Technical Report Documentation Page

1. Report No. FHWA/TX-07/0-4834-1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Winter Maintenance Issues Associated with New Generation Open-Graded Friction Courses		5. Report Date November 2005; August 2006 6. Performing Organization Code
7. Author(s) Yetkin Yildirim, Terry Dossey, Ken Fults, and Manuel Trevino		8. Performing Organization Report No. 0-4834-1
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, TX 78705-2650		10. Work Unit No. (TRAIS) 11. Contract or Grant No. 0-4834
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered Technical Report Sept. 2004–Aug. 2005 14. Sponsoring Agency Code

15. Supplementary Notes
Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration. Project Title: *Cold Weather Performance of New Generation Open-Graded Friction Courses*

16. Abstract
The improved ride quality and other possible safety benefits associated with New Generation Open-Graded Friction Course (NGOGFC) or Porous Friction Course (PFC) pavements—better friction, lower noise, less splash and spray, higher visibility, reduced hydroplaning, and reduced nighttime surface glare in wet weather conditions—have made them highly attractive to engineers and contractors in the last 3 decades. Nevertheless, the durability problems and performance and maintenance issues exhibited by NGOGFCs under winter weather conditions, especially the fast formation of black ice, have prevented their widespread use. Recent research has investigated new preventive methods and materials for handling these winter maintenance issues and improving durability in NGOGFCs. In 2005, the Center for Transportation Research (CTR) conducted an online survey of different districts within the Texas Department of Transportation (TxDOT) to gather information on NGOGFCs and in 2004–2005 CTR conducted lab and field experiments to test the methodology for detecting black ice formation on NGOGFCs. This report presents the findings of the CTR survey results and research.

17. Key Words Open-Graded Friction Course, Porous mixes, noise, skid, black ice, winter maintenance, wet weather accidents.	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. www.ntis.gov

19. Security Classif. (of report)	20. Security Classif. (of this page)	21. No. of pages	22. Price
Unclassified	Unclassified	128	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Winter Maintenance Issues Associated with New Generation Open-Graded Friction Courses

Yetkin Yildirim
Terry Dossey
Kenneth W. Fults
Manuel Trevino

CTR Technical Report:	0-4834-1
Report Date:	November 2005; August 2006
Research Project:	0-4834
Research Project Title:	Cold Weather Performance of New Generation Open-Graded Friction Courses
Sponsoring Agency:	Texas Department of Transportation
Performing Agency:	Center for Transportation Research at The University of Texas at Austin

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Center for Transportation Research
The University of Texas at Austin
3208 Red River
Austin, TX 78705

www.utexas.edu/research/ctr

Preface

This is the first report from the Center for Transportation Research (CTR) on Project 0-4834. This report presents the results and findings of the information collected from the test sections for the first year of a 2-year project.

Acknowledgments

This project was initiated and has been sponsored by the Texas Department of Transportation (TxDOT). The financial support of TxDOT is greatly appreciated. The authors would like to thank TxDOT Project Director, Dr. Andrew Wimsatt, P.E. for his guidance. Special thanks are also extended to personnel in the Amarillo, Wichita Falls, and Fort Worth districts for assistance in placing pavement sensors and for everyone involved in responding to the questionnaire.

Products

This report contains Products 1, 2, 3, and 4. Product 1, Literature Synthesis, is in Chapter 2. Product 2, District Questionnaire Results, is in Chapter 3. Product 3, Field Measurements, is in Chapter 4. Product 4, Preliminary Guidelines for Cold-Weather NGOGFC, is in Chapter 5.

Disclaimers

Dr. Yetkin Yildirim, P.E. (Texas No. 92787)

Kenneth W. Fults, P.E. (Texas No. 38994)

Table of Contents

List of Tables

List of Figures

1. Introduction

The possible benefits that came with using New Generation Open-Graded Friction Course (NGOGFC) or Porous Friction Course (PFC) have produced an increased interest in PFCs in the last 3 decades. However, widespread use of PFC surfaces has been largely curtailed by durability problems and performance and maintenance issues exhibited by PFCs under winter weather conditions, such as the more rapid accumulation of black ice. Recent research and studies have investigated methods of improving PFC durability under these conditions, and many state transportation agencies are also researching new materials and preventive methods that can best deal with winter maintenance problems of PFC pavements.

The precedent for PFCs was the Open-Graded Friction Course (OGFC) mix, which yielded potential safety benefits but exhibited durability problems and winter and maintenance hazards, eventually causing them to be discontinued. New research produced an improved version of OGFC, the New Generation Open-Graded Friction Course (NGOGFC) or Porous Friction Course (PFC). Like the first-generation OGFC, NGOGFCs and PFCs yield possible benefits, including lower noise, reduced splash and spray, higher visibility, reduced hydroplaning, and reduced nighttime surface glare in wet weather conditions. NGOGFCs are more open-graded, have increased air void structures, contain more asphalt content, and are enhanced with polymer asphalt, rubber asphalt, and fiber additives. These improvements found in NGOGFC have effectively reduced some of the durability problems related to the first-generation OGFC.

Despite these technological advances in durability, however, it is still uncertain whether the new, improved NGOGFCs will perform well under winter conditions. It is possible that these open mixes may still trap and accumulate moisture in the event of rain, snow, or sleet, which, in rapid-freezing conditions, may cause the formation of “black ice”—an extremely hazardous condition for vehicles driving at high speeds or with improper tires. Different states using NGOGFCs have had varying experiences during winter conditions, with some experiencing performance problems, and in Texas, districts in North Texas are particularly concerned about the performance of NGOGFCs during winter conditions.

In 2005, the Center for Transportation Research (CTR) conducted an online survey of different districts within the Texas Department of Transportation (TxDOT) to gather information regarding NGOGFCs. Respondents to the survey answered fifty-seven questions relating to NGOGFC design, maintenance, performance, regional practices, and, in particular, cold weather performance and associated practices. The survey defined NGOGFCs (PFCs) as having at least 18 percent air voids, often containing polymer modifiers and/or asphalt rubber. The survey was not intended to address old plant mix seals or first-generation OGFCs. Overall, most districts claimed to have good experiences with NGOGFC surfaces, although many of these same districts also noted that they had been using NGOGFC for only a short period of time. Reduced splash and spray, improved skid resistance, and smoothness were the most common criteria for districts choosing to use NGOGFC, and of these, the main advantage of NGOGFC use cited by most districts was its improved skid resistance in wet weather conditions. Most districts cited the main disadvantage of NGOGFC use is its initial cost of construction.

In the winter of 2004–2005, CTR conducted lab and field work to test the methodology in detecting black ice in PFC pavements in three locations in North Texas. Preliminary lab work began just before the project started in August of 2004, and the installation of field devices was completed prior to the winter of 2004–2005. This report summarizes the research that has been conducted on the maintenance and performance issues of NGOGFCs (PFCs) in winter weather conditions and presents the findings gathered from the 2005 CTR survey of TxDOT districts' use of NGOGFCs.

2. Summary of Literature Review

This chapter is a review of research that has been conducted on the performance and maintenance of Porous Friction Courses (PFCs) in terms of winter issues. For the past 3 decades, there has been much interest in the use of PFCs due to certain possible benefits. However, durability problems and performance and maintenance issues under winter conditions, such as the faster accumulation of black ice, have discouraged more widespread use of these types of surfaces. Past research and studies currently under way have investigated how to improve the durability of PFCs. In addition, many transportation agencies are investigating materials, such as new de-icing chemicals, and methods in winter maintenance to understand how to best deal with problems in winter conditions.

2.1 Introduction

The use of Open-Graded Friction Course (OGFC) mixes has many potential benefits of interest to transportation engineering. However, the early OGFC mixes had problems related to lack of durability of the surfaces, and concerns with winter performance and maintenance issues, which caused discontinued use of the mixes. With changes in open-graded mixture technology in the past decade, there has been increased interest in the use of New Generation Open-Graded Friction Courses (NGOGFC), or Porous Friction Courses (PFC). These second-generation OGFCs are more open-graded, have increased air void structures, have more asphalt, and are enhanced with polymer asphalt, rubber asphalt, and fiber additives. The design of the NGOGFC has reduced some of the durability problems associated with the first-generation OGFC.

However, it is unclear whether advances in NGOGFC technology will solve the problems with performance in winter conditions. These open mixes may still allow accumulations of moisture through rain, snow, or sleet, and during rapid freezing events, black ice can be produced, which can be a very dangerous condition for vehicles traveling at imprudent speeds or for vehicles with improper tire inflation or tread depth. Some of the North Texas areas have reported that these mixes are "the first to freeze and the last to thaw" and therefore, are problematic during rapidly advancing freeze conditions and especially during rapid freeze-thaw cycles. Many regions prone to snow or ice have not considered using PFCs due to potential winter problems, but some countries in Europe have established winter maintenance programs to address these potential safety concerns. Some states in the U.S. are implementing similar winter maintenance programs.

2.2 Background

The open-graded structure of Open-Graded Friction Courses (OGFC) draws water off the surface of the pavement, which may lead to increased safety in wet weather conditions (1).

OGFC mixes have potential benefits such as:

- Lower noise
- Improved visibility in wet weather conditions
- Reduced splash and spray in wet weather conditions
- Reduced hydroplaning
- Reduced nighttime surface glare in wet weather conditions

The early OGFC mixes had problems in terms of lack of durability and concerns with winter performance and maintenance issues, which caused discontinued use of the mixes. Research on first generation OGFCs has shown that raveling can occur in a short time, in as little as 6 to 8 years, in addition to clogging of the open permeable pores that give the OGFCs most of their benefit. Also, OGFCs' lower temperature and open mixes allow frost and ice to accumulate earlier, more quickly, and more frequently, compared to other surfaces (2).

However, with changes in open-graded mixture technology in the past decade, there has been increased interest in the use of New Generation Open-Graded Friction Courses (NGOGFCs), or Porous Friction Courses (PFCs). Currently, many countries in Europe, including Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Switzerland, the U.K.; as well as states in the U.S., mostly in the western and southern regions, including Arizona, Georgia, Oregon, Texas, and Utah, are using PFCs (3). These second-generation OGFCs are more open-graded, have increased air void structures at a minimum of 18 percent, as opposed to the first-generation OGFC, which had air void structures between 10 percent and 15 percent; have more asphalt (20 percent more), and are enhanced with polymer asphalt, rubber asphalt, and fiber additives (4). The design of PFCs has reduced some of the durability problems associated with the first-generation OGFC. First, using modified asphalt counters the tendency of PFCs to ravel by keeping the aggregate pieces together better. Second, more asphalt is used and placed 1.5 to 2.0 in. thicker, providing thicker films that resist aging and allow water to drain more quickly (2). Third, the open texture of PFCs allows water to be flushed out by high-speed traffic, therefore reducing the potential to get clogged over time (5).

While the more open air void range may allow water to drain more quickly, it is unclear whether or not advances in PFCs will solve the problems with performance in winter conditions. These open mixes may still allow accumulations of moisture through rain, snow, or sleet; and during rapid-freezing events, black ice can be produced, which can create very dangerous conditions for vehicles traveling at imprudent speeds or with improper tire inflation or tread depth. Some of the North Texas areas (Dallas/Fort Worth) have reported that these mixes are "the first to freeze and the last to thaw" and are therefore problematic during rapidly advancing freeze conditions (Blue Norther) and especially problematic during rapid freeze-thaw cycles (nightly freeze with daily thaw). At least one European country has discontinued the use of PFC mixes as a result of major black ice problems. Other European countries have established winter maintenance programs that seem to adequately address these potential safety concerns. At least two U.S. states have implemented some of these European maintenance strategies (6).

2.3 Design and Performance of PFCs

In 1978, the Transportation Research Board published the report *Open-Graded Friction Courses for Highways*. This report discusses mix designs, material selection, construction procedures, cost effectiveness, maintenance, safety aspects, and pavement performance of OGFCs, concentrating on the advantages and disadvantages of using OGFCs. The advantages included the virtual elimination of the danger of hydroplaning under wet conditions, increased skid resistance, the minimization of splash and spray during wet weather, reduced glare at night, better visibility of traffic stripes during wet weather, improvements in road smoothness, minimization in wheel-path rutting, quieter riding surfaces, cost savings, quick turn-around time for traffic use, and reduced tire-pavement noise. Disadvantages included a shorter expected service life, earlier preventative maintenance, and perhaps variable winter maintenance procedures (7).

In 1987, the Texas Transportation Institute published a report that discusses Texas' experience with OGFCs, in terms of materials selection, final serviceability, mixture design procedures, handling and construction, specifications, maintenance, and recommendations. Texas has high temperatures and lots of sunshine in the summer, coupled with demanding traffic loads and volumes. The researchers noted that natural coarse aggregate required for functional OGFC (trap rock, sandstone, rhyolite, and limestone) was in limited supply in Texas; therefore, large quantities of manufactured, lightweight aggregate were used instead, which was suitable for OGFC mix as long as they were properly tested. Manufactured, lightweight aggregate started being used for Texas pavements in 1962, and several Texas districts began using it in OGFC beginning in 1972. It was noted that, in general, Texas used mineral aggregates in compliance with specification standards with two exceptions: the stone must have had a polish value of 35 or higher, and no uncrushed gravel could be permitted. The effective life of OGFC overlays in Texas ranged from about 5 to 12 years (8).

In 1990, the U.S. Department of Transportation published a technical advisory that provided a background and recommendations for use of OGFCs. It addressed both the advantages and the limitations of OGFCs at that time, discussing factors such as environmental conditions, alignment, accident rates, and frictional properties, and presented the FHWA mix design procedure for an OGFC (9). Then in 2000, Huber published a report that provides recommendations for materials selection, mix design, construction, structural pavement design, winter maintenance, and rehabilitation to maximize the potential for new generation PFCs, citing that problems of raveling, delamination, and loss of permeability after a few years of service have been solved; with many states in the U.S. having experienced excellent performance in terms of safety and durability, most using polymer-modified asphalt binders, relatively high asphalt content (by using fibers), and relatively open gradations (2).

A 1992 article presents the use of OGFCs as a viable option for Massachusetts and Vermont highway agencies, citing the durability, environmental, and safety features of such pavements. There is a particular emphasis on noise reduction, reduced hydroplaning, and enhanced skid resistance as environmental and safety advantages. OGFCs are presented as a sensitive mix because they are more sensitive to temperature control and placement location. Problems encountered with OGFCs include the difficulty of ice removal and low temperature transverse cracking (10).

In 1993, the Florida DOT required OGFC use for all multilane primary and interstate highways that had a design speed greater than 45mph (72 km/hr), in order to improve wet weather vehicular safety. Their FC-2 mix used locally available aggregates, such as crushed granite, gravel, slag, or oolitic limestone, and was produced at a reasonable cost. Changes and additions to specification criteria have been made over the years to address undesirable results such as periodic flushing, rich and lean areas, texture closing up with traffic, low friction numbers, moisture damage, premature raveling, and embedment of the OGFC in underlying layers. These problems have been countered, respectively, by keeping tight controls on the temperature of the mix, employing a shorter storage time, keeping the placement of the mix as thin as possible, having only one pass of the roller, disallowing the overlay of OGFC, opening up the sections to traffic as soon as possible, and not placing OGFC on fine-graded leveling course mixes. Maintenance, rehabilitation techniques, and improved performance are being studied. Asphalt additives show promise in increasing the design life of OGFC (11).

A mix design method has been developed for a new-generation OGFC or PFC by the National Center for Asphalt Technology (NCAT), published in a report in 2000. In addition to using polymer-modified asphalt binder and fiber, the mix is highly open-graded with high permeability. The study in this report evaluated the performance of PFCs with different gradations and types of additives to arrive at the best mix design. Construction and performance of pavements with similar mixes already in use are evaluated as well (4). A study to evaluate the use of cellulose fibers in PFC mixes in order to prevent draindown was also conducted by NCAT in 2000. This study entailed both a field and a laboratory phase with six mixes, each with different combinations of binder polymer and additives (12).

In Europe, numerous studies have also been done to investigate porous asphalts. Since 1982, Switzerland has been carrying out a program to observe the long-term behavior of porous mixtures. Observations about the reduction of permeability to water and favorable conditions for maintaining a sufficient permeability are included (5). Also, research started in 1999 in Copenhagen studied the development and testing of two-layer porous asphalt under Danish conditions in terms of noise, absorption, surface structure, traffic safety, pavement condition, and winter maintenance (13).

A summary of the current knowledge of the potential safety benefits related to low noise surfaces, with particular attention paid to porous asphalt, was published in Oslo, Norway in 2003 (14). The report surveyed nine different risk factors: driver behavior induced by traffic noise, visibility in wet weather, risk of aquaplaning, stopping distance, rutting, light reflection, winter performance, speed, and need for more frequent resurfacing. Of these nine, four risk factors are favorably affected by porous asphalt: visibility in wet weather, risk of aquaplaning, rutting, and light reflection. Three risk factors were adversely affected: winter performance, speed, and need for more frequent resurfacing. The report concluded that porous asphalt's effect on accidents could not be predicted based on its effects of these risk factors and that more research was needed to make such a determination. Still, it was found that improved skid resistance reduced the number of accidents.

A report published by Richard Lane (15) summarized the composition of open grade asphalt (OGPA), its expected life cycle, and the characteristics of its water-draining properties. The report noted that two major changes occur over time when OGPA becomes clogged. The build-up of debris clogs the air voids and reduces the effectiveness of the OGPA's properties. Secondly, during wet weather conditions, oily material that also accumulates in the air voids rises to the surface. It is this oily substance that contributes to motor vehicle accidents. The report also discusses the OGPA Cleaning Trial Contract CA2445 and the methodology used for establishing the cleaning process, test methods, and environmental considerations.

In 2003, the work on PFCs continued with ongoing research into mix design and performance. One study performed by NCAT endeavored to refine and field-validate the new-generation mix present in their 2000 report, by assessing mixes with more aggregate sources, including granite, crushed gravel, and trap rock. Several objectives were identified that needed to be addressed (16). Also, the Georgia Department of Transportation (GDOT) modified its use by changing the PFC mix used in that state to include anti-stripping agents and polymer-modified AC as well as varying production and construction procedures (17).

Finally, in 2004, Flintsch, the Virginia Department of Transportation, and the University of Virginia conducted a study to assess the functional performance of a variety of pavement surfaces, including PFCs, in controlled wet and wintry weather events. The study investigated performance in terms of skid resistance and splash and spray during wet conditions and response to de-icing, anti-icing, snow removal, and ice control techniques. The techniques tested included the application of sodium chloride (salt) in granular, prewetted, and liquid forms, and snow removal and ice control measures. The study also defined and tested a methodology for testing winter maintenance operations. Except for increased spray and splash performance of PFCs, the results showed that there were no significant differences in the performance of the different surface mixes tested, and that the winter maintenance tests were unable to significantly improve the functional condition of the road. However, test conditions did not exactly correspond to natural conditions, suggesting that the test might not be complete in evaluating the effectiveness of the various chemicals used (18).

2.4 Previous Questionnaires on PFC Performance and Practices

Several questionnaires administered in the past 2 decades have attempted to address the questions surrounding PFCs. In 1992, Smith conducted a study to describe the design and construction, performance benefits and limitations, and maintenance and rehabilitation of PFCs, as well as to collect information on state highway agencies' and European experience with PFCs, current usage of PFCs, and conclusions about information gaps and recommendations for use. He noted that in terms of winter maintenance, European countries had much more experience, and that in general, in Europe and the U.S., winter maintenance activities require special procedures and an increase in de-icing chemicals, although there is much variety from place to place (19).

Then in 1998, Kandhal and Mallick, at the National Center for Asphalt Technology (NCAT), carried out another study to assess the experience of states that use PFCs in terms of design and construction practices. The experience of these states varied widely. In terms of winter maintenance issues, many states found that removing snow and ice was difficult, that more salt and de-icing chemicals were needed, and that freezing was prolonged. In addition, the states using polymer-modified binders had fewer problems such as raveling, debonding, stripping of underlying layers, and scrapes by snowplows.

In 2000, another survey on the performance of PFCs was carried out by Huber to describe the current state-of-the-practice on the use of PFC mixes regarding design, materials, construction, maintenance, and rehabilitation strategies. Information for the synthesis was collected by surveying U.S. and Canadian transportation agencies and by conducting a literature search to gather further information on North American and European practices. The survey also describes new material and design methods in use, as well as the applicability of the new generation of open-graded mixtures to North American use (2).

Finally, in 2002, Rogge, with the Oregon Department of Transportation (ODOT), conducted survey and field evaluations to study maintenance practices for F-Mix, which is their PFC mix, with the goal of improving preventative maintenance, corrective surface maintenance, and winter maintenance practices in Oregon. Standard pavement maintenance procedures developed for dense-graded mixes were not effective for F-mix, especially for winter maintenance. Researchers surveyed ODOT maintenance personnel to collect experience and recommendations for best practices for F-mix maintenance (20).

While each of these previous surveys conducted on PFCs briefly discusses issues pertaining to winter maintenance, there has been no comprehensive and conclusive study or survey that concentrates solely on the evaluation of PFC performance, construction and design, and maintenance of PFCs with winter conditions in mind. Thus far, surveys have concentrated on durability and wet weather performance, construction and design of different mixes, and general maintenance issues. Mostly, general problems with winter maintenance have been discussed, such as snow and ice removal and faster freezing, but these have been limited in scope in terms of the number of agencies surveyed and breadth of topic.

2.5 Winter Performance Evaluation Studies

Many problems with winter performance and maintenance have been identified in the literature. In both Europe and the U.S., it has been documented that the accumulation of snow, formation of ice, and action of salt and de-icing chemicals are different on PFC surfaces than on dense-graded ones. Because of its open-graded characteristics, the surface temperature of PFCs naturally tends to be several degrees lower than dense-graded pavements because the high air void range makes the pavement less heat conductive, at about 40 to 70 percent that of a dense-graded mixture. Ice and snow accumulate faster on PFC pavements due to its more open-graded structure and thaw more slowly and refreeze more quickly. More de-icing materials are needed to melt snow and ice. In addition, black ice has been reported to be a serious problem when water is allowed to accumulate on curves in the road and in rapid freeze-thaw cycles (2).

The most serious pavement performance problems caused by winter issues are tire stud rutting, gouging and scarring from snowplows, and clogging. Rutting caused by studded tires was cited as the most serious maintenance problem for PFCs in Oregon in 2001 (20). PFCs are more susceptible to gouging by snowplows with less resistance to the snowplow's blade. More serious damage is seen in areas with repeated plowing. In Oregon, maintenance managers have attempted to use run shoes on plows and have reduced plow speeds to combat the problem of gouging, but they have discontinued the use of PFC pavements in mountain snow zones (20). In general, the damage caused by studded tires and snowplows is so extensive that states that permit the use of studded tires do not apply PFCs, and in regions where snowplow use is widespread, the use of PFCs is not recommended (2).

2.6 Winter Maintenance Practices

Recommendations for winter maintenance of PFCs present in the literature include special procedures, investigations of new technology, and mix design suggestions. First of all, PFCs need to have their own winter maintenance regimen. Maintenance personnel must be provided with the correct information on the different behavior of PFCs at temperatures near or below freezing (20). Then procedures before and after winter storms must be established, including giving special and frequent training to drivers of snowplows and utilizing preventative salting or using de-icing chemicals. In order to maintain ice- and snow-free roads during winter storms with rapidly dropping temperatures, the schedule of de-icing and snow-removal procedures must accommodate the tendency of PFC surfaces to freeze and accumulate snow faster and thaw more slowly by pretreating roadways, increasing the frequency of de-icers, and mixing abrasives with chemicals, or a combination of these practices (19, 21).

In terms of materials, sanding is not as effective, as the small sand particles get into the pavement's pores more easily and cause clogging. The elimination of sand from maintenance procedures helps keep PFCs from clogging. Because of PFCs' efficient draining properties, salt and de-icing agents drain away very quickly, and therefore must be applied more frequently, leading to higher costs and environmental concerns (5, 21). Because of this tendency to wash away, salting is only useful when applied on dry surfaces before precipitation occurs and when temperatures are lower than 14ºF; therefore preventative salting at the right time is important (2). In general, there is a need for greater quantities of de-icing agents for PFC storm maintenance than for dense surfaces. For instance, in Italy, in the winter, there is a 50 percent increase in the use of salt on PFC pavements (21).

New technologies can also help maintain PFCs in winter conditions and help reverse damage incurred during winter conditions. One avenue of research includes investigating new materials or alternatives for salt for de-icing roads. These include using prewetted salt that may stick better to the pavement surface, using new ways of spreading salt solutions to reduce the chance of it's being washed away, using alternatives to sodium chloride to reduce corrosion, such as two de-icing agents, CMA (Calcium Magnesium Acetate) and Clearway (a non-corrosive, liquid-acetate solution); using de-icing agents that are more viscous and can be retained on the surface for longer periods of time, and investigating electrostatic charge technology as a way of bonding de-icing agents to the surfaces (20, 22).

For instance, in Denmark, friction media (sand) is not used, but instead, a wetted salt solution (water applied at the back of the truck) is used to control icing. The wetted salt is used to increase the even distribution of the salt and to prevent the formation of ice hats. The ice hats form because the salt tends to wash from the top of the open-graded surfaces into the pore spaces, leaving the surfaces susceptible to icing. They are also looking at larger salt grains to perhaps minimize this problem. Calcium chloride is currently used. The porous surfaces increase salt consumption by 30 percent to 100 percent. Freezing rain could be a real problem and "very difficult to treat." The salt will drain away almost immediately, for which no solution has been found at this time (21). In France, in the event of prolonged snowing, salt is supplemented with a calcium chloride solution to remove thick ice and snow packs from the spaces in the asphalt. The French use a combination of dry salt, wet salt, wet salt enhanced with calcium, and a straight calcium chloride solution, depending on pavement conditions (i.e., ice versus snow, wet or dry surfaces) and preventive or reactive situations. In Italy, a combination of magnesium and calcium is used as a de-icing agent (21).

Another technology that is being used and researched in Europe and Asia includes machines that clean clogged pavements and unclog the pores of the pavement (23, 21). Three cleaning methods have been cited in the literature: cleaning with fire hoses, cleaning with high pressure cleaners, and cleaning with specially manufactured cleaning vehicles (2). Finally, creating mixes with higher air voids can also allow high-speed traffic to perhaps help clear out clogged pavement (5). Also, the new generation PFCs that are both polymer-modified and contain fibers with lower moisture susceptibility can have a lower tendency to ravel in cold climates and freeze-thaw cycles (4).

In terms of placement of PFCs, transitions from dense to porous surfaces might disturb drivers in winter conditions and therefore, short sections of PFCs should be avoided. In Denmark, they recommend not using porous surfaces in intersections due to the winter risks. They also recommend the use of warning signs in advance of porous surfaces, bringing attention to potentially icy surfaces in winter conditions (21). Table 2.1 summarizes winter problems and treatments.

Table 2.1 Summary of Winter Issues

Winter Use Problems	Treatments	Treatment Advantages	Treatment Disadvantages
Black Ice	Sand	Inexpensive, Quick	Clogging
	Salt	Inexpensive, Quick	Drains away (need to use more); Corrosion
	De-icing Chemicals	Alternative to Salt	Expensive; Insufficient information on use (studies needed)
	Special Procedures such as anti-icing	Preventing ice formation	Insufficient information or research
Clogging Over Time	Using Salt	No Clogging, Inexpensive, Quick	Drains away (need to use more); Corrosion
	De-icing Chemicals	No Clogging	Expensive; Insufficient information on use (studies needed)
	Cleaning	More effective	Expensive
Tire Stud Rutting and Snowplow Gouging	Discontinue use of tire studs and snowplows on PFCs	Better Pavement Maintenance	Difficult to achieve in northern climates with severe winter conditions

2.7 Conclusions

There continues to be much interest in the use of PFCs, due to possible safety improvements, especially during wet weather conditions. PFCs may demonstrate better friction, lower noise in general, less splash and spray, higher visibility, reduced hydroplaning, and reduced nighttime surface glare in wet weather conditions. With the continuing advancement in the design of PFCs, the long-term quality of surfaces has been increasing, therefore making these surfaces more and more appealing. However, the continuing issues of maintenance and performance in the winter prevent PFCs from being utilized to their full potential.

Research done in the past has not been sufficient to make firm conclusions about the use of PFCs in the winter and combating the disadvantages associated with winter maintenance and performance issues.

Black ice is a formidable problem with all pavements, but especially with PFCs, due to their inherently lower temperatures and open-graded qualities, which allow more water to be trapped more easily and freeze more quickly than other pavement surfaces.

Sand and salt are usually used to treat pavements during winter conditions, including black ice, but with PFC surfaces, these materials may not be as effective. Sand clogs the pores of PFC pavements, thereby eliminating the benefits of using PFCs. Salt, on the other hand, because of the open-graded structure of the PFC surface, drains away quickly, necessitating the use of more salt.

Clogging of the surface over time is an issue with long-term performance in general, and in terms of winter maintenance can be caused by the use of sand during snow and ice removal treatments. The problems encountered with sand can be combated in two ways. First, other materials, such as salt or other de-icing chemicals that do not clog the surface pores, can replace sand. Second, the pavements can be cleaned regularly so that pores become unclogged.

Tire stud rutting and snowplow gouging is especially a problem with PFC surfaces because after short periods of time, the pavements may be destroyed. The solution to these problems is the discontinued use of tire studs and snowplows, which is a difficult plan to implement in northern climates with severe winter conditions.

However, advances in technology have produced better-performing PFC surfaces and have contributed to the possibility of using these surfaces during winter months.

New and existing **de-icing chemicals** have been and continue to be studied to find out how to improve their effectiveness.

New **methods** of applying these chemicals, as well as salt, have been investigated to better prevent the materials from being drained off the surface, such as applying wetted salt that sticks to the road better.

Also, proper **training of maintenance personnel** may help the situation of PFCs in winter conditions, such as the timing of the application of the chemicals to the pavement before precipitation falls to help prevent the formation of ice. PFCs require a different maintenance routine, but research suggests that with accurate planning, problems in winter conditions can be combated.

Further investigations can be done to determine the exact performance of PFCs under severe winter conditions and what maintenance techniques can be employed to make full use of these surfaces.

3. Cold Weather Performance of New Generation Open-Graded Friction Courses TxDOT District Survey

New Generation Open-Graded Friction Course (NGOGFC) or Porous Friction Course (PFC) pavements have been valued by transportation agencies due to their potential benefits, especially in wet weather conditions. However, the experience of different states with NGOGFC mixes has varied, with some states experiencing durability problems and performance and maintenance issues under winter conditions. The tendency for NGOGFC pavements to freeze faster and longer and to accumulate black ice has discouraged more widespread use of these types of surfaces in many areas. This chapter summarizes the results from a survey distributed to maintenance personnel from different districts in the Texas Department of Transportation (TxDOT). Twenty-three respondents answered questions about NGOGFC use in their districts, including questions about pavement choices, construction, cost, and general maintenance and winter maintenance issues. In general, many districts claim that they have had good experiences with the use of NGOGFC pavements in their areas, although many also state that they have used NGOGFC mixes for only short periods of time. Reduced splash and spray, skid resistance, and smoothness are the main criteria used to determine use of NGOGFCs; the main advantage cited was improved wet weather skid resistance, and the main disadvantage was initial cost of construction.

3.1 Introduction

The use of New Generation Open-Graded Friction Course (NGOGFC) mixes has possible benefits of interest to transportation engineering, such as good friction, lower noise, reduced hydroplaning, high visibility, reduced splash and spray, and reduced nighttime surface glare in wet weather conditions (1). However, the early Open-Graded Friction Course mixes had problems in terms of lack of durability and concerns about winter performance and maintenance issues, which caused discontinued use of the mixes. With changes in open-graded mixture technology in the past decade, there has been increased interest in the use of NGOGFCs or Porous Friction Courses (PFCs). NGOGFC mixes are more open-graded, have increased air void structures, have more asphalt, and are enhanced with polymer asphalt, rubber asphalt, and fiber additives. The design of the NGOGFC has reduced some of the durability problems associated with the first-generation mixes (2).

However, it is unclear whether advances in NGOGFC technology will solve the problems of performance in winter conditions. These open mixes may still allow accumulations of moisture through rain, snow, or sleet, and during rapid-freezing events, black ice can be produced, which can be a serious concern for vehicles traveling at high speeds or that have improper tire inflation or tread depth. Many regions prone to snow or ice have not considered using NGOGFCs due to potential winter problems, but some countries in Europe have established winter maintenance programs to address these potential safety concerns, programs which have been implemented in some states in the U.S.

In order to answer specific questions surrounding the actual use of NGOGFC mixes, a survey of maintenance officials in Texas Department of Transportation (TxDOT) districts and state transportation agencies was conducted to establish patterns of NGOGFC use and issues related to mix design, construction, performance, and maintenance, especially concerning winter performance and maintenance. Results of this survey will be used in coordination with results from a study of NGOGFC in the field. The following discussion will review the results of the survey from TxDOT districts.

3.2 Survey

An online survey regarding use, mix design, construction, and general as well as winter performance and maintenance was sent out to pavement and laboratory managers in all twenty-five TxDOT districts (24). Twenty-three respondents from TxDOT districts replied to the survey. These responses were compiled and analyzed to obtain specific information about NGOGFC mixes. The results are presented according to specific questions asked in the survey.

3.3 NGOGFC Use

Out of the twenty-three districts that responded, eleven currently use NGOGFCs, nine have never used the mix, and three have used it in the past but currently do not. Of the reasons cited for discontinuing the use of NGOGFCs, all three respondents who discontinued use cite performance as an issue, followed by one response for maintenance problems and one for cost. One respondent mentioned that the Area Engineer wanted to first evaluate the performance of NGOGFCs.

In terms of where NGOGFC mixes are used, fourteen (74 percent) respondents use the mix in high-speed areas, with speed limits greater than 45 mph, and five (26 percent) use the mix in low-speed areas, with speed limits equal to or less than 45 mph. Of seventeen respondents, 5 (29 percent) have used NGOGFCs in curb and gutter sections and twelve (17 percent) have not.

3.3.1 Criteria for Use

The questionnaire listed eight issues that agencies may use to determine whether to use NGOGFC mixes in their areas, with the option of listing other criteria used in their decision-making processes. These eight criteria included:

- Traffic level
- Environment (freezing or not; wet or dry)
- Skid resistance
- Noise reduction
- Reduced splash and spray
- Smoothness
- Cost
- Durability
- Other

Respondents were asked to rank the criteria from 1 to 9, with 1 being the most important criterion. A copy of the questions and results is presented in the Appendix as Figure A. When analyzing the results, criteria that were given the rankings 1 through 4 were considered to be the most important factors in making decisions about NGOGFC use. The number of respondents per criteria ranked 1 through 4 was calculated. Figure 3.1 shows the results from this question. Reduced splash and spray was ranked highest by the most respondents, fifteen in total. Skid resistance and smoothness were the second most important, as ranked by the respondents (ten each). Finally, in order of importance, were durability (eight), traffic level (six), noise (five), cost (two), and environment (one).

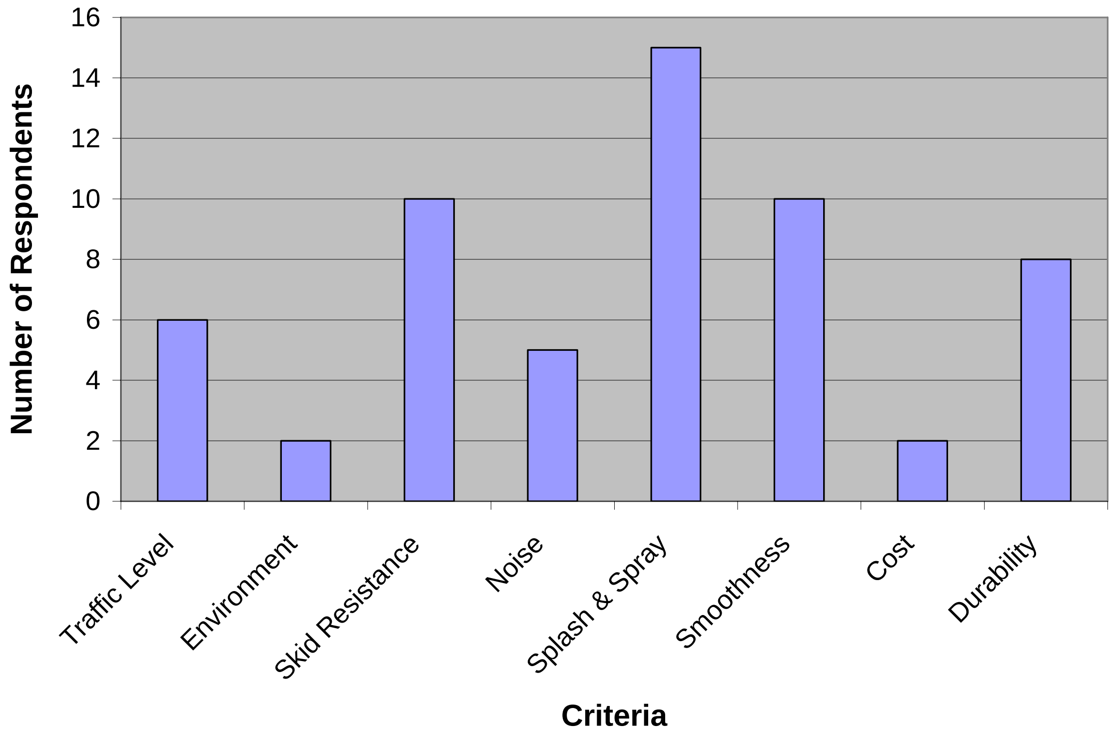

Figure 3.1 Criteria for Use of NGOGFC Pavements

3.3.2 Advantages and Disadvantages of NGOGFC Mixes

The questionnaire asked respondents to identify the main advantages and disadvantages in the use of NGOGFC mixes. Six possible advantages were offered to respondents, with the option of identifying other advantages not listed. A copy of this question and results is located in the Appendix as Figure B. The possible advantages include:

- Improved driver visibility on wet pavement (reduced spray)
- Improved wet weather skid resistance
- Improved road marking visibility during wet weather
- Noise reduction
- Cost
- Durability
- Other

Respondents were asked to rank the advantages from 1 to 7, with 1 being the greatest advantage. When analyzing the results, criteria that were given the rankings 1 through 3 were considered to be the most important advantages to using NGOGFCs. The number of respondents per category ranked 1 through 3 was calculated. Figure 3.2 shows the results from this question. Improved wet weather skid resistance and improved road marking visibility during wet weather were deemed the most advantageous by respondents, with thirteen respondents in each category ranking them in the top three. Improved driver visibility on wet pavement (reduced spray) followed closely with eleven respondents ranking it in the top three. Noise reduction (five), durability (one) and cost (zero) were ranked low as advantages. No additional advantages were identified by the respondents.

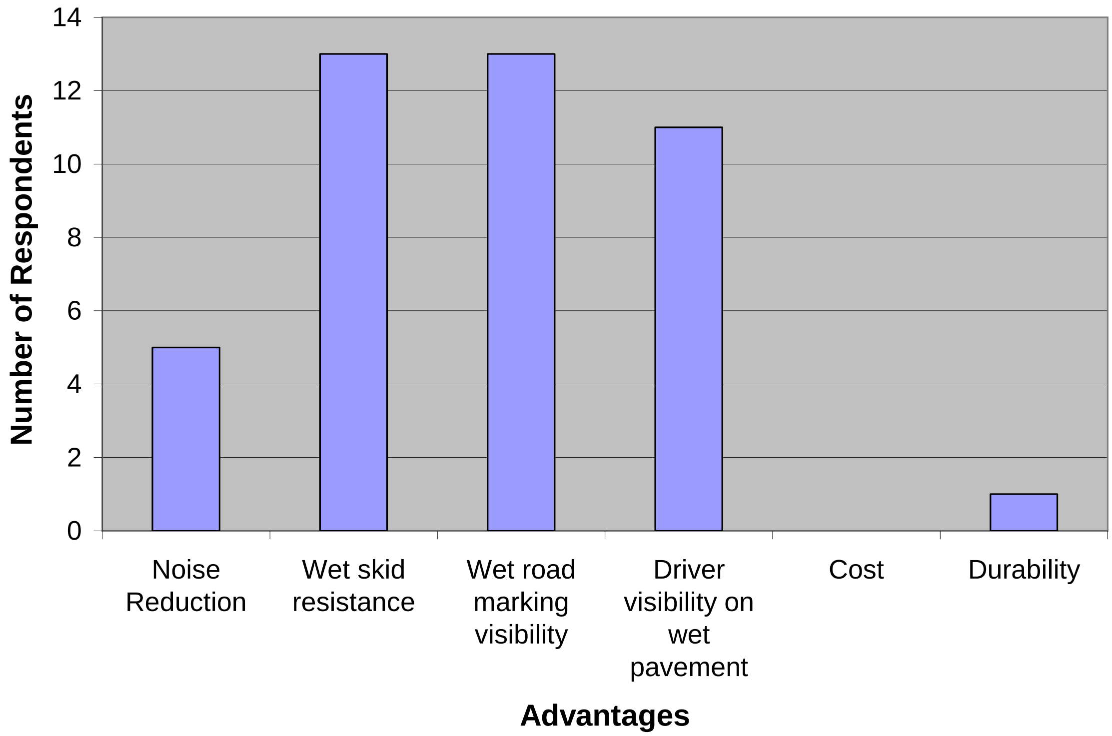

Figure 3.2 Advantages of using NGOGFC pavements

Five possible disadvantages were offered to respondents, with the option of identifying other disadvantages not listed. A copy of this question and results is presented in the Appendix as Figure C. The possible disadvantages include:

- Initial or construction cost
- Winter maintenance problems
- Durability
- Performance
- General maintenance
- Other

Respondents were once again asked to rank the advantages from 1 to 6, with 1 being the biggest disadvantage. When analyzing the results, criteria that were given the rankings 1 through 3 were considered to be the most important disadvantages to using NGOGFCs. The number of respondents per category ranked 1 through 3 was calculated. Figure 3.3 shows the results from this question. Construction or initial cost was considered to be the biggest disadvantage by respondents, with eleven respondents ranking this category in the top three. Winter maintenance problems followed, with eight respondents ranking it in the top three. Finally, general maintenance problems, with six respondents, and durability and performance, with three respondents each, were ranked fairly low as disadvantages. There were no additional disadvantages identified by the respondents.

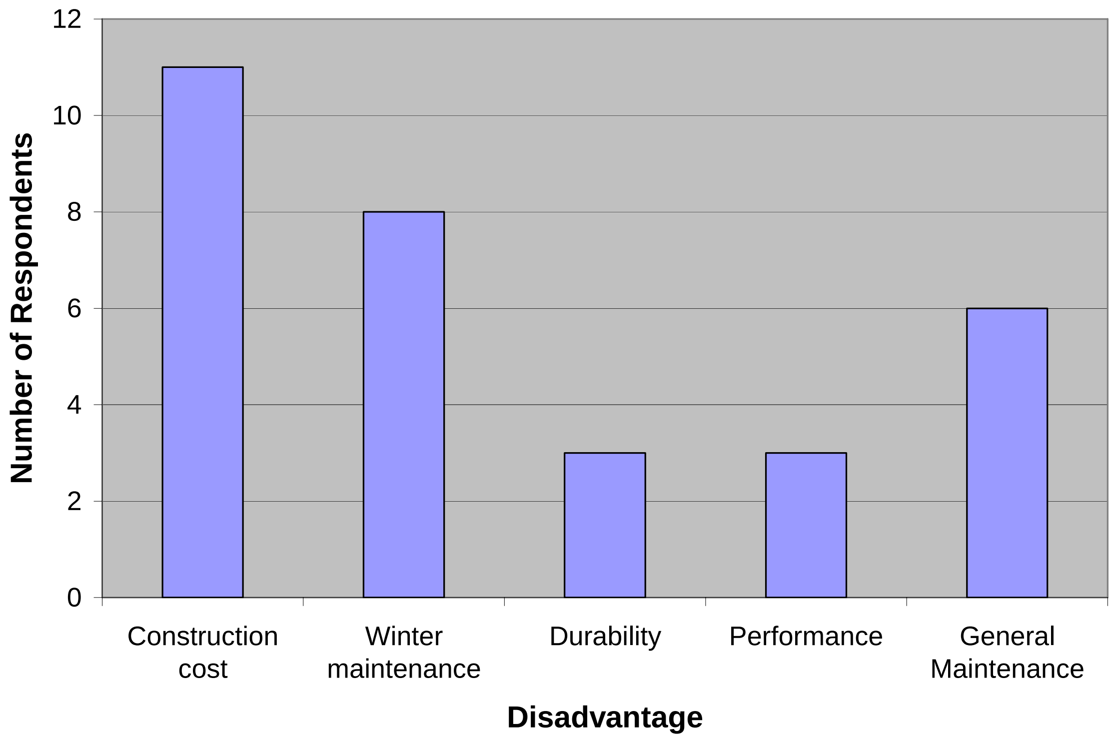

Figure 3.3 Disadvantages to using NGOGFC pavements

3.4 Performance

Out of twelve responses, five (42 percent) indicated that their NGOGFC mixes had a service life of between 10 and 12 years, four (33 percent) between 8 and 10 years, one (8 percent) between 6 and 8 years, and two (17 percent) indicated fewer than 6 years. No respondent indicated having a NGOGFC pavement that had a service life of more than 12 years. Figure 3.4 shows the results of this question.

Performance was rated in terms of five indices, including:

- Durability (i.e., stripping, raveling)
- Surface friction
- Splash and spray
- Noise
- Smoothness

These indices were ranked on a 5-point scale from 5 (excellent) to 1 (poor). For all of the indices, the majority of rankings were either excellent or very good. Only one response for all indices ranked below good (3); one respondent ranked surface friction as fair (2). Splash and spray received the best ratings, with nine (69 percent) of the thirteen respondents ranking it excellent and four (31 percent) ranking it very good. A copy of this question and the results are located in the Appendix as Figure D. For analysis, the averages of all the rankings given by respondents for each category were calculated. Figure 3.5 shows the results of this question. Splash and spray ranked the highest with an average of 4.7, followed by noise and smoothness, each with an average rank of 4.5. The final performance indices were surface friction, with an average of 4.3, and durability, with an average of 4.2.

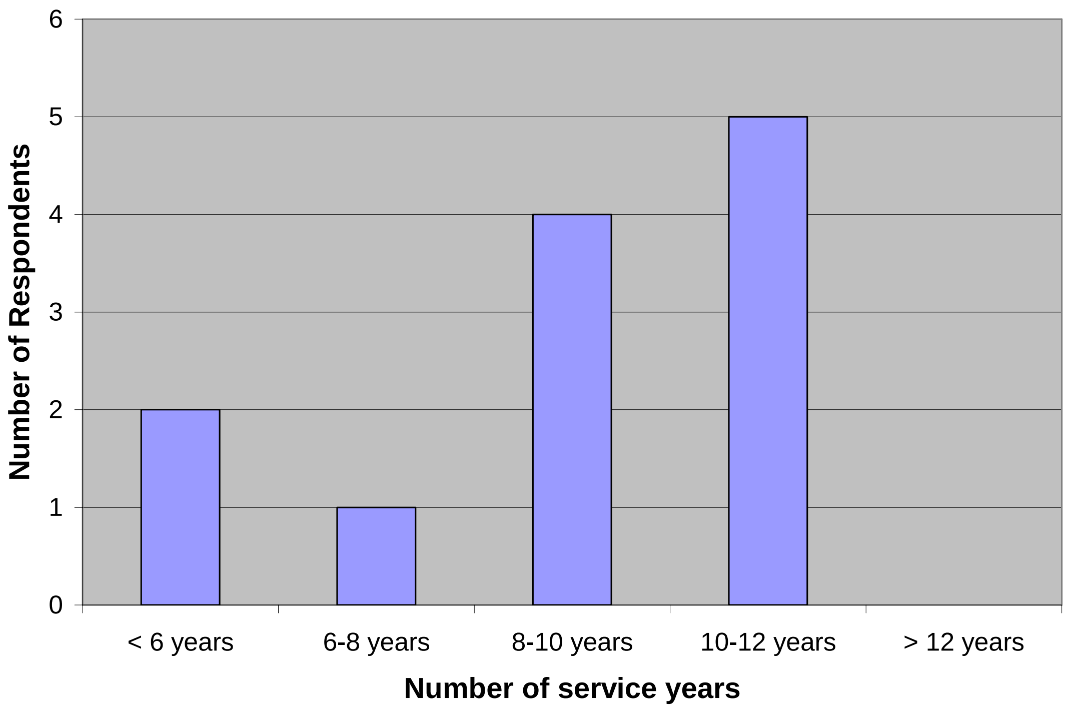

Figure 3.4 Service life of NGOGFC pavements

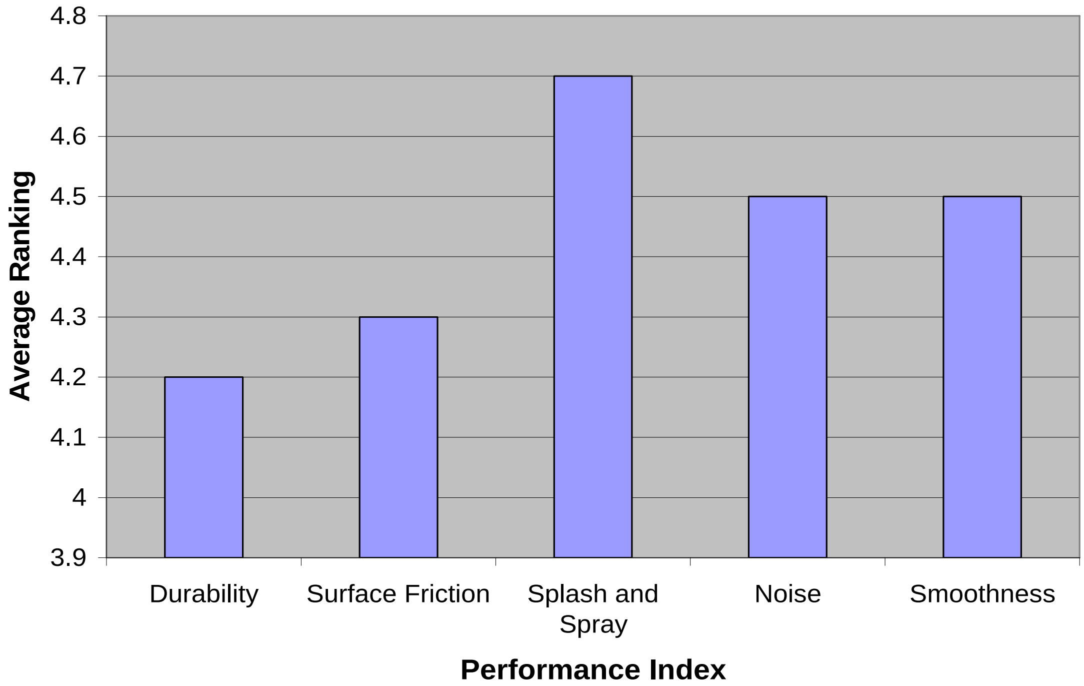

Figure 3.5 Performance indices

In addition, the questionnaire included questions related to the frequency of occurrence of various problems including:

- Raveling in wheel paths (percentage area)
- Deformation rutting (average depth)
- Potholes
- Fat spots/bleeding
- Stripping (percentage area)
- Reflective cracking
- Thermal cracking
- Tire stud rutting
- Gouging/scarring (snowplow, etc.) (percentage area)
- New Construction Roughness (IRI)
- Clogging (based on splash and spray)
- Noise level inside vehicle
- Icing

Results from these questions show that there are not any significant performance problems cited by respondents. Results from respondents show that the frequency of occurrence of durability problems is low. For instance, eleven out of thirteen respondents state that raveling in wheel paths is less than 5 percent. Ten out of thirteen replied that there were no occurrences of potholes or deformation rutting (rutting less than 0.25 in.). Eight out of twelve respondents replied that there were no occurrences of fat spots or bleeding and that stripping is experienced in less than 5 percent of the area. Twelve out of thirteen respondents replied that they have noticed no reflective or thermal cracking in their NGOGFC pavements, and all ten respondents experienced very smooth (less than 40 IRI) or smooth (40-60 IRI) new construction roughness.

Twelve of thirteen respondents replied that noise levels inside vehicles were low. Four experienced no clogging of the NGOGFC pavements, eight experienced low levels of clogging, and one experienced medium levels. Finally, in terms of winter maintenance, there was a wide range of experiences with winter weather conditions. Out of thirteen respondents, four never experienced icing and three experienced it fewer than 5 days a year. Four respondents replied that they have five to ten icing events in a year, and two have more than ten. The amount of tire-stud rutting and gouging and scarring from snowplows was low; eleven out of thirteen experienced no tire-stud rutting, and eleven of twelve replied that less than 5 percent of the total area where NGOGFCs were used experienced gouging or scarring.

Stripping is sometimes indicated by the presence of raveling, popping out of aggregate or flushed areas on the surface of the pavement accompanied by shoving or roughness in the wheel path. Techniques to evaluate stripping include coring the area, visual inspection, and measurement. One respondent noted that his district has not experienced stripping since using crumb rubber, and two other respondents have not experienced stripping in the NGOGFCs in their districts.

3.5 Cost

In terms of cost, the relative cost of the material in place is more expensive compared to the equivalent depth of a typical AC surface mix. No respondents indicated that NGOGFC mixes were less expensive or the same as a typical mix. Out of twelve respondents, five replied that NGOGFC mixes were 15–20 percent more expensive, thirty replied that they were 15 percent more expensive, and two replied that they were more than 30 percent more expensive. Overall, NGOGFC pavements were an average of 22.5 percent more expensive.

3.6 Maintenance

Respondents ranked the seven biggest maintenance challenges experienced with NGOGFC pavements, with the option of indicating other maintenance issues not listed. The seven possible challenges are listed below.

- Pushing, shoving, and tearing
- Delamination
- Stripping difficulties
- Fuel or oil spills
- Snowplow damage (gouging and scarring)
- Staying frozen longer
- Formation of black ice

Among the seven possible problems, three respondents listed fuel or oil spills as the most significant problem, with one respondent each indicating that pushing, shoving, and tearing, and staying frozen longer are the most significant problems. Three respondents indicated that either maintenance was not viewed as a significant problem or the sections with NGOGFC pavements were too new to see maintenance problems. One respondent stated that spot-repairing damaged areas with these mixes is a challenge.

All of the eleven respondents indicated that in Texas no special activities were used on NGOGFC pavements in their areas, and only one out of the eleven stated using fog seal to maintain the surface condition of NGOGFC pavements. One respondent replied that his district was waiting to see what was needed for the pavement because the pavements were too new for maintenance yet.

In terms of permeability, no respondents indicated that permeability is periodically monitored after construction. Five respondents stated that permeability is measured when the pavement is constructed. Of those who measure permeability, one respondent uses the NCAT procedure, two respondents use the TEX-246-F measurement, and one respondent applies water from a water truck to check drainage.

Only one respondent cited an increase in the rate of accidents on NGOGFC pavements, while nine cited no increase.

3.6.1 Winter Maintenance

Various winter maintenance techniques were evaluated by respondents; they were asked to rank five techniques from 1 (ineffective) to 4 (very effective). These techniques included using:

- Sanding
- Liquid de-icer agent
- Anti-icing agent
- Prewetted salts
- Advisory signs

The average rankings that respondents gave each technique are represented in Figure 3.6. Overall, anti-icing agents were ranked as the most effective technique, with an average rating of 3.5 (between very good and excellent) followed by liquid de-icing agents and sanding.

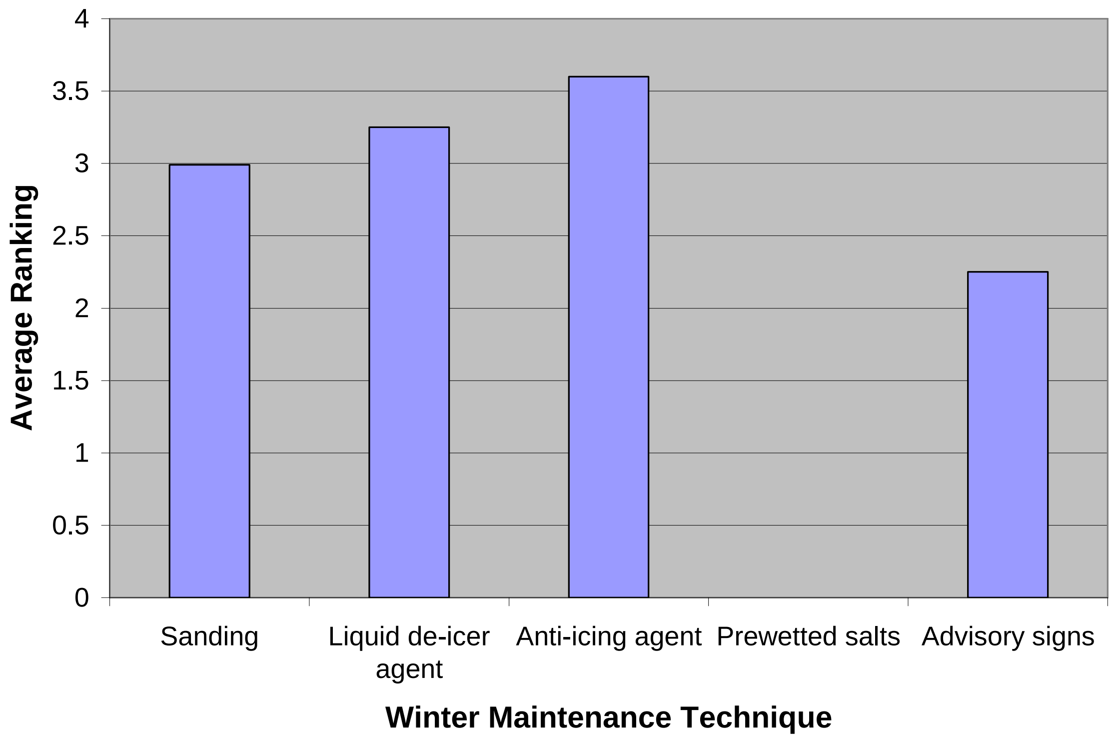

Figure 3.6 Average ranking of the effectiveness of winter maintenance techniques

More specifically, one respondent noted that staying frozen longer was the most significant maintenance problem in his district. The NGOGFC pavement's tendency to stay frozen longer was also the most often cited problem, ranked relatively high by respondents. The most often cited problem was the formation of black ice, ranked 2, 4, and 5 by four respondents. In addition, one respondent added "first to freeze" as a significant maintenance problem with maintaining their NGOGFC pavement. In contrast to these general comments, one maintenance supervisor in a TxDOT district claims that NGOGFC pavements are the last to freeze and the first to thaw. Snowplow damage, stripping difficulties, and slippage cracks were relatively insignificant problems for the respondents, brought up by only a few respondents and ranked low in every case.

The most common winter maintenance activity was the use of sand during winter weather events in NGOGFC pavement areas; nine out thirteen respondents indicated using this material. However, only one respondent indicated that sanding was very effective, with six suggesting that it is an effective technique and two indicating only moderate effectiveness. Only four of thirteen used a liquid de-icer agent and four of twelve used anti-icing agents. However, all of the respondents who use chemical agents ranked them as being effective to very effective. All twelve respondents indicated that they do not use prewetted salts in their winter maintenance activities on NGOGFC pavements. Eight out of twelve respondents cite using advisory signs in NGOGFC pavement areas; however, two indicated that the signs are ineffective, two indicated they were moderately effective, and four indicated they were effective. One respondent stated using a Lightweight Grade 5 Manufactured Rock or Limestone Grade 5 instead of sand for winter maintenance, because the material in these aggregates is large enough to not become lodged in the pores, which can prevent the mix from draining. Sand and limestone screenings should be avoided except in emergency situations.

In order to combat black ice, the most common method used was sanding, followed by advisory signs, anti-icing agents, and liquid de-icers. No respondents indicated using prewetted salt. Similar to the responses for overall winter maintenance activities, advisory signs were considered to be either ineffective or effective, whereas liquid de-icers and anti-icing agents were rated as either effective or very effective. The majority of respondents who use sanding maintained that it is an effective technique. Two respondents cited that sanding is moderately effective, and one maintained that it is very effective.

Compared to other pavements, six respondents maintained that they use the same amount of chemical de-icing agents on NGOGFC pavements as with other pavement types. One respondent indicated using 25 percent more. In terms of the cost of de-icers, six respondents cited spending the same for de-icers on NGOGFC pavements, with one respondent spending less and one spending 25 percent more.

Finally, one respondent claimed that the maintenance supervisors in that district do not feel that NGOGFC pavements present any more problems in cold weather than other pavement types. Normally only the bridges are treated, and snowplows are used on the roadways. In the last ice event they experienced, the more serious accidents occurred mostly on the concrete pavement. Overall, since that district experiences many more rainy days than icy days, they feel that the safety benefits attributed to NGOGFC pavements in reducing accidents during wet weather far outweigh any potential problems related to winter weather events.

3.7 Design and Construction

3.7.1 Design

All thirteen respondents in this category mention that the range of asphalt content is specified. Five respondents indicate that the ranges used are 5–7 percent and 7–8 percent. Only two use 9–10 percent asphalt content. The average asphalt content specified is 7.2 percent.

Seven out of eleven respondents stated that the mix temperature range established to prevent asphalt drain-down was greater than 23^{o}F. Eleven of the respondents use polymer asphalt binder in their NGOGFC mixes, eleven use cellulose fiber additives, and six use rubber additives. PG grades of binder were specified by respondents; nine use PG 76-22 (including PG 76-22 TR and PG 76-22 S), two use PG 70-28, and one uses crumb rubber modified asphalt with higher drain-down temperatures and with an AC content between 8.5–9.0.

In terms of the performance of NGOGFC mixes with different additives, only two respondents indicated that NGOGFC mixes with rubber perform better than those without. One respondent maintained that NGOGFC mixes with rubber perform worse. Respondents indicated that rubber affects the durability (stripping and raveling) of the pavement, noise, smoothness, and surface friction.

Six respondents claim that NGOGFC mixes with fiber additives are better than those without. Fibers affect performance mostly in terms of durability (stripping and raveling), but also in terms of splash and spray. Three respondents stated that fibers are necessary to prevent drain-down, and two respondents stated that they have only used NGOGFC mixes with fibers, and therefore have no basis for comparison.

The most common specified target air void requirement for NGOGFC mixes was 18–20 percent, reported by seven respondents.

3.7.2 Construction

Only two respondents reported placing NGOGFC pavements over newly constructed concrete pavement, and two have placed NGOGFC pavements over existing concrete pavement. Pretreatments used included milling, seal coat, tack coat, crack and strip sealing, a 1.5-in. course of dense-graded ACP, and grinding off of existing HMA overlay.

Eight respondents reported using emulsion tack coat material, and three reported using asphalt cement. One respondent reported using an underseal, usually Hot Rubber Seal, one reported using emulsion or AC or nothing, depending on the engineer, and one reported using a novachip machine to place a thin, bonded NGOGFC. The most common specified application rate of tack coat was 0.05–0.07 gallons per square yard, reported by eight respondents.

3.8 Summary

This chapter presents TxDOT's experience with NGOGFC mixes, according to the survey. Information in the survey was collected from twenty-three respondents from the TxDOT districts. Out of the twenty-three respondents, eleven use NGOGFC mixes, and nine have never used them. Three districts reported that they used plant mix seals and stopped using them, although they have not used NGOGFC.

The most important reasons cited for using NGOGFC pavements include reduced splash and spray in wet weather conditions, smoothness, and skid resistance. The main advantages include improved driver visibility, improved skid resistance, and improved road marker visibility during wet weather. The main disadvantages include initial cost of construction, winter maintenance issues, and general maintenance issues.

In general, many districts claim that they have had good experiences in terms of performance with the use of NGOGFC pavements in their areas, although many also state that they have used NGOGFC mixes only for a short period of time. The average service life of the pavements ranged from less than 6 years to 10 to 12 years, with most respondents indicating a service life of 10 to 12 years. Reduced splash and spray ranked the highest in terms of performance indices, followed by noise and smoothness, each with an average ranking between excellent and very good. Respondents did not indicate any serious problems with NGOGFC pavements in terms of raveling in wheel paths, deformation rutting, potholes, fat spots/bleeding, stripping, reflective cracking, thermal cracking, tire stud rutting, gouging/scarring, new construction roughness (IRI), clogging, noise level inside vehicle, or icing.

Results show that NGOGFC mixes are 22.5 percent more expensive than dense-graded mixes. However, few special (and more expensive) maintenance activities are used to maintain the surface of NGOGFC pavements, and no other special activities are used on NGOGFC pavements. Respondents indicated that the biggest general maintenance problem was fuel spills. In terms of winter maintenance, overall, anti-icing agents were ranked as the most effective technique.

Finally, permeability is not measured regularly, but many respondents indicated that it is measured at the time of construction, generally using the NCAT procedure, the TEX-246-F method, or by applying water from a water truck to check drainage. In terms of design, the binder grade most often used is PG 76-22.

4. Field Work

The material in this chapter describes the work performed in the lab and field to detect black ice formation in NGOGFC pavements. The preliminary lab work began just before the project started in August 2004, and the installation of field devices was undertaken prior to the winter of 2004–2005. The following sections describe the equipment, methodology, and results of the first round of winter testing at three locations in North Texas.

4.1 Instrumentation

The objective of this phase of the research was to develop a methodology for studying in-situ formation of black ice in permeable pavements. With only a 2-year project duration, just two winter seasons were available for field study during icy conditions. Accordingly, a plan was put together rapidly, and existing sensors that had been used successfully in other TxDOT studies were quickly adapted and tested for use in pavement sections. The two sensors chosen for the field work were the Thermochron and Hygrochron i-Buttons (Fig 4.1), manufactured by Dallas Semiconductor, a subsidiary of Maxim Corporation. The Thermochrons measure and log temperature; the Hygrochrons measure and log relative humidity.

Figure 4.1 Dallas Semiconductor Thermochron i-Button

The Thermochron i-Button is a self-contained, dime-sized computer and temperature sensor that is capable of logging 2,048 (8,192 with the expanded model) temperature readings and storing them for a duration of up to 10 years. The devices can be programmed to begin logging at a preset date and to stop at a specified second date. Because of these features, and because they require no external device to capture the data, they are ideal for installing in pavements at any depth and recovering the data at a later date.

These devices have been used with great success and reliability in concrete pavements under TxDOT studies 0-1700, 5-1700-1, and 5-1700-3 (25). In those studies, they were installed before paving and used to log the relatively high temperatures found in curing concrete during summer conditions, requiring an insulating coating to function in the highly alkaline and galvanic environment of fresh concrete.

A concurrent study, Project 0-1778 (26), was conducted in North Texas to measure winter temperatures at several depths in existing concrete pavement. In this case, the devices were retrofitted into the pavements by drilling and sealing with quick set epoxy. The purpose of this experiment was to determine the minimum internal temperatures of the concrete during the winter season. However, the data from the 3 years of field study also indicated that ice on the pavements could easily be detected (Fig 4.2).

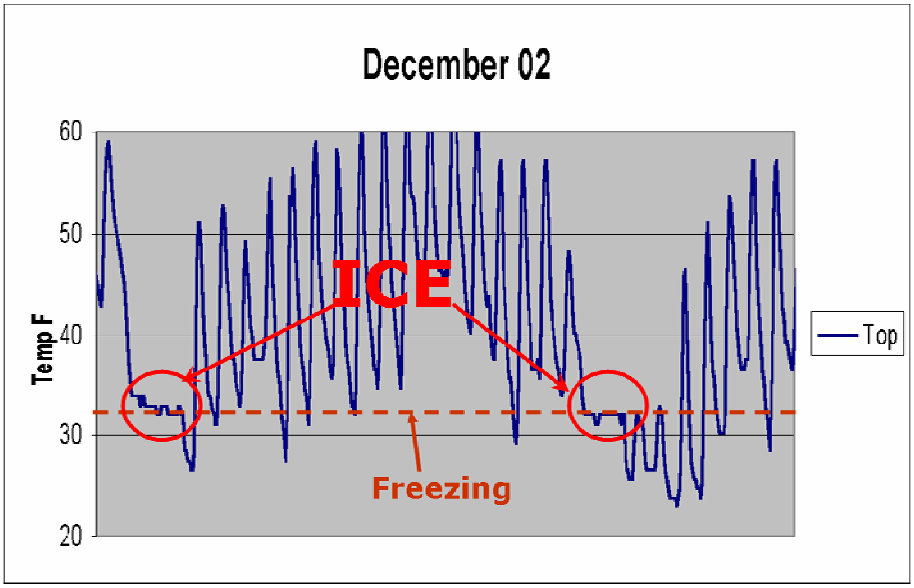

Figure 4.2 Ice on CRCP pavement, Amarillo TX

Since the instrumentation had not been installed in flexible pavements before, and specifically not in PFCs, a preliminary laboratory test was conducted to determine the best installation and sealing procedure. Results from the Thermochrons were also compared directly to a conventional instrument, a calibrated thermocouple connected to a Fluke meter. A conventional dense-graded asphalt beam was prepared, drilled out to accommodate the devices, soaked in a water bath, iced down for an hour, then flash-frozen below 32° F using Freon (Fig 4.3).

Fig 4.3a shows the 0.75-in. by 0.5-in. drilled hole needed to insert the Thermochron, while Fig 4.3b shows the Thermochron after being sealed into the beam with epoxy. Fig 4.3c shows the method of soaking and freezing the asphalt beam to simulate field conditions, and Fig 4.3d shows the installation after the area temperature has been lowered below 32°F using liquid Freon to flash-freeze it.

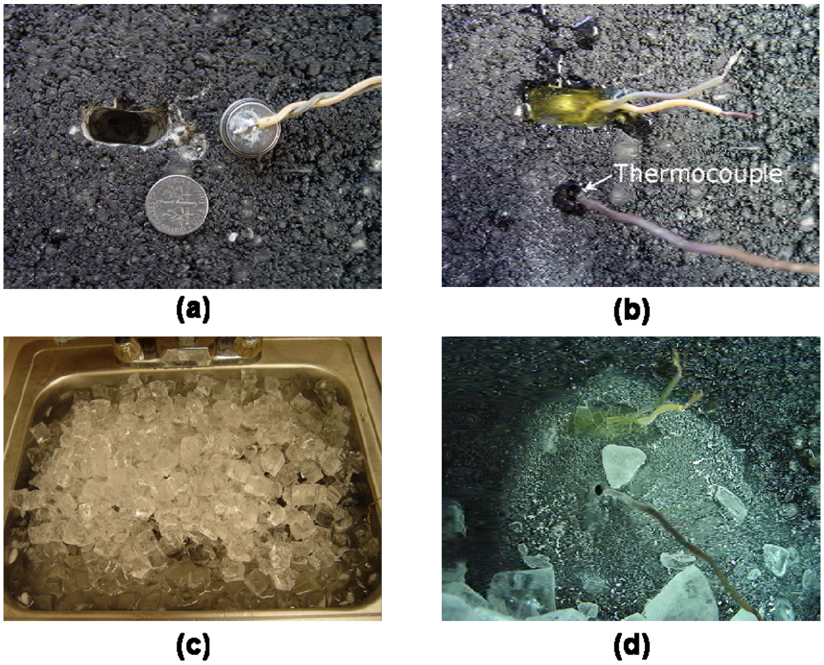

Figure 4.3 Instrumentation and test of Thermochrons in an asphalt specimen

Fig 4.4 shows the results of the test, which was performed over a period of 2 hours as indicated by the time scale (in minutes) at the bottom of the figure. The beam was first soaked in a room temperature water bath; ice was added, and the specimen was allowed to soak and chill for approximately 1 ½ hours until 32^{o}F was reached. Finally, the Freon was used to lower the surface temperature below freezing.

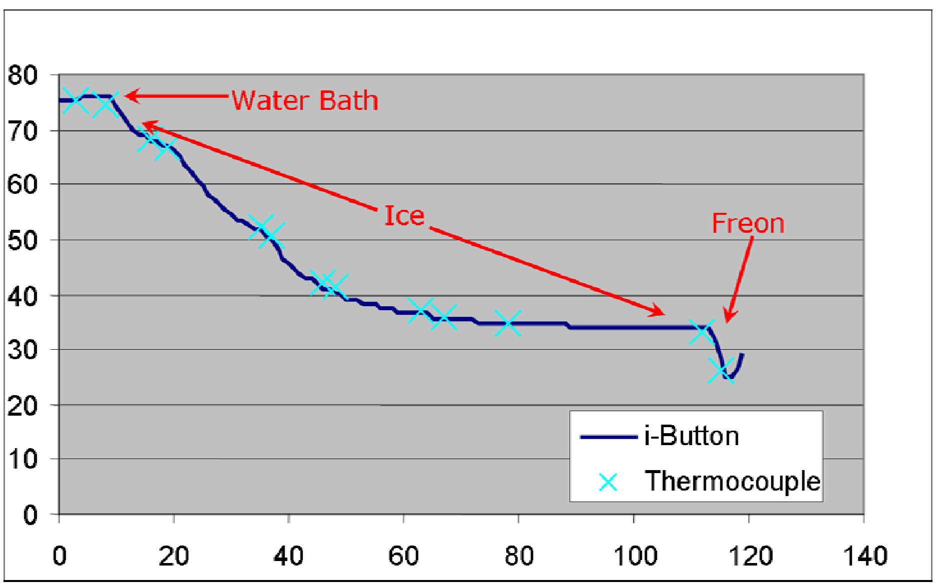

Figure 4.4 Results of preliminary lab test using instrumented beam

As can be seen from the figure, the temperature data from the Thermochron and conventional thermocouple are in close agreement throughout the entire temperature range, as would be expected since they were both calibrated to the same reference, and the Thermochron has a certified accuracy of +/- 1ºC. It is interesting to note that there was no temperature plateau effect detected from freezing water, as the specimen was flash-frozen with Freon; most likely this was due to the use of a conventional (non-porous) surface for the test, a one-minute sampling interval set on the Thermochrons, and copious amounts of Freon quickly applied. As will be seen, the field sections behaved differently.

4.2 Concept of Latent Heat of Fusion

The specific latent heat of fusion of a substance is the amount of heat required to convert a unit mass of the solid into the liquid (or vice versa) without a change in temperature. The specific latent heat of fusion of ice at 0ºC is $\frac{335kJ}{kg}$. This means that to convert 1 kg of ice at 0ºC to 1 kg of water at 0ºC, 334 kJ of heat must be absorbed by the ice. Conversely, when 1 kg of water at 0ºC freezes to give 1 kg of ice at 0ºC, 334 kJ of heat will be released to the surrounding area. During melting or thawing, this has the net result of keeping the measured temperature of a porous pavement constant at 0ºC until all the water has changed phase from liquid to solid or vice versa. It creates a characteristic temperature plateau that can be readily detected by the embedded sensors and is positive proof that ice is present, especially when used in conjunction with devices monitoring the ambient temperature and humidity conditions, and as verified by temperature and precipitation data recorded by the National Climatic Data Center (Fig 4.5).

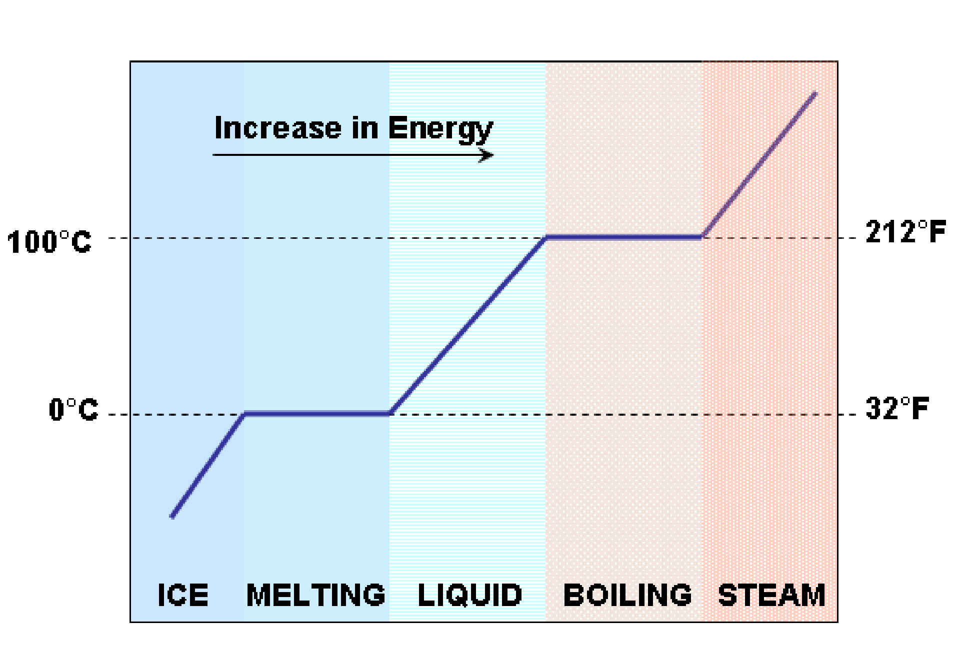

Figure 4.5 Phase change temperature plateaus illustrating latent heat of fusion

4.3 Selection of Field Test Sections

After selection and validation of the instrumentation, the next step taken was to choose field test sections. There were only two criteria for section selection, the first being high probability of freezing weather and precipitation, and the second requiring the existence of porous friction course sections. It was also highly desirable to have conventional, non-porous surface sections nearby for use as control sections to help distinguish between frozen precipitation falling on the section versus freezing of water within the pavement. As loose as these criteria might seem, only the portion of Texas north of Dallas–Ft. Worth routinely experiences freezing precipitation, and the only existing NGOGFC pavements in this climate area are located in the Amarillo, Wichita Falls, and Fort Worth Districts. Lubbock District had some PFC sections in the planning stage, but none built prior to winter 2004.

Accordingly, three test locations were selected for the experiment in the three TxDOT districts listed above. Two of the three locations chosen (Amarillo and Wichita Falls) were near the pre-existing instrumented CRCP sections that had been studied under Project 0-1778. The installed pavement and ambient devices for these older test sections would be useful as an independent check against the data recorded on the new test sections.

4.3.1 Amarillo Location

The Amarillo District sections are located on SH 136, about 5 miles northeast of Amarillo (Fig 4.6). These sections provide a unique opportunity for study as they include short sections of conventional asphaltic pavements in line with a test PFC section (Fig 4.7). Thus, the traffic, environmental conditions, and cold weather maintenance activities can be assumed to be identical for the control section and the NGOGFC test section. The Amarillo NGOGFC section is a 1.25-in. thick PFC constructed in 2001, with PG 76-28 asphalt and Class B aggregate and a minimum of 18% of air voids. It is a 1100-ft long experimental section, constructed following TxDOT Special Specification 3231.

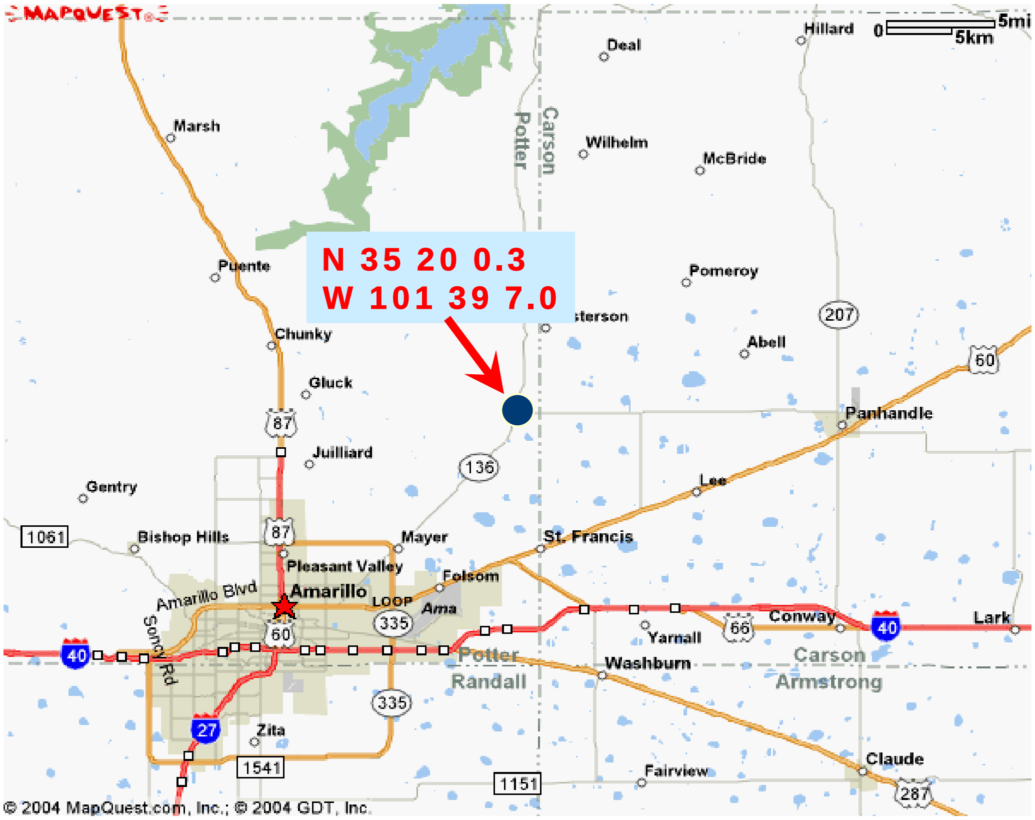

Figure 4.6 Location of Amarillo test sections

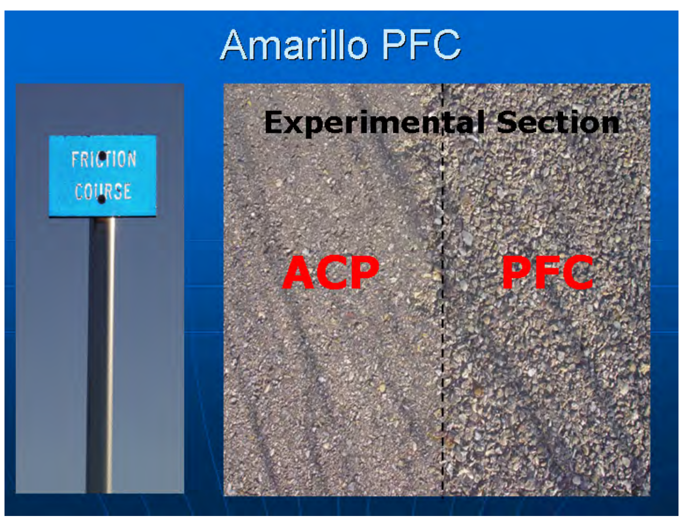

Figure 4.7 Experimental asphalt sections on SH 136, Amarillo TX

For the Amarillo test sections, three Thermochrons were placed in the PFC pavement and two in the conventional asphalt control section (Fig 4.8). The multiple devices were intended to give some measure of variability but primarily to insure that at least one device survived the winter intact. Because the devices were embedded just below the surface of the pavement, it was possible that traffic might dislodge and destroy them. While the crew was in the area, ambient temperature, and humidity sensors were added, and additional full depth sensors were installed in the nearby CRCP test section.

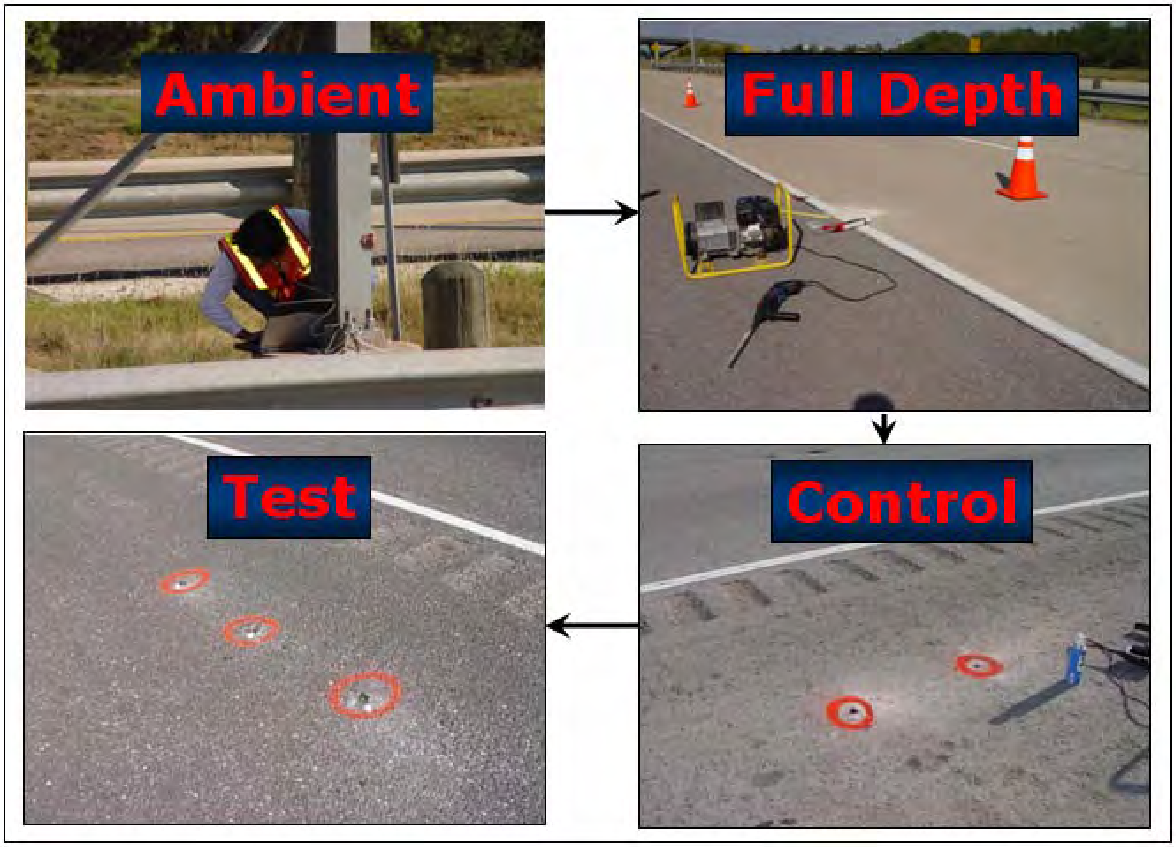

Figure 4.8 Installation of ambient and pavement sensors

For the Amarillo test sections as well as the other test sections in Wichita Falls and Decatur, the ambient sensors were placed in shaded but open areas using epoxy adhesive to prevent loss or vandalism (Fig 4.9). A small right-angled wand is used to easily program them and download data. Photographs and GPS coordinates were recorded to facilitate easy relocation of all the devices.

Figure 4.9 Amarillo ambient sensor hidden under base of sign (inset is close-up of circled area)

4.3.2 Wichita Falls Location

The Wichita Falls District has several ideal NGOGFC sections available for testing. A section of NGOGFC near a conventional asphalt was selected on US 287 near Henrietta (Fig 4.10), and sets of Thermochrons were installed in the same manner as the Amarillo devices, i.e., three buttons in the shoulder of the NGOGFC test section, and two in the shoulder of the control section, plus devices to record ambient temperature and humidity. The precise locations of the devices were logged using GPS, and the pavement sections and sensor locations were clearly marked with orange paint. The control section is a 2-in thick Type C hotmix, constructed in 1999 following Special Specification 3022, with PG 70-22-S asphalt. The NGOGFC is a 1 ½ -in. thick PFC, placed in 2002 following Special Specification 3229, with PG 76-22-TR asphalt. Like the Amarillo buttons, the Wichita Falls buttons were programmed for the maximum available delay before the onset of data collection, which was the second week of November.

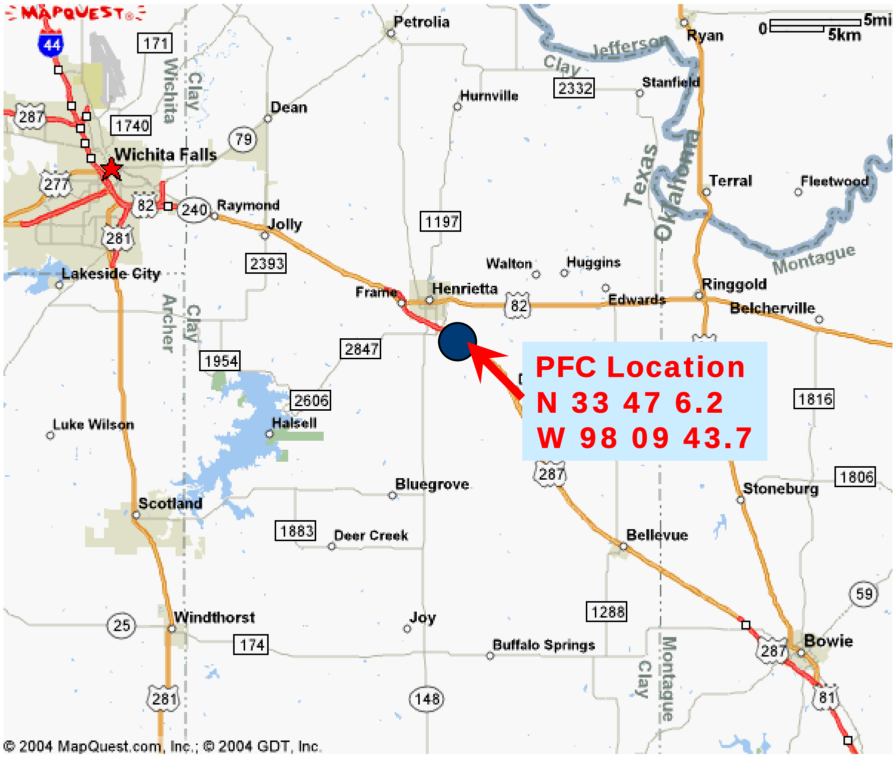

Figure 4.10 Location and GPS coordinates of Wichita Falls District test sections

4.3.3 Fort Worth District Location

In midwinter, additional test sections were added in the Fort Worth District. The 2 sections, one a conventional asphalt and the other a NGOGFC, are located in Decatur, north of Fort Worth, in Wise County, on the US 287 southbound exit ramp to FM 730. The NGOGFC was constructed in 1993. It is a 1-in. thick asphalt similar to a PFC, with a 20% estimated void content. The section is 0.2-mi long. The same procedure that was used for the sensor installation in the other two locations described before was followed in the Decatur sections, except that in this case, some devices were also installed in the travel lane wheel path, in addition to those placed in the shoulder. This addition was made to verify whether the sensors could work properly while withstanding traffic loads. From experience in the first few months of winter, it was thought that the i-Button installations would withstand direct vehicular traffic sufficiently, and later inspection of the devices proved that to be the case.

Use of latex "Tool Dip" coating was also discontinued at this time, based on successful results from the uncoated i-Buttons in the other two districts. As of the last field crew visit to the Decatur section in April of 2005, all devices were still intact and functioning, and no wear or damage was noted for the devices in the right wheel path.

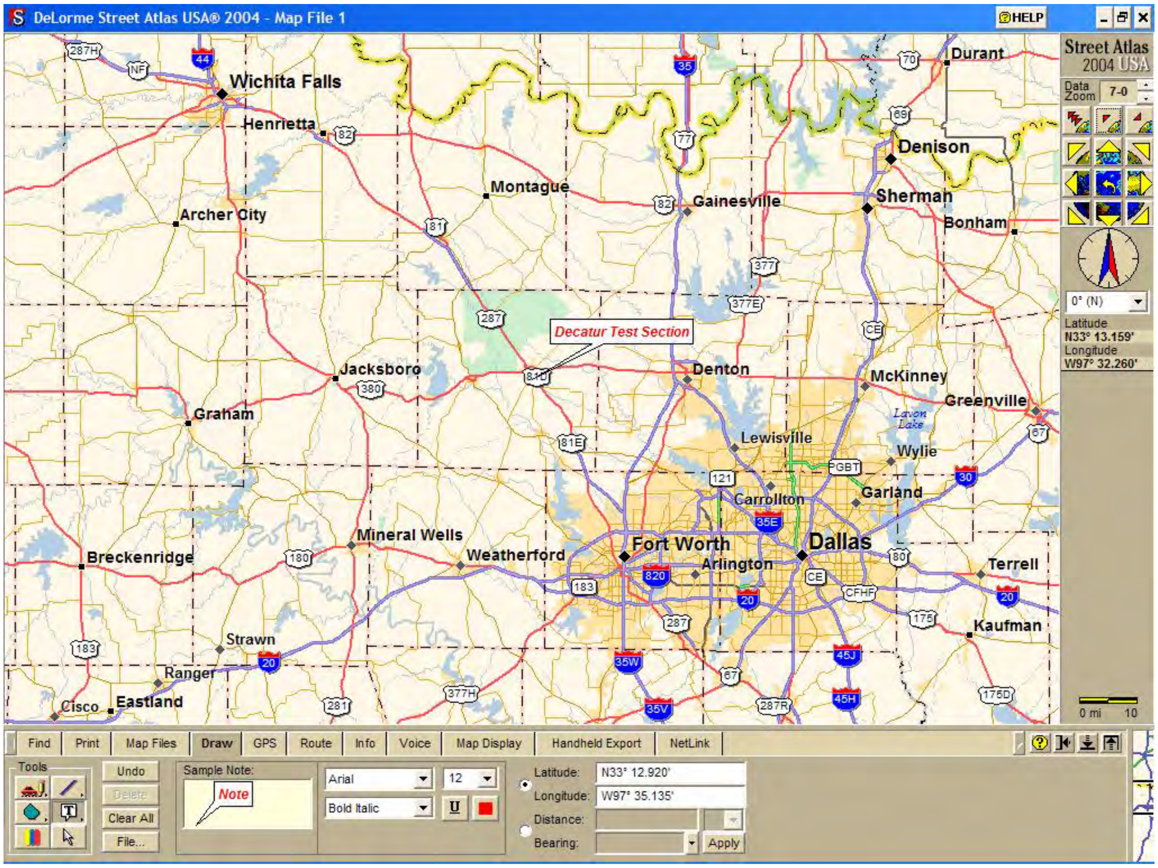

Figure 4.11 Location and GPS coordinates for Ft. Worth District test section

4.4 Experimental Results

As noted, the devices and installation procedure were an unqualified success. As of March 2005 when the final winter field data was collected, not a single device had failed or been dislodged from the pavement. All winter data was downloaded successfully, though the test section in Amarillo experienced one more cold front and associated icy conditions after data collection had been discontinued.

In order to test the concept of ice detection by observing the latent heat of fusion for water, it was necessary to have both freezing temperatures and the presence of water from rain or melted ice and snow. Fortunately for the driving public, but unfortunately for the experiment, North Texas had a fairly dry winter in 2004–2005. The National Climatic Data Center (NDC) (http://www.noaa.gov/climate.html) records revealed not one day in the Wichita Falls and Fort Worth District sections in which both freezing temperatures and precipitation were recorded. This observation coincides with the data from the field and the recollection of District maintenance personnel who were contacted shortly after the data was analyzed. Fig 4.12 (Wichita Falls) and Fig 4.13 (Ft. Worth) show the ambient temperatures recorded starting November 26, 2004 and January 21, 2005, respectively.

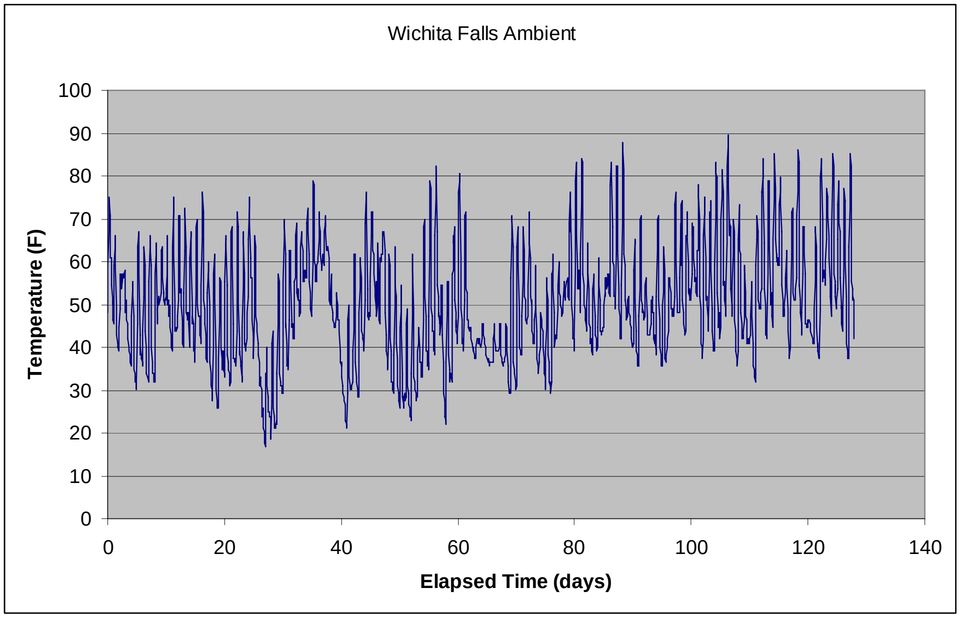

Figure 4.12 Thermochron ambient temperatures for Wichita Falls test section

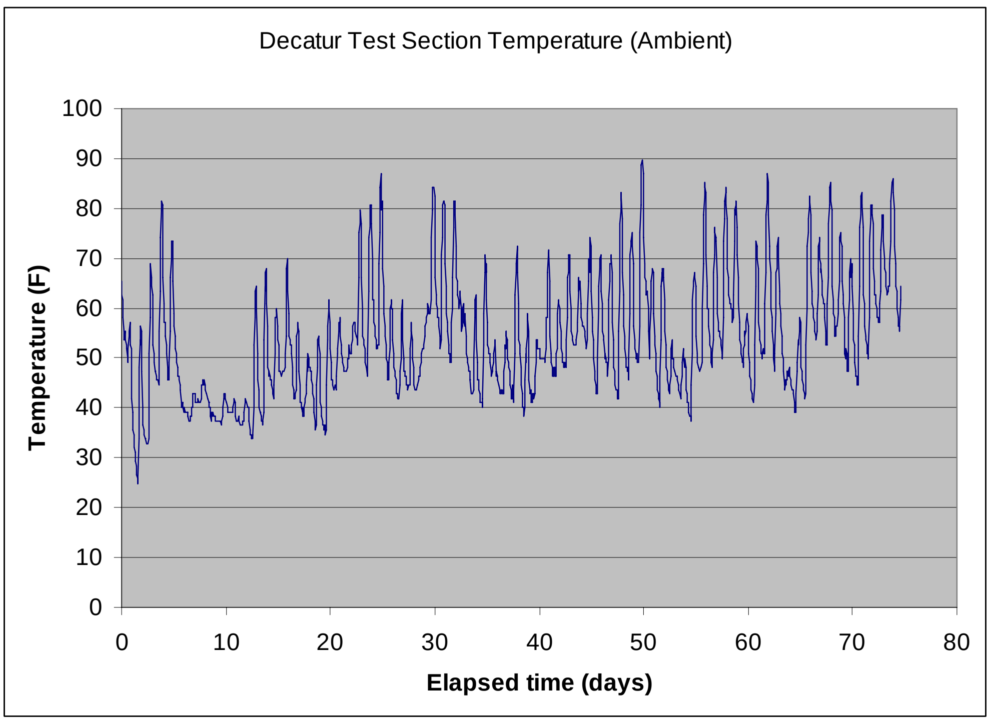

Figure 4.13 Thermochron ambient temperatures for Decatur (Ft. Worth Dist.)

As can be seen from the figures, the Wichita Falls test section experienced freezing temperatures on more than half a dozen occasions, but a check of the NCDC database indicates that no precipitation occurred during any of those time periods. The Decatur test section, which was instrumented later in the season, experienced only one freeze cycle shortly after the instruments were installed, which occurred during a dry period.

The Amarillo section, by contrast, experienced more than fifteen freeze events during the monitoring period of November 25, 2004 through March 4, 2005 (the data was downloaded in April after the devices had finished their data collection cycles). The NCDC database indicates that five of these freeze events were accompanied by some form of precipitation. Fig 4.14 shows the overall temperature data for the Amarillo sections, including ambient temperature plus the three test and two control Thermochrons imbedded in the pavement.

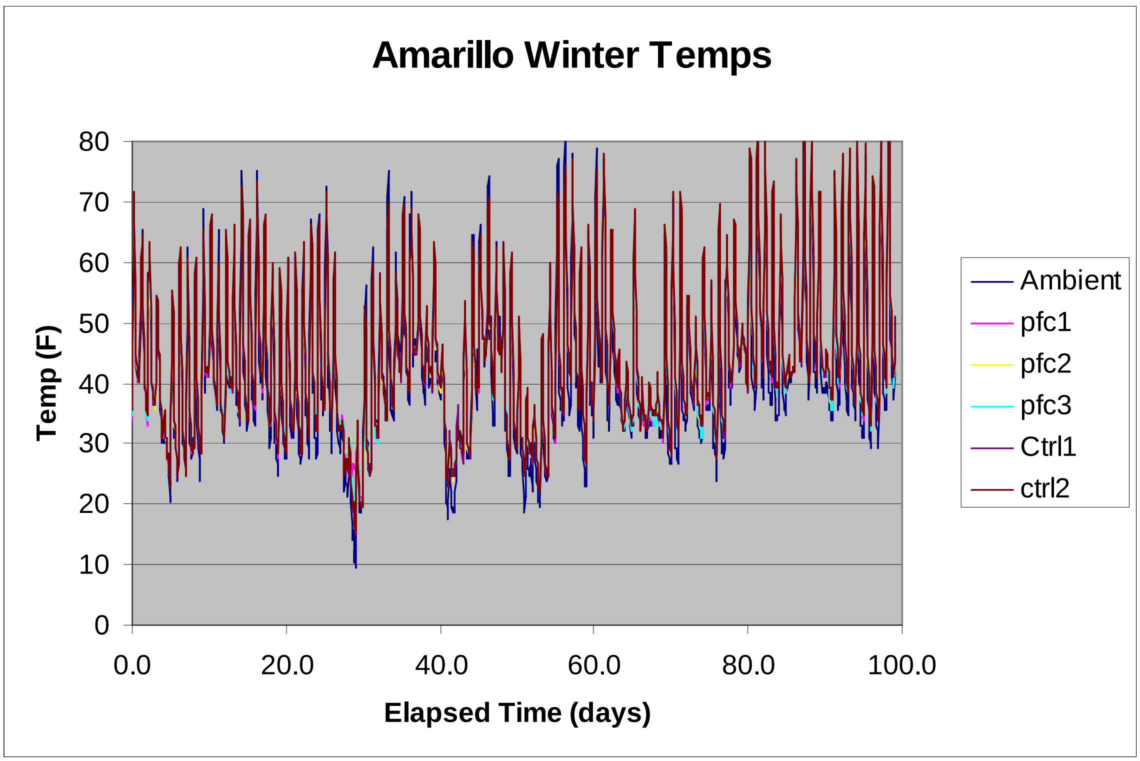

Figure 4.14 Thermochron data from Amarillo, winter 2004 – 2005

Fig 4.15 shows an expanded view of the first freezing event in Amarillo, which took place just 4 days into the data collection cycle, on November 29. The onset and duration of the snowfall event superimposed on the chart was obtained from NCDC precipitation records.

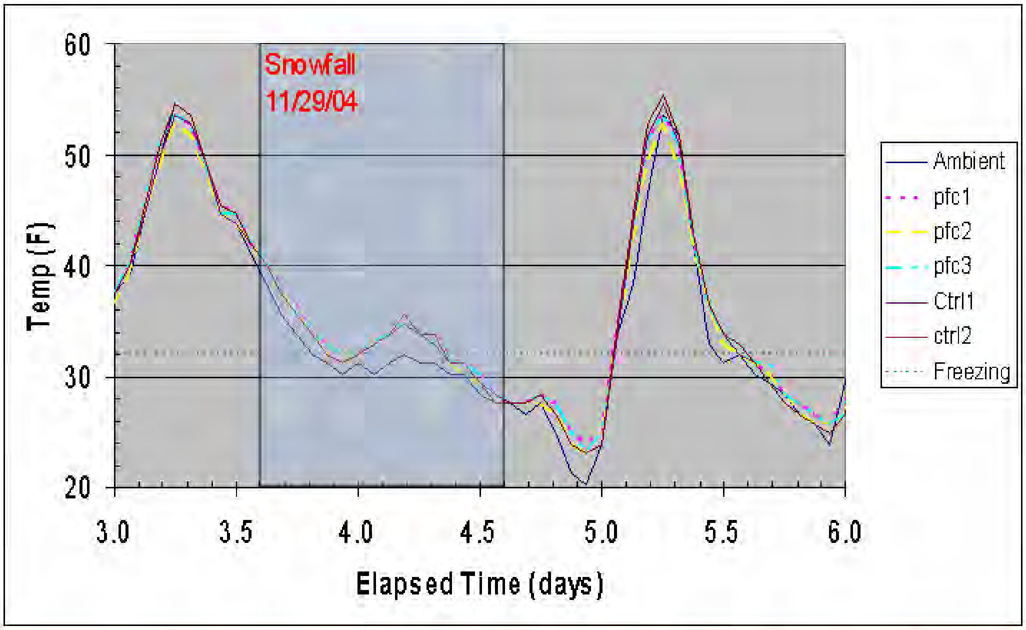

Figure 4.15 Snowfall event at Amarillo test section, November 29, 2004.

Narrowing the focus of the chart even further, Fig 4.16 shows the individual data points from all the sensors during this first freeze event. As had been expected, the three PFC sections show a brief temperature plateau at exactly 32ºF (latent heat being released as the water freezes), whereas the two control sections do not.

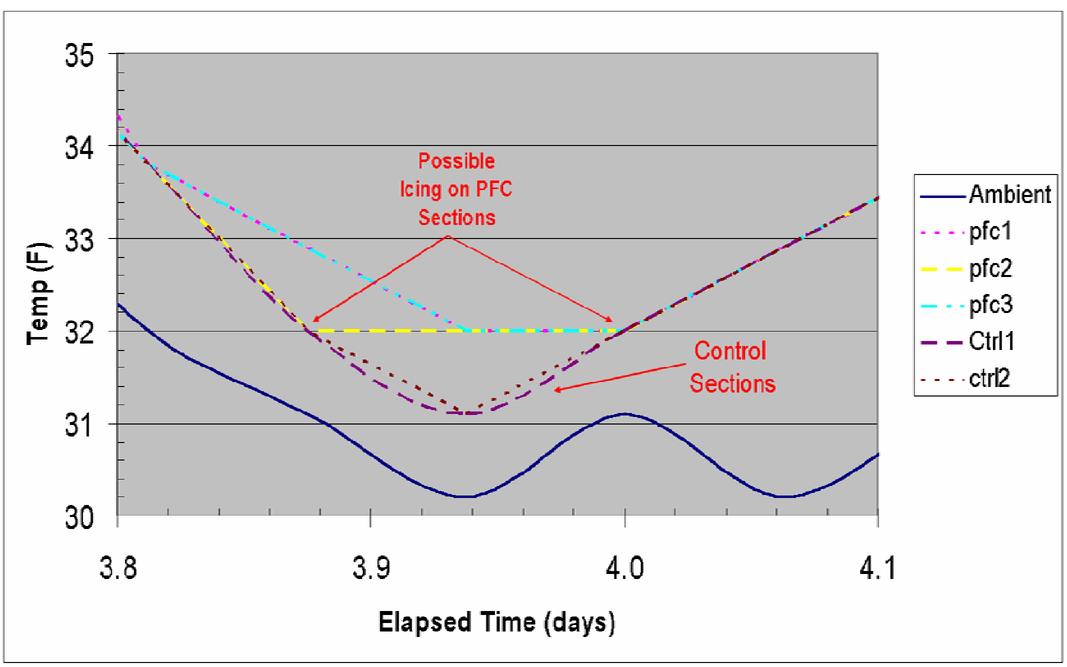

Figure 4.16 Possible evidence of freezing in Amarillo PFC sections, November 29, 2004

The remaining four freeze events with precipitation present were examined for similar evidence of freezing. Two appear similar to Fig 4.16 above; two do not. The reason for this discrepancy is not known, except to speculate that snow or sleet falling on already frozen pavement or dry pavement would not be expected to show latent heat of fusion effects since there is no freezing or thawing taking place during the precipitation event. At the time of this writing, the NCDC records for the latter events in Amarillo are not complete and available to the public, which makes further analysis problematic for the present.

4.5 Icing Probability Analysis

Independently from the field work described in this chapter, an analysis was conducted of the probability of icing occurrences in Texas. The probability of icing, obtained from the product of the probability of freezing temperatures and the probability of precipitation, was investigated using historical records kept by the National Oceanic and Atmospheric Administration (NOAA).

Information from 1971 through 2000 was retrieved from those records for five north Texas cities: Amarillo, Dallas, Wichita Falls, Texarkana, and Lubbock. The files analyzed include data for the months of October through May, when it is more likely that the conditions of interest can occur. The NOAA data for this analysis is comprised of the following:

1. The average number of days in which the minimum temperature was below 32º F for each city in each month. This average is divided by the total number of days in the month to obtain the probability that freezing temperatures existed.

2. The average numbers of days (over the same historical period) when even a small amount of precipitation was present for each city in each month. This average is divided by the total number of days in the month to obtain the probability that on a given day there was water to freeze if temperatures permit.

For example, for the period of 1971-2000, Amarillo experienced an average of 27.5 days in January in which temperatures dropped below freezing. This means there is a probability of 0.89 for freezing each day in January (27.5/31). Similarly, Amarillo experienced at least a trace of precipitation (enough to form black ice) 4.4 days on average in January, for a probability of 0.14 (4.4/31). The probability of icing resulting from the product of both probabilities, is therefore roughly 13 percent (0.89*0.14) on any given day in January, assuming that those two variables are independent.

Table 4.1 presents these two sets of averages for each city and for each month, along with the combined probability that both will be present. These probability figures do not represent the exact probability, because the two variables of precipitation are slightly correlated, both being related somewhat to the passage of fronts. However, NOAA does not specifically record icy road conditions; therefore, the use of the combined probabilities was deemed a good approximation.

Table 4.1 Icing Probabilities in Five Texas Cities (data from 1971-2000)

City	October			November			December			January			February			March			April			May		
	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)	P(rain)	P(freeze)	P(rain and freeze)
Amarillo	0.16	0.07	0.01	0.14	0.53	0.07	0.14	0.87	0.12	0.14	0.89	0.13	0.16	0.76	0.12	0.17	0.46	0.08	0.18	0.14	0.03	0.27	0.00	0.00
Dallas	0.23	0.00	0.00	0.22	0.07	0.02	0.21	0.26	0.05	0.23	0.37	0.09	0.22	0.23	0.05	0.24	0.06	0.01	0.24	0.00	0.00	0.30	0.00	0.00
Wichita Falls	0.23	0.01	0.00	0.18	0.22	0.04	0.16	0.55	0.09	0.16	0.66	0.10	0.18	0.46	0.08	0.21	0.18	0.04	0.22	0.02	0.01	0.28	0.00	0.00
Texarkana	0.25	0.01	0.00	0.33	0.17	0.06	0.33	0.44	0.14	0.33	0.57	0.19	0.31	0.39	0.12	0.31	0.12	0.04	0.29	0.02	0.00	0.33	0.00	0.00
Lubbock	0.16	0.03	0.01	0.12	0.34	0.04	0.14	0.73	0.10	0.14	0.80	0.11	0.16	0.61	0.10	0.13	0.28	0.04	0.17	0.05	0.01	0.23	0.00	0.00

Appendix B presents six tables obtained from NOAA. The first five include the data utilized to perform this analysis, with each one of those tables corresponding to each of the five cities analyzed. The last table (Freeze/Frost Occurrence Data), presents three temperature thresholds (36, 32 and 28º F) and three probability levels for the late occurrence of such temperatures in the spring, and the early occurrence of such temperatures in the fall, given by date for a large number of stations in Texas. It also gives the number of days of freeze-free periods that can occur for those thee probability levels. Finally, the probability of freeze/frost in the yearly period is given in the last column (the percent of days with temperatures at or below the threshold temperature).

4.6 Conclusions and Recommendations

The field experiment documented in this chapter was hastily planned and quickly executed, due to a very short time frame between the project start date and the onset of winter in North Texas. However, a great deal was learned both about the problem under study and the equipment and techniques employed to perform the study. The i-Buttons proved reliable under field conditions and traffic exposure and yielded information that has never been recorded in such detail before.

The methodology of detecting ice formation in porous pavements appears to be sound or at least promising, and the preliminary findings tend to agree with the opinions of TxDOT maintenance personnel revealed in the District survey results reported in Chapter 3, i.e., that PFC is the first to freeze and the last to thaw.

The following additional work is recommended for the upcoming stages of the project:

A controlled study in the laboratory should be conducted to verify the heat of fusion temperature plateau effect postulated and observed in some of the Amarillo field data. This could take the form of a simple experiment wherein a NGOGFC mold or core is instrumented with i-Buttons, insulated on all sides except the top to simulate field pavement, and then frozen and thawed repeatedly (Fig 4.17). Anti-icing or de-icing compounds could also be tested using this instrumented sample.

The i-Buttons in the field, particularly those in the Amarillo District, should be reprogrammed as soon as possible and replaced, if needed, to insure that pavement temperature data continues to be collected during freezing and thawing conditions. Hygrobuttons should be added to the older test sections to collect humidity data as well. Additional NGOGFC sections in Lubbock or elsewhere in the Panhandle should be immediately identified and buttons installed prior to the coldest months, i.e., December and January.

The 1-wire network wireless devices available from vendors such as PointSix (www.pointsix.com) and Embedded Data Systems (www.embeddeddatasystems.com) should be installed, if possible, at one or two of the test sites to test feasibility of real time pavement temperature monitoring and ice detection (Fig 4.18). It is recommended that these units be installed at the Amarillo site (which has the most freeze events) and at the Decatur site (which is most readily monitored during icing conditions).

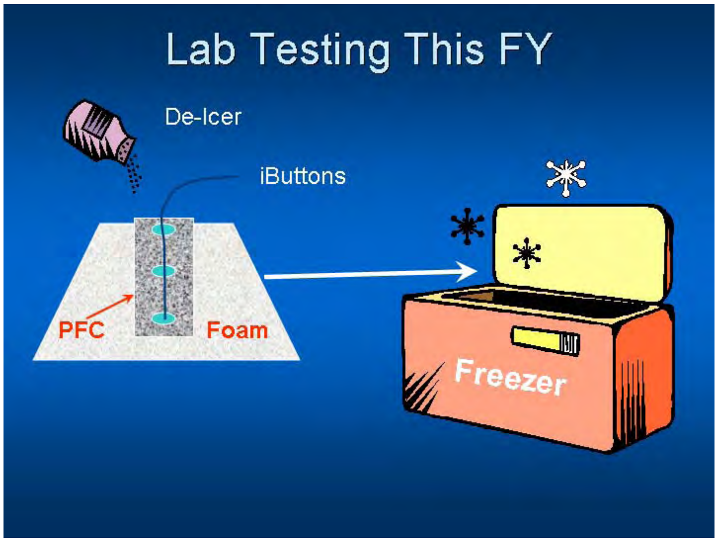

Figure 4.17 Laboratory test setup for investigation of PFC field conditions

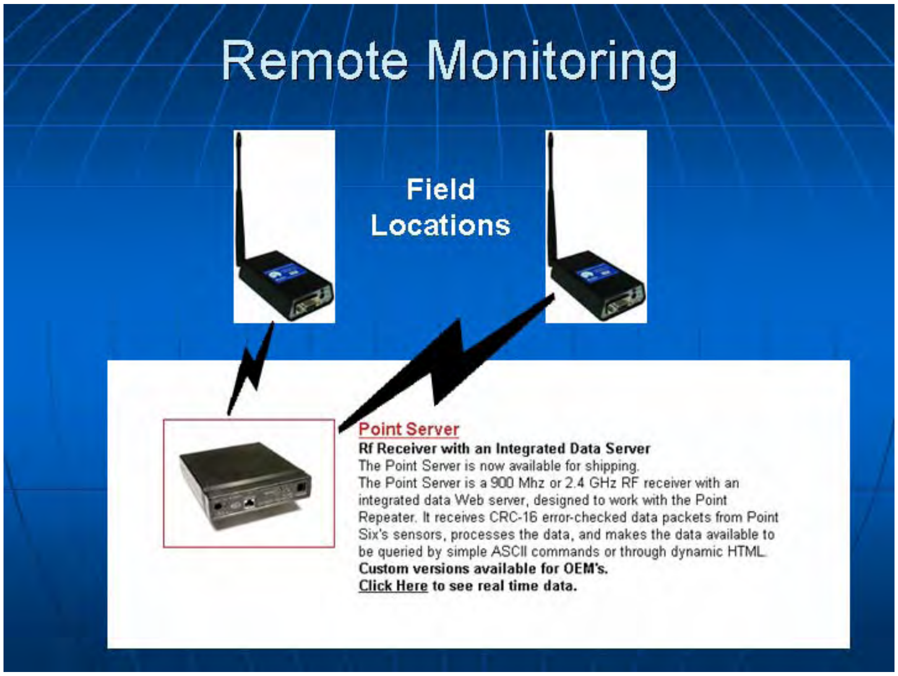

Figure 4.18 Conceptual setup for real time monitoring of embedded Thermochrons

5. Recommendations for Winter Maintenance of New Generation Open-Graded Friction Courses

5.1 Introduction

In recent research in both Europe and the U.S. it has been documented that the accumulation of snow, formation of ice, and use of salt and de-icing chemicals are different on pavements with New Generation Open-Graded Friction Course (NGOGFC) mixes than on dense-graded ones. As a result of its open-graded characteristics, the surface temperature of NGOGFCs tends naturally to be several degrees lower than dense-graded pavements because the high air void range makes the pavement less heat conductive, at about 40 to 70 percent that of a dense-graded mixture. Ice and snow may accumulate faster on NGOGFC pavements, thaw more slowly, and refreeze more quickly. Black ice in particular has been reported to be a serious problem when water is allowed to accumulate on curves in the road and in rapid freeze-thaw cycles (2). Recommendations for winter maintenance of NGOGFCs present in the literature include investigations of new materials and technology, special procedures, and design suggestions.

5.2 Materials

In terms of materials, sand is the most commonly used and is moderately effective, but its small particles get into the pavement's pores easily and cause clogging. Although sand is one of the most commonly used materials and provides good friction, the elimination of sand from maintenance procedures would help keep NGOGFCs from clogging. In addition, sand is not as effective in melting ice or preventing refreezing. As an alternative to sand for friction, other materials such as Lightweight Grade 5 Manufactured Rock or Limestone Grade 5 can be used because the material in these aggregates is large enough not to become lodged in the pores and prevent the mix from draining.

The use of dry solid chemicals can be effective only when there is sufficient moisture or accumulation on the pavement to prevent loss of material off a dry pavement and to trigger the solution of the salt. A maintenance team must be ready to apply the chemical soon after sufficient precipitation has fallen, but before snow or ice bonds to the pavement. After snow or ice bonds to the surface, more material will be necessary for de-icing procedures.

Liquid chemicals are useful in their ability to be placed uniformly over the pavement at relatively fast spreading speeds and onto dry pavement as a prestorm treatment. Liquid chemicals include calcium magnesium acetate (CMA), calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), and potassium acetate (KAc). Non-salt chemicals may also reduce the corrosion experienced from salt.

However, because of NGOGFCs' efficient draining properties, salt and liquid de-icing and anti-icing agents may drain away more quickly, and therefore, may have to be applied more frequently, leading to higher costs and environmental concerns (5). For instance, in Italy, there is a 50 percent increase in the use of salt on NGOGFC pavements (21). However, a recent survey of TxDOT districts suggests that the same amount of chemicals can be used on NGOGFC pavements as on more dense-graded pavements. Larger salt grains may minimize the draining away of the material.

Liquid chemicals can be used to prevent the formation of frost or black ice. However, the chemical should be applied before the expected time of ice formation so that the water component of the chemical will evaporate or be removed by traffic action. Traffic condition is a dominant factor only between 28°F and 35°F.

Prewetted salt may stick better to the pavement surface, preventing draining and lowering the amount of material needed. There are also chemical agents that are more viscous and can be retained on the surface for a longer period of time (29, 22).

Table 5.1 shows a summary of possible materials used for treatment for various winter conditions, including the advantages and disadvantages of each material.

Table 5.1 Summary of the Winter Pavement Treatment Materials

Treatment Materials	Treatment Advantages	Treatment Disadvantages
Sand	Inexpensive Provides Quick Friction	Clogging
Salt	Inexpensive Melts Ice	Drains away (need to use more) Corrosion
Dry Chemicals	Effective	Non-uniform application Need moisture to activate and stop loss of material
Liquid Chemicals	Uniform application	May drain away (need to use more); Not recommended for freezing rain or sleet storm
Prewetted salts	Better adhesion to road surface More even distribution of material	Not often used Need more material

5.3 Procedures

In terms of procedures, NGOGFCs need to have their own winter maintenance regimen, but research suggests that with accurate planning, problems in winter conditions can be combated. Maintenance personnel must be provided with the correct information on the different behavior of NGOGFCs at temperatures near or below freezing (20). Then procedures before and after winter storms must be established, such as the timing of the application of chemicals to the pavement before precipitation falls to help prevent the formation of ice, including giving special and frequent training to personnel. Table 5.2 shows a summary of possible treatments for various winter conditions, including the advantages and disadvantages of each treatment.

NGOGFCs, unfortunately, are more susceptible to gouging by snowplows with less resistance to snowplow blades. Rutting caused by studded tires was cited as the most serious maintenance problem for NGOGFCs in Oregon in 2001. In Oregon, maintenance managers have attempted to use run shoes on plows and have reduced plow speeds to combat the problem of gouging (20). In general, the damage caused by studded tires and snowplows is so extensive that in regions where snowplow use is widespread, the use of NGOGFCs is not recommended (2).

However, in areas with NGOGFCs, drivers of snowplows should be properly trained in how to plow these types of pavements.

Anti-icing is a useful and effective proactive technique that is currently not as widespread as other techniques. In a recent survey of TxDOT districts, anti-icing was indicated as the most effective, if not the most common, winter maintenance technique (24). Anti-icing procedures can provide safe road conditions during a storm due to the prevention of ice and snow formation on the road. However, successful and efficient anti-icing procedures require precise timing of operations in order to be consistent with the objective of preventing the formation or development of bonded snow and ice. This procedure requires a systematic approach where there is more judgment in making decisions, available information sources are utilized methodically, and operations are anticipatory and prompt (27).

De-icing procedures are reactionary in breaking the bond of snow and ice that are already on the pavement surface; such procedures are not considered as effective as anti-icing procedures (24). De-icing operations are commonly initiated only after 1 in. or more of snow has accumulated and bonded to the road. De-icing is not as useful as anti-icing in maintaining the safest road conditions during a winter storm. Moreover, more de-icing materials may be needed to melt snow and ice than is required for anti-icing procedures.

Liquid chemicals are more useful as anti-icing agents than de-icing agents. Liquid chemicals must be put down before snow has accumulated because snow keeps the chemical from reaching the pavement and may dilute the chemical. For optimal efficiency, liquid chemicals should be used at temperatures above 23^{o}F. However, liquids can be used at pavement temperatures lower than recommended by increasing the application rate over the levels recommended. The cost effectiveness of using higher liquid chemical application rates at lower pavement temperatures needs to be evaluated on a case-by-case basis (27).

For both anti-icing and de-icing procedures, new ways of spreading salt solutions can reduce the chance of the material being washed away. For instance, salting may only be useful when applied on dry surfaces before precipitation occurs and when temperatures are lower than 14ºF; therefore, preventative salting at the right time is important (2). In addition, in the event of prolonged snowing, salt can be supplemented with a calcium chloride solution to remove thick ice and snow pack from the spaces in the surface. A combination of magnesium and calcium can also be used as a de-icing agent.

The use of prewetted salts and chemicals may be effective as an anti-icing treatment. These salts may spread more uniformly, adhere better to the road surface, and work faster and longer. In addition, prewetted salts may be spread more quickly and may make the road surface dry more quickly. As with any anti-icing technique, the use of prewetted salts must be timed correctly to be effective. In a survey of TxDOT districts, no district used prewetted salts in their maintenance regime (24).

New technologies and advancements may improve anti-icing and de-icing procedures. A new technology that is being investigated is the use of electrostatic charge as a way to bond de-icing agents to the surface. However, this technology is still experimental (20).

Table 5.2 Summary of Winter Pavement Treatment Procedures

Treatment Procedure	Treatment Advantages	Treatment Disadvantages
Anti-icing	Proactive Prevents ice & snow formation Maintains safe road conditions	Requires precise timing
Using Prewetted Salts & Chemicals	Improve Effectiveness Spread more uniformly Better adhesion to road surface Faster & longer-lasting effect Increased spreading speed Road surface may dry more quickly	Requires precise timing
De-icing	Useful in removing snow & ice already bonded to the surface	Reactive Cannot maintain the safest road conditions Uses more material than anti-icing
Snowplows and tire studs	Useful in northern climates with heavy snow and severe winter conditions	Gouging and Scarring of pavement
New Technologies: Electrostatic charge technology	Bonds de-icing agents to the surface	Experimental

Ultimately, any winter maintenance plan should use a combination of anti-icing and de-icing procedures as necessary. A combination of dry salt, wet salt, wet salt enhanced with calcium, and a straight calcium chloride solution can be used, depending on pavement conditions (ice versus snow), anti-icing or de-icing practices, and wet surface versus dry surface conditions. The use of various methods should include preventative salting or use of de-icing or anti-icing chemicals, increasing the frequency of de-icers, mixing abrasives with chemicals, or a combination of these practices (19). For instance, Table 5.3 shows a plan for anti-icing and de-icing operations suggested by the FHWA in a black ice event (27).

Table 5.3 Weather Event: Frost or Black Ice (27)

PAVEMENT TEMPERATURE RANGE AND TREND	TRAFFIC CONDITION	INITIAL OPERATION			SUBSEQUENT OPERATIONS			COMMENTS
		maintenance action	dry chemical spread rate, kg/lane-km (lb/lane-mi)		maintenance action	dry chemical spread rate, kg/lane-km (lb/lane-mi)		
			liquid	solid or prewetted solid		liquid	solid or prewetted solid	
-2 to 2°C (28 to 35°F), remaining in range or falling to 0°C **(32°F) or below**, *and* equal to or below dew point	Traffic rate less than 100 vehicles per hr	Apply prewetted solid chemical		7-18 (25-65)	Reapply prewetted solid chemical as needed		7-18 (25-65)	1) If pavement becomes wet or if thin ice forms, reapply chemical at higher indicated rate 2) Do not apply liquid chemical on ice so thick that the pavement can not be seen
	Traffic rate greater than 100 vehicles per hr	Apply liquid or prewetted solid chemical	7-18 (25-65)	7-18 (25-65)	Reapply liquid or prewetted solid chemical as needed	11-32 (40-115)	7-18 (25-65)	
-7 to -2°C (20 to 28°F), remaining in range, *and* equal to or below dew point	Any level	Apply liquid or prewetted solid chemical	18-36 (65-130)	18-36 (65-130)	Reapply liquid or prewetted solid chemical when needed	18-36 (65-130)	18-36 (65-130)	1) If thin ice forms, reapply chemical at higher indicated rate 2) If traffic volumes are not enough to disperse condensation, it may be necessary to increase frequency 3) It is not advisable to apply a liquid chemical at the indicated spread rate when the pavement temperature drops below -5°C (23°F)
-10 to -7°C (15 to 20°F), remaining in range, *and* equal to or below dew point	Any level	Apply prewetted solid chemical		36-55 (130-200)	Reapply prewetted solid chemical when needed		36-55 (130-200)	1) If thin ice forms, reapply chemical at higher indicated rate 2) Applications will need to be more frequent at higher levels of condensation; if traffic volumes are not enough to disperse condensation, it may be necessary to increase frequency
Below -10°C (15°F), steady or falling	Any level	Apply abrasives			Apply abrasives as needed			It is not recommended that chemicals be applied in this temperature range

TIMING. (1) Conduct initial operation in advance of freezing. Apply liquid chemical up to 3 hrs in advance. Use longer advance times in this range to effect drying when traffic volume is low. Apply prewetted solid 1 to 2 hrs in advance. (2) In the absence of precipitation, liquid chemical at 21 kg/lane-km (75 lb/lane-mi) has been successful in preventing bridge deck icing when placed up to 4 days before freezing on higher volume roads and 7 days before on lower volume roads.

5.4 Design

Clogging is one of the drawbacks of many winter maintenance procedures involving NGOGFC pavements. As previously mentioned, although sand can cause faster clogging, over time, clogging is a natural occurrence with these pavements. A technology that is being used and researched in Europe and Asia includes machines that clean clogged pavements and unclog the pores of the pavement (23). Cleaning methods include cleaning with a fire hose, a high pressure cleaner, and a specially manufactured cleaning vehicle (2). Creating mixes with higher air voids can also allow high-speed traffic to help clear out clogged pavement (5).

New generation NGOGFCs that are polymer modified and contain fibers with lower moisture susceptibility can have a lower tendency to ravel in cold climates and freeze-thaw cycles (4).

In terms of placement of NGOGFCs, short sections of NGOGFCs should be avoided because transitions from dense to porous surfaces may confuse drivers in winter conditions. Use of porous surfaces in intersections is not recommended due to the winter risks. Also recommended is the use of warning signs in advance of porous surfaces to bring attention to the potentially icy surface in winter conditions, although this procedure has not been very effective in practice (24).

5.5 Summary

In Texas, severe winter weather events are generally confined to the northern section of the state, as is shown in Figure 5.1. North of the "ice line" is where ice and snow are most likely to occur. It is in these areas that district personnel must prepare for winter maintenance strategies for NGOGFC pavements.

As is indicated from the literature and the current practice of TxDOT districts, anti-icing procedures may produce the best result to combat black ice, freezing rain, and light snow events. Anti-icing procedures involve a combination of liquid, dry solid, and prewetted chemicals applied at the appropriate times, taking into consideration temperature, the amount of moisture, and traffic conditions. De-icing procedures should be reserved for events in which ice and snow have already bonded. These procedures generally require more materials and do not maintain safe road conditions as well as anti-icing procedures.

Sand should only be used in emergency situations where quick friction is needed, for instance, during a surprise ice or snow event. Use of sand on these pavements may cause clogging to occur, which reduces the draining benefits of the NGOGFC pavements. The use of other materials may be used to generate the needed friction.

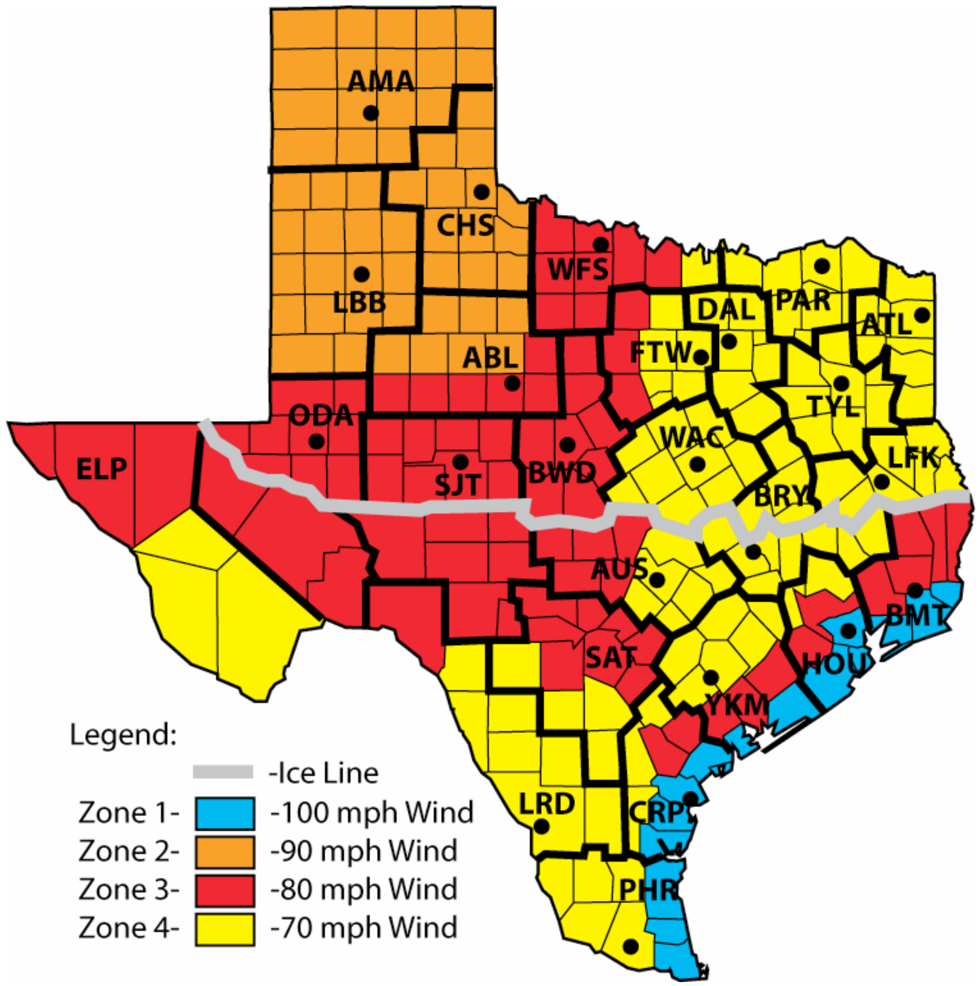

Figure 5.1 Texas Ice and Wind Map

6. Conclusions

NGOGFCs (PFCs) have been attractive to many engineers for their potential safety features, especially during wet weather conditions. NGOGFCs feature improved friction, low noise, reduced splash and spray, higher visibility, reduced hydroplaning, and reduced night-time surface glare. Widespread use of NGOFCs, however, has been curtailed by their maintenance and performance issues during winter weather conditions. The qualities of NGOGFCs raise special problems in winter maintenance. For example, the lower temperatures and greater air voids of NGOGFCs allow water to become trapped more easily and freeze more quickly than other pavement surfaces. This is known as black ice, and it is a serious road hazard for drivers. Sand and salt are not effective on NGOGFC surfaces. Sand clogs the air voids of NGOGFCs and eliminates their special benefits. Salt drains away too quickly within the open-graded structure of the pavement, proving ineffective against ice. Tire studs and snowplows cause ruts and gouges in NGOGFCs over a shorter period of time. Research and studies have been conducted to solve these special winter maintenance problems with NGOGFCs, including the development and use of de-icing chemical agents, new methods for chemical application, and training of maintenance personnel.

In 2005, the Center for Transportation Research (CTR) conducted an online survey on NGOGFC design, maintenance, performance, regional practices, in particular, cold weather maintenance practices and performance ratings. The survey was distributed online to all TxDOT districts. Twenty-three personnel from TxDOT districts responded to the survey, of which eleven currently use NGOGFCs. Nine out of the twenty-three respondents never used NGOGFCs, and three used them in the past but have since discontinued their use. As expected, the most cited reasons for using NGOGFCs were reduced splash and spray, improved skid resistance in wet weather conditions, and surface smoothness. Respondents cited the main disadvantages of using NGOGFCs as being their initial cost of construction, winter maintenance issues, and general maintenance issues. Indeed, results show that NGOGFCs are 22.5 percent more expensive than other dense-graded pavements. Fuel spills were the most reported general maintenance issue by respondents, but respondents did not report any serious problems with raveling, deformation rutting, potholes, fat spots/bleeding, stripping, reflective cracking, thermal cracking, tire stud rutting, gouging/scarring, new construction roughness (IRI), clogging, noise level, or icing. Overall, the respondent districts report satisfactory performance of NGOGFCs. It is important to note, however, that many districts have been using NGOGFC pavements for only a short period of time. In regard to winter maintenance techniques, respondent districts reported anti-icing chemical agents as the most effective.

The methodology for detecting ice formation in NGOGFC pavements was implemented at three locations in North Texas. I-Buttons were installed in the field, and they proved to be reliable under field conditions and traffic exposure, yielding an unprecedented set of highly detailed data. The methodology for black ice detection developed with the combined used of sensors (both inside the pavement and outside) appears to be very sound. The results of the experiment coincide with the 2005 CTR survey results that indicate that NGOGFC is the first to freeze and the last to thaw in winter conditions.

In Texas, severe winter weather is experienced mostly in the northern area of the state. It is in this area that snow and ice are most likely to occur, and it is here that district personnel are concerned about winter maintenance practices and performance issues with NGOGFC pavements. Anti-icing procedures have proven effective in combating black ice, freezing rain, and light snow. The use of de-icing chemical agents should be used in response to ice and snow that have already bonded with the pavement surface. De-icing procedures require more materials and are not as capable in maintaining safe road conditions as well as anti-icing procedures. Sand should only be used in emergency situations in response to surprise ice or snow events, especially considering that sand may cause clogging and long-term damage to NGOGFC pavements. Other materials other than sand should be considered for providing friction in these circumstances.

References

1. Kandhal, P. V. 2002. *Design, Construction, and Maintenance of Open-Graded Asphalt Friction Courses.* Information Series 115. National Asphalt Pavement Association: Lanham, MD.
2. Huber, G. 2000. *Performance Survey on Open-Graded Friction Course Mixes.* Synthesis of Highway Practice 284. National Cooperative Highway Research Program. Washington, D.C.
3. Geistlinger, L. 1996. *Safety First: Open-Graded Friction Courses.* Roads and Bridges, September.
4. Mallick, R. B., Kandhal, P. S., Cooley, L. A., Jr., and Watson, D. E. 2000. *Design, Construction, and Performance of New-Generation Open-Graded Friction Courses.* National Center for Asphalt Technology, Auburn University.
5. Isenring, T., Köster, H., and Scazziga, I. 1990. *Experiences with Porous Asphalt in Switzerland.* Transportation Research Record 1265.
6. Fults, W. K., Yildirim, Y., and Dossey, T. 2003. Quiet Pavement Systems. *Desk Scan Report*, FHWA International Technology Scanning Program.
7. *Open-Graded Friction Courses for Highways.* 1978. NCHRP Synthesis of Highway Practice, Transportation Research Board, Washington, D.C.
8. Gallaway, B. M., Bass, D. A., Fults, K. W., and Little, C. H. 1987. *Open-Graded Friction Courses in Texas – Specifications, Design, Construction and Maintenance,* Transportation Research Board, Washington, D.C.
9. *Technical Advisory: Open-Graded Friction Courses.* 1990. U.S. Department of Transportation and Federal Highway Administration. T 5040.31.
10. Joubert, R. M. 1992. *Durable Open-Graded Mixes Enhance Safety and Reduce Noise.* Asphalt Institute, ASPHALT Magazine, Volume 6, No. 1.
11. Page, G. C. 1993. *Open-Graded Friction Courses: Florida's Experience.* Transportation Research Record 1427, Washington, D.C.
12. Cooley, L. A., Jr., Brown, E. R. and Watson, D. E. 2000. *Evaluation of OGFC Mixtures Containing Cellulose Fibers.* National Center for Asphalt Technology, Auburn University.
13. Bendtsen, H. and Larsen, L. E. *Two-Layer Porous Pavement and Noise Reductions in Denmark.* Noise Reducing Pavements. 4: 1-3.
14. Elvik, Rune and Greibe, Poul. 2003. *Safety Aspects Related to Low Noise Road Surfaces.* TØI Report, Institute of Transportation Economics, Oslo, Norway.
15. Lane, Richard. *Cleaning Open Grade Asphalt to Improve Safety*. Pavement Treatments Ltd.
16. Watson, D. E., Moore, K. A., Williams, K., and Cooley, L. A., Jr. 2003. *Refinement of New-Generation Open-Graded Friction Course Mix Design.* Transportation Research Record, Washington, D.C.
17. *Georgia Department of Transportation's Progress in Open-Graded Friction Course Development.* 2003. Georgia Department of Transportation.
18. Flintsch, Gerardo W. 2004. Assessment of the Performance of Several Roadways under Rain, Snow, and Winter Maintenance Activities.

19. Smith, H. A. 1992. *Performance Characteristics of Open-Graded Friction Courses.* NCHRP Synthesis 180. Transportation Research Board.
20. Rogge, D. 2002. *Development of Maintenance Practices for Oregon F-Mix. Final Report.* Oregon DOT and FHWA.
21. FHWA/AASHTO International Technology Scan. 2004. Quiet Pavements: A Scanning Tour of Denmark, the Netherlands, France, Italy and the United Kingdom with an Informal Visit to Belgium. Executive Summary Report.
22. Simonsson, B. (Swedish Road Traffic Inst), Gustafson, K. (Swedish Road Traffic Inst). 1991. *Maintenance Practice in Sweden* in *Highway Research: Sharing the Benefits.* Proceedings of the Conference, The United States Strategic Highway Research Program, London, October 29–31, 1990.
23. Abe, T., and Y. Kishi. *Development of Low-Noise Pavement Function-Recovery Machine.* Noise Reducing Pavements. 4:1–4.
24. CTR. 2005. TxDOT Survey for Cold Weather Performance of New Generation Open-Graded Friction Course. http://www.zoomerang.com/recipient/survey-intro.zgi?p=U23CZYTNUJBP.
25. Dossey, T., Ramaiah, S. and McCullough, B. F. 2003. *Estimating In-situ Strength of Concrete Pavements under various Field Conditions.* Research Report 1700-1. Center for Transportation Research, The University of Texas at Austin, Austin, TX.
26. Dossey, T., Medina, C. and McCullough, B. 2004. *Analysis and Validation of the Usefulness of the Rigid Pavement Database.* Final Report 1778-6. Center for Transportation Research, The University of Texas at Austin, Austin, TX.
27. Federal Highway Administration. (FHWA) 1996. *Manual of Practice for an Effective Anti-Icing Program: A Guide for Highway Winter Maintenance Personnel.* US Army Cold Regions Research and Engineering Laboratory Corps of Engineers. Hanover, New Hampshire.

Appendix A: Sample Survey Questions

What criteria are used to select an NGOGFC mixture? Check all that apply. Rank order 1-9 with 1 being the most important criteria (use each rank number only once).

The top percentage indicates total respondent ratio; the bottom number represents actual number of respondents selecting the option	1	2	3	4	5	6	7	8	9	Not Used
1. Traffic Level	13% 2	7% 1	27% 4	0% 0	7% 1	7% 1	7% 1	7% 1	13% 2	13% 2
2. Environment	0% 0	6% 1	0% 0	6% 1	17% 3	17% 3	6% 1	22% 4	0% 0	28% 5
3. Skid Resistance	13% 2	25% 4	19% 3	19% 3	6% 1	6% 1	0% 0	0% 0	0% 0	13% 2
4. Noise	0% 0	13% 2	19% 3	19% 3	19% 3	6% 1	6% 1	0% 0	0% 0	19% 3
5. Reduced Splash & Spray	60% 12	15% 3	5% 1	5% 1	0% 0	0% 0	0% 0	5% 1	0% 0	10% 2
6. Smoothness	0% 0	28% 5	17% 3	17% 3	17% 3	6% 1	6% 1	0% 0	0% 0	11% 2
7. Cost	6% 1	0% 0	12% 2	0% 0	12% 2	24% 4	18% 3	18% 3	0% 0	12% 2
8. Durability	5% 1	10% 2	15% 3	15% 3	5% 1	15% 3	20% 4	5% 1	0% 0	10% 2
9. Other	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	10% 1	0% 0	50% 5	40% 4

Figure A-1 Question on Criteria for NGOGFC selection

What are the advantages of using NGOGFCs in your region? Please rank from 1-7 with 1 being the greatest advantage (use each number once):

The top percentage indicates total respondent ratio; the bottom number represents actual number of respondents selecting the option	1	2	3	4	5	6	7	N/A
1. Improved driver visibility on wet pavement (reduced spray)	50% 9	22% 4	0% 0	0% 0	6% 1	0% 0	6% 1	17% 3
2. Improved wet weather skid resistance	25% 5	30% 6	20% 4	5% 1	0% 0	5% 1	0% 0	15% 3
3. Improved road marking visibility during wet weather	5% 1	20% 4	50% 10	5% 1	5% 1	0% 0	0% 0	15% 3
4. Noise reduction	5% 1	10% 2	14% 3	33% 7	19% 4	5% 1	0% 0	14% 3
5. Cost	0% 0	0% 0	0% 0	5% 1	20% 4	45% 9	10% 2	20% 4
6. Durability	0% 0	0% 0	5% 1	29% 6	29% 6	14% 3	0% 0	24% 5
7. Other	0% 0	0% 0	0% 0	0% 0	0% 0	0% 0	58% 7	42%

Figure A-2 Question and Results for Advantages of NGOGFC Use

What are the disadvantages of using NGOGFCs in your region? Please rank 1-6, with 1 being the biggest disadvantage (use each number once).

The top percentage indicates total respondent ratio; the bottom number represents actual number of respondents selecting the option	1	2	3	4	5	6	N/A
1. Initial or construction cost	47% 9	11% 2	0% 0	11% 2	5% 1	5% 1	21% 4
2. Winter maintenance problems	21% 4	26% 5	11% 2	5% 1	5% 1	0% 0	32% 6
3. Durability	0% 0	0% 0	22% 4	17% 3	22% 4	0% 0	39% 7
4. Performance	0% 0	10% 2	10% 2	25% 5	15% 3	5% 1	35% 7
5. General Maintenance	0% 0	25% 5	15% 3	10% 2	15% 3	0% 0	35% 7
6. Other	0% 0	0% 0	0% 0	0% 0	0% 0	42% 5	58% 7

Figure A-3 Question and Results for Disadvantages of NGOGFC Use

How do you rate the performance of NGOGFC in your area:

The top percentage indicates total respondent ratio; the bottom number represents actual number of respondents selecting the option	1 Excellent	2 Very Good	3 Good	4 Fair	5 Poor	N/A
1. Durability (stripping, raveling, etc.)	44% 7	31% 5	19% 3	6% 1	0% 0	0% 0
2. Surface friction	50% 8	38% 6	6% 1	6% 1	0% 0	0% 0
3. Splash and spray	69% 11	25% 4	6% 1	0% 0	0% 0	0% 0
4. Noise	38% 6	50% 8	6% 1	0% 0	0% 0	6% 1
5. Smoothness	56% 9	38% 6	6% 1	0% 0	0% 0	0% 0

Figure A-4 Question on Performance Rating for NGOGFC

Survey Questionnaire

Do you currently use PFCs or NGOGFCs?

- Yes
- Never have used it
- Used before but not now

If you've used it before but not now, please indicate reason.

- Maintenance Problems
- Cost
- Performance
- Other

Where do you use NGOGFCs?

- Urban
  - > 45 mph
  - < 45 mph
  - Other
- Rural
  - > 45 mph
  - < 45 mph
  - Other

Have you used NGOGFC in Curb and Gutter Sections?

- Urban
  - Yes
  - No
- Rural
  - Yes
  - No

What criteria are used to select an NGOGFC mixture? Check all that apply. Rank order 1-9, with 1 the highest.

- Traffic level
- Environment (freezing or not; wet or dry)
- Skid resistance
- Noise
- Reduced splash and spray
- Smoothness
- Cost
- Durability
- Other

What are the advantages of using NGOGFCs in your region? Rank order 1-7, with 1 the highest

- Improved driver visibility on wet pavement (reduced spray)
- Improved wet weather skid resistance
- Improved road marking visibility during wet weather
- Noise
- Cost
- Durability
- Other

What are the disadvantages of using NGOGFCs in your region? Rank order 1-5, with 1 the highest

- Initial or Construction Cost
- Winter Maintenance Problems
- Durability
- Performance
- General Maintenance
- Other

PERFORMANCE

What is the estimated average typical service life of NGOGFC in years?

- <6
- 6-8
- 8-10
- 10-12
- >12

How do you rate the performance of NGOGFCs in your area in terms of:
Poor –5, Fair – 4, Good – 3, Very Good – 2, Excellent - 1

- Structural Durability (i.e. stripping, raveling, etc.)
- Surface Friction
- Splash and Spray
- Noise
- Smoothness

What is the frequency of occurrence of the following types of distresses?

- Tire stud rutting
    - none
    - low
    - medium
    - high

- Icing
  - none
  - < 5 days/yr
  - > 5 days/yr

- Raveling
  - < 5%
  - 5-25%
  - >25%

- Gouging/scarring (snow-plow, etc.)
  - < 5%
  - 5-25%
  - > 25%

- Deformation rutting
  - none: <0.25”
  - low: 0.25” – 0.50”
  - medium: 0.50” – 0.75”
  - high: > 0.75”

- Clogging
  - none
  - low
  - medium
  - high

- Potholes
  - none
  - low: < 3 per mile
  - medium: 3 - 5 per mile
  - high: > 5 per mile

- Fat spots/bleeding
  - none
  - low: < 3 per mile
  - medium: 3 - 5 per mile
  - high: > 5 per mile

- Noisy ride
  - none
  - low
  - medium
  - high

- Stripping
    - < 5%
    - 5-25%
    - > 25%

- New Construction Roughness (IRI)
    - none: < 40
    - low: 40 - 60
    - medium: 60 - 80
    - high: > 80

- Reflective cracking
    - none
    - low: < 5%
    - medium 5% - 10%
    - high: > 10%

- Thermal cracking
    - none
    - low: < 5%
    - medium: 5% - 10%
    - high: > 10%

COST

What is the relative cost of the material in-place compared to the cost of the equivalent depth of a typical ACP surface mix?

- < typical mix
- same as the typical mix
- + 15%
- + 15 – 20%
- + 20 – 25%
- + 25 – 30%
- > 30%

MAINTENANCE

What are the biggest maintenance challenges? Rank order 1-8, with 1 the highest

- Pushing, shoving and tearing
- Delamination
- Stripping difficulties
- Fuel or oil spills
- Snowplow damage
- Stays frozen longer
- Formation of black ice
- Other

Are special activities used to maintain the surface condition of NGOGFC pavements?

- No special activities
- Fog seal
- Others

Are special major maintenance activities used on NGOGFC pavements?

- No special activities
- Cleaning to restore permeability
- Others

What are the current winter maintenance techniques used in your region? How effective are they? Ineffective – 1, Moderately effective – 2, Effective – 3, Very effective – 4

- Sanding
- Liquid de-icer agent
- Anti-icing agent
- Magnesium Chloride
- CMA
- Larger quantity de-icer
- Run shoes on plows
- Reduce plow speeds
- Rubber bits
- CMA & CF 7
- Magnesium Chloride and CF 7
- Prewetted salts
- Advisory signs
- None

For NGOGFCs, percentage-wise, how much additional de-icing chemical is needed?

- None
- 25%
- 50%
- 75%
- 100%

How much more do you spend on salt, de-icers, etc. for NGOGFC pavements?

- Same
- \+ 25%
- \+ 25-50%
- \+ 50-75%
- +75-100%

What maintenance techniques have worked best for your area?

- Anti-icing
- Sanding
- Use of salts
- Use of liquids
- Use of prewetted salts
- Advance warnings signs
- Other
- None

Have you observed an increase in the rate of accidents on NGOGFC pavements during non-freeze events?

- Yes
- No
- Don't know

What kinds of maintenance techniques do you use to counter black ice? How effective are they? Ineffective – 1, Moderately effective – 2, Effective – 3, Very effective - 4

- Sanding
- Liquid de-icer agent
- Anti-icing agent
- Magnesium Chloride
- CMA
- Larger quantity de-icer
- Run shoes on plows
- Reduce plow speeds
- Rubber bits
- CMA & CF 7
- Magnesium Chloride and CF 7
- Prewetted salt
- Advisory signs
- None

Is permeability of NGOGFC pavements monitored periodically?

- Yes
- No
- Don't know

How often is permeability measured?

- When constructed
- Every __ months
- Annually
- Other

How is permeability measured?

- NCAT procedure
- Other

OTHER

Is the range of asphalt content specified?

- Yes
- No

If the range of asphalt content is specified, what is the percentage rate?

- N/A
- 5-6 %
- 7-8 %
- 9-10 %
- 11-12 %

What mix temperature range has been established to prevent asphalt draindown?

- 190-200˚F
- 200-215˚F
- 215-230˚F
- 230-250˚F

Is polymer modified asphalt binder used in NGOGFC?

- Yes
- No

What other additives are used?

- Rubber
- Cellulose fibers
- Rock fibers
- Other

If rubber is used how does the performance compare to NGOGFCs without rubber?

- Better
- No change
- Worse

If rubber does affect performance, on which indices does it have the most impact?

- Structural Durability (i.e. stripping, raveling, etc.)
- Surface Friction
- Splash and Spray
- Noise
- Smoothness

If fibers are used how does the performance compare to NGOGFCs without fibers?

- Better
- No change
- Worse

If fibers do affect performance, on which indices do they have the most impact?

- Structural Durability (i.e., stripping, raveling, etc.)
- Surface Friction
- Splash and Spray
- Noise
- Smoothness

What type of tack coat material is used?

- Emulsion
- Hard asphalt
- None
- Other

What is the specified application rate of tack coat in gal/sq yd?

- < 0.05
- 0.05 – 0.07
- > 0.07
- Other
- N/A

What are the specified target air void requirements for NGOGFC?

- < 12%
- 12 – 15%
- 15 – 18%
- 18 – 20%
- Other

Have you placed NGOGFC over newly constructed concrete pavement?

- Yes
- No

Have you placed NGOGFC over existing concrete pavement?

- Yes
- No

If you have placed NGOGFC over existing concrete pavement, what pre-treatment was used?

- None
- Milling
- Grinding
- Seal Coat
- Tack Coat
- Rubberized

Appendix B: NOAA Climatic Data

This appendix presents the climatographic records for the five North Texas cities from 1971–2000, as kept by the National Oceanic and Atmospheric Administration (NOAA). Also provided is NOAA's Freeze/Frost Occurrence Data.

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: AMARILLO INTL AP, TX **COOP ID: 410211**

Climate Division: TX 1 **NWS Call Sign: AMA** **Elevation: 3,586 Feet** **Lat: 35˚13N** **Lon: 101˚42W**

Temperature (˚F)

	Mean (1)			Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	48.9	22.6	35.8	81	1950	21	43.2	1986	-11+	1984	18	25.6	1979	920	0	.0	.0	16.5	4.6	27.5	.5
Feb	54.1	27.0	40.6	88	1963	1	48.1	1976	-14	1951	1	30.4	1978	699	0	.0	.0	18.4	2.7	21.4	.5
Mar	62.2	33.6	47.9	94	1971	27	53.4	1974	-3	1948	11	43.5	1998	542	2	.0	.1	26.2	.7	14.4	.0
Apr	70.6	41.7	56.2	98+	1989	22	63.6	1981	17+	1997	12	48.9	1997	291	18	.0	.7	28.4	.1	4.3	.0
May	78.6	51.7	65.2	103	1996	16	72.5	1996	28	1954	3	60.4	1976	94	90	.3	4.0	30.8	.0	.1	.0
Jun	87.4	61.1	74.3	108+	1998	28	81.3	1990	41	1998	6	69.4	1989	7	285	2.2	12.8	30.0	.0	.0	.0
Jul	91.0	65.3	78.2	105+	1994	1	83.1	1980	51	1990	14	74.3	1972	1	405	1.7	19.9	31.0	.0	.0	.0
Aug	88.7	63.8	76.3	104+	1994	18	81.8	2000	49	1956	21	71.9	1971	1	345	.7	16.5	31.0	.0	.0	.0
Sep	81.8	56.3	69.1	103	1995	5	75.8	1998	30	1984	30	62.5	1974	56	173	.3	7.0	29.8	.0	.2	.0
Oct	71.8	44.6	58.2	99	2000	3	61.7	1973	12	1993	30	49.6	1976	239	26	.0	.8	29.9	.1	2.3	.0
Nov	58.4	31.8	45.1	87	1980	8	52.3	1999	0	1976	28	36.8	1972	594	0	.0	.0	22.6	.9	15.9	@
Dec	49.8	24.1	37.0	81	1955	24	42.0	1980	-8	1989	22	25.3	1983	874	0	.0	.0	17.0	3.6	27.0	.7
Ann	70.3	43.6	57.0	108+	Jun 1998	28	83.1	Jul 1980	-14	Feb 1951	1	25.3	Dec 1983	4318	1344	5.2	61.8	311.6	12.7	113.1	1.7

\+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1948-2001

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: AMARILLO INTL AP, TX **COOP ID: 410211**

Climate Division: TX 1 **NWS Call Sign: AMA** **Elevation: 3,586 Feet** **Lat: 35˚13N** **Lon: 101˚42W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	.63	.56	1.57	1999	29	2.67	1999	.00+	1986	4.4	1.8	.3	@	.00	.06	.17	.26	.37	.48	.62	.78	1.01	1.38	1.74
Feb	.55	.38	1.25	1971	21	2.08	1998	.00+	1999	4.4	1.4	.2	.1	.00	.00	.09	.18	.27	.38	.52	.68	.91	1.31	1.70
Mar	1.13	.94	1.84	2000	22	4.14	2000	.01	1997	5.4	2.7	.6	.2	.07	.14	.28	.43	.60	.80	1.05	1.36	1.80	2.54	3.28
Apr	1.33	.87	2.65	1999	30	6.45	1997	.00	1996	5.4	3.1	.7	.2	.02	.08	.23	.41	.62	.87	1.19	1.60	2.18	3.20	4.21
May	2.50	2.32	3.95	1951	15	6.02	1988	.04	1984	8.3	4.7	1.8	.6	.35	.56	.92	1.27	1.63	2.03	2.49	3.06	3.82	5.06	6.26
Jun	3.28	3.14	4.92	1984	10	7.57	1992	.12	1998	8.3	5.4	2.6	.8	.50	.78	1.25	1.71	2.18	2.69	3.28	4.01	4.98	6.56	8.08
Jul	2.68	2.66	3.47	1997	29	6.23	1982	.16	2000	7.8	4.5	1.7	.7	.54	.78	1.17	1.53	1.90	2.29	2.73	3.26	3.97	5.10	6.17
Aug	2.94	2.30	3.58	1979	26	7.55	1974	.28	1983	8.4	5.4	2.0	.7	.48	.73	1.16	1.56	1.98	2.43	2.95	3.58	4.43	5.80	7.12
Sep	1.88	1.60	2.33	1990	29	4.96	1985	.03+	2000	6.4	3.6	1.3	.5	.14	.26	.50	.76	1.05	1.38	1.78	2.28	2.98	4.15	5.31
Oct	1.50	.91	2.38	1998	30	6.48	1998	.26	1977	5.0	3.1	1.0	.2	.15	.25	.46	.67	.89	1.15	1.45	1.83	2.34	3.20	4.05
Nov	.68	.51	2.01	1948	1	2.08	1971	.00+	1999	4.1	2.1	.3	@	.00	.09	.21	.32	.43	.55	.69	.85	1.07	1.42	1.76
Dec	.61	.42	1.64	1959	15	2.24	1991	.00	1976	4.2	1.7	.3	@	.02	.06	.14	.23	.33	.44	.58	.75	.99	1.39	1.79
Ann	19.71	19.36	4.92	Jun 1984	10	7.57	Jun 1992	.00+	Nov 1999	72.1	39.5	12.8	4.0	14.54	15.56	16.85	17.82	18.69	19.52	20.37	21.32	22.45	24.10	25.52

\+ Also occurred on an earlier date(s)
\# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
****** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1948-2001
(3) Derived from 1971-2000 serially complete daily data
Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: AMARILLO INTL AP, TX **COOP ID: 410211**

Climate Division: TX 1 **NWS Call Sign: AMA** **Elevation: 3,586 Feet** **Lat: 35°13N** **Lon: 101°42W**

Snow (inches)																							
Snow Totals															Mean Number of Days (1)								
Means/Medians (1)					Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	4.8	3.8	#	0	9.2	1994	31	14.5	1983	10+	1994	31	2+	1987	3.1	1.7	.4	.2	.0	4.5	2.1	.9	.1
Feb	4.1	2.6	1	0	11.4	1971	21	17.3	1971	14+	1983	5	3+	1984	2.7	1.2	.4	.2	@	3.2	1.7	.9	.2
Mar	1.7	1.0	#	0	6.0	1983	19	8.5	1988	4+	1998	17	#	1998	1.5	.6	.2	@	.0	.7	.2	.0	.0
Apr	.8	.0	#	0	6.5	1997	25	6.5	1997	6	1973	8	#	1997	.4	.3	.1	@	.0	.3	.1	@	.0
May	.0	.0	#	0	.5	1978	3	.5	1978	#+	1988	31	#	2000	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jun	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.0	.0	0	0	.3	1984	29	.3	1984	#	1984	29	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Oct	.4	.0	#	0	3.0	1976	28	3.9	1976	3	1991	31	#	1991	.3	.1	@	.0	.0	@	@	.0	.0
Nov	2.4	.4	#	0	8.9	2000	7	9.9	1972	7	2000	7	1+	2000	1.4	.8	.3	.1	.0	1.4	.4	.1	.0
Dec	3.7	2.0	#	0	16.8	2000	26	21.2	2000	15	2000	27	2+	2000	2.6	1.0	.3	.2	@	3.0	1.1	.6	.2
Ann	17.9	9.8	N/A	N/A	16.8	Dec 2000	26	21.2	Dec 2000	15	Dec 2000	27	3+	Feb 1984	12.0	5.7	1.7	.7	@	13.1	5.6	2.5	.5

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: AMARILLO INTL AP, TX **COOP ID: 410211**

Climate Division: TX 1 **NWS Call Sign: AMA** **Elevation: 3,586 Feet** **Lat: 35˚13N** **Lon: 101˚42W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	5/12	5/07	5/03	4/29	4/26	4/23	4/20	4/16	4/11
32	5/01	4/26	4/23	4/20	4/18	4/15	4/13	4/10	4/05
28	4/15	4/11	4/08	4/05	4/02	3/31	3/28	3/25	3/20
24	4/08	4/03	3/30	3/27	3/23	3/20	3/17	3/13	3/07
20	4/06	3/28	3/22	3/16	3/11	3/06	2/28	2/22	2/13
16	3/22	3/13	3/07	3/02	2/26	2/21	2/16	2/10	2/01

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	9/27	10/02	10/05	10/09	10/12	10/15	10/18	10/22	10/27
32	10/03	10/09	10/13	10/17	10/20	10/24	10/27	11/01	11/07
28	10/20	10/25	10/28	10/31	11/03	11/06	11/09	11/12	11/17
24	10/30	11/04	11/08	11/11	11/14	11/17	11/20	11/24	11/29
20	11/03	11/09	11/13	11/16	11/20	11/23	11/26	12/01	12/06
16	11/10	11/16	11/21	11/25	11/29	12/03	12/07	12/12	12/19

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	187	180	175	171	168	164	160	155	148
32	206	199	194	189	185	181	176	171	163
28	233	227	222	218	214	210	206	202	195
24	257	249	244	239	235	231	226	220	213
20	285	274	266	259	253	246	240	232	220
16	305	295	288	282	276	270	264	257	246

***** Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: AMARILLO INTL AP, TX **COOP ID: 410211**

Climate Division: TX 1 **NWS Call Sign: AMA** **Elevation: 3,586 Feet** **Lat: 35˚13N** **Lon: 101˚42W**

Degree Days to Selected Base Temperatures (˚F)

Heating Degree Days (1)

Base Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	920	699	542	291	94	7	1	1	56	239	594	874	4318
60	752	545	378	177	43	2	0	0	14	116	454	716	3197
57	659	466	292	124	23	0	0	0	5	69	372	623	2633
55	598	414	238	94	13	0	0	0	2	47	321	562	2289
50	451	291	127	38	3	0	0	0	0	14	209	417	1550
32	73	33	1	0	0	0	0	0	0	0	15	55	177

Cooling Degree Days (1)

Base Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	198	282	496	719	1023	1266	1429	1373	1111	813	407	217	9334
55	1	6	36	126	323	576	716	660	432	166	21	2	3065
57	0	3	23	94	268	516	654	598	376	127	12	1	2672
60	0	1	11	56	194	427	562	505	297	79	4	0	2136
65	0	0	2	18	90	285	405	345	173	26	0	0	1344
70	0	0	0	3	34	156	256	205	83	5	0	0	742

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	71	136	287	494	785	1031	1192	1132	876	577	221	80	71	207	494	988	1773	2804	3996	5128	6004	6581	6802	6882
45	27	68	178	354	631	881	1037	977	728	428	131	34	27	95	273	627	1258	2139	3176	4153	4881	5309	5440	5474
50	4	27	92	230	479	731	882	822	580	292	62	6	4	31	123	353	832	1563	2445	3267	3847	4139	4201	4207
55	0	6	40	130	331	581	727	667	437	174	23	0	0	6	46	176	507	1088	1815	2482	2919	3093	3116	3116
60	0	0	12	58	204	432	572	512	303	84	3	0	0	0	12	70	274	706	1278	1790	2093	2177	2180	2180
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	87	129	222	331	488	674	786	756	566	365	171	88	87	216	438	769	1257	1931	2717	3473	4039	4404	4575	4663

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Notes

a. The monthly means are simple arithmetic averages computed by summing the monthly values for the period 1971-2000 and dividing by thirty. Prior to averaging, the data are adjusted if necessary to compensate for data quality issues, station moves or changes in station reporting practices. Missing months are replaced by estimates based on neighboring stations.

b. The median is defined as the middle value in an ordered set of values. The median is being provided for the snow and precipitation elements because the mean can be a misleading value for precipitation normals.

c. Only observed validated values were used to select the extreme daily values.

d. Extreme monthly temperature/precipitation means were selected from the monthly normals data.
Monthly snow extremes were calculated from daily values quality controlled to be consistent with the Snow Climatology.

e. Degree Days were derived using the same techniques as the 1971-2000 normals.
Compete documentation for the 1971-2000 Normals is available on the internet from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

f. Mean "number of days statistics" for temperature and precipitation were calculated from a serially complete daily data set .
Documentation of the serially complete data set is available from the link below:

g. Snowfall and snow depth statistics were derived from the Snow Climatology.
Documentation for the Snow Climatology project is available from the link under references.

Data Sources for Tables

Several different data sources were used to create the Clim20 climate summaries. In some cases the daily extremes appear inconsistent with the monthly extremes and or the mean number of days statistics. For example, a high daily extreme value may not be reflected in the highest monthly value or the mean number of days threshold that is less than and equal to the extreme value. Some of these difference are caused by different periods of record. Daily extremes are derived from the station's entire period of record while the serial data and normals data were are for the 1971-2000 period. Therefore extremes observed before 1971 would not be included in the 1971-2000 normals or the 1971-2000 serial daily data set. Inconsistencies can also occur when monthly values are adjusted to reflect the current observing conditions or were replaced during the 1971-2000 Monthly Normals processing and are not reconciled with the Summary of the Day data.

a. Temperature/ Precipitation Tables
1. 1971-2000 Monthly Normals
2. Cooperative Summary of the Day
3. National Weather Service station records
4. 1971-2000 serially complete daily data

b. Degree Day Table
1. Monthly and Annual Heating and Cooling Degree Days Normals to Selected Bases derived from 1971-2000 Monthly Normals
2. Daily Normal Growing Degree Units to Selected Base Temperatures derived from 1971-2000 serially complete daily data

c. Snow Tables
1. Snow Climatology
2. Cooperative Summary of the Day

d. Freeze Data Table
1971-2000 serially complete daily data

References

U.S. Climate Normals 1971-2000, www.ncdc.noaa.gov/normals.html

U.S. Climate Normals 1971-2000-Products Clim20, www.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html

Snow Climatology Project Description, www.ncdc.noaa.gov/oa/climate/monitoring/snowclim/mainpage.html

Eischeid, J. K., P. Pasteris, H. F. Diaz, M. Plantico, and N. Lott, 2000: Creating a serially complete, national daily time series of temperature and precipitation for the Western United States. J. Appl. Meteorol., 39, 1580-1591,
www1.ncdc.noaa.gov/pub/data/special/ serialcomplete_jam_0900.pdf

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: DALLAS LOVE AP, TX **COOP ID: 412244**

Climate Division: TX 3 **NWS Call Sign: DAL** **Elevation: 440 Feet** **Lat: 32˚51N** **Lon: 96˚51W**

Temperature (˚F)																					
	Mean (1)			Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	55.4	36.4	45.9	95	1911	31	53.6	1990	2	1949	31	35.1	1978	605	2	.0	.0	20.5	1.4	11.6	.0
Feb	61.0	41.0	51.0	95+	1996	22	59.7	1976	2+	1910	19	38.3	1978	415	9	.0	.1	22.1	.8	6.3	.0
Mar	69.1	48.5	58.8	98	1911	10	64.5	1974	12	1948	11	54.9	1996	238	39	.0	.3	29.4	.1	1.8	.0
Apr	76.5	56.1	66.3	99	1963	10	71.1	1981	29+	1914	10	60.9	1983	75	110	.0	1.1	30.0	.0	@	.0
May	83.8	64.9	74.4	103+	1985	31	80.8	1996	36+	1908	1	69.1	1976	9	290	.1	6.9	31.0	.0	.0	.0
Jun	91.6	72.7	82.2	112+	1980	27	87.2	1998	48	1903	1	78.8	1989	0	511	1.6	20.5	30.0	.0	.0	.0
Jul	96.1	76.8	86.5	111	1954	25	92.1	1998	57	1905	10	82.4	1976	0	659	8.3	27.8	31.0	.0	.0	.0
Aug	95.8	76.4	86.1	115	1909	18	90.5	2000	55+	1906	29	81.0	1992	0	646	8.6	26.9	31.0	.0	.0	.0
Sep	88.5	69.2	78.9	110	2000	4	84.8	1998	40+	1908	29	69.1	1974	7	417	1.7	15.9	30.0	.0	.0	.0
Oct	78.6	58.2	68.4	100+	1979	1	71.9	1998	26	1910	30	61.2	1976	62	162	@	3.3	30.9	.0	.1	.0
Nov	66.0	46.8	56.4	92	1910	24	62.6	1999	15+	1911	30	50.0	1976	281	28	.0	.0	27.7	.0	2.2	.0
Dec	57.4	38.6	48.0	89	1955	24	54.7	1984	1	1989	23	35.8	1983	527	5	.0	.0	23.4	.9	8.2	.0
Ann	76.7	57.1	66.9	115	Aug 1909	18	92.1	Jul 1998	1	Dec 1989	23	35.1	Jan 1978	2219	2878	20.3	102.8	337.0	3.2	30.2	.0

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1897-2001

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: DALLAS LOVE AP, TX **COOP ID: 412244**

Climate Division: TX 3 **NWS Call Sign: DAL** **Elevation: 440 Feet** **Lat: 32˚51N** **Lon: 96˚51W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels. These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	1.89	1.93	5.14	1949	24	5.49	1998	.00+	1988	7.2	3.7	1.1	.3	.00	.34	.72	1.02	1.32	1.63	1.97	2.37	2.90	3.76	4.58
Feb	2.31	2.09	3.35	1997	12	7.91	1997	.17	1996	6.1	3.8	1.5	.8	.34	.53	.87	1.19	1.52	1.89	2.31	2.83	3.52	4.66	5.75
Mar	3.13	2.65	6.02	1977	27	9.09	1977	.26	1972	7.4	4.7	2.2	.9	.42	.67	1.12	1.56	2.02	2.52	3.11	3.83	4.80	6.40	7.94
Apr	3.46	3.40	5.10	1957	26	8.05	1997	.04	1983	7.2	4.7	2.5	1.1	.34	.59	1.07	1.55	2.07	2.66	3.35	4.22	5.40	7.38	9.30
May	5.30	5.91	5.14	1949	17	10.56	1989	.54	1977	9.3	6.3	3.6	2.0	1.12	1.60	2.38	3.09	3.80	4.56	5.42	6.45	7.80	9.97	12.02
Jun	3.92	2.97	3.64	1989	13	10.87	1989	1.26	1983	7.2	4.8	2.8	1.5	.84	1.20	1.77	2.30	2.82	3.38	4.01	4.77	5.76	7.36	8.86
Jul	2.43	2.06	4.62	1962	27	6.14	1988	.00+	2000	4.7	3.4	1.5	.7	.00	.40	.88	1.27	1.65	2.06	2.52	3.04	3.76	4.91	6.00
Aug	2.17	1.79	4.42	1915	18	5.98	1974	.00+	2000	4.6	3.1	1.6	.6	.00	.12	.43	.76	1.12	1.54	2.04	2.67	3.55	5.04	6.51
Sep	2.65	2.30	4.32	1965	21	7.16	1974	.03	2000	5.8	3.9	1.8	.8	.32	.52	.89	1.26	1.66	2.09	2.60	3.23	4.09	5.50	6.88
Oct	4.65	3.43	6.01	1959	1	16.05	1981	.00	1975	7.1	5.0	2.8	1.6	.13	.45	1.08	1.74	2.49	3.34	4.37	5.68	7.49	10.55	13.58
Nov	2.61	2.14	3.40	1902	4	7.01	2000	.17	1979	6.6	4.2	2.0	.7	.42	.64	1.02	1.38	1.75	2.16	2.62	3.19	3.95	5.18	6.36
Dec	2.53	2.02	3.98	1991	20	9.25	1991	.05	1981	6.4	3.9	1.9	.8	.23	.41	.75	1.10	1.48	1.92	2.43	3.08	3.97	5.45	6.91
Ann	37.05	36.98	6.02	Mar 1977	27	16.05	Oct 1981	.00+	Aug 2000	79.6	51.5	25.3	11.8	23.54	26.04	29.32	31.84	34.11	36.33	38.64	41.22	44.38	49.03	53.09

\+ Also occurred on an earlier date(s)
\# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1897-2001
(3) Derived from 1971-2000 serially complete daily data
Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: DALLAS LOVE AP, TX **COOP ID: 412244**

Climate Division: TX 3 **NWS Call Sign: DAL** **Elevation: 440 Feet** **Lat: 32˚51N** **Lon: 96˚51W**

Snow (inches)																							
Snow Totals															Mean Number of Days (1)								
Means/Medians (1)					Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	.7	.0	#	0	4.5	1977	30	5.5	1977	4	1977	31	#	1988	.6	.4	.1	.0	.0	.5	.2	.0	.0
Feb	.6	.0	#	0	6.0	1978	17	10.1	1978	4	1978	18	1	1978	.5	.3	@	@	.0	.5	.2	.0	.0
Mar	.0	.0	#	0	.8	1971	2	.8	1971	1+	1989	6	#	1989	.1	.0	.0	.0	.0	.1	.0	.0	.0
Apr	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
May	.0	.0	#	0	.0	0	0	.0	0	0	0	0	#	1997	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jun	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Oct	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Nov	.2	.0	#	0	3.1	1976	13	3.1	1976	3	1976	14	#	1993	.1	.0	@	.0	.0	.2	@	.0	.0
Dec	.2	#	#	0	4.0	1983	16	4.0	1983	2	1983	16	#	1983	.1	.0	@	.0	.0	@	.0	.0	.0
Ann	1.7	#	N/A	N/A	6.0	Feb 1978	17	10.1	Feb 1978	4+	Feb 1978	18	1	Feb 1978	1.4	.7	.1	@	.0	1.3	.4	.0	.0

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: DALLAS LOVE AP, TX **COOP ID: 412244**

Climate Division: TX 3 **NWS Call Sign: DAL** **Elevation: 440 Feet** **Lat: 32˚51N** **Lon: 96˚51W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	4/09	4/03	3/29	3/25	3/22	3/18	3/14	3/10	3/03
32	3/28	3/19	3/13	3/08	3/03	2/26	2/21	2/15	2/06
28	3/12	3/03	2/25	2/20	2/15	2/10	2/05	1/29	1/21
24	3/10	2/26	2/18	2/11	2/05	1/29	1/22	1/14	1/03
20	2/21	2/11	2/03	1/28	1/21	1/14	1/04	0/00	0/00
16	2/19	2/07	1/29	1/20	1/07	0/00	0/00	0/00	0/00

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	10/30	11/04	11/08	11/11	11/14	11/17	11/20	11/23	11/28
32	11/04	11/11	11/17	11/21	11/25	11/30	12/04	12/09	12/17
28	11/15	11/23	11/29	12/04	12/09	12/14	12/19	12/25	1/03
24	11/20	12/01	12/09	12/16	12/23	12/29	1/05	1/13	1/24
20	12/09	12/17	12/23	12/29	1/04	1/10	1/20	0/00	0/00
16	12/25	1/06	1/16	1/27	2/14	0/00	0/00	0/00	0/00

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	256	249	245	240	236	233	228	223	217
32	294	285	278	272	267	261	255	248	239
28	327	317	309	303	297	291	284	276	266
24	>365	347	329	319	311	304	297	288	277
20	>365	>365	>365	>365	364	341	328	315	300
16	>365	>365	>365	>365	>365	>365	363	344	326

***** Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: DALLAS LOVE AP, TX **COOP ID: 412244**

Climate Division: TX 3 **NWS Call Sign: DAL** **Elevation: 440 Feet** **Lat: 32˚51N** **Lon: 96˚51W**

Degree Days to Selected Base Temperatures (˚F)

Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	605	415	238	75	9	0	0	0	7	62	281	527	2219
60	456	290	107	15	1	0	0	0	0	9	169	388	1435
57	375	229	65	5	0	0	0	0	0	3	118	308	1103
55	325	194	44	2	0	0	0	0	0	1	90	260	916
50	218	120	13	0	0	0	0	0	0	0	40	161	552
32	18	6	0	0	0	0	0	0	0	0	0	6	30

Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	433	529	829	1024	1301	1494	1676	1670	1396	1123	728	508	12711
55	32	72	185	345	588	804	963	957	706	418	141	43	5254
57	21	53	146	291	527	744	901	895	646	362	109	30	4725
60	10	31	96	216	435	654	808	802	558	281	71	16	3978
65	2	9	39	110	290	511	659	646	417	162	28	5	2878
70	0	1	10	40	157	355	498	492	279	75	6	1	1914

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	249	354	589	790	1067	1263	1441	1431	1170	887	501	294	249	603	1192	1982	3049	4312	5753	7184	8354	9241	9742	10036
45	150	240	445	640	912	1113	1286	1276	1020	732	362	181	150	390	835	1475	2387	3500	4786	6062	7082	7814	8176	8357
50	81	147	308	491	757	963	1131	1121	870	578	243	96	81	228	536	1027	1784	2747	3878	4999	5869	6447	6690	6786
55	38	78	189	348	602	813	976	966	720	427	146	46	38	116	305	653	1255	2068	3044	4010	4730	5157	5303	5349
60	9	37	100	222	448	663	821	811	571	291	76	15	9	46	146	368	816	1479	2300	3111	3682	3973	4049	4064
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	146	208	355	505	732	875	972	965	797	577	292	168	146	354	709	1214	1946	2821	3793	4758	5555	6132	6424	6592

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Notes

a. The monthly means are simple arithmetic averages computed by summing the monthly values for the period 1971-2000 and dividing by thirty. Prior to averaging, the data are adjusted if necessary to compensate for data quality issues, station moves or changes in station reporting practices. Missing months are replaced by estimates based on neighboring stations.

b. The median is defined as the middle value in an ordered set of values. The median is being provided for the snow and precipitation elements because the mean can be a misleading value for precipitation normals.

c. Only observed validated values were used to select the extreme daily values.

d. Extreme monthly temperature/precipitation means were selected from the monthly normals data.
Monthly snow extremes were calculated from daily values quality controlled to be consistent with the Snow Climatology.

e. Degree Days were derived using the same techniques as the 1971-2000 normals.
Compete documentation for the 1971-2000 Normals is available on the internet from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

f. Mean "number of days statistics" for temperature and precipitation were calculated from a serially complete daily data set .
Documentation of the serially complete data set is available from the link below:

g. Snowfall and snow depth statistics were derived from the Snow Climatology.
Documentation for the Snow Climatology project is available from the link under references.

Data Sources for Tables

Several different data sources were used to create the Clim20 climate summaries. In some cases the daily extremes appear inconsistent with the monthly extremes and or the mean number of days statistics. For example, a high daily extreme value may not be reflected in the highest monthly value or the mean number of days threshold that is less than and equal to the extreme value. Some of these difference are caused by different periods of record. Daily extremes are derived from the station's entire period of record while the serial data and normals data were are for the 1971-2000 period. Therefore extremes observed before 1971 would not be included in the 1971-2000 normals or the 1971-2000 serial daily data set. Inconsistencies can also occur when monthly values are adjusted to reflect the current observing conditions or were replaced during the 1971-2000 Monthly Normals processing and are not reconciled with the Summary of the Day data.

a. Temperature/ Precipitation Tables
1. 1971-2000 Monthly Normals
2. Cooperative Summary of the Day
3. National Weather Service station records
4. 1971-2000 serially complete daily data

b. Degree Day Table
1. Monthly and Annual Heating and Cooling Degree Days Normals to Selected Bases derived from 1971-2000 Monthly Normals
2. Daily Normal Growing Degree Units to Selected Base Temperatures derived from 1971-2000 serially complete daily data

c. Snow Tables
1. Snow Climatology
2. Cooperative Summary of the Day

d. Freeze Data Table
1971-2000 serially complete daily data

References

U.S. Climate Normals 1971-2000, www.ncdc.noaa.gov/normals.html
U.S. Climate Normals 1971-2000-Products Clim20, www.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html
Snow Climatology Project Description, www.ncdc.noaa.gov/oa/climate/monitoring/snowclim/mainpage.html
Eischeid, J. K., P. Pasteris, H. F. Diaz, M. Plantico, and N. Lott, 2000: Creating a serially complete, national daily time series of temperature and precipitation for the Western United States. J. Appl. Meteorol., 39, 1580-1591,
www1.ncdc.noaa.gov/pub/data/special/ serialcomplete_jam_0900.pdf

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: LUBBOCK RGNL AP, TX **COOP ID: 415411**

Climate Division: TX 1 **NWS Call Sign: LBB** **Elevation: 3,254 Feet** **Lat: 33˚40N** **Lon: 101˚49W**

Temperature (˚F)

	Mean (1)			Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	51.9	24.4	38.1	87	1914	17	44.0	1998	-16	1963	13	30.2	1979	818	0	.0	.0	19.5	3.0	24.8	.2
Feb	57.8	28.9	43.3	89	1918	24	50.4	2000	-17	1933	8	32.5	1978	592	0	.0	.0	21.7	1.6	17.2	.1
Mar	66.2	36.2	51.2	95+	1989	11	57.3	1974	-2	1922	2	47.4	1987	419	7	.0	.2	28.3	.3	8.6	.0
Apr	74.7	45.4	60.0	100+	1989	22	64.7	1972	18	1920	4	53.8	1997	182	48	@	1.6	29.2	.0	1.4	.0
May	82.8	55.6	69.2	109	2000	24	76.8	1996	29	1917	7	65.2	1976	38	179	.9	8.6	31.0	.0	.0	.0
Jun	90.0	64.1	77.1	114	1994	27	83.3	1990	39	1917	2	73.3	1989	2	381	3.7	17.4	30.0	.0	.0	.0
Jul	91.9	67.7	79.8	109	1940	10	84.0	1998	49	1915	5	74.5	1976	0	472	2.8	22.4	31.0	.0	.0	.0
Aug	90.0	66.0	78.0	107+	1944	3	81.4	1999	43	1915	31	73.0	1971	0	413	.7	19.2	31.0	.0	.0	.0
Sep	83.4	58.4	70.9	105	1930	19	76.9	1977	33+	1983	21	63.5	1974	33	223	.3	9.2	29.9	.0	.0	.0
Oct	74.4	47.0	60.7	100	2000	3	64.2	1998	18	1993	30	53.3	1976	163	46	@	1.2	30.4	@	1.0	.0
Nov	61.6	34.5	48.1	89	1916	7	54.4	1999	-1	1957	23	41.3	1972	491	0	.0	.0	25.0	.2	10.3	.0
Dec	53.2	26.1	39.7	83	1939	6	44.3	1980	-2+	1989	22	30.5	1983	770	0	.0	.0	20.3	2.0	22.6	.2
Ann	73.2	46.2	59.7	114	Jun 1994	27	84.0	Jul 1998	-17	Feb 1933	8	30.2	Jan 1979	3508	1769	8.4	79.8	327.3	7.1	85.9	.5

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1911-2001

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: LUBBOCK RGNL AP, TX **COOP ID: 415411**

Climate Division: TX 1 **NWS Call Sign: LBB** **Elevation: 3,254 Feet** **Lat: 33˚40N** **Lon: 101˚49W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	.50	.35	1.96	1939	8	2.75	1983	.00+	2000	4.2	1.3	.2	.1	.00	.00	.03	.12	.22	.33	.46	.63	.86	1.25	1.64
Feb	.71	.42	2.11	1961	20	2.14	1990	.00	1999	4.4	2.1	.4	.1	.01	.04	.12	.21	.33	.46	.63	.85	1.16	1.70	2.24
Mar	.76	.48	1.72	1929	27	2.95	1979	.00	1972	4.1	2.0	.5	.1	.01	.05	.14	.25	.37	.51	.68	.91	1.23	1.78	2.33
Apr	1.29	1.11	2.18	1982	30	5.79	1997	.04	1989	5.0	2.6	.7	.2	.06	.13	.28	.45	.65	.89	1.18	1.55	2.08	2.98	3.89
May	2.31	2.45	4.32	1941	23	5.25	1992	.04	1998	7.1	4.3	1.5	.5	.33	.53	.86	1.18	1.52	1.88	2.31	2.83	3.53	4.67	5.76
Jun	2.98	2.43	5.70	1967	1	8.48	2000	.00	1990	7.4	5.1	1.9	.6	.34	.71	1.21	1.64	2.07	2.53	3.05	3.68	4.51	5.83	7.09
Jul	2.13	2.06	3.42	1928	22	7.20	1976	.15	1978	6.3	4.0	1.5	.6	.19	.34	.63	.92	1.24	1.61	2.05	2.59	3.34	4.60	5.83
Aug	2.36	1.93	3.30	1946	28	5.41	1981	.01	2000	7.6	4.2	1.7	.6	.15	.30	.59	.91	1.28	1.70	2.21	2.85	3.76	5.28	6.80
Sep	2.57	2.13	5.50	1936	21	8.17	1995	.00	2000	6.3	3.9	1.7	.7	.03	.15	.43	.77	1.18	1.67	2.28	3.07	4.21	6.17	8.15
Oct	1.70	.98	5.43	1983	19	10.80	1983	.00+	1992	5.1	3.1	1.0	.3	.00	.04	.21	.43	.70	1.04	1.46	2.02	2.82	4.22	5.64
Nov	.71	.58	1.59	2001	15	2.29	1980	.00+	1999	3.7	1.8	.4	.1	.00	.00	.11	.23	.37	.51	.68	.90	1.20	1.67	2.15
Dec	.67	.43	1.50	1942	21	2.24	1991	.00	1973	4.4	2.1	.2	@	.01	.04	.11	.20	.31	.43	.59	.80	1.09	1.60	2.12
Ann	18.69	19.47	5.70	Jun 1967	1	10.80	Oct 1983	.00+	Sep 2000	65.6	36.5	11.7	3.9	12.06	13.29	14.90	16.13	17.24	18.33	19.46	20.71	22.25	24.51	26.48

\+ Also occurred on an earlier date(s)
\# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
****** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1911-2001
(3) Derived from 1971-2000 serially complete daily data
Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: LUBBOCK RGNL AP, TX **COOP ID: 415411**

Climate Division: TX 1 **NWS Call Sign: LBB** **Elevation: 3,254 Feet** **Lat: 33˚40N** **Lon: 101˚49W**

Snow (inches)																							
Snow Totals															Mean Number of Days (1)								
Means/Medians (1)					Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	2.9	1.7	#	0	11.4	1983	20	25.3	1983	17	1983	22	5	1983	2.3	.9	.3	.1	@	2.1	.8	.5	.2
Feb	2.4	1.4	#	0	7.6	1978	16	10.2	1978	9	1978	17	1+	1986	1.7	.8	.2	.1	.0	1.7	.8	.3	.0
Mar	.5	.0	#	0	2.5	1989	21	3.9	1989	3	1989	21	#	1998	.6	.1	.0	.0	.0	.1	@	.0	.0
Apr	.2	.0	#	0	4.4	1983	7	5.3	1983	3	1983	8	#	1983	.2	.1	@	.0	.0	.1	@	.0	.0
May	.0	.0	#	0	.0	0	0	.0	0	0	0	0	#	2000	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jun	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Oct	.3	.0	#	0	4.0	1976	28	7.5	1976	1+	1976	29	#	1976	.2	.1	.1	.0	.0	.1	.0	.0	.0
Nov	1.6	.0	#	0	10.6	1980	25	21.4	1980	11+	1980	26	2	1980	.8	.4	.2	.1	.1	.4	.3	.2	.1
Dec	2.5	1.7	#	0	8.3	2000	26	8.5	2000	8	2000	27	1	2000	2.0	.8	.3	.1	.0	1.7	.6	.1	.0
Ann	10.4	4.8	N/A	N/A	11.4	Jan 1983	20	25.3	Jan 1983	17	Jan 1983	22	5	Jan 1983	7.8	3.2	1.1	.4	.1	6.2	2.5	1.1	.3

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: LUBBOCK RGNL AP, TX **COOP ID: 415411**

Climate Division: TX 1 **NWS Call Sign: LBB** **Elevation: 3,254 Feet** **Lat: 33˚40N** **Lon: 101˚49W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	4/23	4/20	4/17	4/15	4/12	4/10	4/08	4/05	4/02
32	4/14	4/10	4/07	4/05	4/03	3/31	3/29	3/26	3/22
28	4/08	4/03	3/31	3/28	3/26	3/23	3/20	3/17	3/12
24	4/02	3/25	3/20	3/15	3/10	3/06	3/01	2/24	2/16
20	3/22	3/14	3/08	3/03	2/27	2/22	2/17	2/11	2/03
16	3/12	3/02	2/23	2/17	2/11	2/05	1/29	1/21	1/09

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	10/05	10/11	10/15	10/18	10/21	10/24	10/28	11/01	11/06
32	10/17	10/22	10/26	10/29	11/01	11/04	11/07	11/11	11/16
28	10/29	11/04	11/08	11/11	11/15	11/18	11/21	11/25	12/01
24	11/05	11/11	11/14	11/18	11/21	11/24	11/27	12/01	12/06
20	11/10	11/17	11/22	11/26	11/30	12/04	12/08	12/13	12/20
16	11/23	12/01	12/06	12/11	12/15	12/20	12/25	12/31	1/09

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	207	201	197	194	191	188	185	181	175
32	226	221	217	214	211	209	206	202	197
28	254	247	242	237	233	229	225	220	212
24	281	272	265	260	255	249	244	237	228
20	304	294	287	281	275	269	263	256	246
16	358	337	325	316	308	300	292	283	269

***** Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: LUBBOCK RGNL AP, TX **COOP ID: 415411**

Climate Division: TX 1 **NWS Call Sign: LBB** **Elevation: 3,254 Feet** **Lat: 33˚40N** **Lon: 101˚49W**

Degree Days to Selected Base Temperatures (˚F)

Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	818	592	419	182	38	2	0	0	33	163	491	770	3508
60	677	469	280	94	14	0	0	0	7	71	368	630	2610
57	586	391	199	54	6	0	0	0	2	38	290	538	2104
55	526	339	153	35	3	0	0	0	0	23	243	477	1799
50	383	223	66	9	0	0	0	0	0	5	144	334	1164
32	47	16	0	0	0	0	0	0	0	0	5	24	92

Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	276	372	627	861	1170	1367	1495	1439	1186	915	519	310	10537
55	2	16	73	216	460	677	782	726	501	236	42	5	3736
57	1	9	51	173	401	617	720	664	443	188	27	2	3296
60	0	3	27	116	315	527	627	571	359	125	12	0	2682
65	0	0	7	48	179	381	472	413	223	46	0	0	1769
70	0	0	1	13	89	237	318	264	118	13	0	0	1053

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	120	204	400	628	930	1134	1259	1199	955	675	308	137	120	324	724	1352	2282	3416	4675	5874	6829	7504	7812	7949
45	51	115	269	488	775	984	1104	1044	805	522	198	65	51	166	435	923	1698	2682	3786	4830	5635	6157	6355	6420
50	14	55	158	345	620	834	949	889	655	377	103	22	14	69	227	572	1192	2026	2975	3864	4519	4896	4999	5021
55	0	19	78	225	468	684	794	734	510	246	46	2	0	19	97	322	790	1474	2268	3002	3512	3758	3804	3806
60	0	1	31	120	322	534	639	579	365	134	10	0	0	1	32	152	474	1008	1647	2226	2591	2725	2735	2735
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	118	173	282	409	594	745	837	804	624	425	212	126	118	291	573	982	1576	2321	3158	3962	4586	5011	5223	5349

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Notes

a. The monthly means are simple arithmetic averages computed by summing the monthly values for the period 1971-2000 and dividing by thirty. Prior to averaging, the data are adjusted if necessary to compensate for data quality issues, station moves or changes in station reporting practices. Missing months are replaced by estimates based on neighboring stations.

b. The median is defined as the middle value in an ordered set of values. The median is being provided for the snow and precipitation elements because the mean can be a misleading value for precipitation normals.

c. Only observed validated values were used to select the extreme daily values.

d. Extreme monthly temperature/precipitation means were selected from the monthly normals data.
Monthly snow extremes were calculated from daily values quality controlled to be consistent with the Snow Climatology.

e. Degree Days were derived using the same techniques as the 1971-2000 normals.
Compete documentation for the 1971-2000 Normals is available on the internet from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

f. Mean "number of days statistics" for temperature and precipitation were calculated from a serially complete daily data set .
Documentation of the serially complete data set is available from the link below:

g. Snowfall and snow depth statistics were derived from the Snow Climatology.
Documentation for the Snow Climatology project is available from the link under references.

Data Sources for Tables

Several different data sources were used to create the Clim20 climate summaries. In some cases the daily extremes appear inconsistent with the monthly extremes and or the mean number of days statistics. For example, a high daily extreme value may not be reflected in the highest monthly value or the mean number of days threshold that is less than and equal to the extreme value. Some of these difference are caused by different periods of record. Daily extremes are derived from the station's entire period of record while the serial data and normals data were are for the 1971-2000 period. Therefore extremes observed before 1971 would not be included in the 1971-2000 normals or the 1971-2000 serial daily data set. Inconsistencies can also occur when monthly values are adjusted to reflect the current observing conditions or were replaced during the 1971-2000 Monthly Normals processing and are not reconciled with the Summary of the Day data.

a. Temperature/ Precipitation Tables
1. 1971-2000 Monthly Normals
2. Cooperative Summary of the Day
3. National Weather Service station records
4. 1971-2000 serially complete daily data

b. Degree Day Table
1. Monthly and Annual Heating and Cooling Degree Days Normals to Selected Bases derived from 1971-2000 Monthly Normals
2. Daily Normal Growing Degree Units to Selected Base Temperatures derived from 1971-2000 serially complete daily data

c. Snow Tables
1. Snow Climatology
2. Cooperative Summary of the Day

d. Freeze Data Table
1971-2000 serially complete daily data

References

U.S. Climate Normals 1971-2000, www.ncdc.noaa.gov/normals.html

U.S. Climate Normals 1971-2000-Products Clim20, www.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html

Snow Climatology Project Description, www.ncdc.noaa.gov/oa/climate/monitoring/snowclim/mainpage.html

Eischeid, J. K., P. Pasteris, H. F. Diaz, M. Plantico, and N. Lott, 2000: Creating a serially complete, national daily time series of temperature and precipitation for the Western United States. J. Appl. Meteorol., 39, 1580-1591,
www1.ncdc.noaa.gov/pub/data/special/ serialcomplete_jam_0900.pdf

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEXARKANA, TX **COOP ID: 418942**

Climate Division: TX 4 **NWS Call Sign:** **Elevation: 390 Feet** **Lat: 33˚25N** **Lon: 94˚05W**

Temperature (˚F)

	Mean (1)			Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	52.5	30.7	41.6	81	1997	5	48.8	1990	3	1982	11	30.8	1979	726	0	.0	.0	18.7	1.6	17.6	.0
Feb	58.3	34.3	46.3	90	1986	27	54.0	1999	8	1981	11	34.1	1978	531	6	.0	@	21.5	.9	11.0	.0
Mar	66.5	41.8	54.2	89	1995	23	59.8	1985	15	1980	2	48.0	1980	347	11	.0	.0	29.1	.1	3.7	.0
Apr	74.6	50.0	62.3	95	1987	20	66.6	1999	28	1975	3	58.1	1997	128	47	.0	.4	29.9	.0	.5	.0
May	81.6	60.4	71.0	98	1998	31	75.9	1987	40	1970	1	66.0	1981	23	209	.0	2.8	31.0	.0	.0	.0
Jun	88.9	68.3	78.6	101+	1998	20	83.5	1998	52	1970	3	74.3	1974	0	408	.3	15.6	30.0	.0	.0	.0
Jul	93.1	72.0	82.6	105+	1998	31	88.6	1998	57+	1972	6	80.0+	1989	0	543	3.1	24.9	31.0	.0	.0	.0
Aug	93.1	70.5	81.8	106	2000	31	86.8	2000	55+	1986	30	77.5	1992	0	520	3.6	24.6	31.0	.0	.0	.0
Sep	86.3	63.6	75.0	108	2000	1	80.5	1998	38	1984	30	67.7	1974	8	306	.6	12.4	30.0	.0	.0	.0
Oct	76.5	51.7	64.1	95	1969	5	68.1	1971	27	1993	30	56.6	1976	103	76	.0	1.1	30.9	.0	.3	.0
Nov	63.9	41.1	52.5	86	1972	1	58.8+	1990	16	1976	29	45.0	1976	385	11	.0	.0	27.2	@	5.0	.0
Dec	55.1	33.5	44.3	80+	1998	6	53.9	1984	-6+	1989	24	33.1	1983	642	1	.0	.0	21.9	.9	13.5	.1
Ann	74.2	51.5	62.9	108	Sep 2000	1	88.6	Jul 1998	-6+	Dec 1989	24	30.8	Jan 1979	2893	2138	7.6	81.8	332.2	3.5	51.6	.1

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1968-2001

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEXARKANA, TX **COOP ID: 418942**

Climate Division: TX 4 **NWS Call Sign:** **Elevation: 390 Feet** **Lat: 33˚25N** **Lon: 94˚05W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	3.91	3.64	2.50	1990	17	8.25	1998	.10	1986	10.3	6.5	2.6	1.1	.76	1.12	1.69	2.22	2.75	3.33	3.98	4.76	5.80	7.47	9.06
Feb	3.80	3.38	4.02	2001	16	8.62	1989	.61	1999	8.8	5.7	2.8	1.2	1.08	1.44	1.98	2.46	2.92	3.41	3.94	4.57	5.39	6.68	7.88
Mar	4.46	4.36	5.45	1989	28	9.79	1973	.67	1974	9.5	6.2	3.1	1.2	1.25	1.67	2.31	2.87	3.42	3.99	4.62	5.37	6.34	7.86	9.28
Apr	4.23	3.86	3.86	1985	22	9.85	1991	.53	1987	8.6	6.0	2.6	1.1	.98	1.38	2.00	2.55	3.10	3.69	4.35	5.13	6.16	7.79	9.33
May	4.97	4.66	3.75	1975	3	11.97	1981	.43	1988	10.2	6.7	3.4	1.7	1.16	1.62	2.35	3.00	3.65	4.34	5.11	6.03	7.23	9.15	10.95
Jun	4.82	4.96	5.07	1976	18	10.46	1982	.50	1988	8.1	5.9	3.0	1.5	.72	1.12	1.82	2.48	3.18	3.94	4.81	5.89	7.32	9.67	11.92
Jul	3.62	3.50	4.39	1984	4	8.29	1971	.28	2000	7.4	5.1	2.3	1.1	.65	.97	1.50	1.99	2.49	3.04	3.66	4.41	5.41	7.02	8.56
Aug	2.41	2.08	4.25	1970	19	9.57	1996	.05	1985	6.5	4.2	1.8	.5	.19	.35	.66	1.00	1.37	1.79	2.29	2.93	3.82	5.30	6.77
Sep	3.77	3.00	3.60	1980	29	9.99	1986	.41	1994	7.5	4.8	2.5	1.4	.45	.75	1.28	1.80	2.36	2.98	3.71	4.61	5.83	7.84	9.79
Oct	4.61	3.99	4.95	1996	22	13.05	1984	.77	1977	7.8	5.6	2.9	1.4	.84	1.25	1.93	2.56	3.20	3.89	4.67	5.62	6.89	8.92	10.86
Nov	5.69	4.99	5.30	1994	5	15.13	2000	.78	1999	10.0	6.6	3.5	1.9	1.16	1.68	2.52	3.28	4.05	4.87	5.80	6.92	8.40	10.76	13.00
Dec	4.95	4.62	5.15	1985	10	14.86	1987	.58	1981	10.2	6.4	3.3	1.6	1.35	1.82	2.54	3.16	3.77	4.41	5.12	5.97	7.06	8.78	10.38
Ann	51.24	51.47	5.45	Mar 1989	28	15.13	Nov 2000	.05	Aug 1985	104.9	69.7	33.8	15.7	37.28	40.01	43.49	46.12	48.46	50.71	53.03	55.59	58.69	63.17	67.04

\+ Also occurred on an earlier date(s)
\# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
****** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1968-2001
(3) Derived from 1971-2000 serially complete daily data
Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEXARKANA, TX **COOP ID: 418942**

Climate Division: TX 4 **NWS Call Sign:** **Elevation: 390 Feet** **Lat: 33˚25N** **Lon: 94˚05W**

Snow (inches)

	Snow Totals														Mean Number of Days (1)								
	Means/Medians (1)				Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	.5	.0	#	0	3.0	1997	7	3.8	1997	8	2000	31	1	2000	.2	.2	.1	.0	.0	.1	.0	.0	.0
Feb	.4	.0	#	0	2.0	1997	13	2.0	1997	5	1985	1	#+	1997	.4	.2	.0	.0	.0	.2	.0	.0	.0
Mar	.1	.0	#	0	.5	1971	3	.5+	1987	1	1971	3	#	1971	.1	.0	.0	.0	.0	@	.0	.0	.0
Apr	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
May	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jun	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Oct	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Nov	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Dec	.1	.0	#	0	2.0	2000	13	2.0+	2000	2	2000	13	#+	2000	.2	.1	.0	.0	.0	.0	.0	.0	.0
Ann	1.1	.0	N/A	N/A	3.0	Jan 1997	7	3.8	Jan 1997	8	Jan 2000	31	1	Jan 2000	.9	.5	.1	.0	.0	.3	.0	.0	.0

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEXARKANA, TX **COOP ID: 418942**

Climate Division: TX 4 **NWS Call Sign:** **Elevation: 390 Feet** **Lat: 33°25N** **Lon: 94°05W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	4/14	4/09	4/06	4/03	3/31	3/28	3/25	3/21	3/16
32	4/10	4/03	3/29	3/24	3/20	3/16	3/12	3/06	2/27
28	3/25	3/16	3/10	3/05	2/28	2/23	2/17	2/11	2/02
24	3/10	3/01	2/22	2/17	2/11	2/06	1/31	1/25	1/16
20	2/22	2/13	2/07	2/01	1/26	1/20	1/12	12/29	0/00
16	2/13	2/04	1/28	1/21	1/13	1/03	0/00	0/00	0/00

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	10/20	10/25	10/29	11/02	11/05	11/08	11/11	11/15	11/20
32	10/27	11/02	11/07	11/10	11/14	11/18	11/22	11/26	12/03
28	11/10	11/17	11/22	11/26	11/30	12/04	12/09	12/14	12/21
24	11/17	11/28	12/06	12/13	12/19	12/25	1/01	1/09	1/20
20	12/04	12/12	12/18	12/24	12/29	1/04	1/11	1/24	0/00
16	12/17	12/27	1/04	1/11	1/20	2/05	0/00	0/00	0/00

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	240	232	227	222	218	214	209	204	196
32	269	258	251	244	238	232	226	218	208
28	307	296	288	281	275	269	262	254	243
24	353	333	322	314	306	299	291	282	270
20	>365	>365	>365	>365	340	328	318	309	297
16	>365	>365	>365	>365	>365	>365	356	341	327

***** Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: TEXARKANA, TX **COOP ID: 418942**

Climate Division: TX 4 **NWS Call Sign:** **Elevation: 390 Feet** **Lat: 33°25N** **Lon: 94°05W**

Degree Days to Selected Base Temperatures (°F)

Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	726	531	347	128	23	0	0	0	8	103	385	642	2893
60	581	401	219	52	5	0	0	0	1	40	258	497	2054
57	495	329	157	25	1	0	0	0	0	19	194	412	1632
55	440	285	123	14	0	0	0	0	0	11	157	359	1389
50	314	191	58	2	0	0	0	0	0	2	84	242	893
32	45	17	0	0	0	0	0	0	0	0	1	22	85

Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	342	416	687	909	1209	1398	1566	1543	1288	996	617	404	11375
55	24	40	97	233	496	708	853	830	598	294	83	28	4284
57	18	29	69	184	435	648	791	768	538	240	59	19	3798
60	11	17	37	121	346	558	698	675	449	168	33	11	3124
65	0	6	11	47	209	408	543	520	306	76	11	1	2138
70	0	0	0	12	104	262	388	368	183	25	1	0	1343

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	177	268	484	698	977	1175	1332	1315	1068	776	415	223	177	445	929	1627	2604	3779	5111	6426	7494	8270	8685	8908
45	93	170	340	549	822	1025	1177	1160	918	621	287	127	93	263	603	1152	1974	2999	4176	5336	6254	6875	7162	7289
50	46	92	220	403	667	875	1022	1005	768	470	177	63	46	138	358	761	1428	2303	3325	4330	5098	5568	5745	5808
55	19	42	124	267	512	725	867	850	618	323	97	31	19	61	185	452	964	1689	2556	3406	4024	4347	4444	4475
60	2	14	56	153	358	575	712	695	470	196	43	8	2	16	72	225	583	1158	1870	2565	3035	3231	3274	3282
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	115	173	303	443	660	815	905	886	721	494	255	142	115	288	591	1034	1694	2509	3414	4300	5021	5515	5770	5912

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Notes

a. The monthly means are simple arithmetic averages computed by summing the monthly values for the period 1971-2000 and dividing by thirty. Prior to averaging, the data are adjusted if necessary to compensate for data quality issues, station moves or changes in station reporting practices. Missing months are replaced by estimates based on neighboring stations.

b. The median is defined as the middle value in an ordered set of values. The median is being provided for the snow and precipitation elements because the mean can be a misleading value for precipitation normals.

c. Only observed validated values were used to select the extreme daily values.

d. Extreme monthly temperature/precipitation means were selected from the monthly normals data. Monthly snow extremes were calculated from daily values quality controlled to be consistent with the Snow Climatology.

e. Degree Days were derived using the same techniques as the 1971-2000 normals. Compete documentation for the 1971-2000 Normals is available on the internet from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

f. Mean "number of days statistics" for temperature and precipitation were calculated from a serially complete daily data set . Documentation of the serially complete data set is available from the link below:

g. Snowfall and snow depth statistics were derived from the Snow Climatology. Documentation for the Snow Climatology project is available from the link under references.

Data Sources for Tables

Several different data sources were used to create the Clim20 climate summaries. In some cases the daily extremes appear inconsistent with the monthly extremes and or the mean number of days statistics. For example, a high daily extreme value may not be reflected in the highest monthly value or the mean number of days threshold that is less than and equal to the extreme value. Some of these difference are caused by different periods of record. Daily extremes are derived from the station's entire period of record while the serial data and normals data were are for the 1971-2000 period. Therefore extremes observed before 1971 would not be included in the 1971-2000 normals or the 1971-2000 serial daily data set. Inconsistencies can also occur when monthly values are adjusted to reflect the current observing conditions or were replaced during the 1971-2000 Monthly Normals processing and are not reconciled with the Summary of the Day data.

a. Temperature/ Precipitation Tables
   1. 1971-2000 Monthly Normals
   2. Cooperative Summary of the Day
   3. National Weather Service station records
   4. 1971-2000 serially complete daily data

b. Degree Day Table
   1. Monthly and Annual Heating and Cooling Degree Days Normals to Selected Bases derived from 1971-2000 Monthly Normals
   2. Daily Normal Growing Degree Units to Selected Base Temperatures derived from 1971-2000 serially complete daily data

c. Snow Tables
   1. Snow Climatology
   2. Cooperative Summary of the Day

d. Freeze Data Table
   1971-2000 serially complete daily data

References

U.S. Climate Normals 1971-2000, www.ncdc.noaa.gov/normals.html

U.S. Climate Normals 1971-2000-Products Clim20, www.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html

Snow Climatology Project Description, www.ncdc.noaa.gov/oa/climate/monitoring/snowclim/mainpage.html

Eischeid, J. K., P. Pasteris, H. F. Diaz, M. Plantico, and N. Lott, 2000: Creating a serially complete, national daily time series of temperature and precipitation for the Western United States. J. Appl. Meteorol., 39, 1580-1591, www1.ncdc.noaa.gov/pub/data/special/ serialcomplete_jam_0900.pdf

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: WICHITA FALLS SHEPPRD AP, TX **COOP ID: 419729**

Climate Division: TX 2 **NWS Call Sign: SPS** **Elevation: 1,030 Feet** **Lat: 33˚59N** **Lon: 98˚30W**

Temperature (˚F)

Mean (1)				Extremes										Degree Days (1) Base Temp 65		Mean Number of Days (3)					
Month	Daily Max	Daily Min	Mean	Highest Daily(2)	Year	Day	Highest Month(1) Mean	Year	Lowest Daily(2)	Year	Day	Lowest Month(1) Mean	Year	Heating	Cooling	Max >= 100	Max >= 90	Max >= 50	Max <= 32	Min <= 32	Min <= 0
Jan	52.1	28.9	40.5	89+	1943	24	47.9	1990	-12	1947	4	29.8	1978	762	0	.0	.0	18.3	3.1	20.5	@
Feb	58.1	33.4	45.7	93	1996	22	55.0	1976	-8	1985	2	32.9	1978	550	2	.0	.1	20.7	1.8	12.8	@
Mar	67.2	41.1	54.2	100	1971	27	60.3	1974	6	1948	11	49.9	1980	354	19	@	.7	28.3	.1	5.5	.0
Apr	75.5	49.3	62.4	102	1972	12	68.3	1981	24	1975	3	57.4	1973	140	66	@	1.9	29.9	.0	.7	.0
May	83.5	59.3	71.4	110+	2000	24	79.0	1996	36+	1979	12	67.1	1976	23	220	.8	7.9	31.0	.0	.0	.0
Jun	91.7	67.8	79.7	117	1980	28	84.8	1980	50	1928	5	75.7	1983	0	448	3.5	19.9	30.0	.0	.0	.0
Jul	97.2	72.4	84.8	114+	1980	3	91.9	1980	54+	1970	23	80.2	1976	0	618	12.0	28.0	31.0	.0	.0	.0
Aug	95.8	71.3	83.5	113+	1964	6	90.3	2000	53	1992	28	78.9	1992	0	574	11.2	26.5	31.0	.0	.0	.0
Sep	87.5	63.7	75.6	111	2000	4	83.4	1998	38+	1989	24	67.3	1974	18	339	2.5	15.1	30.0	.0	.0	.0
Oct	77.1	52.4	64.7	102+	2000	3	68.6	1979	21	1993	31	57.0	1976	106	99	.2	3.3	30.8	.0	.4	.0
Nov	63.7	40.1	51.9	89+	1988	9	59.0	1999	14	1950	24	45.5	1972	395	10	.0	.0	25.9	.1	6.6	.0
Dec	54.5	31.3	42.9	88	1954	4	46.8	1999	-7	1989	23	30.5	1983	676	1	.0	.0	20.8	1.7	17.2	.1
Ann	75.3	50.9	63.1	117	Jun 1980	28	91.9	Jul 1980	-12	Jan 1947	4	29.8	Jan 1978	3024	2396	30.2	103.4	327.7	6.8	63.7	.1

+ Also occurred on an earlier date(s)

@ Denotes mean number of days greater than 0 but less than .05

Complete documentation available from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

(1) From the 1971-2000 Monthly Normals

(2) Derived from station's available digital record: 1897-2001

(3) Derived from 1971-2000 serially complete daily data

Issue Date: February 2004

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: WICHITA FALLS SHEPPRD AP, TX **COOP ID: 419729**

Climate Division: TX 2 **NWS Call Sign: SPS** **Elevation: 1,030 Feet** **Lat: 33˚59N** **Lon: 98˚30W**

Precipitation (inches)

	Precipitation Totals									Mean Number of Days (3)				Precipitation Probabilities (1) Probability that the monthly/annual precipitation will be equal to or less than the indicated amount										
	Means/ Medians(1)		Extremes							Daily Precipitation				Monthly/Annual Precipitation vs Probability Levels These values were determined from the incomplete gamma distribution										
Month	Mean	Med-ian	Highest Daily(2)	Year	Day	Highest Monthly(1)	Year	Lowest Monthly(1)	Year	>= 0.01	>= 0.10	>= 0.50	>= 1.00	.05	.10	.20	.30	.40	.50	.60	.70	.80	.90	.95
Jan	1.12	1.06	2.25	1919	22	2.74	1973	.00+	1986	4.9	2.3	.8	.2	.00	.08	.27	.44	.63	.84	1.08	1.39	1.81	2.51	3.20
Feb	1.58	1.18	2.97	1938	15	4.55	1990	.00+	1996	5.1	3.2	1.0	.4	.00	.14	.41	.66	.92	1.21	1.55	1.96	2.52	3.46	4.37
Mar	2.27	1.90	3.60	1988	1	6.29	1999	.12	1971	6.4	3.8	1.4	.5	.32	.51	.84	1.15	1.48	1.84	2.26	2.78	3.47	4.60	5.68
Apr	2.62	2.45	3.87	1967	12	6.95	1990	.08	1996	6.5	4.4	1.8	.7	.25	.44	.80	1.16	1.56	2.00	2.53	3.19	4.09	5.60	7.07
May	3.92	3.55	5.12	1975	22	13.22	1982	.18	1996	8.6	5.5	2.5	1.1	.40	.69	1.22	1.77	2.36	3.02	3.81	4.78	6.12	8.33	10.50
Jun	3.69	2.93	5.36	1985	5	8.60	1989	.26	1980	7.2	4.4	2.3	1.2	.70	1.03	1.57	2.07	2.58	3.13	3.75	4.50	5.50	7.10	8.62
Jul	1.58	1.40	3.10	1914	2	4.51	1973	.00	1999	4.7	2.9	1.1	.5	.05	.17	.38	.61	.86	1.15	1.50	1.94	2.54	3.56	4.56
Aug	2.39	2.09	4.52	1971	15	7.61	1971	.00	2000	6.3	4.0	1.4	.6	.08	.26	.59	.93	1.31	1.75	2.27	2.92	3.83	5.35	6.84
Sep	3.19	2.11	6.19	1980	27	10.23	1980	.00	1983	6.4	4.0	2.0	1.0	.05	.22	.60	1.04	1.55	2.15	2.89	3.85	5.21	7.54	9.87
Oct	3.11	2.22	4.00	1900	28	7.86	1972	.11	1987	7.0	4.3	2.4	1.0	.30	.53	.95	1.38	1.85	2.38	3.01	3.79	4.86	6.64	8.38
Nov	1.68	1.44	3.15	1902	2	5.16	2000	.00	1999	5.5	3.2	1.1	.5	.06	.19	.43	.67	.94	1.24	1.61	2.06	2.69	3.74	4.77
Dec	1.68	.99	3.12	1926	6	6.93	1991	.00	1996	5.1	2.8	1.2	.5	.03	.13	.33	.57	.83	1.15	1.54	2.04	2.74	3.94	5.14
Ann	28.83	29.15	6.19	Sep 1980	27	13.22	May 1982	.00+	Aug 2000	73.7	44.8	19.0	8.2	20.58	22.18	24.23	25.78	27.16	28.49	29.87	31.39	33.23	35.90	38.21

+ Also occurred on an earlier date(s)
# Denotes amounts of a trace
@ Denotes mean number of days greater than 0 but less than .05
****** Statistics not computed because less than six years out of thirty had measurable precipitation

(1) From the 1971-2000 Monthly Normals
(2) Derived from station's available digital record: 1897-2001
(3) Derived from 1971-2000 serially complete daily data
Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Services

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: WICHITA FALLS SHEPPRD AP, TX **COOP ID: 419729**

Climate Division: TX 2 **NWS Call Sign: SPS** **Elevation: 1,030 Feet** **Lat: 33˚59N** **Lon: 98˚30W**

Snow (inches)

	Snow Totals														Mean Number of Days (1)								
	Means/Medians (1)				Extremes (2)										Snow Fall >= Thresholds					Snow Depth >= Thresholds			
Month	Snow Fall Mean	Snow Fall Median	Snow Depth Mean	Snow Depth Median	Highest Daily Snow Fall	Year	Day	Highest Monthly Snow Fall	Year	Highest Daily Snow Depth	Year	Day	Highest Monthly Mean Snow Depth	Year	0.1	1.0	3.0	5.0	10.0	1	3	5	10
Jan	2.3	.4	#	0	8.1	1985	31	8.7	1985	5+	1992	19	1+	1988	1.1	.7	.3	.1	.0	1.9	.5	.2	.0
Feb	1.2	.0	#	0	4.2	1978	17	11.8	1978	8	1985	1	1+	1985	.8	.5	.1	.0	.0	1.2	.5	.2	.0
Mar	.6	.0	#	0	9.7	1989	5	10.9	1989	10	1989	6	1	1989	.2	.1	.1	@	.0	.2	.1	@	@
Apr	.0	.0	0	0	.8	1973	8	.8	1973	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
May	.0	.0	#	0	.0	0	0	.0	0	0	0	0	#	1992	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jun	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Jul	.0	.0	#	0	.0	0	0	.0	0	0	0	0	#	1993	.0	.0	.0	.0	.0	.0	.0	.0	.0
Aug	.0	.0	#	0	.0	0	0	.0	0	0	0	0	#	1997	.0	.0	.0	.0	.0	.0	.0	.0	.0
Sep	.0	.0	0	0	.0	0	0	.0	0	0	0	0	0	0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Oct	.0	.0	#	0	1.0	1993	30	1.0	1993	1	1993	30	#	1993	.0	.0	.0	.0	.0	@	.0	.0	.0
Nov	.4	.0	#	0	3.0	1976	13	3.7	1976	4	1976	14	#	1980	.3	.1	@	.0	.0	.2	@	.0	.0
Dec	1.0	.0	#	0	5.6	1983	15	7.1	1983	2	1978	31	#	1990	.8	.3	.1	@	.0	.3	.0	.0	.0
Ann	5.5	.4	N/A	N/A	9.7	Mar 1989	5	11.8	Feb 1978	10	Mar 1989	6	1+	Mar 1989	3.2	1.7	.6	.1	.0	3.8	1.1	.4	.0

+ Also occurred on an earlier date(s) #Denotes trace amounts

@ Denotes mean number of days greater than 0 but less than .05

-9/-9.9 represents missing values
Annual statistics for Mean/Median snow depths are not appropriate

(1) Derived from Snow Climatology and 1971-2000 daily data

(2) Derived from 1971-2000 daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: WICHITA FALLS SHEPPRD AP, TX

COOP ID: 419729

Climate Division: TX 2 **NWS Call Sign: SPS** **Elevation: 1,030 Feet** **Lat: 33˚59N** **Lon: 98˚30W**

Freeze Data

Spring Freeze Dates (Month/Day)

Temp (F)	Probability of later date in spring (thru Jul 31) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	4/19	4/15	4/12	4/10	4/07	4/05	4/02	3/30	3/26
32	4/12	4/07	4/03	3/31	3/28	3/25	3/22	3/19	3/14
28	4/02	3/26	3/20	3/15	3/11	3/07	3/02	2/24	2/17
24	3/22	3/13	3/07	3/02	2/25	2/20	2/15	2/09	2/01
20	3/09	2/28	2/21	2/16	2/11	2/05	1/30	1/23	1/13
16	3/01	2/19	2/11	2/04	1/29	1/22	1/13	12/27	0/00

Fall Freeze Dates (Month/Day)

Temp (F)	Probability of earlier date in fall (beginning Aug 1) than indicated(*)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	10/18	10/23	10/27	10/30	11/01	11/04	11/07	11/10	11/15
32	10/23	10/29	11/02	11/06	11/09	11/13	11/16	11/21	11/27
28	11/04	11/10	11/14	11/18	11/22	11/25	11/29	12/03	12/10
24	11/12	11/20	11/25	11/30	12/04	12/08	12/12	12/18	12/25
20	11/19	11/27	12/03	12/09	12/14	12/19	12/24	12/31	1/10
16	11/29	12/11	12/20	12/28	1/05	1/14	1/26	0/00	0/00

Freeze Free Period

Temp (F)	Probability of longer than indicated freeze free period (Days)								
	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	226	219	215	211	207	204	200	195	189
32	247	239	234	229	225	221	217	211	204
28	282	272	266	260	255	250	244	237	228
24	310	300	293	287	281	275	269	262	252
20	>365	324	315	308	302	296	290	284	274
16	>365	>365	>365	>365	348	333	320	308	292

***** Probability of observing a temperature as cold, or colder, later in the spring or earlier in the fall than the indicated date.

0/00 Indicates that the probability of occurrence of threshold temperature is less than the indicated probability.

Derived from 1971-2000 serially complete daily data

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data,
and Information Service

Climatography of the United States No. 20 1971-2000

National Climatic Data Center
Federal Building
151 Patton Avenue
Asheville, North Carolina 28801
www.ncdc.noaa.gov

Station: WICHITA FALLS SHEPPRD AP, TX **COOP ID: 419729**

Climate Division: TX 2 **NWS Call Sign: SPS** **Elevation: 1,030 Feet** **Lat: 33˚59N** **Lon: 98˚30W**

Degree Days to Selected Base Temperatures (˚F)

Base	Heating Degree Days (1)												
Below	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
65	762	550	354	140	23	0	0	0	18	106	395	676	3024
60	609	419	203	54	7	0	0	0	2	32	267	534	2127
57	523	347	138	26	2	0	0	0	0	14	199	448	1697
55	466	303	103	14	1	0	0	0	0	7	160	392	1446
50	333	209	42	2	0	0	0	0	0	1	84	264	935
32	44	23	0	0	0	0	0	0	0	0	1	22	90

Base	Cooling Degree Days (1)												
Above	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
32	310	411	693	916	1225	1437	1643	1604	1314	1019	600	369	11541
55	9	33	110	253	513	747	930	891	626	326	79	15	4532
57	5	23	83	206	452	687	868	829	567	273	58	9	4060
60	2	11	51	143	363	597	775	736	481	200	33	4	3396
65	0	2	19	66	220	448	618	574	339	99	10	1	2396
70	0	0	5	23	114	299	465	427	218	39	1	0	1591

Growing Degree Units (2)

Base	Growing Degree Units (Monthly)												Growing Degree Units (Accumulated Monthly)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
40	150	247	466	683	987	1207	1401	1365	1082	781	383	184	150	397	863	1546	2533	3740	5141	6506	7588	8369	8752	8936
45	78	154	327	534	832	1057	1246	1210	932	628	258	95	78	232	559	1093	1925	2982	4228	5438	6370	6998	7256	7351
50	31	83	209	390	677	907	1091	1055	782	475	155	45	31	114	323	713	1390	2297	3388	4443	5225	5700	5855	5900
55	9	43	115	260	523	757	936	900	633	335	84	17	9	52	167	427	950	1707	2643	3543	4176	4511	4595	4612
60	1	14	55	152	373	607	781	745	488	207	37	2	1	15	70	222	595	1202	1983	2728	3216	3423	3460	3462
Base	Growing Degree Units for Corn (Monthly)												Growing Degree Units for Corn (Accumulated Monthly)											
50/86	114	176	295	434	647	805	913	894	711	497	241	133	114	290	585	1019	1666	2471	3384	4278	4989	5486	5727	5860

(1) Derived from the 1971-2000 Monthly Normals
(2) Derived from 1971-2000 serially complete daily data
Note: For corn, temperatures below 50 are set to 50, and temperatures above 86 are set to 86

Complete documentation available from:
www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

Notes

a. The monthly means are simple arithmetic averages computed by summing the monthly values for the period 1971-2000 and dividing by thirty. Prior to averaging, the data are adjusted if necessary to compensate for data quality issues, station moves or changes in station reporting practices. Missing months are replaced by estimates based on neighboring stations.

b. The median is defined as the middle value in an ordered set of values. The median is being provided for the snow and precipitation elements because the mean can be a misleading value for precipitation normals.

c. Only observed validated values were used to select the extreme daily values.

d. Extreme monthly temperature/precipitation means were selected from the monthly normals data. Monthly snow extremes were calculated from daily values quality controlled to be consistent with the Snow Climatology.

e. Degree Days were derived using the same techniques as the 1971-2000 normals. Compete documentation for the 1971-2000 Normals is available on the internet from: www.ncdc.noaa.gov/oa/climate/normals/usnormals.html

f. Mean "number of days statistics" for temperature and precipitation were calculated from a serially complete daily data set . Documentation of the serially complete data set is available from the link below:

g. Snowfall and snow depth statistics were derived from the Snow Climatology. Documentation for the Snow Climatology project is available from the link under references.

Data Sources for Tables

Several different data sources were used to create the Clim20 climate summaries. In some cases the daily extremes appear inconsistent with the monthly extremes and or the mean number of days statistics. For example, a high daily extreme value may not be reflected in the highest monthly value or the mean number of days threshold that is less than and equal to the extreme value. Some of these difference are caused by different periods of record. Daily extremes are derived from the station's entire period of record while the serial data and normals data were are for the 1971-2000 period. Therefore extremes observed before 1971 would not be included in the 1971-2000 normals or the 1971-2000 serial daily data set. Inconsistencies can also occur when monthly values are adjusted to reflect the current observing conditions or were replaced during the 1971-2000 Monthly Normals processing and are not reconciled with the Summary of the Day data.

a. Temperature/ Precipitation Tables
   1. 1971-2000 Monthly Normals
   2. Cooperative Summary of the Day
   3. National Weather Service station records
   4. 1971-2000 serially complete daily data

b. Degree Day Table
   1. Monthly and Annual Heating and Cooling Degree Days Normals to Selected Bases derived from 1971-2000 Monthly Normals
   2. Daily Normal Growing Degree Units to Selected Base Temperatures derived from 1971-2000 serially complete daily data

c. Snow Tables
   1. Snow Climatology
   2. Cooperative Summary of the Day

d. Freeze Data Table
   1971-2000 serially complete daily data

References

U.S. Climate Normals 1971-2000, www.ncdc.noaa.gov/normals.html

U.S. Climate Normals 1971-2000-Products Clim20, www.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html

Snow Climatology Project Description, www.ncdc.noaa.gov/oa/climate/monitoring/snowclim/mainpage.html

Eischeid, J. K., P. Pasteris, H. F. Diaz, M. Plantico, and N. Lott, 2000: Creating a serially complete, national daily time series of temperature and precipitation for the Western United States. J. Appl. Meteorol., 39, 1580-1591,
www1.ncdc.noaa.gov/pub/data/special/ serialcomplete_jam_0900.pdf

Freeze / Frost Occurrence Data

All probabilities in whole percent. See notes for probability level description.

- Indicates the probability of occurrence of threshold temperature is less than indicated probability.

State And Station Name	Threshold (F)	Spring (Date) Probability Level (1)			Fall (Date) Probability Level (2)			Freeze Free Period (Days) Probability Level (3)			Probability Level (4)
Texas		90	50	10	10	50	90	10	50	90	
ABILENE MUNICIPAL AP	36	Mar22	Apr05	Apr19	Oct20	Nov04	Nov18	232	212	193	20
	32	Mar07	Mar24	Apr10	Oct26	Nov12	Nov28	253	232	210	14
	28	Feb16	Mar10	Apr02	Nov03	Nov22	Dec11	285	256	227	8
ALBANY	36	Mar19	Apr07	Apr25	Oct10	Oct27	Nov13	230	203	175	23
	32	Mar11	Mar28	Apr13	Oct20	Nov06	Nov23	246	222	199	16
	28	Feb22	Mar14	Apr03	Oct30	Nov17	Dec04	272	247	222	10
ALICE	36	Jan21	Feb19	Mar20	Nov15	Dec04	Dec23	322	287	252	5
	32	Dec06	Jan29	Mar13	Nov19	Dec15	Jan19	>365	320	278	2
	28	-	Jan15	Feb19	Nov28	Jan07	-	>365	350	312	1
ALPINE	36	Apr08	Apr21	May04	Oct02	Oct21	Nov08	204	182	160	24
	32	Mar23	Apr08	Apr23	Oct12	Nov01	Nov22	232	207	182	17
	28	Mar06	Mar25	Apr13	Oct25	Nov14	Dec04	260	233	206	11
ALVIN	36	Feb08	Mar05	Mar29	Nov01	Nov23	Dec15	296	263	229	7
	32	Jan10	Feb15	Mar20	Nov19	Dec09	Jan01	349	297	257	4
	28	Dec14	Jan27	Mar02	Nov29	Dec31	-	>365	334	295	1
AMARILLO INTL AP	36	Apr11	Apr26	May12	Sep27	Oct12	Oct27	187	168	148	39
	32	Apr05	Apr18	May01	Oct03	Oct20	Nov07	206	185	163	31
	28	Mar20	Apr02	Apr15	Oct20	Nov03	Nov17	233	214	195	23
AMISTAD DAM	36	Feb11	Mar06	Mar30	Nov05	Nov22	Dec09	290	260	230	9
	32	Jan08	Feb10	Mar12	Nov14	Dec06	Dec30	>365	297	263	5
	28	-	Jan27	Feb25	Dec04	Dec31	-	>365	339	293	2
ANAHUAC	36	Feb12	Mar04	Mar25	Nov02	Nov23	Dec13	289	263	236	7
	32	Jan11	Feb12	Mar16	Nov15	Dec09	Jan03	338	299	263	4
	28	-	Jan25	Mar01	Nov27	Dec23	-	>365	332	292	2
ANDREWS	36	Mar27	Apr08	Apr21	Oct15	Oct31	Nov15	221	204	188	23
	32	Mar09	Mar29	Apr17	Oct25	Nov10	Nov27	251	226	201	16
	28	Feb19	Mar15	Apr09	Nov03	Nov18	Dec04	276	248	219	10
ANGLETON 2 W	36	Feb09	Mar09	Apr05	Nov02	Nov21	Dec10	293	257	220	8
	32	Jan04	Feb15	Mar26	Nov13	Dec05	Dec29	>365	290	252	4
	28	-	Jan30	Mar12	Nov27	Dec22	-	>365	326	278	2
ANSON	36	Mar23	Apr03	Apr14	Oct16	Nov03	Nov22	234	214	193	20
	32	Mar13	Mar28	Apr12	Oct23	Nov12	Dec01	253	228	204	14
	28	Feb15	Mar10	Apr03	Oct30	Nov20	Dec10	281	254	226	8
ARANSAS WILDLIFE REF	36	Jan31	Feb26	Mar23	Nov08	Nov28	Dec18	305	275	244	4
	32	Dec30	Feb02	Mar07	Nov20	Dec09	Dec28	349	309	272	2
	28	-	Jan17	Feb25	Nov28	Jan03	-	>365	345	304	1
ARCHER CITY	36	Mar27	Apr06	Apr16	Oct10	Oct29	Nov16	227	205	183	24
	32	Mar16	Mar28	Apr09	Oct22	Nov09	Nov28	247	225	203	17
	28	Feb20	Mar14	Apr05	Nov07	Nov22	Dec07	279	252	225	11
ASPERMONT	36	Mar27	Apr11	Apr27	Oct02	Oct22	Nov11	217	193	169	28
	32	Mar17	Mar30	Apr12	Oct24	Nov08	Nov24	245	223	200	20
	28	Feb26	Mar20	Apr11	Oct29	Nov15	Dec01	268	239	211	13

ATHENS	36	Mar19	Apr02	Apr16	Oct14	Nov02	Nov22	239	214	189	17
	32	Mar01	Mar19	Apr07	Oct23	Nov14	Dec05	267	239	210	11
	28	Feb05	Feb28	Mar23	Oct31	Nov23	Dec17	299	268	236	6
AUSTIN CITY (CAMP MABRY)	36	Feb10	Mar06	Mar29	Nov04	Nov20	Dec06	285	259	232	9
	32	Jan23	Feb17	Mar15	Nov15	Dec06	Dec28	323	291	259	5
	28	Dec27	Feb04	Mar06	Nov28	Dec21	Jan20	>365	319	281	2
BAKERSFIELD	36	Mar14	Apr02	Apr21	Oct15	Nov02	Nov19	240	213	186	19
	32	Mar02	Mar22	Apr11	Oct29	Nov14	Nov30	262	236	211	12
	28	Feb11	Mar09	Apr04	Nov06	Nov24	Dec12	290	260	230	7
BALLINGER 2 NW	36	Mar23	Apr07	Apr22	Oct14	Oct29	Nov13	226	204	182	21
	32	Mar12	Mar28	Apr13	Oct23	Nov09	Nov25	245	225	204	15
	28	Feb19	Mar15	Apr08	Oct31	Nov15	Dec01	274	245	216	10
BALMORHEA	36	Mar27	Apr10	Apr24	Oct12	Oct29	Nov14	221	201	180	27
	32	Mar15	Mar30	Apr14	Oct23	Nov09	Nov25	244	223	202	19
	28	Feb22	Mar16	Apr07	Nov01	Nov17	Dec03	274	245	216	12
BARDWELL DAM	36	Mar10	Mar27	Apr12	Oct24	Nov10	Nov28	252	228	204	19
	32	Feb18	Mar12	Apr04	Oct30	Nov19	Dec09	283	251	220	12
	28	Jan30	Feb24	Mar21	Nov07	Nov28	Dec19	312	276	240	7
BAY CITY WATERWORKS	36	Feb02	Feb27	Mar25	Nov02	Nov24	Dec17	304	269	234	6
	32	Dec29	Feb11	Mar17	Nov17	Dec13	Jan15	>365	306	262	3
	28	-	Jan19	Feb25	Nov29	Dec31	-	>365	350	297	1
BAYTOWN	36	Feb04	Feb27	Mar23	Nov06	Nov27	Dec17	305	272	239	7
	32	Jan06	Feb10	Mar14	Nov19	Dec10	Jan01	>365	301	261	3
	28	-	Jan25	Feb28	Nov21	Dec29	-	>365	335	287	1
BEAUMONT RESEARCH CTR	36	Feb20	Mar11	Mar29	Oct29	Nov17	Dec05	278	250	223	9
	32	Jan30	Feb25	Mar24	Nov11	Dec02	Dec22	311	279	247	5
	28	Dec20	Feb04	Mar12	Nov21	Dec20	Jan25	>365	318	274	2
BEEVILLE 5 NE	36	Feb12	Mar08	Apr02	Nov04	Nov22	Dec10	288	258	228	7
	32	Jan12	Feb14	Mar17	Nov17	Dec06	Dec27	343	294	257	4
	28	-	Jan27	Mar01	Nov22	Dec22	-	>365	329	291	2
BENAVIDES 2	36	Feb10	Mar09	Apr05	Oct31	Nov21	Dec11	288	256	224	7
	32	Jan06	Feb18	Mar29	Nov12	Dec02	Dec23	337	286	246	4
	28	-	Jan30	Mar11	Nov23	Dec19	-	>365	315	275	2
BENBROOK DAM	36	Mar12	Mar27	Apr12	Oct26	Nov08	Nov22	242	225	209	20
	32	Feb20	Mar15	Apr06	Oct30	Nov17	Dec06	275	247	218	13
	28	Jan31	Feb26	Mar24	Nov09	Nov30	Dec22	309	277	244	7
BIG LAKE 2	36	Mar26	Apr09	Apr24	Oct01	Oct25	Nov19	226	198	171	25
	32	Mar17	Apr01	Apr15	Oct17	Nov05	Nov24	242	218	194	18
	28	Mar01	Mar19	Apr07	Oct28	Nov17	Dec06	268	242	215	12
BIG SPRING	36	Mar19	Apr04	Apr20	Oct21	Nov05	Nov21	236	214	192	24
	32	Feb28	Mar23	Apr14	Oct30	Nov13	Nov27	258	235	212	17
	28	Feb19	Mar13	Apr04	Nov07	Nov23	Dec09	284	255	226	10
BLANCO	36	Mar19	Apr04	Apr19	Oct14	Nov01	Nov18	231	210	189	19
	32	Feb24	Mar20	Apr13	Oct24	Nov11	Nov30	265	235	206	13
	28	Feb10	Mar04	Mar26	Oct31	Nov23	Dec16	296	263	231	7
BOERNE	36	Mar17	Apr04	Apr22	Oct12	Oct31	Nov20	236	210	183	19
	32	Feb25	Mar20	Apr11	Oct27	Nov13	Nov30	268	238	207	13
	28	Feb07	Mar04	Mar28	Nov04	Nov24	Dec14	296	264	233	7
BONHAM 3 NNE	36	Mar25	Apr06	Apr17	Oct10	Oct27	Nov13	225	204	183	22
	32	Mar11	Mar27	Apr12	Oct22	Nov08	Nov24	247	225	202	15
	28	Feb18	Mar10	Mar31	Oct30	Nov18	Dec08	283	252	222	9
BOQUILLAS RANGER STN	36	Mar14	Mar29	Apr14	Oct22	Nov08	Nov24	246	223	199	23
	32	Feb24	Mar14	Apr01	Oct27	Nov13	Dec01	267	244	220	15
	28	Jan29	Feb23	Mar21	Nov11	Nov26	Dec10	305	275	244	9
BORGER	36	Apr08	Apr23	May09	Sep28	Oct14	Oct29	196	172	149	35
	32	Mar29	Apr14	Apr29	Oct09	Oct25	Nov10	212	193	175	27
	28	Mar20	Apr02	Apr14	Oct23	Nov05	Nov18	234	216	199	20

BOWIE	36	Mar22	Apr03	Apr15	Oct25	Nov05	Nov17	233	216	199	21
	32	Mar05	Mar21	Apr06	Oct27	Nov12	Nov27	256	235	214	14
	28	Feb13	Mar08	Mar31	Nov02	Nov24	Dec16	293	260	228	9
BOYS RANCH	36	Apr16	Apr29	May12	Sep27	Oct07	Oct17	177	160	143	43
	32	Mar30	Apr13	Apr28	Oct02	Oct16	Oct31	204	186	167	36
	28	Mar23	Apr07	Apr21	Oct14	Oct27	Nov10	222	203	184	29
BRACKETTVILLE	36	Feb21	Mar19	Apr14	Oct14	Nov07	Dec01	268	232	196	13
	32	Feb06	Mar05	Apr01	Oct23	Nov15	Dec08	291	255	218	7
	28	Jan18	Feb14	Mar11	Nov03	Dec12	Jan24	>365	295	258	3
BRADY	36	Mar18	Apr02	Apr16	Oct22	Nov04	Nov18	234	216	198	20
	32	Mar01	Mar21	Apr10	Oct27	Nov11	Nov27	258	235	211	14
	28	Feb04	Mar04	Apr01	Nov03	Nov21	Dec08	293	261	228	8
BRAVO	36	Apr21	May04	May18	Sep24	Oct05	Oct17	173	153	134	44
	32	Apr12	Apr26	May09	Sep30	Oct13	Oct26	188	170	152	36
	28	Mar30	Apr12	Apr25	Oct09	Oct24	Nov09	216	195	174	27
BRECKENRIDGE	36	Mar24	Apr09	Apr24	Oct19	Nov01	Nov15	228	206	184	23
	32	Mar13	Mar29	Apr14	Oct27	Nov10	Nov24	246	226	205	17
	28	Feb16	Mar11	Apr03	Nov05	Nov21	Dec06	282	253	225	10
BRENHAM	36	Feb11	Mar07	Mar31	Oct30	Nov19	Dec09	285	257	228	10
	32	Jan25	Feb20	Mar18	Nov14	Dec05	Dec27	320	288	256	5
	28	Dec22	Jan30	Mar06	Nov28	Dec19	Jan10	>365	322	282	3
BRIDGEPORT	36	Mar26	Apr08	Apr21	Oct07	Oct25	Nov12	223	199	176	24
	32	Mar11	Mar30	Apr18	Oct20	Nov07	Nov25	247	222	197	18
	28	Feb19	Mar15	Apr08	Oct30	Nov17	Dec05	273	246	219	12
BROWNFIELD 2	36	Apr03	Apr15	Apr28	Oct06	Oct22	Nov07	206	189	173	34
	32	Mar20	Apr03	Apr17	Oct16	Nov03	Nov20	233	213	193	25
	28	Mar09	Mar24	Apr08	Oct31	Nov15	Nov30	255	235	215	17
BROWNSVILLE AP	36	-	Jan23	Mar08	Nov26	Dec24	-	>365	337	287	2
	32	-	Dec25	Feb13	Dec11	Jan24	-	>365	>365	313	1
	28	-	-	Jan17	Dec31	-	-	>365	>365	>365	0
BROWNWOOD	36	Mar22	Apr06	Apr22	Oct14	Nov02	Nov21	235	209	183	22
	32	Mar09	Mar25	Apr10	Oct26	Nov11	Nov28	252	231	209	15
	28	Feb10	Mar06	Mar29	Oct31	Nov19	Dec08	290	258	226	9
BURNET	36	Mar19	Apr02	Apr16	Oct15	Nov02	Nov20	236	214	192	19
	32	Feb23	Mar20	Apr13	Oct25	Nov12	Nov30	264	237	210	12
	28	Feb04	Mar03	Mar30	Nov03	Nov25	Dec17	296	266	236	6
CAMERON	36	Feb28	Mar22	Apr13	Oct26	Nov13	Nov30	262	235	209	11
	32	Feb10	Mar07	Mar31	Nov01	Nov22	Dec13	289	260	230	7
	28	Jan17	Feb16	Mar19	Nov10	Dec08	Jan05	332	290	257	4
CAMP WOOD	36	Mar21	Apr05	Apr20	Oct18	Nov03	Nov19	233	211	188	19
	32	Feb28	Mar22	Apr13	Oct25	Nov11	Nov27	258	233	209	13
	28	Feb09	Mar06	Mar31	Oct30	Nov22	Dec14	288	260	232	7
CANADIAN	36	Apr10	Apr23	May07	Sep25	Oct09	Oct22	186	168	150	37
	32	Mar28	Apr10	Apr24	Oct02	Oct16	Oct30	208	188	167	30
	28	Mar17	Mar31	Apr14	Oct10	Oct30	Nov18	235	212	188	22
CANDELARIA	36	Mar24	Apr11	Apr28	Oct10	Oct29	Nov17	227	201	174	25
	32	Mar02	Mar25	Apr16	Oct18	Nov06	Nov26	260	226	191	17
	28	Feb08	Mar10	Apr09	Nov02	Nov18	Dec03	288	251	215	9
CANYON DAM	36	Mar01	Mar17	Apr02	Oct31	Nov19	Dec08	272	246	221	11
	32	Jan30	Feb24	Mar21	Nov11	Dec01	Dec21	310	280	249	6
	28	Jan07	Feb09	Mar10	Nov16	Dec12	Jan10	>365	305	268	3
CANYON	36	Apr11	Apr25	May09	Sep26	Oct13	Oct30	190	170	150	36
	32	Mar29	Apr13	Apr27	Oct04	Oct22	Nov08	211	191	171	28
	28	Mar20	Apr02	Apr15	Oct19	Nov04	Nov19	236	215	193	20
CARRIZO SPRINGS	36	Feb04	Mar04	Mar31	Oct30	Nov18	Dec07	290	259	228	9
	32	Jan11	Feb14	Mar21	Nov09	Dec04	Dec29	338	292	247	4
	28	-	Jan29	Feb25	Nov27	Dec24	-	>365	330	291	2

CARTA VALLEY 4 W	36	Mar16	Apr01	Apr17	Oct16	Nov03	Nov21	238	216	193	16
	32	Feb20	Mar15	Apr08	Oct09	Nov12	Dec16	283	241	198	10
	28	Feb05	Mar07	Apr04	Nov01	Nov23	Dec18	311	261	221	6
CARTHAGE	36	Mar21	Apr04	Apr17	Oct14	Nov01	Nov18	232	210	188	18
	32	Feb25	Mar17	Apr05	Oct27	Nov14	Dec02	267	242	216	12
	28	Feb05	Feb27	Mar21	Nov06	Nov26	Dec17	302	272	242	7
CASTOLON	36	Feb19	Mar14	Apr05	Oct30	Nov16	Dec04	275	247	218	16
	32	Jan28	Feb27	Mar30	Nov05	Nov26	Dec17	309	271	232	10
	28	Dec31	Feb03	Mar09	Nov14	Dec05	Dec27	346	305	263	6
CATARINA	36	Feb05	Mar01	Mar26	Oct29	Nov21	Dec14	292	264	235	7
	32	Jan22	Feb19	Mar19	Nov10	Dec05	Dec30	326	289	252	4
	28	-	Jan28	Feb22	Dec01	Dec22	-	>365	329	294	2
CENTER	36	Mar18	Apr03	Apr18	Oct11	Oct29	Nov16	234	209	183	21
	32	Mar02	Mar20	Apr07	Oct22	Nov10	Nov28	261	234	207	14
	28	Feb07	Mar02	Mar26	Nov03	Nov24	Dec15	300	266	232	8
CENTERVILLE	36	Mar12	Mar31	Apr19	Oct16	Nov03	Nov20	244	216	188	18
	32	Feb23	Mar17	Apr07	Oct28	Nov14	Dec01	273	242	212	12
	28	Feb04	Feb28	Mar25	Nov08	Nov27	Dec16	305	271	237	7
CHANNING 2	36	Apr16	Apr28	May11	Sep29	Oct12	Oct26	184	166	149	41
	32	Apr08	Apr19	May01	Oct02	Oct19	Nov05	200	182	164	34
	28	Mar26	Apr07	Apr19	Oct18	Nov01	Nov16	224	208	191	26
CHAPMAN RANCH	36	Jan23	Feb21	Mar22	Nov10	Dec03	Dec26	320	285	250	4
	32	Dec18	Feb02	Mar15	Nov23	Dec20	Jan18	>365	321	285	2
	28	-	Jan12	Feb21	Dec04	Jan18	-	>365	>365	315	1
CHARLOTTE 5 NNW	36	Feb20	Mar17	Apr12	Oct26	Nov14	Dec04	273	241	210	9
	32	Feb02	Mar02	Mar29	Nov06	Nov24	Dec13	301	267	233	5
	28	Jan03	Feb07	Mar15	Nov17	Dec12	Jan05	345	306	270	2
CHILDRESS MUNICIPAL AP	36	Mar27	Apr08	Apr21	Oct06	Oct25	Nov12	219	198	178	29
	32	Mar20	Apr01	Apr13	Oct20	Nov06	Nov22	236	218	199	22
	28	Feb27	Mar18	Apr06	Nov01	Nov16	Dec01	266	243	219	14
CHISOS BASIN	36	Mar11	Mar30	Apr18	Oct11	Nov03	Nov25	244	217	190	15
	32	Feb18	Mar16	Apr10	Oct25	Nov17	Dec10	277	246	215	9
	28	Jan25	Feb28	Apr04	Oct31	Nov28	Dec26	313	272	231	5
CLARENDON	36	Apr11	Apr25	May10	Sep24	Oct11	Oct27	188	168	147	38
	32	Mar30	Apr11	Apr23	Oct08	Oct25	Nov10	215	196	178	30
	28	Mar16	Mar30	Apr13	Oct24	Nov07	Nov21	237	221	204	21
CLARKSVILLE 2 NE	36	Mar22	Apr05	Apr18	Oct12	Oct26	Nov10	225	204	183	25
	32	Mar12	Mar28	Apr13	Oct22	Nov09	Nov28	249	226	203	18
	28	Feb21	Mar11	Mar29	Oct28	Nov19	Dec10	281	252	224	11
CLAUDE	36	Apr12	Apr29	May16	Sep28	Oct12	Oct25	188	165	142	40
	32	Apr04	Apr19	May03	Oct04	Oct20	Nov05	204	184	163	33
	28	Mar24	Apr05	Apr18	Oct17	Nov03	Nov19	230	210	191	25
CLEBURNE	36	Mar21	Apr03	Apr16	Oct22	Nov05	Nov20	234	215	196	17
	32	Feb24	Mar18	Apr09	Oct28	Nov13	Nov29	265	240	215	11
	28	Feb05	Mar02	Mar27	Nov02	Nov25	Dec17	301	267	234	6
CLEVELAND	36	Feb25	Mar19	Apr09	Oct27	Nov12	Nov29	265	238	211	13
	32	Feb09	Mar05	Mar29	Oct31	Nov21	Dec12	291	260	230	8
	28	Dec31	Feb13	Mar19	Nov18	Dec10	Jan06	>365	297	258	4
COLDSPRING 5 SSW	36	Mar03	Mar24	Apr14	Oct23	Nov09	Nov27	258	230	202	15
	32	Feb12	Mar11	Apr06	Oct28	Nov22	Dec17	287	255	224	10
	28	Jan24	Feb24	Mar27	Nov09	Dec05	Jan01	325	284	243	5
COLEMAN	36	Mar21	Apr01	Apr13	Oct19	Nov06	Nov23	239	217	196	19
	32	Mar07	Mar23	Apr08	Oct28	Nov13	Nov28	252	234	215	12
	28	Feb05	Mar05	Apr02	Nov02	Nov22	Dec12	296	261	227	7
COLLEGE STATION ETRWD AP	36	Feb20	Mar16	Apr09	Oct28	Nov14	Dec01	271	242	214	10
	32	Feb08	Mar02	Mar25	Nov10	Nov29	Dec17	295	271	246	6
	28	Jan18	Feb14	Mar13	Nov15	Dec11	Jan06	336	299	263	3

COLORADO CITY	36	Mar21	Apr11	May01	Oct08	Oct25	Nov11	221	197	172	27
	32	Mar06	Mar25	Apr13	Oct20	Nov07	Nov25	254	226	199	19
	28	Feb23	Mar16	Apr06	Oct29	Nov13	Nov28	267	242	216	12
COLUMBUS	36	Feb27	Mar22	Apr15	Oct17	Nov08	Nov30	262	230	199	15
	32	Feb16	Mar11	Apr03	Oct25	Nov16	Dec08	278	250	222	9
	28	Jan18	Feb19	Mar22	Nov07	Dec03	Dec29	326	287	248	5
CONROE	36	Feb23	Mar16	Apr06	Oct28	Nov15	Dec03	269	243	217	11
	32	Feb06	Feb27	Mar20	Nov02	Nov25	Dec17	300	270	240	6
	28	Dec31	Feb09	Mar17	Nov14	Dec11	Jan10	>365	304	260	3
COPE RANCH	36	Apr03	Apr18	May02	Sep30	Oct18	Nov06	207	183	159	30
	32	Mar24	Apr05	Apr18	Oct12	Oct31	Nov19	232	208	184	23
	28	Mar07	Mar25	Apr11	Oct21	Nov09	Nov27	251	228	205	16
CORNUDAS SERVICE STN	36	Apr12	Apr29	May16	Oct04	Oct18	Nov02	194	171	148	37
	32	Apr01	Apr17	May04	Oct13	Oct27	Nov11	213	192	172	29
	28	Mar23	Apr07	Apr22	Oct20	Nov06	Nov22	230	212	194	21
CORPUS CHRISTI INTL AP	36	Jan22	Feb21	Mar22	Nov12	Dec05	Dec28	325	287	249	4
	32	Dec24	Feb03	Mar13	Nov25	Dec23	Jan23	>365	319	286	2
	28	-	Jan16	Feb21	Dec07	Jan10	-	>365	>365	311	1
CORSICANA	36	Mar06	Mar24	Apr10	Oct27	Nov10	Nov23	251	230	209	17
	32	Feb13	Mar09	Apr02	Nov04	Nov23	Dec12	285	259	232	11
	28	Jan29	Feb20	Mar14	Nov13	Dec05	Dec27	315	287	259	6
CRANE 2 E	36	Mar16	Apr02	Apr20	Oct15	Nov02	Nov20	237	213	189	21
	32	Mar01	Mar23	Apr13	Oct24	Nov11	Nov29	261	232	204	14
	28	Feb10	Mar08	Apr02	Nov05	Nov21	Dec07	289	258	227	8
CROCKETT	36	Mar01	Mar23	Apr15	Oct24	Nov09	Nov25	257	230	202	16
	32	Feb16	Mar10	Apr01	Oct27	Nov18	Dec10	279	252	225	10
	28	Jan26	Feb22	Mar22	Nov11	Dec04	Dec28	318	284	251	5
CROSBYTON	36	Mar30	Apr15	Apr30	Oct04	Oct21	Nov07	205	188	172	34
	32	Mar21	Apr02	Apr15	Oct13	Nov01	Nov21	237	212	187	26
	28	Mar07	Mar24	Apr11	Oct29	Nov13	Nov27	255	232	210	18
CRYSTAL CITY	36	Feb05	Mar01	Mar25	Nov05	Nov22	Dec09	293	266	238	6
	32	Jan16	Feb16	Mar20	Nov10	Dec06	Jan01	336	292	248	3
	28	-	Jan22	Feb23	Nov30	Dec24	-	>365	337	297	1
CUERO	36	Feb25	Mar20	Apr12	Oct24	Nov14	Dec05	268	238	208	9
	32	Feb04	Feb28	Mar24	Nov04	Nov25	Dec17	301	270	240	5
	28	Jan09	Feb10	Mar15	Nov16	Dec11	Jan04	341	303	264	2
DAINGERFIELD 9 S	36	Mar07	Mar25	Apr12	Oct27	Nov11	Nov25	255	230	205	15
	32	Feb09	Mar03	Mar26	Nov02	Nov22	Dec12	292	263	233	9
	28	Jan23	Feb17	Mar14	Nov14	Dec04	Dec23	319	289	259	5
DALHART MUNICIPAL AP	36	Apr22	May03	May14	Sep28	Oct10	Oct22	176	159	142	43
	32	Apr08	Apr23	May08	Oct01	Oct16	Oct31	194	175	157	36
	28	Mar26	Apr10	Apr26	Oct12	Oct27	Nov11	218	199	180	28
DALLAS LOVE AP	36	Mar03	Mar22	Apr09	Oct30	Nov14	Nov28	256	236	217	13
	32	Feb06	Mar03	Mar28	Nov04	Nov25	Dec17	294	267	239	8
	28	Jan21	Feb15	Mar12	Nov15	Dec09	Jan03	327	297	266	4
DANEVANG 1 W	36	Feb09	Mar05	Mar30	Oct31	Nov21	Dec13	294	260	226	7
	32	Jan23	Feb20	Mar21	Nov08	Dec11	Jan14	330	292	257	3
	28	-	Feb02	Mar09	Nov18	Jan04	-	>365	329	288	1
DEL RIO INTL AP	36	Feb11	Mar05	Mar28	Oct31	Nov17	Dec04	282	256	230	8
	32	Jan26	Feb19	Mar15	Nov04	Dec01	Dec28	322	284	247	4
	28	Dec12	Jan25	Feb27	Nov22	Dec22	Jan28	>365	330	294	2
DENTON 2 SE	36	Mar13	Mar28	Apr11	Oct23	Nov06	Nov20	241	223	204	18
	32	Feb27	Mar18	Apr06	Oct30	Nov16	Dec04	265	243	220	12
	28	Feb02	Feb27	Mar25	Nov10	Dec01	Dec22	309	276	243	7
DILLEY	36	Feb02	Feb28	Mar26	Nov02	Nov22	Dec11	294	266	237	8
	32	Jan17	Feb16	Mar17	Nov09	Dec09	Jan08	344	294	249	4
	28	-	Jan26	Feb26	Nov24	Dec28	-	>365	338	291	2

DIMMITT 2 N	36	Apr21	May04	May16	Sep23	Oct06	Oct20	173	155	137	44
	32	Apr10	Apr25	May11	Oct02	Oct16	Oct29	192	172	153	37
	28	Mar29	Apr10	Apr22	Oct15	Oct31	Nov17	224	204	183	28
DUBLIN	36	Mar21	Apr02	Apr14	Oct21	Nov06	Nov22	235	217	199	20
	32	Feb28	Mar18	Apr05	Oct29	Nov15	Dec02	264	241	218	13
	28	Feb06	Mar05	Apr01	Nov08	Nov29	Dec20	302	269	235	8
DUMAS	36	Apr14	Apr28	May12	Sep29	Oct14	Oct30	188	169	149	41
	32	Apr02	Apr18	May03	Oct05	Oct22	Nov07	205	186	167	34
	28	Mar23	Apr05	Apr18	Oct20	Nov03	Nov17	229	211	193	26
EAGLE PASS	36	Feb05	Mar01	Mar26	Oct31	Nov21	Dec12	293	264	236	8
	32	Jan13	Feb12	Mar10	Nov14	Dec05	Dec29	334	295	265	4
	28	-	Jan19	Feb19	Dec02	Dec28	-	>365	341	308	2
EASTLAND	36	Mar26	Apr07	Apr20	Oct13	Oct30	Nov17	225	206	186	24
	32	Mar16	Apr01	Apr16	Oct23	Nov08	Nov24	243	221	198	18
	28	Feb22	Mar16	Apr07	Nov02	Nov19	Dec05	275	247	219	11
EL PASO INTL AP	36	Mar21	Apr09	Apr27	Oct18	Oct30	Nov12	226	204	182	24
	32	Mar01	Mar22	Apr12	Oct25	Nov08	Nov22	257	230	204	16
	28	Feb12	Mar09	Apr03	Oct31	Nov19	Dec08	290	255	219	10
ELGIN	36	Feb22	Mar17	Apr09	Oct26	Nov16	Dec06	272	243	215	10
	32	Feb01	Feb24	Mar20	Nov07	Nov28	Dec19	305	276	247	5
	28	Jan10	Feb10	Mar13	Nov20	Dec12	Jan04	339	303	270	3
EMORY	36	Mar20	Apr04	Apr19	Oct17	Oct31	Nov14	232	209	187	21
	32	Mar04	Mar22	Apr09	Oct27	Nov12	Nov29	258	234	210	15
	28	Feb11	Mar04	Mar25	Nov01	Nov22	Dec14	294	263	232	9
ENCINAL	36	Feb09	Mar06	Mar31	Nov06	Nov24	Dec12	297	262	227	8
	32	Jan01	Feb16	Mar30	Nov15	Dec06	Dec30	>365	292	243	4
	28	-	Jan28	Mar02	Nov28	Dec26	-	>365	332	282	2
EVANT 1 SSW	36	Mar16	Mar31	Apr16	Oct24	Nov06	Nov19	235	219	203	17
	32	Feb19	Mar17	Apr12	Oct27	Nov16	Dec06	276	243	211	11
	28	Jan29	Feb28	Mar29	Nov05	Nov28	Dec22	311	273	235	6
FAIRFIELD 3 W	36	Mar17	Apr01	Apr16	Oct24	Nov09	Nov24	243	221	199	15
	32	Feb25	Mar19	Apr10	Oct27	Nov17	Dec08	272	242	213	9
	28	Feb04	Feb28	Mar24	Nov06	Nov27	Dec18	302	271	240	5
FALCON DAM	36	Jan15	Feb15	Mar14	Nov13	Dec10	Jan09	353	299	256	3
	32	-	Jan22	Mar05	Nov28	Jan05	-	>365	348	300	1
	28	-	Dec02	Feb06	Dec13	Feb16	-	>365	>365	337	0
FALFURRIAS	36	Jan27	Feb25	Mar27	Nov07	Nov28	Dec18	311	275	239	6
	32	Dec24	Feb06	Mar18	Nov19	Dec13	Jan10	364	311	269	3
	28	-	Jan16	Feb20	Dec02	Jan02	-	>365	347	314	1
FERRIS	36	Mar11	Mar26	Apr10	Oct23	Nov08	Nov25	246	227	207	17
	32	Feb20	Mar12	Apr02	Oct29	Nov15	Dec03	274	247	220	11
	28	Jan29	Feb23	Mar19	Nov12	Nov29	Dec17	308	279	250	6
FLATONIA	36	Feb13	Mar10	Apr04	Oct31	Nov20	Dec09	284	254	224	8
	32	Jan24	Feb23	Mar24	Nov08	Dec04	Dec29	323	284	244	5
	28	Dec25	Feb04	Mar13	Nov20	Dec22	Jan26	>365	316	270	2
FLORESVILLE	36	Feb24	Mar21	Apr16	Oct21	Nov09	Nov28	261	232	203	13
	32	Feb08	Mar08	Apr05	Oct31	Nov21	Dec11	290	257	224	8
	28	Jan09	Feb11	Mar16	Nov16	Dec07	Dec28	334	297	264	4
FLOYDADA	36	Apr06	Apr20	May04	Oct02	Oct18	Nov04	204	181	157	36
	32	Mar26	Apr08	Apr20	Oct13	Oct30	Nov17	226	205	184	29
	28	Mar15	Mar29	Apr11	Oct27	Nov10	Nov24	244	225	207	20
FOLLETT	36	Apr12	Apr27	May11	Sep23	Oct10	Oct27	189	166	143	39
	32	Apr03	Apr17	Apr30	Oct03	Oct21	Nov08	210	186	163	32
	28	Mar22	Apr05	Apr19	Oct18	Nov03	Nov18	233	211	189	24
FORT DAVIS	36	Apr06	Apr20	May03	Oct03	Oct22	Nov10	209	184	159	32
	32	Mar25	Apr09	Apr23	Oct13	Nov02	Nov21	234	206	178	23
	28	Mar08	Mar26	Apr13	Oct18	Nov12	Dec08	266	231	196	14

FORT HANCOCK 8 SSE	36	Apr07	Apr22	May07	Oct04	Oct21	Nov06	203	181	159	35
	32	Mar18	Apr06	Apr24	Oct10	Oct27	Nov13	226	204	182	27
	28	Mar07	Mar25	Apr11	Oct25	Nov09	Nov23	250	228	207	19
FORT STOCKTON	36	Mar22	Apr06	Apr21	Oct13	Nov03	Nov23	233	210	186	22
	32	Mar05	Mar26	Apr16	Oct23	Nov12	Dec03	256	230	204	15
	28	Feb17	Mar15	Apr10	Nov01	Nov20	Dec08	282	249	216	9
FOWLERTON	36	Feb14	Mar12	Apr07	Oct30	Nov19	Dec08	283	251	219	10
	32	Feb02	Feb27	Mar25	Nov08	Nov26	Dec13	303	271	239	6
	28	Dec30	Feb03	Mar08	Nov23	Dec14	Jan07	>365	312	275	2
FRANKLIN	36	Mar11	Mar27	Apr12	Oct26	Nov11	Nov27	251	228	206	13
	32	Feb11	Mar09	Apr04	Oct28	Nov19	Dec10	287	254	221	8
	28	Jan27	Feb20	Mar17	Nov12	Dec03	Dec23	316	285	254	4
FREDERICKSBURG	36	Mar15	Apr02	Apr20	Oct15	Nov02	Nov20	237	213	189	16
	32	Feb22	Mar18	Apr11	Oct26	Nov12	Nov28	267	238	209	10
	28	Feb04	Mar01	Mar26	Nov04	Nov24	Dec13	300	267	234	6
FREEPORT 2 NW	36	Jan14	Feb18	Mar24	Nov12	Dec07	Dec31	338	290	247	4
	32	-	Jan31	Mar03	Nov28	Dec28	-	>365	340	286	2
	28	-	Jan09	Feb17	Dec08	Jan14	-	>365	>365	307	1
FREER	36	Feb02	Mar07	Apr08	Nov04	Nov24	Dec14	296	262	227	6
	32	Jan15	Feb13	Mar15	Nov10	Dec08	Jan04	344	297	250	3
	28	-	Jan22	Feb23	Nov25	Dec24	-	>365	336	294	1
FRIONA	36	Apr19	May02	May14	Sep29	Oct12	Oct26	181	163	146	41
	32	Apr05	Apr19	May03	Oct02	Oct20	Nov06	203	183	162	34
	28	Mar25	Apr06	Apr18	Oct20	Nov03	Nov16	229	210	190	25
GAIL	36	Mar28	Apr07	Apr18	Oct10	Oct29	Nov16	225	204	183	22
	32	Mar09	Mar27	Apr14	Oct26	Nov08	Nov22	248	226	204	15
	28	Feb25	Mar16	Apr05	Nov02	Nov20	Dec08	276	248	220	10
GALVESTON	36	Dec23	Feb01	Mar04	Nov23	Dec20	Jan22	>365	319	281	3
	32	-	Jan19	Feb21	Dec06	Jan09	-	>365	358	314	1
	28	-	Dec18	Feb09	Dec19	Feb18	-	>365	>365	340	1
GARDEN CITY 1 E	36	Mar29	Apr14	May01	Oct04	Oct23	Nov11	214	191	169	30
	32	Mar20	Apr03	Apr18	Oct15	Nov03	Nov23	235	213	191	22
	28	Mar10	Mar24	Apr07	Oct26	Nov12	Nov28	253	232	210	15
GATESVILLE 4 SSE	36	Mar22	Apr05	Apr19	Oct17	Nov02	Nov19	231	211	190	18
	32	Mar04	Mar24	Apr14	Oct29	Nov13	Nov29	260	234	207	12
	28	Feb05	Mar05	Apr01	Nov03	Nov19	Dec05	291	258	226	7
GILMER 4 WNW	36	Mar28	Apr08	Apr18	Oct10	Oct25	Nov09	218	200	181	23
	32	Mar12	Mar29	Apr14	Oct17	Nov05	Nov23	244	220	196	17
	28	Feb24	Mar15	Apr04	Oct29	Nov19	Dec09	278	248	218	10
GLEN ROSE 2 W	36	Mar30	Apr18	May07	Sep22	Oct11	Oct30	203	175	148	26
	32	Mar21	Apr11	May02	Oct05	Oct29	Nov22	235	200	166	20
	28	Mar08	Mar28	Apr18	Oct14	Nov06	Nov29	251	222	193	14
GOLDTHWAITE 1 WSW	36	Mar18	Apr02	Apr17	Oct23	Nov08	Nov24	243	219	196	15
	32	Feb28	Mar20	Apr09	Oct27	Nov15	Dec05	264	239	215	10
	28	Feb04	Mar01	Mar26	Nov05	Nov28	Dec21	303	271	240	6
GOLIAD	36	Feb18	Mar16	Apr10	Oct24	Nov12	Dec02	273	241	209	8
	32	Jan22	Feb25	Mar31	Nov02	Nov26	Dec21	316	273	231	4
	28	Dec30	Feb06	Mar14	Nov17	Dec14	Jan19	>365	309	265	2
GONZALES 1 N	36	Feb20	Mar14	Apr06	Oct28	Nov15	Dec03	272	245	218	11
	32	Feb03	Feb26	Mar21	Nov07	Dec01	Dec24	310	277	244	6
	28	Dec31	Feb03	Mar06	Nov19	Dec13	Jan09	>365	310	279	3
GRAHAM	36	Mar26	Apr11	Apr26	Oct09	Oct25	Nov11	222	197	171	27
	32	Mar15	Apr02	Apr20	Oct20	Nov06	Nov23	243	217	192	20
	28	Feb22	Mar17	Apr09	Oct30	Nov16	Dec04	271	244	216	13
GRANDFALLS 3 SSE	36	Apr03	Apr14	Apr26	Oct07	Oct25	Nov13	214	193	173	31
	32	Mar21	Apr04	Apr18	Oct19	Nov05	Nov22	236	214	193	24
	28	Mar04	Mar22	Apr09	Oct28	Nov13	Nov30	260	235	210	16

GRAPEVINE DAM	36	Mar18	Apr01	Apr16	Oct20	Nov05	Nov21	240	217	194	21
	32	Mar03	Mar21	Apr09	Oct29	Nov15	Dec01	261	237	214	14
	28	Feb07	Mar01	Mar22	Nov06	Nov27	Dec17	298	271	243	8
GREENVILLE KGVL RADIO	36	Mar17	Apr04	Apr22	Oct15	Nov01	Nov18	240	211	182	23
	32	Mar06	Mar23	Apr08	Oct28	Nov13	Nov30	259	235	211	16
	28	Feb17	Mar10	Mar31	Nov03	Nov23	Dec13	289	257	225	10
GROVETON	36	Mar10	Mar28	Apr14	Oct17	Nov06	Nov26	252	223	194	16
	32	Feb19	Mar14	Apr06	Oct27	Nov14	Dec01	273	244	216	9
	28	Jan31	Feb25	Mar23	Nov08	Dec02	Dec25	310	278	247	4
GRUVER	36	Apr15	Apr29	May13	Sep23	Oct07	Oct20	179	160	141	42
	32	Apr06	Apr20	May04	Oct02	Oct17	Nov01	196	179	163	34
	28	Mar26	Apr08	Apr21	Oct11	Oct27	Nov12	221	201	181	26
GUTHRIE	36	Mar31	Apr13	Apr26	Oct02	Oct18	Nov04	209	188	166	33
	32	Mar26	Apr06	Apr18	Oct23	Nov04	Nov15	228	211	193	25
	28	Mar06	Mar24	Apr11	Oct27	Nov10	Nov23	251	230	208	18
HALLETTSVILLE 2 N	36	Feb16	Mar13	Apr06	Oct29	Nov15	Dec03	275	247	219	9
	32	Jan22	Feb25	Mar30	Nov04	Nov29	Dec24	318	277	236	5
	28	Dec30	Feb07	Mar14	Nov19	Dec14	Jan11	>365	308	267	2
HAMILTON 1 NW	36	Mar13	Mar29	Apr15	Oct24	Nov07	Nov21	239	222	205	20
	32	Feb24	Mar16	Apr06	Oct25	Nov15	Dec05	271	243	214	13
	28	Feb03	Mar02	Mar29	Nov07	Nov27	Dec17	297	269	241	7
HARLINGEN	36	-	Feb01	Mar10	Nov22	Dec21	-	>365	320	270	2
	32	-	Jan10	Feb19	Dec12	Jan23	-	>365	>365	312	1
	28	-	-	Jan23	Dec26	-	-	>365	>365	355	0
HASKELL	36	Mar25	Apr05	Apr16	Oct19	Nov05	Nov22	232	213	194	24
	32	Mar13	Mar27	Apr10	Oct27	Nov12	Nov27	248	229	210	17
	28	Feb13	Mar10	Apr05	Nov06	Nov21	Dec06	279	255	230	11
HEBBRONVILLE	36	Jan31	Feb28	Mar28	Nov13	Nov29	Dec15	306	273	239	5
	32	Jan04	Feb08	Mar12	Nov17	Dec11	Jan06	361	307	265	3
	28	-	Jan24	Feb24	Nov29	Jan05	-	>365	354	302	1
HENDERSON	36	Mar18	Apr02	Apr17	Oct21	Nov04	Nov19	238	216	193	19
	32	Feb28	Mar20	Apr08	Oct29	Nov15	Dec01	266	239	213	13
	28	Feb08	Mar02	Mar23	Nov05	Nov28	Dec21	302	271	239	7
HENRIETTA	36	Mar28	Apr10	Apr23	Oct11	Oct26	Nov09	219	198	176	27
	32	Mar15	Mar30	Apr13	Oct18	Nov05	Nov23	241	220	199	21
	28	Feb21	Mar14	Apr04	Nov02	Nov17	Dec03	275	247	220	14
HEREFORD	36	Apr14	Apr29	May13	Sep27	Oct10	Oct24	185	164	143	42
	32	Apr04	Apr19	May04	Oct04	Oct19	Nov04	197	182	167	34
	28	Mar21	Apr02	Apr14	Oct18	Nov03	Nov19	232	214	196	26
HICO	36	Mar23	Apr06	Apr20	Oct18	Oct31	Nov13	226	207	188	20
	32	Mar05	Mar25	Apr15	Oct26	Nov10	Nov25	253	229	205	14
	28	Feb12	Mar09	Apr04	Nov01	Nov18	Dec05	283	253	223	9
HILLSBORO	36	Mar18	Apr02	Apr17	Oct21	Nov06	Nov22	238	217	196	17
	32	Feb28	Mar19	Apr06	Oct28	Nov14	Dec02	265	240	215	11
	28	Feb08	Mar02	Mar25	Nov05	Nov28	Dec21	294	270	245	6
HORDS CREEK DAM	36	Mar26	Apr11	Apr27	Oct05	Oct26	Nov17	227	198	168	24
	32	Mar10	Mar29	Apr17	Oct18	Nov06	Nov24	248	221	195	17
	28	Feb20	Mar17	Apr12	Oct28	Nov14	Nov30	272	241	209	11
HOUSTON BUSH INTL AP	36	Feb19	Mar12	Apr01	Oct26	Nov13	Dec01	274	246	217	9
	32	Jan31	Mar01	Mar30	Nov05	Nov30	Dec25	309	273	236	5
	28	Dec22	Jan31	Mar10	Nov24	Dec18	Jan14	>365	319	282	2
HOUSTON HOBBY AP	36	Jan20	Feb22	Mar26	Nov09	Dec02	Dec25	320	282	245	5
	32	Jan02	Feb08	Mar18	Nov17	Dec20	Jan22	>365	308	265	2
	28	-	Jan21	Mar04	Dec03	Jan17	-	>365	360	292	1
HUNTSVILLE	36	Feb22	Mar13	Apr01	Oct31	Nov18	Dec06	273	249	225	10
	32	Jan28	Feb23	Mar21	Nov10	Nov30	Dec19	310	279	247	6
	28	Jan02	Feb05	Mar09	Nov20	Dec18	Jan17	>365	313	277	3

JACKSBORO	36	Mar21	Apr02	Apr14	Oct20	Nov04	Nov18	232	215	198	20
	32	Mar04	Mar21	Apr08	Oct28	Nov14	Nov30	259	237	215	14
	28	Feb13	Mar06	Mar28	Nov06	Nov25	Dec15	295	263	231	8
JACKSONVILLE	36	Mar13	Mar29	Apr15	Oct27	Nov12	Nov27	252	227	201	14
	32	Feb18	Mar13	Apr05	Oct27	Nov17	Dec08	283	249	215	9
	28	Feb01	Feb24	Mar19	Nov15	Dec05	Dec26	311	283	256	5
JAYTON	36	Mar30	Apr10	Apr22	Oct03	Oct22	Nov10	214	194	174	31
	32	Mar20	Apr02	Apr15	Oct22	Nov07	Nov23	238	218	199	23
	28	Mar05	Mar22	Apr08	Oct29	Nov15	Dec01	260	237	214	16
JEFFERSON	36	Mar24	Apr05	Apr17	Oct07	Oct22	Nov07	218	199	180	23
	32	Mar08	Mar25	Apr12	Oct21	Nov06	Nov23	253	225	198	16
	28	Feb14	Mar05	Mar24	Oct29	Nov23	Dec17	294	262	230	9
JOHNSON CITY	36	Mar18	Apr05	Apr24	Oct15	Nov03	Nov22	235	211	187	18
	32	Feb26	Mar20	Apr11	Oct23	Nov12	Dec02	265	236	207	12
	28	Feb08	Mar02	Mar23	Oct31	Nov21	Dec12	296	264	231	7
JUNCTION 4 SSW	36	Mar26	Apr14	May03	Oct02	Oct22	Nov10	217	190	163	23
	32	Mar10	Apr02	Apr25	Oct15	Nov01	Nov18	239	212	185	17
	28	Feb24	Mar19	Apr11	Oct25	Nov12	Nov29	267	237	208	11
KAUFMAN 3 SE	36	Mar20	Apr03	Apr17	Oct20	Nov07	Nov26	242	218	194	19
	32	Feb27	Mar19	Apr08	Oct25	Nov14	Dec04	271	240	208	12
	28	Feb04	Mar01	Mar27	Nov02	Nov24	Dec16	302	267	232	7
KINGSVILLE	36	Jan26	Feb27	Mar28	Nov09	Nov28	Dec19	319	273	238	5
	32	Jan02	Feb10	Mar17	Nov20	Dec11	Jan04	>365	303	266	2
	28	-	Jan23	Mar06	Dec04	Jan12	-	>365	346	295	1
LA GRANGE	36	Feb23	Mar16	Apr07	Oct25	Nov15	Dec05	269	243	216	10
	32	Feb04	Feb26	Mar21	Oct31	Nov23	Dec16	298	269	239	5
	28	Jan05	Feb09	Mar15	Nov18	Dec12	Jan05	345	305	268	2
LA TUNA 1 S	36	Mar24	Apr09	Apr26	Oct17	Oct31	Nov15	224	204	185	27
	32	Mar09	Mar24	Apr08	Oct25	Nov09	Nov24	249	230	210	20
	28	Feb12	Mar07	Mar29	Oct31	Nov18	Dec05	286	256	225	12
LAKE KEMP	36	Mar23	Apr04	Apr16	Oct14	Nov02	Nov22	234	212	189	25
	32	Mar02	Mar21	Apr10	Oct27	Nov11	Nov27	257	234	211	18
	28	Feb19	Mar13	Apr05	Nov06	Nov22	Dec07	282	252	223	11
LAMESA 1 SSE	36	Mar31	Apr14	Apr27	Oct06	Oct25	Nov13	215	194	172	33
	32	Mar21	Apr04	Apr18	Oct19	Nov05	Nov21	237	214	192	25
	28	Mar06	Mar24	Apr10	Oct28	Nov14	Dec01	258	235	211	16
LAMPASAS	36	Mar21	Apr08	Apr26	Oct08	Oct27	Nov14	227	201	174	25
	32	Mar15	Apr01	Apr18	Oct18	Nov07	Nov26	241	219	197	19
	28	Feb24	Mar18	Apr09	Oct27	Nov16	Dec05	269	242	214	12
LANGTRY	36	Feb25	Mar18	Apr08	Oct26	Nov11	Nov28	263	238	212	16
	32	Feb14	Mar09	Mar31	Nov01	Nov21	Dec10	284	257	229	11
	28	Jan22	Feb16	Mar13	Nov09	Dec04	Dec29	330	290	251	5
LAREDO 2	36	Jan30	Feb24	Mar21	Nov07	Nov25	Dec13	307	273	239	5
	32	Jan11	Feb09	Mar10	Nov12	Dec05	Dec29	337	299	261	3
	28	-	Jan23	Mar05	Nov25	Dec23	-	>365	334	290	1
LAVON DAM	36	Mar12	Mar28	Apr13	Oct19	Nov08	Nov27	249	224	199	19
	32	Feb22	Mar15	Apr04	Oct22	Nov14	Dec07	275	244	212	13
	28	Jan27	Feb23	Mar22	Nov06	Nov27	Dec19	312	277	241	7
LEVELLAND	36	Apr05	Apr20	May04	Sep30	Oct13	Oct27	193	176	159	38
	32	Mar26	Apr08	Apr21	Oct14	Oct27	Nov09	215	201	187	30
	28	Mar16	Mar30	Apr12	Oct20	Nov07	Nov25	242	222	201	21
LEXINGTON	36	Feb22	Mar16	Apr08	Oct25	Nov15	Dec05	274	243	212	13
	32	Feb05	Mar01	Mar26	Nov02	Nov22	Dec12	292	265	239	7
	28	Jan15	Feb13	Mar14	Nov17	Dec09	Dec31	329	297	269	4
LIBERTY	36	Feb12	Mar08	Apr01	Oct26	Nov14	Dec03	283	251	218	10
	32	Jan16	Feb18	Mar23	Nov09	Dec01	Dec22	327	285	242	5
	28	-	Jan27	Mar06	Nov21	Dec20	-	>365	324	282	2

LIPSCOMB	36	Apr19	May03	May16	Sep21	Oct04	Oct17	172	154	136	43
	32	Apr10	Apr23	May06	Sep26	Oct11	Oct26	187	170	154	37
	28	Mar26	Apr08	Apr20	Oct05	Oct22	Nov07	214	196	178	30
LITTLEFIELD 2 NW	36	Apr08	Apr23	May07	Sep28	Oct13	Oct29	196	173	150	39
	32	Mar30	Apr11	Apr22	Oct06	Oct25	Nov13	217	196	176	31
	28	Mar19	Mar31	Apr12	Oct24	Nov08	Nov22	238	221	204	23
LIVINGSTON 2 NNE	36	Mar15	Apr01	Apr18	Oct13	Nov03	Nov23	243	215	187	17
	32	Feb26	Mar17	Apr05	Oct27	Nov13	Nov30	265	241	216	12
	28	Feb04	Feb27	Mar22	Nov06	Nov30	Dec23	308	275	243	7
LLANO	36	Mar14	Apr01	Apr19	Oct17	Nov03	Nov19	238	215	192	21
	32	Feb25	Mar18	Apr09	Oct26	Nov12	Nov29	266	238	211	14
	28	Feb02	Feb26	Mar23	Nov06	Nov23	Dec10	299	269	239	8
LONGVIEW	36	Mar19	Apr03	Apr18	Oct16	Nov03	Nov20	238	213	188	20
	32	Feb27	Mar19	Apr08	Oct28	Nov15	Dec03	266	240	213	13
	28	Feb04	Mar01	Mar26	Nov04	Nov26	Dec17	305	269	233	7
LUBBOCK RGNL AP	36	Apr02	Apr12	Apr23	Oct05	Oct21	Nov06	207	191	175	31
	32	Mar22	Apr03	Apr14	Oct17	Nov01	Nov16	226	211	197	23
	28	Mar12	Mar26	Apr08	Oct29	Nov15	Dec01	254	233	212	16
LUFKIN ANGELINA CO AP	36	Mar07	Mar27	Apr16	Oct19	Nov07	Nov26	254	224	194	14
	32	Feb19	Mar13	Apr03	Oct29	Nov15	Dec02	272	247	222	9
	28	Jan25	Feb20	Mar18	Nov06	Nov30	Dec25	314	282	250	4
LULING	36	Mar01	Mar24	Apr16	Oct20	Nov09	Nov28	258	229	201	13
	32	Feb11	Mar07	Mar30	Oct30	Nov20	Dec11	290	258	226	8
	28	Jan10	Feb11	Mar13	Nov15	Dec05	Dec28	>365	296	263	4
MADISONVILLE	36	Mar06	Mar25	Apr14	Oct23	Nov10	Nov27	252	229	206	12
	32	Feb11	Mar07	Mar30	Oct28	Nov18	Dec08	283	255	228	7
	28	Jan24	Feb18	Mar15	Nov17	Dec06	Dec24	318	290	261	3
MARATHON	36	Mar28	Apr16	May05	Oct02	Oct25	Nov16	222	191	160	29
	32	Feb28	Mar30	Apr30	Oct12	Nov03	Nov25	258	217	176	21
	28	Mar03	Mar26	Apr15	Oct20	Nov10	Dec04	269	229	197	13
MARFA # 2	36	Apr09	Apr23	May06	Oct03	Oct18	Nov02	198	178	158	35
	32	Mar23	Apr11	Apr30	Oct14	Oct30	Nov14	225	201	178	27
	28	Mar12	Apr02	Apr22	Oct20	Nov08	Nov28	251	220	189	19
MARLIN 3 NE	36	Mar06	Mar27	Apr17	Oct22	Nov08	Nov24	253	225	197	14
	32	Feb13	Mar10	Apr05	Oct28	Nov17	Dec07	280	251	222	9
	28	Feb03	Feb25	Mar20	Nov07	Nov28	Dec19	304	275	245	5
MARSHALL	36	Mar20	Apr02	Apr15	Oct13	Oct31	Nov19	234	211	189	19
	32	Feb28	Mar20	Apr10	Oct26	Nov12	Nov29	263	236	210	13
	28	Jan30	Feb25	Mar23	Nov04	Nov27	Dec20	309	275	240	7
MASON	36	Mar22	Apr06	Apr22	Oct13	Oct30	Nov15	229	206	182	22
	32	Mar07	Mar26	Apr14	Oct22	Nov09	Nov26	252	227	201	15
	28	Feb11	Mar07	Mar31	Nov02	Nov18	Dec04	285	256	226	9
MATADOR	36	Mar30	Apr11	Apr23	Oct12	Oct27	Nov11	213	199	185	28
	32	Mar19	Apr01	Apr13	Oct24	Nov08	Nov23	238	221	204	20
	28	Feb27	Mar18	Apr06	Oct30	Nov14	Nov30	263	241	218	13
MATAGORDA 2	36	Jan24	Feb23	Mar24	Nov10	Dec01	Dec22	318	279	243	4
	32	Dec24	Feb06	Mar12	Nov21	Dec18	Jan23	>365	316	263	2
	28	-	Jan12	Feb22	Dec07	Jan09	-	>365	362	305	1
MATHIS 4 SSW	36	Jan18	Feb21	Mar23	Nov17	Dec03	Dec21	332	285	249	5
	32	Dec17	Feb01	Mar09	Nov26	Dec21	Jan22	>365	324	278	2
	28	-	Jan15	Feb14	Dec11	Jan10	-	>365	355	314	1
MCALLEN	36	-	Jan30	Mar10	Nov26	Dec20	-	>365	329	277	2
	32	-	Jan05	Feb14	Dec16	Jan30	-	>365	>365	316	1
	28	-	-	Jan16	Dec24	-	-	>365	>365	>365	0
MCALLEN MILLER INTL AP	36	-	Feb01	Mar14	Nov27	Dec25	-	>365	327	283	2
	32	-	Dec27	Feb06	Dec08	Jan15	-	>365	>365	325	1
	28	-	-	Jan22	Dec28	-	-	>365	>365	>365	0

MCCAMEY	36	Mar16	Apr01	Apr16	Oct17	Nov06	Nov25	240	218	196	20
	32	Feb27	Mar20	Apr10	Oct25	Nov12	Nov29	262	236	210	13
	28	Feb12	Mar08	Mar31	Nov11	Nov24	Dec08	288	261	234	8
MC COOK	36	Jan20	Feb19	Mar21	Nov16	Dec05	Dec25	327	288	250	4
	32	-	Jan26	Mar03	Nov26	Dec25	-	>365	334	290	2
	28	-	Dec31	Feb12	Dec16	Jan20	-	>365	>365	313	1
MEDINA 2 W	36	Mar18	Apr03	Apr20	Oct11	Oct30	Nov17	234	209	183	20
	32	Feb26	Mar22	Apr14	Oct26	Nov10	Nov25	262	233	204	13
	28	Feb08	Mar06	Apr01	Nov02	Nov23	Dec14	295	261	227	8
MCGREGOR	36	Mar11	Mar27	Apr12	Oct27	Nov10	Nov24	246	227	208	17
	32	Feb16	Mar11	Apr03	Nov02	Nov19	Dec06	281	252	223	10
	28	Jan26	Feb21	Mar19	Nov10	Dec03	Dec26	315	284	254	6
MC KINNEY 3 S	36	Mar23	Apr03	Apr14	Oct14	Oct31	Nov16	229	210	190	19
	32	Mar03	Mar21	Apr08	Oct27	Nov11	Nov26	256	235	213	12
	28	Feb08	Mar06	Apr01	Nov03	Nov25	Dec18	292	264	236	7
MC LEAN	36	Apr02	Apr18	May05	Sep30	Oct17	Nov02	204	181	158	32
	32	Mar27	Apr09	Apr21	Oct13	Oct28	Nov13	221	202	183	25
	28	Mar14	Mar28	Apr10	Oct27	Nov10	Nov24	247	226	205	17
MEMPHIS	36	Mar26	Apr10	Apr24	Oct03	Oct22	Nov10	221	195	169	32
	32	Mar19	Apr01	Apr13	Oct23	Nov04	Nov17	233	217	202	25
	28	Feb28	Mar18	Apr06	Oct30	Nov13	Nov27	262	239	216	16
MENARD	36	Mar31	Apr18	May07	Oct02	Oct19	Nov05	208	183	158	24
	32	Mar20	Apr07	Apr25	Oct15	Oct29	Nov13	228	204	181	18
	28	Mar03	Mar23	Apr11	Oct21	Nov08	Nov26	257	230	202	12
MEXIA	36	Mar09	Mar26	Apr11	Oct22	Nov10	Nov28	253	228	204	17
	32	Feb10	Mar06	Mar31	Oct28	Nov20	Dec12	293	258	222	11
	28	Jan28	Feb20	Mar16	Nov08	Dec03	Dec27	319	285	251	6
MIAMI	36	Apr12	Apr26	May10	Sep23	Oct07	Oct21	181	164	146	39
	32	Apr01	Apr15	Apr29	Sep30	Oct19	Nov07	208	186	165	33
	28	Mar19	Apr01	Apr14	Oct15	Oct31	Nov17	230	212	194	25
MIDLAND INTL AP	36	Mar30	Apr08	Apr18	Oct12	Oct30	Nov17	222	204	186	25
	32	Mar13	Mar30	Apr15	Oct26	Nov12	Nov28	249	226	204	17
	28	Mar02	Mar20	Apr08	Nov02	Nov20	Dec07	269	244	219	10
MIDLAND 4 ENE	36	Mar27	Apr10	Apr24	Oct12	Oct29	Nov15	219	201	183	25
	32	Mar14	Mar31	Apr17	Oct22	Nov09	Nov26	245	222	199	18
	28	Feb24	Mar19	Apr10	Nov01	Nov18	Dec05	273	243	214	10
MINEOLA 8 ENE	36	Mar27	Apr09	Apr22	Oct06	Oct23	Nov10	219	197	175	23
	32	Mar15	Apr01	Apr19	Oct20	Nov07	Nov25	249	219	189	17
	28	Feb21	Mar14	Apr05	Nov01	Nov17	Dec03	273	247	221	11
MINERAL WELLS AP	36	Mar18	Apr02	Apr18	Oct26	Nov08	Nov20	239	218	198	19
	32	Mar03	Mar23	Apr13	Oct28	Nov13	Nov29	258	233	209	13
	28	Feb10	Mar06	Mar29	Nov04	Nov23	Dec13	293	262	230	7
MONAHANS	36	Mar29	Apr11	Apr23	Oct12	Oct28	Nov14	216	200	183	27
	32	Mar17	Apr01	Apr17	Oct22	Nov07	Nov23	241	219	197	20
	28	Feb25	Mar16	Apr04	Oct30	Nov17	Dec06	274	245	216	12
MORTON	36	Apr12	Apr26	May10	Sep30	Oct15	Oct31	190	172	153	39
	32	Apr01	Apr14	Apr27	Oct08	Oct24	Nov09	210	193	175	31
	28	Mar16	Mar31	Apr15	Oct24	Nov09	Nov25	243	222	201	23
MOUNT LOCKE	36	Apr11	Apr28	May15	Sep22	Oct14	Nov05	192	168	144	24
	32	Apr01	Apr17	May03	Oct03	Oct26	Nov18	219	191	163	17
	28	Mar21	Apr06	Apr22	Oct17	Nov07	Nov27	240	214	188	11
MOUNT PLEASANT	36	Mar26	Apr09	Apr22	Oct02	Oct19	Nov05	215	192	169	25
	32	Mar13	Mar29	Apr14	Oct17	Nov05	Nov24	246	220	194	19
	28	Feb26	Mar15	Apr01	Oct28	Nov19	Dec11	275	248	221	12
MOUNT VERNON	36	Mar22	Apr03	Apr15	Oct16	Oct30	Nov13	227	210	192	20
	32	Mar02	Mar22	Apr11	Oct25	Nov12	Nov30	261	235	209	14
	28	Feb11	Mar04	Mar25	Nov06	Nov27	Dec18	295	267	239	8

MULESHOE 1	36	Apr18	May01	May14	Sep25	Oct07	Oct18	177	158	139	44
	32	Apr01	Apr17	May02	Oct05	Oct21	Nov06	208	186	164	36
	28	Mar23	Apr06	Apr20	Oct12	Oct29	Nov15	228	205	181	28
MUNDAY	36	Mar25	Apr06	Apr17	Oct09	Oct29	Nov19	230	206	182	24
	32	Mar13	Mar28	Apr13	Oct26	Nov12	Nov29	249	228	206	17
	28	Feb20	Mar14	Apr06	Nov02	Nov19	Dec06	276	249	222	11
NAVARRO MILLS DAM	36	Mar09	Mar28	Apr15	Oct23	Nov08	Nov24	250	225	200	19
	32	Feb26	Mar16	Apr03	Oct28	Nov18	Dec09	278	246	214	13
	28	Feb06	Mar02	Mar26	Nov10	Nov30	Dec21	307	272	238	7
NEW BRAUNFELS	36	Feb26	Mar21	Apr12	Oct27	Nov13	Nov30	262	237	211	13
	32	Feb08	Mar04	Mar29	Oct31	Nov21	Dec12	291	261	231	8
	28	Jan24	Feb19	Mar17	Nov15	Dec09	Jan02	325	293	260	4
NIXON	36	Feb18	Mar12	Apr02	Oct27	Nov17	Dec08	276	249	222	9
	32	Jan27	Feb22	Mar19	Nov10	Dec01	Dec22	316	281	247	5
	28	Jan03	Feb05	Mar08	Nov19	Dec14	Jan10	>365	311	271	2
OLNEY	36	Mar28	Apr07	Apr17	Oct17	Nov01	Nov16	225	207	190	22
	32	Mar11	Mar26	Apr10	Oct25	Nov11	Nov27	250	229	208	16
	28	Feb19	Mar12	Apr02	Nov04	Nov20	Dec06	276	252	228	9
OLTON	36	Apr14	Apr27	May11	Sep29	Oct12	Oct26	188	167	147	40
	32	Mar28	Apr12	Apr28	Oct03	Oct20	Nov06	212	190	169	32
	28	Mar19	Apr01	Apr14	Oct19	Nov05	Nov22	236	217	198	24
OZONA 1 SSW	36	Mar25	Apr11	Apr29	Oct07	Oct25	Nov11	218	196	173	25
	32	Mar17	Apr01	Apr15	Oct16	Nov02	Nov19	236	215	194	19
	28	Mar05	Mar22	Apr09	Oct27	Nov12	Nov29	258	234	210	12
PADUCAH	36	Mar27	Apr08	Apr21	Oct06	Oct25	Nov12	218	198	179	30
	32	Mar15	Mar29	Apr11	Oct19	Nov05	Nov23	242	221	199	22
	28	Feb26	Mar17	Apr05	Oct28	Nov15	Dec02	266	242	219	14
PAINT ROCK	36	Mar25	Apr08	Apr22	Oct10	Oct28	Nov14	225	202	179	21
	32	Mar15	Mar31	Apr16	Oct21	Nov06	Nov22	239	219	199	15
	28	Feb23	Mar16	Apr07	Oct29	Nov15	Dec02	269	243	217	9
PALACIOS MUNICIPAL AP	36	Feb10	Mar03	Mar24	Nov08	Nov28	Dec17	299	269	240	5
	32	Dec29	Feb10	Mar21	Nov16	Dec11	Jan08	>365	302	262	3
	28	-	Jan22	Feb25	Dec04	Jan04	-	>365	345	305	1
PALESTINE 2 NE	36	Mar06	Mar26	Apr14	Oct22	Nov08	Nov25	252	227	201	15
	32	Feb23	Mar15	Apr04	Oct28	Nov18	Dec09	277	247	217	10
	28	Jan30	Feb25	Mar23	Nov06	Nov28	Dec20	310	275	240	5
PAMPA 2	36	Apr10	Apr25	May10	Sep29	Oct15	Oct31	192	172	153	38
	32	Mar31	Apr13	Apr25	Oct09	Oct25	Nov10	212	195	178	31
	28	Mar21	Apr02	Apr14	Oct24	Nov07	Nov21	238	218	198	23
PANDALE 1 N	36	Mar11	Mar29	Apr16	Oct18	Nov05	Nov22	247	220	193	20
	32	Feb26	Mar18	Apr08	Oct27	Nov12	Nov28	267	238	209	14
	28	Feb06	Mar03	Mar28	Nov03	Nov23	Dec13	298	264	231	8
PANHANDLE	36	Apr13	Apr29	May14	Sep25	Oct09	Oct23	183	163	143	39
	32	Apr04	Apr18	May02	Oct03	Oct22	Nov09	206	186	166	31
	28	Mar21	Apr04	Apr17	Oct16	Nov01	Nov17	234	210	187	23
PANTHER JUNCTION	36	Mar05	Mar24	Apr12	Oct20	Nov10	Dec01	263	230	197	15
	32	Feb14	Mar11	Apr06	Oct31	Nov19	Dec08	285	252	219	9
	28	Jan19	Feb20	Mar24	Nov07	Dec02	Dec27	324	284	244	4
PARIS	36	Mar17	Mar31	Apr14	Oct20	Nov04	Nov19	238	218	198	21
	32	Feb28	Mar18	Apr06	Oct28	Nov14	Dec01	264	240	215	15
	28	Feb11	Mar03	Mar23	Nov05	Nov25	Dec15	294	266	238	9
PEARSALL	36	Feb17	Mar15	Apr10	Oct23	Nov11	Nov29	272	240	209	11
	32	Jan30	Feb22	Mar18	Nov06	Nov25	Dec14	310	275	240	6
	28	Jan12	Feb13	Mar13	Nov17	Dec12	Jan08	353	303	265	3
PECOS	36	Mar23	Apr07	Apr23	Oct15	Oct29	Nov13	223	204	186	28
	32	Mar09	Mar26	Apr12	Oct21	Nov07	Nov23	249	225	200	21
	28	Feb24	Mar15	Apr03	Nov03	Nov17	Dec02	272	247	221	13

PENWELL	36	Mar29	Apr10	Apr21	Oct13	Oct30	Nov16	224	203	182	26
	32	Mar15	Mar30	Apr13	Oct20	Nov07	Nov26	247	222	197	19
	28	Feb28	Mar19	Apr07	Oct28	Nov16	Dec04	268	241	214	12
PERRYTON	36	Apr20	May02	May15	Sep24	Oct07	Oct20	175	157	139	44
	32	Apr12	Apr25	May08	Sep30	Oct17	Nov02	190	174	159	38
	28	Mar30	Apr11	Apr23	Oct14	Oct28	Nov11	220	200	180	30
PERSIMMON GAP	36	Mar01	Mar22	Apr11	Oct11	Nov02	Nov24	254	224	195	19
	32	Feb14	Mar10	Apr04	Oct19	Nov11	Dec04	280	245	209	12
	28	Jan30	Feb26	Mar24	Nov06	Nov28	Dec21	312	275	238	6
PIERCE 1 E	36	Feb12	Mar10	Apr06	Oct28	Nov17	Dec07	282	251	221	9
	32	Jan19	Feb19	Mar22	Nov03	Dec06	Jan08	334	288	246	4
	28	Dec28	Feb06	Mar15	Nov28	Dec21	Jan21	>365	317	273	2
PILOT POINT	36	Mar21	Apr02	Apr13	Oct23	Nov06	Nov19	234	217	201	23
	32	Feb28	Mar20	Apr10	Oct29	Nov14	Dec01	263	238	213	15
	28	Feb01	Feb28	Mar27	Nov10	Nov29	Dec18	304	273	242	9
PLAINS	36	Apr03	Apr20	May06	Oct01	Oct16	Oct31	199	178	158	36
	32	Mar15	Apr05	Apr26	Oct14	Oct29	Nov14	232	206	181	29
	28	Mar08	Mar28	Apr17	Oct23	Nov09	Nov25	250	225	199	21
PLAINVIEW	36	Apr01	Apr15	Apr30	Oct05	Oct20	Nov04	205	187	169	33
	32	Mar24	Apr04	Apr15	Oct13	Oct31	Nov18	226	209	192	26
	28	Mar09	Mar24	Apr09	Oct30	Nov12	Nov25	251	232	212	17
POINT COMFORT	36	Jan21	Feb25	Mar31	Nov11	Dec03	Dec25	317	279	244	4
	32	-	Jan28	Mar06	Nov25	Dec18	-	>365	325	282	2
	28	-	Jan19	Feb24	Dec06	Jan10	-	>365	355	302	1
PORT ARTHUR AP BEAUMONT	36	Feb07	Mar04	Mar28	Oct30	Nov18	Dec08	290	259	227	7
	32	Jan10	Feb14	Mar21	Nov10	Dec06	Jan02	339	295	250	4
	28	-	Jan30	Mar01	Nov29	Dec25	-	>365	328	287	1
PORT ISABEL	36	-	Jan19	Mar03	Dec03	Dec30	-	>365	342	291	1
	32	-	Dec23	Feb05	Dec23	Jan26	-	>365	>365	330	1
	28	-	-	Jan22	Jan02	-	-	>365	>365	>365	0
PORT MANSFIELD	36	Dec29	Feb08	Mar13	Nov25	Dec17	Jan13	>365	311	272	2
	32	-	Jan10	Feb21	Nov29	Jan07	-	>365	351	308	1
	28	-	-	Jan30	Dec20	-	-	>365	>365	341	0
PORT O CONNOR	36	-	Feb09	Mar18	Nov14	Dec09	-	>365	302	253	3
	32	-	Jan29	Mar04	Nov30	Dec31	-	>365	338	290	1
	28	-	Jan03	Feb14	Dec21	Jan31	-	>365	>365	322	1
POST	36	Mar25	Apr08	Apr22	Oct10	Oct27	Nov13	223	202	180	29
	32	Mar16	Mar30	Apr13	Oct25	Nov09	Nov24	244	223	202	21
	28	Feb26	Mar18	Apr06	Nov01	Nov16	Dec01	267	243	218	14
POTEET	36	Feb19	Mar15	Apr08	Oct29	Nov18	Dec08	280	247	214	11
	32	Jan30	Feb25	Mar23	Nov11	Dec02	Dec22	313	279	245	6
	28	Jan02	Feb02	Mar03	Nov24	Dec17	Jan10	>365	316	281	3
PRADE RANCH	36	Mar25	Apr11	Apr28	Oct09	Oct26	Nov12	223	197	170	23
	32	Mar10	Mar29	Apr18	Oct17	Nov04	Nov22	243	219	195	17
	28	Feb20	Mar16	Apr10	Oct28	Nov16	Dec05	274	244	214	10
PRESIDIO	36	Feb20	Mar20	Apr16	Oct23	Nov11	Nov30	273	235	198	16
	32	Feb04	Mar05	Apr02	Nov02	Nov20	Dec08	296	260	224	9
	28	Jan11	Feb13	Mar18	Nov15	Dec01	Dec17	329	290	252	4
PROCTOR RESERVOIR	36	Mar15	Mar31	Apr16	Oct21	Nov05	Nov21	240	219	198	22
	32	Mar02	Mar20	Apr08	Oct28	Nov15	Dec03	262	238	215	15
	28	Feb10	Mar05	Mar27	Nov02	Nov25	Dec17	296	264	232	8
PUTNAM	36	Mar23	Apr05	Apr17	Oct21	Nov05	Nov21	233	214	194	18
	32	Mar09	Mar24	Apr07	Oct27	Nov13	Nov30	251	234	216	12
	28	Feb19	Mar12	Apr02	Nov04	Nov23	Dec12	284	255	227	7
QUANAH 5 SE	36	Apr01	Apr13	Apr26	Oct01	Oct18	Nov03	207	186	166	31
	32	Mar24	Apr04	Apr16	Oct13	Nov02	Nov22	231	211	190	24
	28	Mar02	Mar22	Apr10	Oct24	Nov11	Nov28	257	233	209	17

RAYMONDVILLE	36	Jan07	Feb16	Mar19	Nov16	Dec10	Jan09	>365	295	256	4
	32	-	Jan19	Mar04	Nov27	Jan01	-	>365	352	290	1
	28	-	-	Feb02	Dec17	-	-	>365	>365	334	0
RED BLUFF DAM	36	Apr03	Apr13	Apr24	Oct11	Oct27	Nov11	212	196	179	27
	32	Mar17	Mar30	Apr12	Oct15	Nov04	Nov23	240	218	195	19
	28	Feb27	Mar17	Apr04	Oct28	Nov14	Dec02	269	241	213	12
RED ROCK	36	Mar10	Apr03	Apr26	Oct11	Oct31	Nov21	245	211	177	16
	32	Feb26	Mar21	Apr13	Oct23	Nov15	Dec07	270	238	205	10
	28	Feb05	Mar01	Mar24	Oct31	Nov22	Dec14	299	266	232	6
RIO GRANDE CITY 1 SE	36	Jan27	Feb27	Mar30	Nov05	Dec03	Dec31	325	278	231	5
	32	Dec29	Feb09	Mar13	Nov14	Dec14	Jan23	>365	309	264	3
	28	-	Jan06	Mar01	Dec03	Dec30	-	>365	>365	298	1
RISING STAR 1 S	36	Mar26	Apr06	Apr17	Oct17	Nov01	Nov16	226	208	190	23
	32	Mar12	Mar27	Apr12	Oct24	Nov10	Nov27	249	227	205	17
	28	Feb22	Mar15	Apr05	Oct31	Nov20	Dec10	279	249	220	10
ROBERT LEE	36	Mar25	Apr06	Apr18	Oct18	Nov01	Nov14	224	208	192	24
	32	Mar11	Mar26	Apr10	Oct26	Nov11	Nov28	253	230	207	18
	28	Feb17	Mar13	Apr06	Nov04	Nov19	Dec03	277	251	224	11
ROBSTOWN	36	Jan21	Feb19	Mar20	Nov16	Dec05	Dec23	323	288	253	4
	32	-	Jan31	Mar03	Nov27	Dec23	-	>365	332	284	2
	28	-	Jan12	Feb16	Dec11	Jan12	-	>365	>365	318	1
ROCKPORT	36	Jan24	Feb18	Mar14	Nov15	Dec05	Dec25	318	289	261	4
	32	-	Feb02	Mar02	Nov24	Dec20	-	>365	318	281	2
	28	-	Jan12	Feb15	Nov30	Jan05	-	>365	355	318	1
ROCKSPRINGS	36	Mar12	Mar29	Apr15	Oct15	Nov07	Dec01	252	223	194	15
	32	Feb20	Mar18	Apr13	Oct25	Nov17	Dec10	278	243	208	9
	28	Jan29	Feb26	Mar26	Oct30	Nov29	Dec30	321	276	230	5
ROSCOE	36	Mar28	Apr11	Apr25	Oct07	Oct28	Nov19	221	199	177	23
	32	Mar17	Mar31	Apr15	Oct24	Nov10	Nov26	244	223	201	16
	28	Mar02	Mar21	Apr09	Oct31	Nov16	Dec02	262	239	216	10
ROTAN	36	Mar23	Apr07	Apr22	Oct10	Oct27	Nov14	223	203	182	23
	32	Mar12	Mar29	Apr14	Oct23	Nov09	Nov25	249	225	200	16
	28	Feb18	Mar14	Apr07	Nov02	Nov17	Dec03	275	248	220	10
RUSK	36	Mar09	Mar27	Apr15	Oct25	Nov11	Nov28	247	228	209	15
	32	Feb16	Mar10	Apr01	Nov05	Nov21	Dec07	282	255	229	9
	28	Jan23	Feb20	Mar20	Nov13	Dec05	Dec27	323	287	251	5
SAM RAYBURN DAM	36	Mar14	Apr01	Apr20	Oct15	Nov02	Nov21	244	214	185	16
	32	Feb20	Mar17	Apr11	Oct26	Nov14	Dec03	274	241	209	11
	28	Feb01	Feb28	Mar26	Nov08	Nov28	Dec18	308	273	237	6
SAN ANGELO MATHIS AP	36	Mar26	Apr06	Apr17	Oct19	Nov02	Nov15	229	209	188	21
	32	Mar11	Mar28	Apr14	Oct29	Nov13	Nov29	252	230	208	14
	28	Feb15	Mar10	Apr03	Nov01	Nov18	Dec05	281	252	223	8
SAN ANTONIO INTL AP	36	Feb22	Mar16	Apr07	Oct26	Nov14	Dec02	270	242	214	11
	32	Feb06	Feb28	Mar21	Nov08	Nov25	Dec13	297	270	242	6
	28	Jan02	Feb06	Mar13	Nov15	Dec10	Jan05	348	306	268	3
SAN MARCOS	36	Feb23	Mar18	Apr10	Oct27	Nov13	Nov29	266	239	211	13
	32	Jan30	Feb28	Mar29	Nov05	Nov24	Dec13	306	268	230	7
	28	Jan14	Feb10	Mar07	Nov16	Dec09	Jan03	346	301	266	4
SAN SABA	36	Mar19	Apr03	Apr17	Oct12	Nov01	Nov20	235	211	188	19
	32	Feb25	Mar20	Apr12	Oct25	Nov11	Nov28	265	236	206	13
	28	Feb07	Mar06	Apr01	Nov02	Nov21	Dec11	289	260	231	7
SANDERSON	36	Mar14	Mar30	Apr15	Oct13	Oct31	Nov18	237	214	192	23
	32	Mar03	Mar22	Apr10	Oct24	Nov10	Nov28	258	233	207	16
	28	Feb13	Mar09	Apr02	Nov02	Nov19	Dec07	285	255	225	9
SEALY	36	Feb13	Mar08	Mar30	Oct27	Nov15	Dec05	281	252	223	9
	32	Jan21	Feb18	Mar17	Nov07	Dec08	Jan09	332	291	254	4
	28	Dec21	Jan31	Mar09	Nov20	Dec16	Jan14	>365	318	279	2

SEMINOLE	36	Apr01	Apr14	Apr27	Oct07	Oct23	Nov08	209	191	174	33
	32	Mar18	Apr02	Apr16	Oct18	Nov03	Nov19	237	215	193	25
	28	Mar07	Mar23	Apr09	Oct30	Nov14	Nov30	257	235	214	16
SEYMOUR	36	Mar28	Apr11	Apr26	Oct07	Oct26	Nov15	221	197	173	28
	32	Mar15	Mar30	Apr14	Oct21	Nov06	Nov22	242	220	199	21
	28	Feb26	Mar18	Apr06	Nov02	Nov17	Dec02	266	243	220	14
SHAMROCK 2	36	Apr05	Apr17	Apr29	Sep30	Oct18	Nov05	204	183	163	35
	32	Mar24	Apr06	Apr19	Oct07	Oct27	Nov16	226	203	180	27
	28	Mar14	Mar27	Apr09	Oct21	Nov07	Nov24	245	224	204	20
SHEFFIELD	36	Mar21	Apr05	Apr21	Oct11	Oct28	Nov14	228	205	182	23
	32	Mar09	Mar26	Apr12	Oct22	Nov07	Nov23	246	225	205	16
	28	Feb23	Mar15	Apr04	Oct28	Nov15	Dec03	274	245	216	10
SHERMAN	36	Mar20	Apr01	Apr14	Oct16	Nov03	Nov21	236	215	193	21
	32	Mar04	Mar22	Apr09	Oct25	Nov14	Dec03	260	236	212	14
	28	Feb03	Mar01	Mar27	Nov03	Nov26	Dec18	304	269	233	8
SIERRA BLANCA 2 E	36	Apr15	Apr27	May10	Oct04	Oct19	Nov04	196	174	153	36
	32	Apr03	Apr18	May03	Oct16	Oct29	Nov12	209	193	177	27
	28	Mar22	Apr07	Apr23	Oct21	Nov06	Nov22	236	212	188	18
SILVERTON	36	Apr12	Apr27	May12	Sep28	Oct11	Oct25	183	167	150	40
	32	Apr01	Apr14	Apr27	Oct07	Oct22	Nov06	207	190	173	33
	28	Mar21	Apr03	Apr15	Oct22	Nov04	Nov17	231	214	198	24
SINTON	36	Jan26	Feb25	Mar26	Nov10	Nov29	Dec19	313	277	241	5
	32	Jan02	Feb07	Mar11	Nov21	Dec13	Jan07	>365	308	270	2
	28	-	Jan23	Feb26	Dec05	Jan03	-	>365	345	299	1
SMITHVILLE	36	Mar01	Mar23	Apr14	Oct25	Nov10	Nov27	260	232	204	15
	32	Feb09	Mar04	Mar27	Oct30	Nov20	Dec11	292	260	228	9
	28	Jan21	Feb19	Mar20	Nov17	Dec05	Dec23	318	289	259	5
SNYDER	36	Mar27	Apr11	Apr26	Oct07	Oct25	Nov13	218	197	176	30
	32	Mar19	Apr01	Apr14	Oct23	Nov07	Nov22	240	219	199	22
	28	Feb24	Mar19	Apr11	Nov02	Nov17	Dec01	267	242	216	15
SOMERVILLE DAM	36	Feb25	Mar20	Apr11	Oct27	Nov13	Nov29	266	237	208	13
	32	Feb08	Mar03	Mar26	Nov02	Nov23	Dec13	294	264	233	8
	28	Jan19	Feb14	Mar13	Nov11	Dec06	Dec30	329	293	258	4
SONORA	36	Mar25	Apr10	Apr26	Oct03	Oct22	Nov10	223	194	166	24
	32	Mar19	Apr04	Apr20	Oct16	Nov03	Nov22	239	213	187	18
	28	Mar04	Mar23	Apr11	Oct20	Nov10	Dec01	259	231	202	11
SPEARMAN	36	Apr12	Apr27	May12	Sep25	Oct12	Oct29	189	168	146	37
	32	Apr03	Apr16	Apr28	Oct07	Oct23	Nov07	205	189	173	30
	28	Mar19	Apr01	Apr14	Oct20	Nov04	Nov19	238	216	194	21
SPUR	36	Mar30	Apr12	Apr25	Oct04	Oct22	Nov09	212	192	172	32
	32	Mar21	Apr02	Apr15	Oct22	Nov04	Nov18	235	215	195	25
	28	Mar05	Mar24	Apr11	Oct28	Nov13	Nov28	258	233	209	17
STAMFORD 1	36	Mar25	Apr06	Apr18	Oct15	Nov01	Nov18	226	208	190	26
	32	Mar12	Mar28	Apr12	Oct26	Nov10	Nov26	248	227	206	18
	28	Feb17	Mar13	Apr07	Nov04	Nov19	Dec05	277	250	224	11
STEPHENVILLE 1 N	36	Mar24	Apr06	Apr20	Oct21	Nov04	Nov19	230	211	193	20
	32	Mar03	Mar22	Apr09	Oct27	Nov13	Nov29	257	235	213	14
	28	Feb12	Mar08	Apr01	Nov04	Nov21	Dec08	286	257	228	8
STERLING CITY	36	Mar30	Apr12	Apr26	Oct01	Oct18	Nov04	209	188	167	27
	32	Mar20	Apr04	Apr20	Oct14	Nov03	Nov23	237	212	187	19
	28	Mar03	Mar23	Apr12	Oct25	Nov13	Dec02	262	234	205	13
STILLHOUSE HOLLOW DAM	36	Mar04	Mar23	Apr12	Oct22	Nov11	Nov30	259	232	204	16
	32	Feb18	Mar11	Mar31	Oct31	Nov22	Dec13	285	255	226	9
	28	Jan31	Feb22	Mar17	Nov15	Dec06	Dec27	317	286	255	5
STRATFORD	36	Apr20	May03	May17	Sep23	Oct07	Oct21	177	156	135	45
	32	Apr10	Apr26	May12	Oct01	Oct15	Oct29	190	171	153	38
	28	Mar31	Apr12	Apr25	Oct10	Oct26	Nov12	215	196	177	30

SUGAR LAND	36	Feb07	Mar04	Mar28	Oct29	Nov21	Dec13	292	261	230	8
	32	Jan14	Feb15	Mar18	Nov10	Dec10	Jan09	339	294	259	4
	28	-	Jan23	Mar02	Nov28	Dec24	-	>365	328	286	2
SULPHUR SPRINGS	36	Mar22	Apr04	Apr16	Oct13	Oct28	Nov12	226	207	187	21
	32	Mar06	Mar25	Apr12	Oct25	Nov12	Dec01	259	232	204	15
	28	Feb05	Mar04	Mar30	Nov03	Nov22	Dec11	295	263	231	9
TAHOKA	36	Mar30	Apr12	Apr26	Oct04	Oct22	Nov08	209	192	174	33
	32	Mar21	Apr04	Apr18	Oct17	Nov04	Nov22	234	213	193	26
	28	Mar14	Mar27	Apr08	Oct30	Nov14	Nov29	251	231	211	17
TAYLOR	36	Mar03	Mar23	Apr12	Oct26	Nov11	Nov28	258	232	206	16
	32	Feb09	Mar05	Mar30	Nov01	Nov20	Dec10	287	259	231	10
	28	Jan28	Feb21	Mar18	Nov12	Dec06	Dec30	320	287	254	5
TEMPLE	36	Mar01	Mar21	Apr11	Oct25	Nov12	Nov30	264	235	206	15
	32	Feb09	Mar03	Mar24	Nov02	Nov22	Dec13	293	264	235	8
	28	Jan23	Feb16	Mar11	Nov14	Dec08	Jan01	322	295	267	5
TEXARKANA	36	Mar16	Mar31	Apr14	Oct20	Nov05	Nov20	240	218	196	21
	32	Feb27	Mar20	Apr10	Oct27	Nov14	Dec03	269	238	208	14
	28	Feb02	Feb28	Mar25	Nov10	Nov30	Dec21	307	275	243	8
THOMPSONS 3 WSW	36	Feb09	Mar04	Mar28	Oct31	Nov20	Dec09	292	260	227	7
	32	Jan09	Feb13	Mar17	Nov12	Dec08	Jan04	353	296	253	3
	28	-	Jan29	Mar04	Nov27	Dec28	-	>365	333	283	1
TILDEN 4 SSE	36	Feb09	Mar08	Apr03	Oct31	Nov19	Dec08	287	256	224	8
	32	Jan26	Feb21	Mar20	Nov16	Dec03	Dec20	314	284	254	4
	28	-	Jan28	Mar03	Nov22	Dec23	-	>365	335	284	2
TOWN BLUFF DAM	36	Mar05	Mar24	Apr12	Oct23	Nov09	Nov27	255	230	204	14
	32	Feb16	Mar09	Mar29	Nov02	Nov19	Dec07	281	255	229	9
	28	Jan22	Feb17	Mar15	Nov10	Dec04	Dec27	327	289	251	4
TRUSCOTT 3 W	36	Mar27	Apr06	Apr16	Oct18	Nov01	Nov15	225	209	193	27
	32	Mar13	Mar28	Apr11	Oct26	Nov09	Nov24	247	226	205	20
	28	Feb25	Mar16	Apr04	Nov01	Nov18	Dec05	272	246	220	13
TULIA	36	Apr16	Apr28	May11	Sep28	Oct13	Oct27	183	167	150	40
	32	Mar31	Apr14	Apr28	Oct09	Oct24	Nov08	209	193	176	32
	28	Mar23	Apr05	Apr18	Oct21	Nov05	Nov21	233	213	193	24
TURKEY	36	Mar29	Apr12	Apr25	Oct06	Oct21	Nov06	212	192	173	28
	32	Mar18	Mar31	Apr13	Oct24	Nov06	Nov19	237	219	202	20
	28	Feb28	Mar19	Apr08	Nov02	Nov17	Dec02	269	242	215	13
VAN HORN	36	Apr03	Apr15	Apr27	Oct15	Oct30	Nov15	215	197	179	29
	32	Mar20	Apr04	Apr18	Oct19	Nov05	Nov22	238	215	192	21
	28	Mar03	Mar23	Apr11	Oct27	Nov14	Dec02	265	236	207	13
VERNON	36	Mar25	Apr08	Apr23	Oct09	Oct27	Nov15	229	201	173	27
	32	Mar17	Mar30	Apr12	Oct23	Nov09	Nov26	244	223	203	20
	28	Feb26	Mar17	Apr06	Oct27	Nov15	Dec05	270	242	215	13
VICTORIA RGNL AP	36	Feb04	Mar02	Mar29	Nov02	Nov22	Dec13	297	264	231	6
	32	Jan11	Feb09	Mar08	Nov16	Dec11	Jan07	349	305	271	3
	28	-	Jan21	Feb25	Dec01	Dec25	-	>365	339	300	1
WACO DAM	36	Mar11	Mar27	Apr13	Oct27	Nov09	Nov23	247	226	206	18
	32	Feb18	Mar15	Apr10	Oct29	Nov17	Dec06	278	246	214	11
	28	Jan31	Feb25	Mar22	Nov08	Dec02	Dec27	313	280	247	6
WACO RGNL AP	36	Mar11	Mar28	Apr14	Oct25	Nov10	Nov27	250	227	204	15
	32	Feb17	Mar13	Apr06	Nov01	Nov19	Dec07	280	250	221	9
	28	Jan24	Feb21	Mar21	Nov11	Dec04	Dec27	318	285	251	5
WASHINGTON STATE PARK	36	Feb21	Mar18	Apr12	Oct25	Nov12	Nov30	269	239	209	12
	32	Feb09	Mar04	Mar26	Nov03	Nov24	Dec15	298	264	231	7
	28	Jan15	Feb15	Mar14	Nov15	Dec08	Jan03	337	296	265	3
WATER VALLEY	36	Apr01	Apr13	Apr26	Oct02	Oct21	Nov10	212	190	169	27
	32	Mar23	Apr05	Apr19	Oct18	Nov02	Nov17	229	210	191	21
	28	Mar02	Mar22	Apr11	Oct27	Nov13	Nov30	258	235	212	14

WAXAHACHIE	36	Mar11	Mar26	Apr09	Oct27	Nov10	Nov24	246	229	211	15
	32	Feb21	Mar14	Apr04	Nov01	Nov18	Dec05	273	248	223	10
	28	Jan25	Feb21	Mar19	Nov11	Dec01	Dec20	310	282	255	5
WEATHERFORD	36	Mar27	Apr09	Apr22	Oct08	Oct25	Nov11	222	198	175	25
	32	Mar12	Mar29	Apr16	Oct22	Nov08	Nov24	244	223	201	18
	28	Feb24	Mar17	Apr06	Oct29	Nov15	Dec03	268	243	218	12
WELLINGTON	36	Mar27	Apr09	Apr22	Oct09	Oct26	Nov12	220	200	179	30
	32	Mar21	Apr01	Apr13	Oct18	Nov04	Nov21	234	216	197	23
	28	Feb28	Mar19	Apr08	Oct27	Nov15	Dec04	266	240	213	15
WESLACO 2 E	36	-	Feb01	Mar09	Nov22	Dec21	-	>365	321	279	2
	32	-	Dec30	Feb17	Dec13	Jan22	-	>365	>365	306	1
	28	-	-	Jan21	Dec23	-	-	>365	>365	>365	0
WHITNEY DAM	36	Mar15	Mar30	Apr15	Oct26	Nov10	Nov25	246	224	201	19
	32	Feb22	Mar15	Apr04	Oct31	Nov17	Dec04	276	247	218	12
	28	Feb01	Feb22	Mar16	Nov07	Nov27	Dec17	305	277	249	6
WICHITA FALLS SHEPPRD AP	36	Mar26	Apr07	Apr19	Oct18	Nov01	Nov15	226	207	189	25
	32	Mar14	Mar28	Apr12	Oct23	Nov09	Nov27	247	225	204	17
	28	Feb17	Mar11	Apr02	Nov04	Nov22	Dec10	282	255	228	11
WILLS POINT	36	Mar17	Mar31	Apr14	Oct28	Nov09	Nov21	240	222	204	18
	32	Feb20	Mar14	Apr05	Oct30	Nov18	Dec07	277	248	220	12
	28	Jan27	Feb22	Mar21	Nov13	Dec03	Dec23	314	283	253	7
WINK WINKLER CO AP	36	Apr01	Apr13	Apr25	Oct09	Oct25	Nov11	215	195	174	27
	32	Mar18	Apr02	Apr17	Oct18	Nov04	Nov21	237	215	194	20
	28	Feb26	Mar17	Apr04	Oct25	Nov11	Nov28	263	239	214	14
WINTERS 1 NNE	36	Mar25	Apr08	Apr23	Oct21	Nov03	Nov16	228	208	188	22
	32	Mar08	Mar26	Apr12	Oct28	Nov11	Nov25	250	230	210	15
	28	Feb13	Mar12	Apr07	Nov03	Nov18	Dec04	282	251	219	9
YOAKUM	36	Feb14	Mar10	Apr03	Oct29	Nov18	Dec08	287	252	218	9
	32	Feb01	Feb27	Mar25	Nov08	Dec02	Dec26	309	278	246	5
	28	Jan02	Feb05	Mar07	Nov17	Dec13	Jan10	364	311	271	2
YSLETA	36	Mar19	Apr04	Apr21	Oct16	Oct30	Nov12	229	207	186	28
	32	Feb25	Mar19	Apr11	Oct23	Nov08	Nov24	257	233	208	19
	28	Feb07	Mar05	Mar30	Nov01	Nov19	Dec07	290	258	227	11
ZAPATA 3 SW	36	Jan07	Feb08	Mar13	Nov12	Dec09	Jan05	349	301	258	3
	32	-	Jan24	Feb24	Nov25	Dec25	-	>365	337	292	1
	28	-	Dec13	Jan31	Dec06	Jan14	-	>365	>365	316	1

Notes:

(1) Probability of later date in spring (thru Jul 31) than indicated.

(2) Probability of earlier date in fall (beginning Aug 1) than indicated.

(3) Probability of longer than indicated freeze free period.

(4) Probability of Freeze/Frost in the yearly period (percent of days with temperatures at or below the threshold temperature).