the county sheriff current instructions for the dissemination of warnings and sounding the sirens. The sheriff works closely with the local CB storm spotter group and felt they were a well-trained and dependable group.

The OIC works very closely with Wichita Falls city officials, also. In addition to frequent contacts, he held a spotter training session for 67 members of the Wichita Falls Two-Meter Repeater Club on March 20, 1979. He also appeared on KAUZ-TV February 21, 1979, to discuss the watch/warning program, tornado safety rules, and NOAA Weather Radio (NWR).

Everyone the team contacted in north Texas knew the people from WSO Wichita Falls and had put to good use the information and procedures passed on by these people.

Similar evidence was found at Lawton, where, because of the frequency of severe weather and the large population, the Warning and Preparedness Meteorologists at Oklahoma City have been very active. In addition to interviews on tornado preparedness with the media, spotter training has been provided on an annual basis through the cooperation of the State and local Civil Defense. Spotters consist of law enforcement, fire, Red Cross, and volunteer Civil Defense personnel as well as amateur and CB radio operators. Reports can be relayed to the WSFO via NAWAS, which is in the basement of the County Courthouse in Lawton. The Oklahoma Highway Patrol office is manned on a 24-hour basis with the county EOC staffed as needed during severe weather.

Over the years, the Lawton-Comanche County Civil Defense director had welcomed NWS assistance and cooperation. The present director has served in the position only since February 1979 and has continued this close working relationship.

In addition to NAWAS, the EOC has a variety of communications equipment including NOAA Weather Wire Service (NWWS). A hotline exists to the weather detachment at Fort Sill. KWSO-TV operates a surplus military radar. The radar display can be broadcast on the local cable system. The cable system also receives NWS forecasts via NWWS and displays the forecasts on

a "weather channel." The Civil Defense director can use the Emergency Broadcast System from the EOC. The siren system is operated from the Lawton Police Department, because the EOC is not manned 24 hours a day.

With the support of the State Civil Defense, the Lawton-Comanche County Civil Defense hosted the annual Spotters Training meeting on March 21, 1979. Some 67 persons attended. "The Day of the Killer Tornadoes," the Defense Civil Preparedness Agency (DCPA)* film based on the tornado outbreak of April 3 - 4, 1974, was shown followed by a slide presentation and the showing of the NWS's tornado spotter film. NWS Tornado Spotter's Guides were provided to all in attendance.

Lawton, Vernon, and Wichita Falls had conclusive evidence of the active NWS participation in an excellent disaster preparedness program. EOC's were activated in response to Watch #67. Responsible city or county authorities sounded sirens as the tornadoes approached.

The survey team and others clearly recognized and credited several items as important lifesaving actions. The most important factor was community teamwork generated by dedicated officials working in concert with motivated civic organizations, business interests, and public-spirited citizens. Organized networks of trained tornado spotters performed according to plan. Radio and television stations recognized the emergency nature of the situation and responded with timely and accurate broadcasts. Civil defense officials used sirens in a timely manner to warn all three of the hard-hit cities.

Just 2 weeks before the tornado struck, Wichita Falls had held a complete citywide drill involving all elements of the total warning system. But the 1979 Wichita Falls tornado drill was not a chance occurrence. Ever since the April 3, 1964, tornado struck the area leaving 7 dead and more than 100 injured, county and city officials have held annual tornado drills. Schools, hospitals, and others participate. The media (radio, television, and newspapers) are involved heavily in the drills, especially emphasizing tornado safety information.

The Fort Worth Star Telegram was right in noting that the 1979 tornado drill "was a perfectly executed rendition of what to do when a tornado comes." This shows the payoff of practice.

Not enough can be said about the value of tornado spotters -- citizen volunteers trained by the NWS offices to watch for and report tornadoes. In most communities they're called SKYWARN observers. Around the Nation there are more than 1,000 local SKYWARN networks in the tornado-prone States. The most effective spotters are State, county, and city law enforcement agencies as well as trained amateur and CB radio groups with their two-way communication capability and mobility.

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* DCPA is now a part of FEMA.

North Texas has about 2,000 very well-trained spotters. Films, slides, and brochures prepared by NOAA are used when NWS employees (frequently on their own time) speak to the spotter groups. These sessions are held often, because of constant turnover of the volunteers.

The OIC at Wichita Falls said that the organized amateur and CB spotter groups were a key element in the warning system. Their reports were vital to issuing timely and accurate warnings. The Wichita Falls Two-Meter Repeater Club weather spotters group dispatched their spotters and established a base of operations at the NWS office as early as 4:30 p.m., April 10. They remained on duty at the WSO until 6:30 p.m., April 11. Along with Civil Defense officials and the Texas Department of Public Safety, they not only assisted in reporting tornadoes, but also were instrumental in maintaining communications. In fact, they provided communications for the Wichita Falls WSO to the community from 6:30 p.m., April 10, until power was restored around 6:30 p.m., April 11.

When the tornado damaged the Texas Electric Power Company plant in Wichita Falls, it also knocked out NAWAS, which was not restored until around 3 a.m. on April 11. The disaster emergency warning hotlines connecting the WSO to the city's two television stations and three radio stations were even out for short periods after 6:30 p.m., April 10.

The base amateur radio station using the emergency power system at the WSO helped coordinate rescue and aid efforts through the EOC, reported on area weather conditions, and confirmed damage reports. Some CB radio clubs also assisted as spotters.

In Lawton, the response of local officials and spotters also was very effective. Early in the afternoon, WSFO Oklahoma City advised the Lawton-Comanche County Civil Defense Director about potential severe weather later in the day. The Civil Defense Director immediately asked Lawton television station KWSO, which operates its own weather radar, to turn on its radar. Using the radar (from the cable-system), NAWAS, and NWWS, he was able to track the movement of the storms northeastward. At around 2:45 p.m., he dispatched spotters into small towns in the southern part of the county. The positions of the spotters were adjusted to allow them to track the storm as it moved toward Lawton. He sent an assistant to the Police Station to be ready to activate the sirens upon his order. He monitored the progress of the storm until he was certain it would reach the city. He then ordered the sirens sounded about 15 minutes before it hit. Seventeen sirens in Lawton reach 90 percent of the people in the city of 75,000. These sirens deserve credit for saving many lives in Lawton.

Spotters in Vernon and other communities in the Red River Valley area also contributed to the early warnings issued that day. Radio and television stations in the affected communities did a superb job in broadcasting the NWS warnings. Presidents, news directors, and program directors of the broadcasting stations were extremely complimentary of NWS personnel involved in the warning and preparedness programs. The survey team was told repeatedly about how invaluable WSO Wichita Falls was in establishing the critically needed effective and reliable operational relationship called for on April 10.

As an example of news media's contribution to the dissemination-public response subsystem, KAUZ-TV aired a "Tornado Safety" program on March 9, 1979. The program included information on what to do in case of a tornado.

Here is how KAUZ-TV in Wichita Falls handled the situation during the afternoon of the tornadoes. The information was compiled from program logs and with the help of individuals involved in the severe weather procedures at KAUZ-TV on April 10.

Around 2:00 p.m.	Message regarding Watch #67 superimposed at the bottom of the television screen.
3:35 p.m.	Broadcast of severe thunderstorm warning for Foard, Hardeman, and Knox Counties. This was a live cut-in with the station's weathercaster.
3:38 p.m.	Broadcast of tornado warning for Wilbarger County, including the city of Vernon. Live cut-in with weathercaster.
4:01 p.m.	Broadcast of warnings issued for Tillman, Stephens, and Comanche Counties of Oklahoma at the same time a thunderstorm cell was moving northeast through Vernon toward the Red River and Oklahoma. Live cut-in with station radar.*
4:07 p.m.	Update situation in Tillman County. Live cut-in with radar.
4:11 p.m.	Weather crawl.
4:22 p.m.	Weather crawl.

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* KAUZ-TV has a weather radar it uses in its programing.

5:10 p.m. Broadcast tornado warning for the northwest corner of Wichita County and update on thunderstorm system moving through Baylor County and the city of Seymour. This was a live cut-in with weathercaster.

5:10 p.m. Superimposed following message over programing "Bonanza" and "Cronkite":

Tornado Warning

Wichita County

Archer County

This message remained on the screen until 6:00 p.m.

5:24 p.m. Confirmed tornado sighting in the Iowa Park area, broadcast tornado warning, and issued safety instructions.

5:33 p.m. Broadcast tornado warning for entire Wichita County and again a warning for Archer County.

5:36 p.m. Updated situation in Wichita County and Archer County.

6:00 p.m. Began local "Eyewitness News." The first 5 minutes were devoted to the Red River Valley tornado outbreak. The news report focused on events earlier in the day to the west of Wichita Falls. The report also mentioned sirens were blowing in Wichita Falls and that a tornado was reported in the southwest part of the city.

At 6:05 p.m., the station lost all power.

NWS offices used all available channels for sending weather warning information to the public that day. This included the direct-to-user NOAA Weather Radio (NWR) system and the NOAA Weather Wire Service (NWWS). NWWS provides simultaneous, direct, hard copy to radio and television stations and many public safety offices. Associated Press and United Press International are subscribers to NWWS and depend upon it for NWS information that is further disseminated to news wire subscribers. The National Warning System (NAWAS)*, a voice circuit, interconnects key civil defense and public safety offices and most WSO's. NWS has access to this NAWAS circuit for information exchange on warning or possible warning situations.

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* In Texas, this is called the Texas Warning System (TEWAS).

o NOAA Weather Radio (NWR)

NWR provides continuous, around-the-clock broadcasts of the latest weather information directly from NWS offices. On severe weather days, NWS offices often broadcast prepared weather safety tapes. On April 10, the Oklahoma City, Fort Worth, and Wichita Falls offices all broadcast severe weather safety messages on NWR.

During severe weather, NWS personnel can interrupt the routine recorded weather broadcasts with warning messages. They can also activate specially designed warning receivers. Such receivers either sound an alarm indicating an emergency exists, alerting the listener to turn the receiver up to an audible volume; or, when operated in a muted mode, automatically increase the volume so the warning message is heard. Warning alarm receivers have proven especially valuable for schools, hospitals, public-safety agencies, and news media offices. All public schools in Wichita Falls have NWR receivers.

In the affected area, NWR broadcasts are transmitted from towers at Lawton and Wichita Falls. WSFO Oklahoma City prepared the broadcasts transmitted from Lawton; WSO Wichita Falls prepared them for Wichita Falls. Much of the severely damaged areas was within the area served by these two transmitters, but Vernon and most of Wilbarger County are outside this area. (See figure 17.)

As the warning messages were issued, they were immediately aired on the NWR. All warnings were preceded by the warning alarm signal. The staffs at the two offices emphasized NWR in their dissemination efforts. At WSFO Oklahoma City, one person was dedicated to NWR. At WSO Wichita Falls, availability of extra staff on overtime enabled several people to share NWR, NWWS, and RAWARC responsibilities.

Power was lost at the Wichita Falls NWR transmitting site around 6:10 p.m., April 10. Standby emergency power for this transmitter is not available. This is generally true for all NWR transmitters except those installed on towers of commercial stations hardened by DCPA as part of the Emergency Broadcast System. Power at the NWR transmitting site was restored around 6 p.m., April 11.

o NOAA Weather Wire Service (NWWS)

This teletypewriter channel, which provides hard copy of all warning information is intended primarily to serve the media. It is available to anyone who wishes to pay for the teletypewriter equipment rental and local line charges. NWWS costs about $100 per month in Texas and about $40 monthly in Oklahoma.

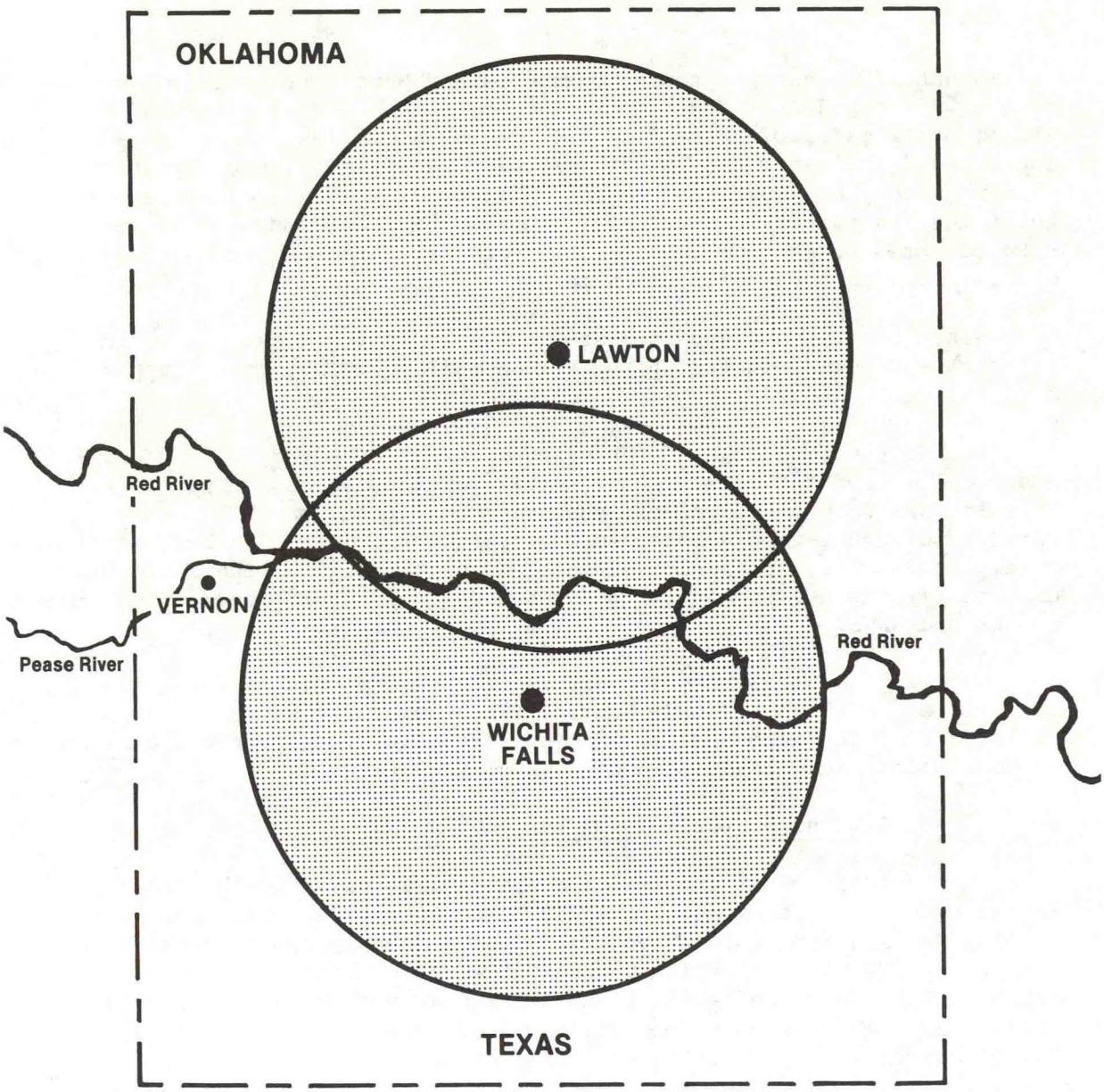

Figure 17 -- NOAA Weather Radio coverage in the Wichita Falls, Vernon, and Lawton areas. Shading reflects the nominal range of the broadcasts.

About 370 subscribe to the Texas Weather Wire Service and about 135 to the Oklahoma NWWS. Most are media subscribers. Many radio and television stations serving the Red River Valley subscribe. Texas broadcasters interviewed indicated they were happy with the service, but expressed concern about the service's escalating costs caused by increasing charges for lines and printers. Several indicated that the economics of the situation may force them to drop this very valuable service unless a way is found to hold the line on costs.

Since the latest rate increase in Texas, at least five subscribers in northwest Texas, including the Vernon radio station, have dropped the service.

Stations not on NWWS and/or without an NWR receiver rely on telephone calls from NWS or emergency service offices or on the wire services to relay NWS watches, warnings, and statements from the NWWS. During warnings of short-fuse events, such as tornadoes, delays in wire service relays can be very critical, and multiple phone calls by the NWS office consume time needed to monitor radar and spotter reports and get warnings on NWR and NWWS.

Watches, warnings, and statements were transmitted on the Texas and Oklahoma NWWS in a timely manner. When power failed in Wichita Falls, WSFO Fort Worth assumed warning responsibility for Wichita Falls' 11-county area and issued warnings and statements on NWWS.

o National Warning System (NAWAS)*

This telephone hotline system operated nationally by the Federal Emergency Management Agency (FEMA) is quite effective in disseminating warning information to local officials and in supplying feedback of storm reports to NWS warning offices. All NWS warning offices, including Oklahoma City and Wichita Falls and all NWS network radar offices in Texas, have NAWAS drops. In addition, drops are also located at 33 Texas Department of Public Safety (DPS) offices, including Wichita Falls and at 34 sites in Oklahoma. Interstate NAWAS is available at WSO Wichita Falls and WSFO Oklahoma City.

WSFO Oklahoma City used the NAWAS nearly 40 times to distribute watch and warning messages to public safety offices and other points during the afternoon and evening of April 10. NAWAS was used numerous times by WSO Wichita Falls, as well.

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* FEMA pays for all NWS NAWAS drops.

For the most part, the Texas and Oklahoma NAWAS systems operated well on April 10. However, when the tornado severed telephone lines in Wichita Falls, the NAWAS at both the NWS office and the Texas Department of Public Safety Office failed. NAWAS was restored around 3:15 a.m., April 11 -- 9 hours later.

o Telephone

The telephone was used effectively to distribute warning information to some key local officials. Although the Wichita Falls phone lists are quite long, there is really no other way to reach some of the outlying communities and counties. Additional staff were on duty at both WSO Wichita Falls and WSFO Oklahoma to ensure adequate phone dissemination. Fan-out procedures were used to a limited extent in Texas and to a greater extent in Oklahoma.

o EBS

To speed the distribution of warnings, broadcasters in many areas voluntarily take part in the Emergency Broadcast System (EBS). About 2 1/2 years ago, the Federal Communications Commission, DCPA, and NWS agreed to work together to revitalize the Nation's EBS. This agreement stressed use of EBS for State and local area dissemination of short-fuse weather warnings. State seminars and workshops have been held to develop specific written plans and procedures for use of EBS.

Plans have been written for about half the Nation's 560 EBS operational areas including Wichita Falls, Tex., and Lawton/Duncan, Okla. New plans providing for areawide implementation of EBS in north Texas were not operational for use of April 10. However, EBS was used by most, if not all, of the Lawton broadcast media during the severe weather outbreak.

Final plans and revised procedures were not yet written for Texas and Oklahoma in April, although key EBS stations existed in each State with procedures generally set up for national but not for State and local emergencies. Seminars have been held in all States, and 12 States have completed their written plans.

o Wichita Falls Emergency Communications Hotline

Wichita Falls has an emergency communications hotline telephone system that provides direct communications with both local TV stations, three local radio stations, the Sheppard AFB Command Post, and the City of Wichita Falls Fire Dispatcher. All participants share the cost. The hotline was of vital importance in the overall success of the warning service on April 10. It was used almost constantly between 5 p.m. and

6:15 p.m. by WSO Wichita Falls to issue warnings, provide the media with updated information and to suppress unfounded rumors. One person at WSO Wichita Falls was assigned the hotline function from 4 p.m. until the tornado struck shortly after 6 p.m.

The hotline was originally established for city use only. It has since expanded as a countywide warning distribution system. On a few occasions, the hotline has been used to distribute information about warnings in nearby counties for broadcast by the media.

o Sirens

Sirens operated by Civil Defense were sounded at all three cities suffering major damage. They were credited by almost everyone with saving countless lives. At Wichita Falls, they were sounded three times -- at 5:25 p.m.; again at 5:45 p.m.; and finally at 5:50 p.m. -- just before the tornado touched down on the southwestern edge of the city.

Sirens were sounded 15 minutes before the tornado struck Lawton.

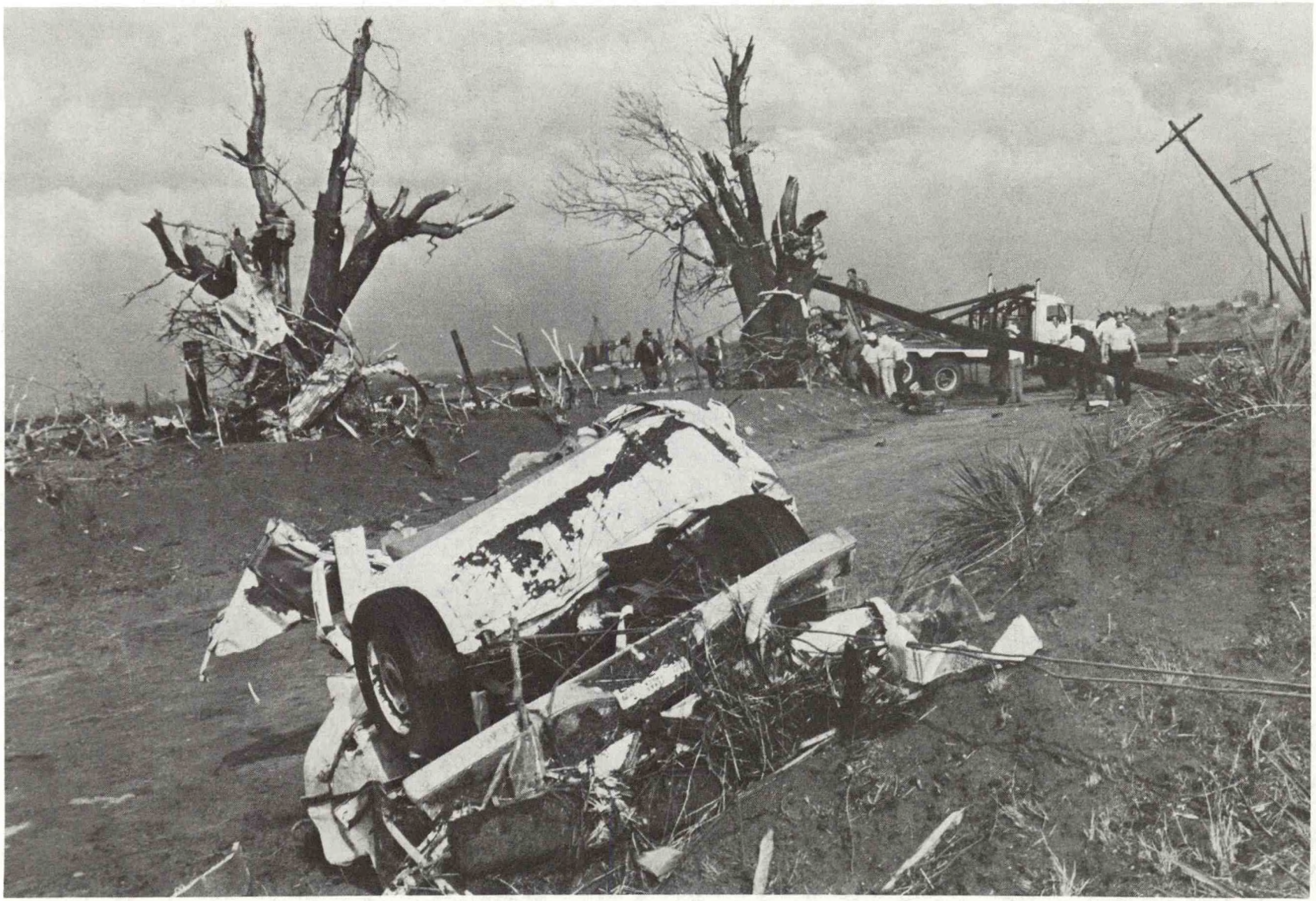
In Vernon, there were only a few minutes from the time the sirens were sounded to the time the tornado hit. But those few critical minutes saved scores of lives.

THE PUBLIC RESPONDS

In almost every survey after major weather-related disasters, NOAA has found a lack of an adequate proper public response in taking life-saving actions. This is usually due to the fact that NWS watches and warnings have had a credibility gap. Not so in north Texas and Oklahoma in this situation. People knew the difference between watches and warnings. They knew to listen to radio, television, and NOAA Weather Radio. They knew what the sirens meant. Most took cover. They were indeed a tornado-savvy people. There was, however, a recurrence of the "safe in my car" syndrome that has been seen before, notably in flash floods. In Wichita Falls, as in the Big Thompson Canyon of Colorado, people were reluctant to abandon cars and seek safety. Nearly 60 percent of the deaths in Wichita Falls involved people in cars.

Here are some examples of the actions people took on April 10 as gleaned from interviews by the survey team or from newspapers.

- A man and his wife operated an ice cream parlor in the Sikes Center Mall. They crawled into an ice cream vault -- cool, but uninjured.



Highway death scene. Remnants of cars caught on U.S. Highway 287. (Photo courtesy Vernon Daily Record.)

- In Lawton, a family dived under a mattress and survived the destruction of their home.

- In Wichita Falls, three people hid in an irrigation pipe, emerging wet, muddy, and uninjured.

- A Wichita Falls resident heard the sirens, saw the storm coming, got into the bathtub with her dog, and covered up with cushions. The house was demolished, but the woman and her dog were unscathed.

- At a restaurant in Wichita Falls, five people went into the restroom and were spared injuries. One of the customers and his wife tried to get to their car. He was killed, and his wife was seriously injured.

- A resident in one of the most heavily damaged areas of Wichita Falls said she and her daughters and their children huddled in a hallway under a mattress as advised by a newscaster in his last warning before the radio station stopped transmitting. She said the last warning was, "If you haven't opened your windows and doors yet, it is too late; take cover right now."

  One daughter said she thought her mother was overreacting when she dragged the mattress from the bedroom and told everyone to get under it. The house was destroyed around them. They were trapped under the wreckage of the house but were unhurt.

- The WSO employee who was home sleeping heard the sirens, looked outside, and saw the tornado approaching. He jumped into the bathtub and survived the total destruction of his home.

- Another Wichita Falls resident said, "I knew I had to go somewhere." She chose the closet. The closet, one wall gone, was all that was left of her home.

- A couple rode out the storm in the bathtub. While pelted by glass and pieces of sheetrock, they escaped serious injury.

- Twelve members of one family huddled in the hallway of the house. The house was completely destroyed. Nobody was seriously hurt.

- One woman remembered hearing a Wichita Falls radio station blaring, "TAKE COVER RIGHT NOW!" She looked out her window, saw the tornado coming, and like hundreds of others rushed to a closet. She found it a haven.

- At a supermarket, the assistant manager saw the tornado coming and put all the customers and employees in the cooler. When the storm passed, the cooler was the only part of the building left standing except for portions of the front and back walls.

- The survival of Southwestern Hospital on the northern fringe of the tornado's path in Lawton was also called a miracle. But they were ready. The hospital had a disaster plan.

  "Disaster plans work," said Southwestern's director of nurses. "If you practice them twice a year, you're ready."

  The director, who lives three blocks away, rushed to the hospital when the sirens sounded to begin directing the movement of 76 patients into the hospital halls and away from windows, according to their plan. The storm broke glass windows and caused some structural damage to the hospital, but none of the patients or hospital staff was injured.

FINDINGS AND RECOMMENDATIONS

FINDING 1:

NWS and NESS personnel collectively made a significant contribution to the watches and warnings issued on April 10, 1979. The skilled and concerned staffs at WSO Wichita Falls and WSFO Oklahoma City not only did an excellent job of warning, but played a significant role in pre-season disaster preparedness and public education efforts.

At Wichita Falls local officials and media representatives praised the entire staff of WSO Wichita Falls for the role they played prior to and during the tornado outbreak of April 10. Similar evidence was found at Lawton, Okla., regarding WSFO Oklahoma City's activities.

RECOMMENDATION:

The employees and their offices should be recognized for the role they played in minimizing casualties during the April 10, 1979, Red River Valley tornadoes.

FINDING 2:

Key upper air data from northern Mexican stations were missing at 6 a.m. on April 10. Data from these stations are often missing or are received too late to be incorporated in NMC computerized analyses and forecasts. In this case satellite data helped to fill some of the void.

RECOMMENDATION:

NOAA/NWS should work closely with the Mexican government to ensure timely and reliable receipt of upper air observations from northern Mexican stations.

FINDING 3:

Trained SKYWARN spotters (law enforcement personnel and organized amateur and CB radio groups) and radar played complementary roles in the timely issuance of severe weather warnings on April 10.

RECOMMENDATION:

NWS should continue to use both radar and trained radio-equipped storm spotters in its warning program. There must be no diminution of this effort or loss of momentum as FEMA comes into being. NOAA and FEMA should reach a full and formal understanding of relative roles and responsibilities without delay.

FINDING 4:

Although loss of life was high in the three hardest hit communities, it could have been significantly higher had it not been for the strong preparedness programs in the area and the cooperation and involvement of public officials, civic organizations, the media, NWS, and the citizens themselves. Wichita Falls, Tex., was especially well prepared (sirens, annual community training drills, hot line telephones, strong interagency cooperation, etc.).

RECOMMENDATION:

- o NWS should recognize those local organizations and individuals who played a major role in the success of the "total warning system" in the area.

- o The National Disaster Preparedness program should publicize the "model" preparedness efforts of communities, such as Wichita Falls, Tex., and encourage other vulnerable communities to develop similar action plans.

- o NWS should ensure that all of its field offices place a very high emphasis on an active community and media visitation program to develop effective lines of communication before disaster strikes.

FINDING 5:

When the tornado knocked out commercial power in much of Wichita Falls around 6:10 p.m., April 10, the NWR transmitter went off the air. There is no standby emergency power for the transmitter.

RECOMMENDATION:

NWS should develop a plan to provide emergency power for the total NWR system.

FINDING 6:

NOAA Weather Wire Service is widely used by broadcasters in Texas and Oklahoma. However, because of a recent significant rate increase in Texas, at least five subscribers in northwest Texas, including the Vernon radio station, have dropped the service. Because of growing media pressure, the Texas Governor's office has begun to look into the rate increase and its impact on warning distribution. Because of the vital nature of NWWS in getting watches and warnings to the media and thence to the public, NOAA and the Department of Commerce must take an active and positive role in efforts to hold the line on NWWS costs.

RECOMMENDATION:

Because of the critical nature of information carried on the NOAA Weather Wire Service, NOAA and the Department of Commerce should recommend to the proper officials in all States that action be taken to establish a special lower rate structure for NWWS so that the maximum number of radio and television stations can afford to subscribe to the service.

FINDING 7:

NAWAS is an invaluable tool for disseminating warnings and soliciting storm information. Yet, it failed when the tornado cut commercial power in Wichita Falls. NAWAS also failed during the Texas Hill Country flash floods of August 1978 and has failed at other times.

RECOMMENDATION:

NWS should work with FEMA in an effort to improve the reliability of NAWAS during disasters.

FINDING 8:

Detailed local area analyses by NSSFC, NESS, and some WSFO forecasters early on April 10 very clearly showed the high-risk severe storm area developing in Texas and Oklahoma. The onset of many other significant weather disasters in recent years (e.g., Johnstown, Penn., and Big Thompson Canyon, Colo., flash floods and the April 3 - 4, 1974, tornado outbreak) and many other localized destructive thunderstorm events was not clearly evident until analyses were prepared in more detail than the synoptic scale.

Although NSSFC and NESS meteorologists are well versed in mesoscale analyses techniques, most NWS field forecasters are not.

RECOMMENDATION:

NWS should place additional effort on training field forecasters in mesoscale analysis techniques to ensure maximum use of all available data. NWS and NESS should consider developing courses (e.g., at the Kansas City Training Center and NSSFC), and NWS Headquarters should consider developing self-study and video tape training materials on this subject.

FINDING 9:

The NOAA film "Tornadoes: A Spotters Guide" has received widespread use in the north Texas-south Oklahoma area. It was, for example, shown

at the Annual Lawton, Okla., Spotters Training meeting on March 21, 1979. In addition, some spotter groups in the area have previewed a draft spotter slide series being developed by NSSFC.

Both the film and the slide series are contributing significantly to the spotter training program. In fact, the film (released more than 2 years ago) has been widely used by NWS and Civil Defense people and has been purchased by more than 200 TV weathercasters, emergency service directors, educators, and others across the country. There has been nearly unanimous praise for it, and people have asked NWS to develop additional films and slide presentations of this type.

RECOMMENDATION:

NWS should complete development of its tornado spotter slide series for nationwide use before next tornado season. NOAA/NWS in coordination with FEMA should continue to develop useful, high-quality disaster-related films.

FINDING 10:

Sirens proved their value as lifesaving warning systems in all three of the hardest hit communities on April 10.

RECOMMENDATION:

All possible warning systems need to be used in getting warning messages to people in danger. NOAA/NWS, working with FEMA and State and local governments to develop a total warning system, should continue to give priority to siren systems in large communities.

FINDING 11:

Wichita Falls and Vernon lie about 100 to 125 nmi from the network radar at Stephenville and about 125 to 150 nmi from the network radar at Amarillo, Tex. The local warning radars at Wichita Falls (installed February 1977) and Abilene indicated the severity of the storms while they were a considerable distance from the major population centers. This early detection resulted in the issuance of longer lead-time warnings and provided extra essential time for storm spotters to reach their assigned locations.

RECOMMENDATION:

Action should be taken to ensure that all offices with warning responsibility are provided direct access to radar information.

FINDING 12:

The emergency power unit at WSO Wichita Falls is too small to support air conditioning for the radar. If commercial outages had lasted longer, or if these storms had occurred in summer, the radar could have been damaged or would have had to be shut down. Air conditioning is also essential for the additional computerized forecast equipment being installed at NWS offices now. There is no funded program to provide emergency power generators for NWS offices.

RECOMMENDATION:

NWS should reassess its emergency power needs.

APPENDIX A

SAMPLE SATELLITE IMAGERY AVAILABLE ON APRIL 10, 1979

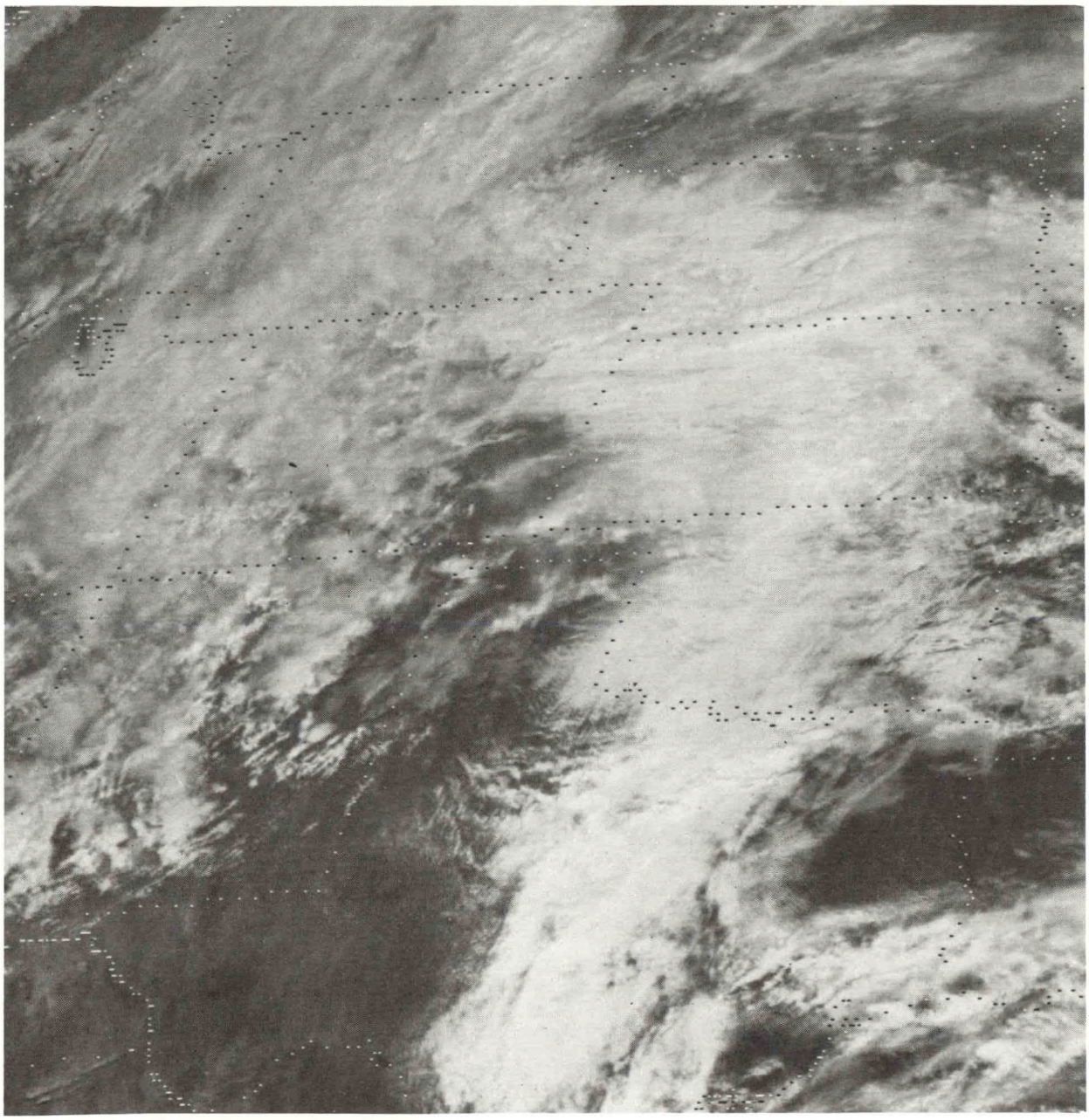


Figure A-1 -- Visible imagery at 11 a.m., April 10, 1979.

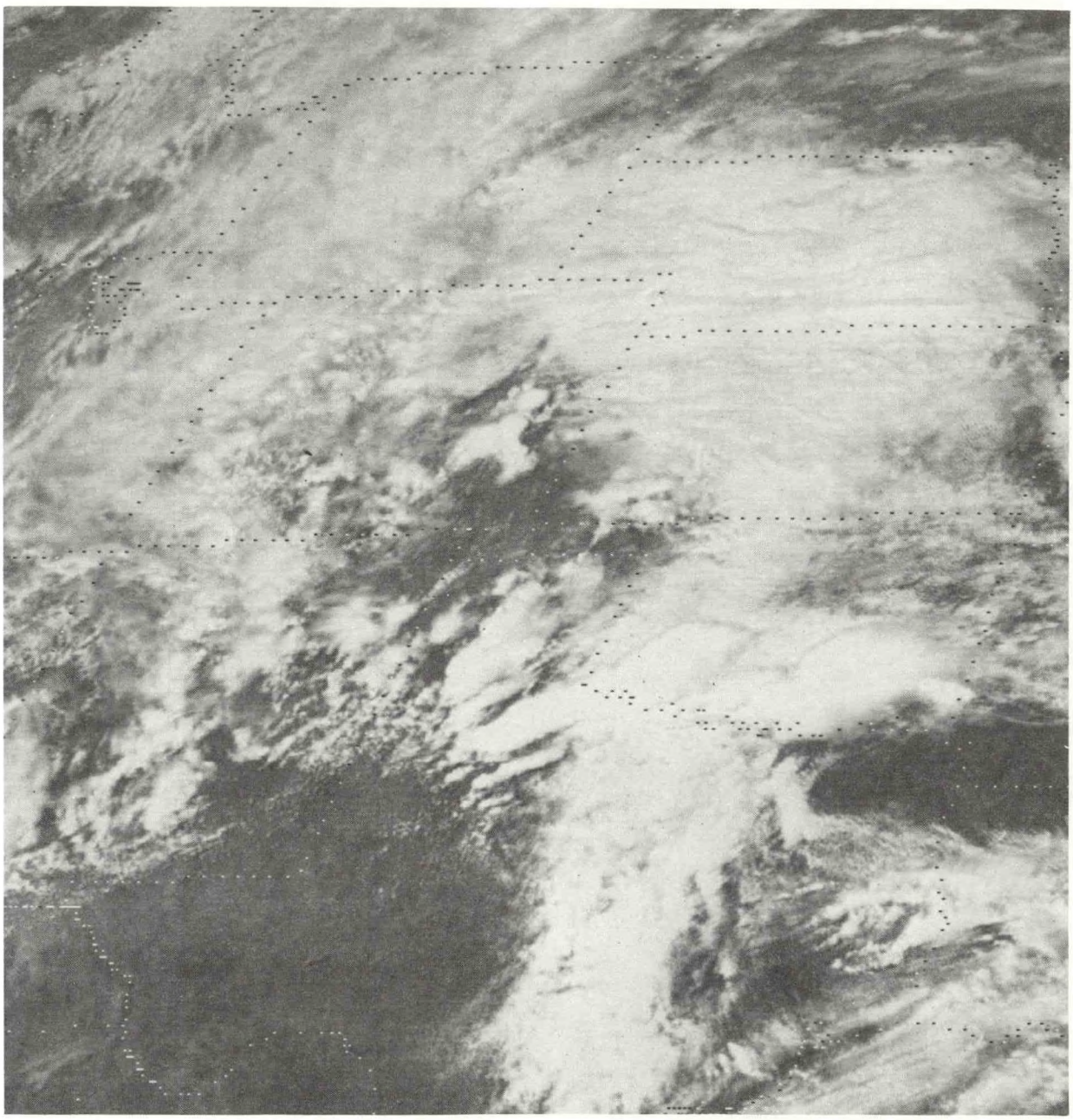


Figure A-2 -- Visible imagery at 1 p.m., April 10, 1979. Note the explosive thunderstorm development in northwestern Texas.

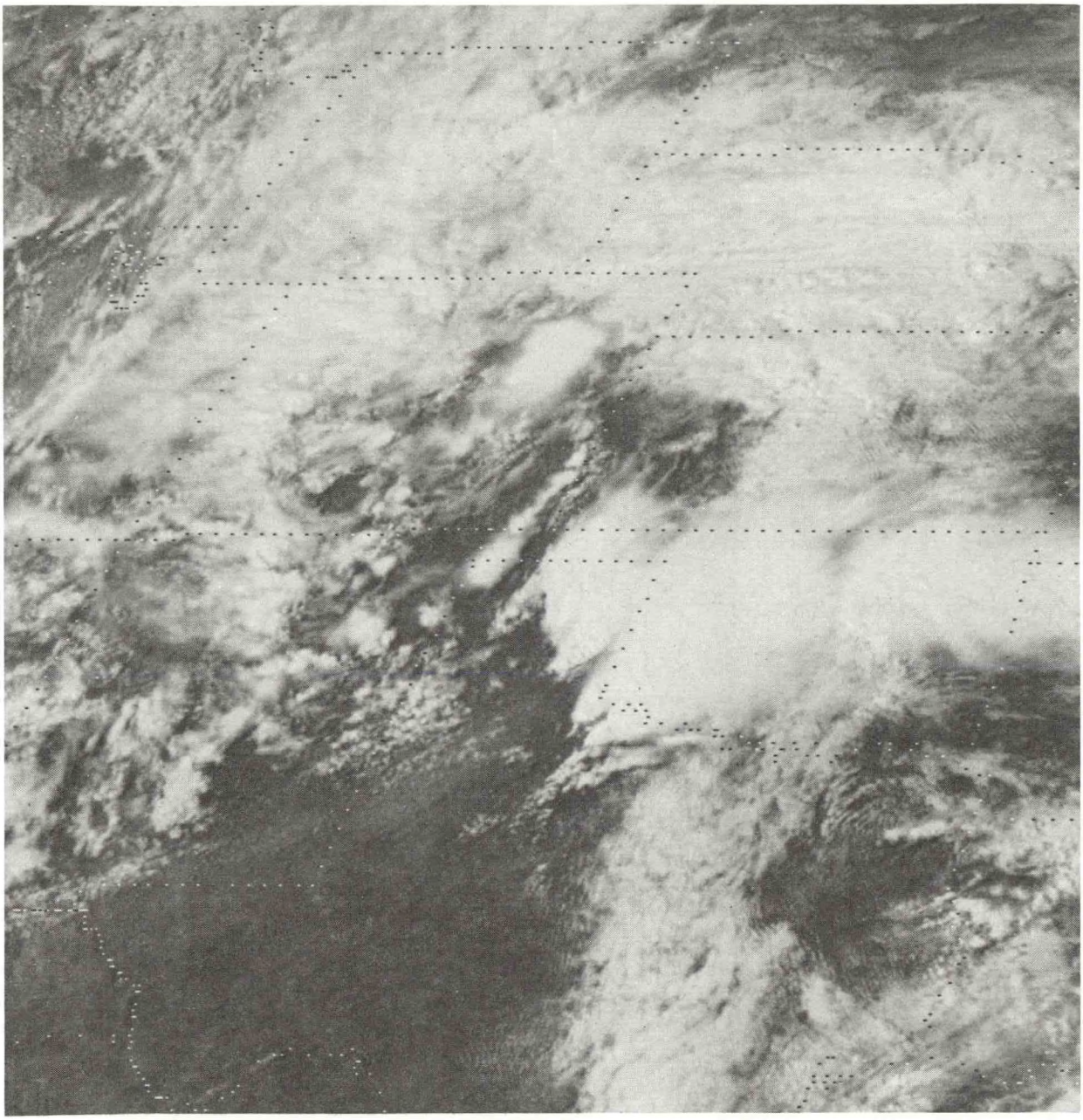


Figure A-3 — Visible imagery at 3 p.m., April 10, 1979. Thunderstorms continue to intensify as they move rapidly northeastward. Blowing dust (lighter area) can be seen in western Texas to the west-southwest of the strongest thunderstorms.

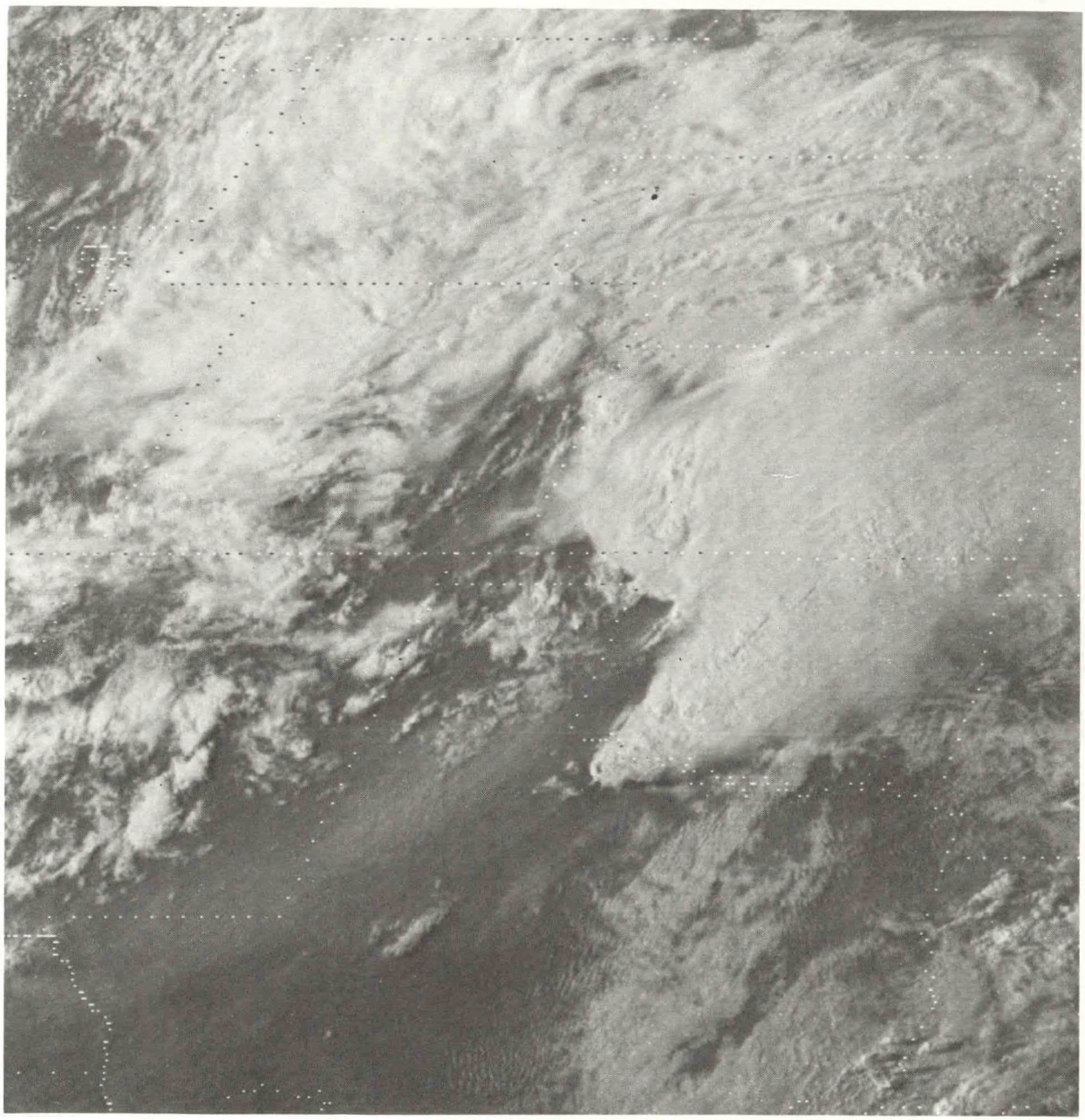


Figure A-4 -- Visible imagery at 5 p.m., April 10, 1979. Dust is very evident in western Texas. Massive thunderstorms extend from just southwest of Wichita Falls northward into Oklahoma.