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16. Abstract

This study examines the role and needs of airports that serve the agricultural communities in Texas. The significance of agriculture to the state is addressed and agricultural airports are identified. The major crops produced in the state are categorized by region and the level of aerial application activity that they generate is discussed. The specific needs of agricultural airports are identified with respect to the level of aerial application activity, the economic significance of the state's crops, and the technological trends of the agricultural aircraft industry. Specific recommendations are presented with respect to supporting agricultural airports through the planning and programming process.

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EVALUATION OF THE ROLE AND NEEDS OF AGRICULTURAL AIRPORTS IN TEXAS

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Research Report 1951-S
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Research Study Title: Evaluation of the Role and Needs of Agricultural Airports

Sponsored by the
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May 2000

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DISCLAIMER

The contents of this report reflect the views of the author who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or policies of the Texas Department of Transportation (TxDOT), the Federal Aviation Administration (FAA), or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. It is not intended for construction, bidding, or permit purposes. This report was prepared by Jeffrey D. Borowiec, assistant research scientist. George B. Dresser, Ph.D. was the research supervisor.

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TABLE OF CONTENTS

LIST OF TABLES ix

LIST OF FIGURES x

SUMMARY xiii

I. Introduction 1
Background and Significance of this Report 1

II. Identification of Agricultural Airports 3
Texas Aerial Applicator Interviews 3
State Interviews 3
Arkansas 5
California 6
Illinois 6
Indiana 7
Iowa 7
Kansas 7
Nebraska 8
North Carolina 8
North Dakota 8
Washington 8
Agricultural Airports 9

III. Technology Trends in Agricultural Aircraft History 11
Current Fleet 11
The Texas Fleet 14
Global Positioning Satellite Systems 17
Dispersal Systems 18
Conclusion 18

IV. Texas Crops 19
High Plains District 24
Low Plains District 25
Cross Timbers District 25
Blacklands District 26
East Texas District 27
Commercial Timberlands 27
Trans-Pecos District 28
Edwards Plateau District 28
South Central/Coastal Bend District 29

Upper Coast District 30
South Texas/Lower Valley District 31

V. Aerial Application Activity in Texas 35
Cotton and the Texas Boll Weevil Eradication Program 36
Major Crops and Aerial Application Activity 43
Corn 43
Sorghum/Milo 44
Wheat 44
Peanuts 44
Rice 45
Soybeans 45
Timberland 45
Vegetables 46
Miscellaneous 48
Summary 48

VI. Agricultural Airport Needs and Recommendations 53
Needs 53
Agricultural Pads 53
Access Roads 57
Stub Taxiways 61
Aircraft Tie-Downs 62
Recommendations 62
Agricultural Loading Pads and Pad Improvements 62
Access Roads 63
Stub Taxiways 64
Aircraft Tie-Downs 64
Conclusion 66

References 67

Appendix A Texas Agricultural Statistics Districts 69

Appendix B Texas Agricultural Airports 73

Appendix C Example Aerial Applicator's Apron Loan Program 77

Appendix D Example Aerial Applicator Apron Specifications 83

Appendix E Example Agricultural Airport Engineering Drawings 93

LIST OF TABLES

Table		Page
1	Top 10 States in Agricultural Exports ($)	4
2	Top 10 States in Cash Receipts for Crops	4
3	Top 10 Crops in Texas in Cash Receipts for 1997	5
4	U.S. Agricultural Aircraft Fleet - 1997	12
5	Specifications of Selected Air Tractor Agricultural Aircraft	15
6	Specifications of Selected Ayres Trubo Thrush Agricultural Aircraft	16
7	Top 10 Crops in Texas and Their Cash Receipts for 1997	19
8	Summary of Agricultural Cash Receipts (1,000s) and Share by Major Crop (%)	23
9	Major Crops in the High Plains District	24
10	Major Crops in the Low Plains District	25
11	Major Crops in the Cross Timbers District	25
12	Major Crops in the Blacklands District	26
13	Major Crops in the East Texas District	27
14	Major Crops in the Trans-Pecos District	28
15	Major Crops in the Edwards Plateau District	28
16	Major Crops in the South Central/Coastal Bend District	29
17	Major Crops in the Upper Coast District	30
18	Major Crops in the South Texas/Lower Valley District	31
19	Summary of Agricultural Districts by Cash Value	32
20	Summary of Agricultural Districts by Major Crops	33
21	National Rank of Texas Crops by Production	33
22	Texas Boll Weevil Eradication Program Airports and Number of Aircraft - 1996	37
23	Texas Boll Weevil Eradication Program Airports and Number of Aircraft - 1997	39
24	Texas Boll Weevil Eradication Program Airports and Number of Aircraft - 1998	41
25	Summary of Boll Weevil-Related Aerial Application Activity, 1996-1998	42
26	Total Acreage Planted by Major Crop - 1997	45
27	Acreage and Cash Value of Selected Vegetable Crops for Fresh Market - 1997	47
28	Summary of Aerial Activity in Texas	50
29	Planting and Harvesting Calendar for Most Major U.S. Crops	51
30	Applicable Design Standards for Agricultural Airports	65
31	Recommended Design Element Changes for Agricultural Airports	65
B-1	Texas Agricultural Airports	75

LIST OF FIGURES

Figure		Page
1.	Turbine-Powered Agricultural Aircraft	13
2	Piston-engine Agricultural Aircraft	13
3	Texas Agricultural Statistics Districts	21
4	Aerial Application Activity at a Public-Use Airport	35
5	Aerial Application Activity at a Private Airstrip	36
6	Fuel Truck Used for Aerial Application	55
7	Fertilizer Truck Used for Aerial Application	55
8	Model Agricultural Pad	56
9	Access Road to Agricultural Pad	57
10	Segregated Access Road to Agricultural Pad	58
11	Example of an Apron Pavement Failure	59
12	Additional Asphalt-Damaged Surface	60
13	Example of a Stub Taxiway	61

IMPLEMENTATION RECOMMENDATIONS

Based on the results of this research project, the author proposes the following recommendations for TxDOT:

1. Where applicable and appropriate, agricultural pads, access roads, stub taxiways, and aircraft tie-downs should be constructed. The nature of the aerial application work to be done, including the frequency and intensity, as well as the particular crop and geographical location should be considered. The specific design details will vary somewhat depending on the part of the state and the level of aerial activity as certain crops generate more activity than others.

2. Particular consideration should be given to the operational safety of the airport with respect to agricultural aircraft and other general aviation traffic. Consequently, when possible, agricultural aircraft activity should be segregated from other aircraft activity on the airport.

3. The recommended improvements may be appropriate for airports not functionally classified as agricultural airports. The type and level of aerial application activity should be considered to determine the necessary infrastructure improvements.

4. Improvements to existing facilities (i.e., agricultural pads or access roads) should be made with the same consideration as if they were built for the first time. The geography, type of crop, and level of aerial application activity are important considerations for the type of facilities needed.

SUMMARY

The Texas general aviation airport system developed over time in a relatively unstructured manner. Many system airports began as either private strips or surplus military facilities with ownership being transferred to communities that now operate the airports for public use. The airport system is also costly to maintain. The current Texas Airport System Plan (TASP) produced by TxDOT's Aviation Division projects 0-5 year development costs for general aviation non-reliever facilities at more than $293 million, or $58.7 million per year. Reliever airport development costs are projected at almost $301 million, or over $60 million per year.

Federal funding for state aviation provided to general aviation reliever and non-reliever airports is approximately $23.0 million. State funding is approximately $15 million annually with the total amount available from all sources for general aviation airports expected to be about $38 million. The total amount needed, however, is $118.7 million, thus leaving an annual shortfall of $92 million.

For many communities, the airport is a vital link that improves their access to jobs and commerce. For some Texas communities whose economies are based on agriculture, the airport is even more critical. It is their lifeblood. These agricultural airports are a special subset of general aviation airports and have special needs. Agriculture is big business in Texas where cash receipts in 1997 exceeded $13.4 billion and farm real estate values led the nation topping $83.8 billion (1). Many businesses, individuals, and financial institutions are involved in agribusiness throughout the state including food and fiber production, processing, transporting, and marketing.

According to the Texas Agricultural Extension Service, agriculture was responsible for approximately $44 billion in economic activity in the state in 1996 (2). According to the Economic Research Service of the U.S. Department of Agriculture, the value of farm assets totaled more than $93 billion in 1997 (3). There is also significant potential for future growth in the agricultural industry in Texas. World demands are certain to play a role in this growth and Texas' ability to capitalize on it is paramount. Texas' warm climate and other conducive natural advantages, along with its excellent transportation facilities, contribute to its success and potential. Among these facilities are its airports, specifically its agricultural airports.

In an effort to better understand the specific needs and concerns of aerial applicators, researchers conducted a series of interviews around the state. The involvement and participation of the Texas Agricultural Aviation Association (TAAA) was solicited for this study. Several aerial applicators were interviewed for this study at their place of business in an effort to better understand the work they perform. This gave researchers first-hand knowledge of aerial application operations as well as an opportunity to discuss issues of interest with them. Interviews of state aviation staff were conducted to ascertain how other states treat agricultural airports in the planning, programming, and funding processes.

Current trends in technology were examined to determine the current and future needs of agricultural aviation. Specifically, the size and weight of agricultural aircraft will inevitably become larger and this will impact the size and other specifications of agricultural pads used to load and wash agricultural aircraft.

Specific needs of these agricultural airports center around adequate agricultural pads that are large enough to accommodate the heaviest and largest aircraft in the industry as well as the necessary trucks and equipment needed in these operations. It is not uncommon to use large 18-wheel trucks for fuel and fertilizer operations. Appropriate facilities will help ensure that this important segment of aviation will safely and efficiently protect and preserve one of Texas' most important economic engines in agriculture.

I. INTRODUCTION

BACKGROUND AND SIGNIFICANCE OF THIS REPORT

The Texas general aviation airport system developed over time in a relatively unstructured manner. Many system airports began as either private strips or surplus military facilities with ownership being transferred to communities that now operate the airports for public use. The airport system is also costly to maintain. The current Texas Airport System Plan (TASP) produced by TxDOT's Aviation Division projects 0-5 year development costs for general aviation non-reliever facilities at more than $293 million, or $58.7 million per year. Reliever airport development costs are projected at almost $301 million, or over $60 million per year.

Federal funding for state aviation provided to general aviation reliever and non-reliever airports is approximately $23.0 million. State funding is approximately $15 million annually with the total amount available from all sources for general aviation airports expected to be about $38 million. The total amount needed, however, is $118.7 million, thus leaving an annual shortfall of $92 million.

With the limited resources available, it is understandable that the perception exists that there are too many airports in the Texas airport system. However, where to trim the system is open to debate. None of the cities or counties that sponsor airports have expressed any interest in having their airports removed from the TASP. For many of these communities, the airport is a vital link that improves their access to jobs and commerce. Additionally, in some Texas communities, those whose economies are based on agriculture, the airport is even more critical. It is their lifeblood.

These agricultural airports are a special subset of general aviation airports and have special needs. Agriculture is big business in Texas where cash receipts in 1997 exceeded $13.4 billion and farm real estate values led the nation, topping $83.8 billion (1). Many businesses, individuals, and financial institutions are involved in agribusiness throughout the state including food and fiber production, processing, transporting, and marketing. According to the Texas Agricultural Extension Service, agriculture was responsible for approximately $44 billion in economic activity in the state in 1996 (2). According to the Economic Research Service of the U.S. Department of Agriculture, the value of farm assets totaled more than $93 billion in 1997 (3). There is also significant potential for future growth in the agricultural industry in Texas. World demands are certain to play a role in this growth and Texas' ability to capitalize on it is paramount. Texas' warm climate and other conducive natural advantages, along with its excellent transportation facilities, contribute to its success and potential. Among these facilities are its airports, specifically its agricultural airports.

For many Texas counties, agriculture is the primary economic activity. The use of aerial application aircraft is critical to the success of many crops and some livestock programs, and consequently, to the counties themselves. Yet, from a financing standpoint, these agricultural airports are viewed in the same manner as the other general aviation airports. From an airport planning and programming perspective, airports whose primary function is supporting agriculture are treated the same as any other general aviation airport. That is, the same system service level and roles are used, the same activity-based programming criteria are used, and the same design standards are used for preparing plans and specifications and estimates. There is a need for a comprehensive study of the needs of agricultural aviation. The Aviation Division of the Texas Department of Transportation has recently developed a separate functional category for agricultural airports. This functional category includes airports that serve areas of intense agricultural production. Agricultural spraying services are required to support the production capability within many small communities; therefore, many of the design standards of these general aviation airports are specifically related to the needs of agricultural operators.

II. IDENTIFICATION OF AGRICULTURAL AIRPORTS

To better understand the specific needs and concerns of aerial applicators, researchers conducted a series of interviews around the state. The involvement and participation of the Texas Agricultural Aviation Association (TAAA) was solicited for this study. The TAAA is a professional association made up of aerial applicators, pilots, and other allied industry members whose primary purpose is to coordinate efforts towards the advancement of the industry. This includes the new self-certification process that requires applicators to earn continuing education units. In addition, interviews with aviation or aeronautics staff in other states where there is significant agricultural activity were performed.

TEXAS AERIAL APPLICATOR INTERVIEWS

Several aerial applicators were interviewed for this study at their place of business in an effort to better understand the work they perform. This gave researchers first-hand knowledge of aerial application operations as well as an opportunity to discuss issues of interest with them. These interviews primarily took place in two regions of the state: the Southern Low Plains and Upper Coast/East Texas regions. In addition, two locations in southwestern Louisiana were visited because of their similarities to the rice-growing regions in Texas and the location of specific agricultural aviation related infrastructure at the airports. These two airports are Jennings Airport in Jennings, and Welsh Airport in Welsh. Both are sites of significant aerial application activity as the region is well known for its rice production. Nearly all of the rice grown in that region is sown by air. The results of these site visits and interviews will be further documented later in this report and will be used to develop specific recommendations.

STATE INTERVIEWS

Researchers conducted interviews with state aviation staff members to ascertain how other states treat agricultural airports in the planning, programming, and funding process. Agricultural airports are those that include aerial application operations. As mentioned earlier, in Texas, they are treated no differently than any other general aviation airport except as identified by an agricultural functional category. Several states were selected based on the level of agricultural activity present in the state. Researchers used two criteria to identify these states. These were the dollar value of agricultural exports and the cash receipt value for crops. Table 1 shows the top 10 states in terms of agricultural exports in dollars. Table 2 presents the top 10 states in terms of their cash receipts for crops.

TABLE 1
Top 10 States in Agricultural Exports ($)

Rank	State
1	California
2	Iowa
3	Illinois
4	Texas
5	Nebraska
6	Kansas
7	Minnesota
8	Indiana
9	Washington
10	North Dakota

Source: Texas Agricultural Statistics, 1997

TABLE 2
Top 10 States in Cash Receipts for Crops

Rank	State
1	California
2	Iowa
3	Illinois
4	Texas
5	Florida
6	Minnesota
7	Nebraska
8	Washington
9	Indiana
10	North Carolina

Source: United States Department of Agriculture, National Agricultural Statistics Service, 1996. Statistical Highlights 1997-98: Farm Economics

In addition to the states listed above, two other states were selected because of their relevance to specific crops grown in Texas. These two states are Georgia, the nation's leading producer of both peanuts and pecans, and Arkansas, the nation's leading producer of rice (1). Table 3 shows the top 10 crops in Texas in 1997 in terms of cash receipt value, as well as the state which leads the nation in the production of that crop. The table does not include greenhouse and nursery crops.

TABLE 3
Top 10 Crops in Texas in Cash Receipts for 1997

Rank	Crop	Leading State
1	Cotton lint	Texas
2	Corn	Iowa
3	Sorghum grain	Kansas
4	Wheat	North Dakota
5	Hay	Texas
6	Cottonseed	Texas
7	Peanuts	Georgia
8	Rice	Arkansas
9	Pecans	Georgia
10	Soybeans	Iowa

Source: Texas Agricultural Statistics, 1997

Table 3 shows the top 10 crops in the state, as well as those states that lead the nation in their production using the criteria mentioned above. The input of those states identified above should prove relevant to this study from an agricultural standpoint as these states produce crops identical to those produced in Texas. Furthermore, as in Texas, those agricultural crops account for a large part of the state's economic activity and impact, both directly and indirectly. Following is a brief summary of the telephone interviews conducted with some of the states listed in Table 3 as well as some other leading agricultural states.

Arkansas

Arkansas, according to the state aeronautics department, has perhaps more agricultural aviation activity than any other state in the country. The state produces more rice than any other in the country. Rice in Arkansas is produced for domestic use, exported to foreign countries (primarily Korea and Japan) and used in chicken feed. This production occurs in the eastern part of the state where aerial applicators use both their own private strips and public-use general aviation facilities. Many of these applicators have their own strips but use public facilities in inclement weather.

Arkansas does not treat these airports any differently than any other airport in its system. The funding of any agricultural-related project is accomplished in the same manner as any other project. The state's view is that the agricultural aviation industry in Arkansas is a viable one and that it can carry its own weight in the planning and funding processes. The aerial applicators are recognized as being important in the state. In fact, several agricultural operators act as the fixed-base operator at some small airports and as the airport manager for the city that owns it. For example, in Dewitt, Arkansas, the airport manager is an aerial applicator who operates approximately six aircraft. It is not uncommon to have these operators dominate activity at an airport where they have more operations and purchase more fuel and ultimately have more of an impact than any other segment of general aviation that may use that facility.

While no special treatment is afforded the state's agricultural airports, it has provided state matching funds to local sponsors for agricultural aviation-related projects. The state only asks that the local sponsor come up with their portion of the matching funds typically on a 50/50 basis. The state does not ask where the local sponsor obtains these funds and it is at least suspected that some of this money may come from private sources such as the aerial applicators themselves. The state does not know for sure nor do they require such disclosure. The projects, however, must conform to standards set forth by the Federal Aviation Administration (FAA).

California

California does not treat its agricultural airports any differently than any other airport in the funding process. While agricultural aviation-related projects can be funded, they are not given any special weight or consideration. According to state officials, only a small number of aerial applicators operate from public-use airports. As is the case in many other states, the majority of applicators use private strips to perform their work.

Illinois

Illinois does not fund agricultural airports any differently than other airports in its system, and provides them no special consideration in the funding process. Because the aerial applicators are for-profit operators in a viable industry, no special consideration is deemed warranted. Further, because of this, these airports may not get much consideration at all for state funding. This does not prevent the operators from constructing facilities on their airport, but this is accomplished on a local level with the specific airport sponsor. While agricultural pads or aprons are not mandatory, the state does recommend that the local authorities have a written agreement with the agricultural operators to protect them from problems arising concerning chemicals and pollution. This agreement, as part of the lease, would address issues regarding safe and clean operating environments and assurances for not degredating the area.

It is the perspective of the Illinois State Division of Aeronautics, as is the case with other states, that capital projects be viewed in terms of the return they provide over time to the community and its users. This includes concerns about airport needs and the value a particular project will bring to the airport. In setting funding priorities where parking aprons and agricultural aprons are concerned, an airport that hosts a few agricultural aviation operations a year may be better off as a whole providing needed parking aprons instead. This, in light of the fact that the agricultural aviation industry is in a position to take on these projects themselves, highlights the stance taken by the aeronautics division.

Indiana

Indiana does not fund agricultural airports in any manner different from other airports in its system. Nor does the state have any special programs such as loan programs to help aerial applicators in their work. Although it is a big agricultural state, it does not have the same level of aerial application activity that is often found in other large agricultural producing states. There are not a lot of aerial applicators, and a significant amount of the agricultural spraying in the state is performed by tractor. The state has approximately 15 to 20 operators who work commercially.

Iowa

Iowa does not treat agricultural airports any differently from other airports in its system. The state does not have an agricultural airport classification and they do not necessarily know where aerial applicators are based. The person interviewed was aware of one small airport that had an agricultural apron on it but indicated that it was constructed locally and not constructed with state or federal monies. As in Texas, many aerial applicators operate in Iowa from dirt or grass strips and some even use old roads for landing strips.

Kansas

Kansas does not have any state funding mechanism for its public-use airports whatsoever. Funding is on a federal and local basis only. Currently, legislation is being debated on developing a state program but none has yet been established. However, when and if such a program is initiated, it will not give any special consideration or weight to airports used by aerial applicators. Nevertheless, many of the public-use airports in the state are used by aerial applicators. Several of these airports do have agricultural pads or aprons, but construction was not funded by the state. The state official interviewed was also not aware of local authorities paying for these aprons, leaving private funds as the source for their development. In addition, the operators must make assurances to the airport sponsors regarding pollution and contamination issues. The state mandates that they comply with state guidelines regarding agricultural industry storm water runoff because someone is operating a business out of the facility. In addition, approximately a third of the counties have mill levies. These are the counties where there is agricultural activity and the funds raised through these levies support county operations that often include the operation of an airport. So indirectly, the farmers are paying towards the airports that are used in their aerial applications. Additionally, when a county shows support for the local airport through local financial contribution or ability to pay, it carries additional weight in the funding process. While these airports do not directly receive special consideration, they can receive a higher preference because of the contribution issue and other related criteria. Finally, the state does not make available state funds for the development of aerial spray pads. Federal money, however, is available.

Nebraska
Nebraska has developed a program to assist local airport sponsors with the development of aerial applicator aprons. This program consists of no-interest loans up to a maximum of $10,000 per airport. The program specifics and eligibility requirements are presented in Appendix C. Appendix D shows the Nebraska Department of Aeronautics' generic plan for spray pads.

North Carolina
North Carolina does not offer any special programs or priority for projects related to the development of agricultural pads at airports in the state.

North Dakota
North Dakota does not offer any priority or special consideration to develop agricultural pads per se. However, extra consideration is given to airports that have fixed-base operators (FBO). If the FBO is a aerial applicator, then this may give the particular project a greater weight.

Washington
Washington has a tremendous amount of aerial application activity in the eastern half of the state where approximately 10% of the state's population resides. However, approximately 98% of this activity is conducted at private airports. The public-use airports that are utilized for agricultural purposes are not treated any differently than the rest of the airports per se, but there is a concerted effort by the state to help this segment of the aviation community. The state recognizes the importance of the agricultural aviation community to the state as a whole and to general aviation in general. The state funding agency is capable of funding up to 90% of the projects for airports which include apron areas, stub taxiways, and loading and washing containment areas for agricultural operators.

It is fair to say that the impetus for such a concerted effort on the part of the state of Washington was derived from two main concerns. First, it became clear to the state that aerial applicators were having difficulty operating in the wake of seemingly constant regulatory concerns from local officials concerning noise and the chemicals they commonly used. This caused operators to move frequently from one place to another constantly in search of a place to conduct business. Secondly, for some of these airports, agricultural activity makes up the vast majority of the operations at the airport. As applicators found it more and more difficult to operate, airports faced losing a major source of business, and, as a result, faced closure. With the substantial investment and impact that accompanies general aviation airports, it became evident that if something was not done to help protect aerial applicators, general aviation as a whole would be the big loser. Consequently, the state felt the time had come to keep the aerial operators from being pushed around while preserving the large investment that had already been made. As a result, great strides were made for general aviation in the state. While no special treatment or consideration is given to these airports, a conscious effort is made to develop projects at the airports where they are needed the most to help agricultural aviation.

AGRICULTURAL AIRPORTS

Identifying agricultural airports in Texas is not a straightforward process. This is clouded by the fact that many aerial applicators operate from private airstrips or grass strips on their own property or on the property of the farmer that hires them. Lacking a comprehensive and exhaustive survey, researchers used other methods to identify agricultural airports. Though not all inclusive, the following list provides a fairly accurate representation of the agricultural airports in Texas.

The following list of agricultural airports were identified in several ways. First, some were identified through interviews with, and site visits to, aerial applicators in different parts of the state. Some applicators were located on these airports or mentioned that they use them in their operations. Efforts on the part of TxDOT's Aviation Division to develop functional categories for the state's airports led to the identification of agricultural airports which are used for that purpose at least 60% of the time. In addition, several airports were identified through data from the Texas Boll Weevil Eradication Foundation that tracks airports from which its program aircraft fly. There is some overlap or duplication among these methods in terms of the identified airports. However, this should bolster the argument or further substantiate the claim that those airports are important agricultural facilities. The following is a list of those airports identified:

- Alice International Airport
- Stonewall County Airport (Aspermont)
- Bruce Field Airport (Ballinger)
- Batesville Airport
- Bay City Municipal Airport
- Beaumont Municipal Airport
- Beeville Municipal Airport
- Benger Air Park (Friona)
- Cameron Municipal Airpark
- Castroville Municipal Airport
- Chambers County Airport (Winnie/Stowell)
- Colorado City Municipal Airport
- Dimmitt Municipal Airport
- Eagle Lake Airport
- El Dorado Airport (Eldorado)
- Fabens Airport
- Fisher County Airport (Rotan/Roby)
- Foard County Airport (Crowell)
- Hamlin Municipal Airport
- Haskell Municipal Airport
- Hondo Municipal Airport
- Kent County Airport (Jayton)

- Kleberg County Airport (Kingsville)
- Knox City Municipal Airport
- La Porte Municipal Airport
- Lamesa Municipal Airport
- Littlefield Municipal Airport
- Munday Municipal Airport
- Oldham County Airport (Vega)
- Olney Municipal Airport
- Palacios Municipal Airport
- Nueces County Airport (Robstown)
- Seymour Municipal Airport
- San Patricio County Airport (Sinton)
- Winston Field Municipal Airport (Snyder)
- Spearman Municipal Airport
- Arledge Field (Stamford)
- Stratford Field (New)
- Sunray Airport
- Avenger Field (Sweetwater)
- T-Bar Airport (Tahoka)
- Uvalde Municipal Airport
- Victoria Regional Airport

While this list includes significant airports involved in the aerial application industry, it is not all inclusive. It only includes public-use airports in the TASP. Many operators who use private facilities, especially grass strips, find it difficult to fly from those facilities following inclement weather. As a result, these operators may move their operations to nearby public-use airports in order to perform their work. Beaumont Municipal Airport is a good example of this where an agricultural pad and an access road are being constructed to accommodate local operators including those that often fly off of private strips when the weather allows. This will become a consideration when determining what airports need agricultural aviation facilities. A good number of the airports listed above already have some agricultural pads and access roads. Many certainly could benefit from new, expanded, and/or additional facilities. Appendix B provides additional information on these facilities. What is clear is that many are inadequate in terms of size. Further, some are not accessible to the public because of exclusive agreements that are a result of an operator also being a fixed-base operator at the airport. Other operators have built their own agricultural pads on private land (leased and/or owned) adjacent to the airport..

III. TECHNOLOGY TRENDS IN AGRICULTURAL AIRCRAFT HISTORY

Like the technology of any industry, the 20th century produced great gains in agricultural aviation equipment. Since its birth in the 1920s using a Curtiss JN-6H "Jenny" (4), agricultural aviation has made great strides. The industry really began to grow following World War II. In 1946 the military made surplus Stearman Aircraft available that were easily adaptable to agricultural uses, specifically spraying and dispensing equipment. They were being acquired for prices ranging upwards from $250 with a few individuals and companies acquired them for less than that. Production aircraft like the Piper J-3 and PA-12 were also used because of their adaptability to agricultural uses. These aircraft would serve the industry well for many years but operators eventually concluded that the agricultural aviation industry needed to keep moving forward. The capital requirements to do so were substantial but proved not to be a barrier.

As some operators upgraded their fleets, others were forced to do so for competitive reasons. This transition to more modern aircraft occurred in the 1970s and by the 1980s, most operators were flying updated equipment. The Stearman aircraft were retired with many of them becoming collector's items (4). The industry began to take on a different look with the large operators giving way to smaller operations with fewer aircraft. The newer aircraft were expensive and "by the middle of the 1970s, operations with 10 or more aircraft had almost completely vanished (4)." New aerial applicators were popping up all over the country when experienced pilots opened their own operations. It was not unusual to find that relationships developed between these pilots and the farmers who hired them. Many became personal friends and still today these relationships can be found among later generations of applicators and farmers who have not only personal but business or professional relationships as well.

CURRENT FLEET

When the first agricultural aircraft took off in 1921 carrying the first load for aerial application, it had a capacity of 100 lbs. Today, modern agricultural aircraft are capable of carrying more than 800 gallons in their hoppers with useful loads approaching 10,000 lbs. and FAA certified gross weights of 16,000 lbs. The largest of the new, turbine-powered agricultural aircraft have wingspans that approach 60 feet, achieve a swath width of 72 feet and operate at a working speed of more than 140 mph.

The advent of these large agricultural aircraft have brought with them increases in productivity as they are able to perform the work of multi-plane operations. Consequently, this also brings about decreases in maintenance and insurance costs. The turbine engine made its debut in agricultural aircraft in the 1970s as Ayres and Air Tractor both put them in their aircraft in the late 1970s. There was a general feeling that the industry would not go the way of turbine engines, but today the market is dominated by manufacturers who produce them. In 1998, Air Tractor, Inc. in Olney, TX, manufactured 120 agricultural aircraft. All but one were turbine-powered. Although piston-engine agricultural aircraft are still being built and used across the country, the trend is undoubtedly toward turbine engines as they are more reliable, less labor intensive, and more fuel-efficient to operate. It is not uncommon to find piston-engine aircraft operators flying with one less aircraft than they have. This prevents aircraft maintenance schedules from interfering with the workflow as one aircraft is typically being serviced. This is expensive because payments are due on the aircraft, but the aircraft is not generating revenue. This is not as true with turbine-powered aircraft operators as the reliability and performance are greater with turbine engines, thus eliminating some maintenance costs. The extra aircraft and its associated costs are not necessary. In sections of the country where the aerial application season is short, the capital expense of turbine-powered aircraft may not always be justified. However, in the southern states, including Texas, where the aerial application activity is greater, turbine-powered aircraft are becoming a necessity. Although piston aircraft are still a large part of the fleet of agricultural aircraft, the trend is clearly towards turbine-powered aircraft. Table 4 shows the current breakdown of aircraft type found in the agricultural fleet in the U.S.. Figure 1 shows a modern Air Tractor agricultural aircraft and Figure 2 shows a piston agricultural aircraft.

TABLE 4
Current U.S. Agricultural Aircraft Fleet - 1997

Type		**Number**
Piston	Single-Engine	3,569
	Twin-Engine	28
	Other	9
Turboprop	Single-Engine	376
	Twin-Engine	16
	Other	7
Turbojet	Single-Engine	0
	Twin-Engine	0
	Other	36
Rotorcraft	Piston	512
	Turbine	247
Experimental		57
TOTAL		**4,857**

Source: FAA, General Aviation and Air Taxi Activity Survey, May 1999

While the national fleet numbers appear heavily slanted towards piston-engine aircraft some explanation or caution is due. These numbers generated by the FAA are based on a sample of 30,000 aircraft of all different types. The numbers are then expanded to represent the larger population. No other governmental agency or industry group makes an accurate record of the active aerial application fleet. However, those who work in the industry believe that, of those aircraft currently actively involved in aerial application, nearly, or just under half, are turbine-powered aircraft.

FIGURE 1. Turbine-Powered Agricultural Aircraft

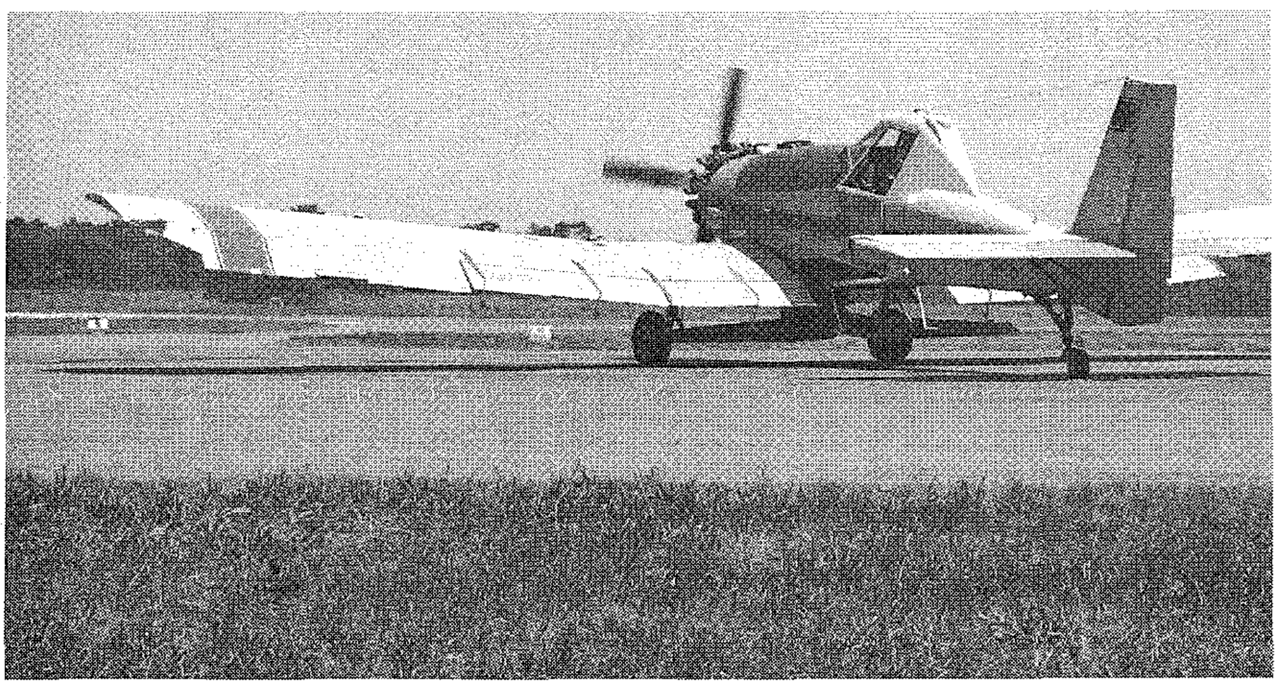


FIGURE 2. Piston-Engine Agricultural Aircraft

THE TEXAS FLEET

Determining fleet information for Texas is also difficult because registration records are not kept. However, those actively involved in the business in Texas estimate the fleet mix to be mostly turbine-powered aircraft and increasing every year. With the large amount of aerial application work performed in Texas, it is more likely that the operators will fly turbine-powered aircraft because they are more reliable and require less maintenance. This produces a more efficient operation for the applicator and makes the large capital expense of upgrading to a turbine-powered aircraft cost effective. Examples of typical agricultural aircraft along with their specifications are shown in Tables 5 and 6.

TABLE 5
Specifications of Selected Air Tractor Agricultural Aircraft

Manufacturer	Model	Take-Off Weight	Landing Weight	Empty Weight *	Useful Load	Length	Wingspan	Working Speed	Stall Speed **
Air Tractor	401B	7,860	6,000	4,244	3,725	30' 7"	51'	120-140	54
Air Tractor	402A	8,600	7,000	3,930	4,670	30' 7"	51'	120-140	53
Air Tractor	402B	9,170	7,000	3,930	5,240	30' 7"	51'	120-140	53
Air Tractor	502	9,700	8,000	4,297	5,403	33' 2"	52'	120-150	53
Air Tractor	602	12,500	12,000	5,600	6,900	34' 2"	56'	145	60
Air Tractor	802	16,000	16,000	6,320	9,680	35' 7"	58'	130-160	61

Note: Weights are in pounds and speeds are in miles per hour
* Empty Weight including sprayer equipment
** Stall speed as typically landed
Source: Air Tractor, Olney, TX

TABLE 6
Specifications of Selected Ayres Turbo Thrush Agricultural Aircraft

Manufacturer	Model	Typical Operating Weight	Empty Weight	Length	Wingspan	Working Speed	Stall Speed *
Ayres	400	9,300	4,200	33'	47' 6"	90-150	57
Ayres	510	9,700	4,300	33'	47' 6"	90-150	57
Ayres	660	12,500	5,250	33' 6"	50'	100-175	57

Note: Weights are in pounds and speeds are in miles per hour
* Stall speed as typically landed
Source: Ayres Corporation, Albany, GA

GLOBAL POSITIONING SATELLITE SYSTEMS

Like the aircraft themselves, the technology applications useful to agricultural aviation have changed too. The emergence of global positioning satellite systems (GPS) has truly changed the way the world does things and this holds for agricultural aviation as well. The early 1990s saw the first GPS system put to use for aerial application. As the GPS system matured and more satellites were put into service, the accuracy of the systems improved to where they had meaningful applications in agricultural aviation. These systems that employ differential GPS methods provide both directional and swath guidance for pilots, have greatly enhanced the accuracy and precision of aerial applications.

The installation of GPS systems requires major modifications that are performed in the aftermarket. It is estimated that approximately 70% to 80% of the national fleet of agricultural aircraft are equipped with GPS systems. Some states have higher percentages of use and Texas is estimated to be at least at the national average, if not somewhat higher. This is true for other southern states that have significant agricultural aviation activity such as Louisiana, Arkansas, and Mississippi. These systems have several uses in this industry. In addition to the precision and accuracy that these systems provide the operator, they also provide a record of the work accomplished. It is not uncommon to have pilots download information from their GPS units and save it in a customer file documenting the coordinates of the land sprayed, the number of swaths made, and the volume of material applied. GPS systems also minimize the use of flaggers or personnel who work on the ground providing help and guidance to the pilot. This translates to reduced costs for the operator including costs associated with vehicles, maintenance, and insurance.

The capabilities of GPS systems also benefit the operators in several ways. They increase the accuracy of their application, decrease their pre-flight planning time, log important data pertaining to the application, and allow the pilot to use the automatic spray on/off control device if desired. These systems allow the operators to replay the job second-by-second, reconstructing their activity from the moment the aircraft engine was started. This includes the actual paths flown and serves as documentation of the work performed for the client.

The increase in GPS system applications along with the normal cycle of technology gains has allowed more people to use the equipment. This has occurred as the costs of this equipment has fallen significantly since its inception. The price of a new GPS system for an agricultural aircraft when the systems were introduced was approximately $30,000. Today, these costs have been cut in half to approximately $15,000 with some basic systems selling for approximately $11,000. Costs are not expected to be significantly reduced in the future as the market has rationalized and stabilized in the past several years.

Prices have more or less stabilized and the level of accuracy and precision that these GPS systems are capable of providing sufficiently accommodates the needs of the aerial applicator. While it is expected that the level of accuracy and precision of GPS systems will continue to improve, it is not likely that the applications to agricultural aviation will greatly increase. Since current capabilities allow applicators to pinpoint applications to the meter, further improvements will not provide significant benefits to the aerial applicator.

DISPERSAL SYSTEMS

With the industry transition to turbine-powered aircraft well underway and GPS technology already well entrenched as part of the current state-of-the-practice, future technological advances in agricultural aviation are primarily centered around dispersal systems. There are basically two different types of dispersal systems and each has its own unique characteristics and ranges of options depending on the size of the aircraft utilized. The two basic types of systems are for liquid and solid or dry applications. Liquid applications include herbicides, pesticides, insecticides, and some fertilizers. Solid applications typically include fertilizer and in the case of rice, planting or seeding. The dry dispersal system is often referred to as a spreader while the liquid dispersal system is often referred to as a sprayer or the boom.

While it is not the goal of this research to examine the research involving dispersal systems, it is important to have an understanding of where the research and technology is headed and how it affects the aircraft that use the system. This, in turn, will ultimately impact the needs of the airports that serve these aircraft.

The current focus of dispersal system research is on increasing the efficacy of the application while minimizing drift and environmental impacts. This includes research on electrostatic technologies and nozzle design. While there certainly is room for technological advancement in all areas of the industry, some believe the biggest gains to be made are in the area of improved dispersal systems.

CONCLUSION

The trend toward larger and more powerful aircraft will continue. The industry transition to turbine-powered aircraft is well underway. The size of the engines has increased as have their useful loads. Hopper capacities now top 800 gallons and wing spans approach 60 feet. High frequency and high volume crops, like rice, will be the first to benefit from further advances in these trends, however, these aircraft characteristics are likely to benefit other crops as well. The economies and efficiencies associated with larger hoppers and more powerful and reliable engines will be recognized throughout the industry. GPS has made quite an impact on agricultural aviation in a short period of time. It has led to greater efficiencies in the industry by increasing the precision of applications and, in some cases, minimizing the need for flaggers. Further technological advances are still anticipated, most notably in the area of dispersal systems.

IV. TEXAS CROPS

As noted previously, agriculture is big business in Texas. Agricultural cash receipts for 1997 exceeded $13.4 billion. Texas is one of the leading agricultural producing states in the country ranking second behind California (5). Texas ranks first in livestock and products value and fourth in cash receipts for crops. More than 39% of the total agricultural cash receipts were generated by crops across the state with cash receipts approaching $5.3 billion. The focus of this chapter is on the major crops grown in Texas. This includes the region where they are grown and their economic value to the state.

With annual cash values in excess of $5 billion, field crops are an important part of the Texas economy. From the wheat in the Panhandle to the citrus in the Rio Grande Valley, crops are important to many communities across the state. Table 7 shows the major crops in Texas and their cash value. The top 10 crops in Texas account for nearly $4 billion and more than 70% of the total crop value.

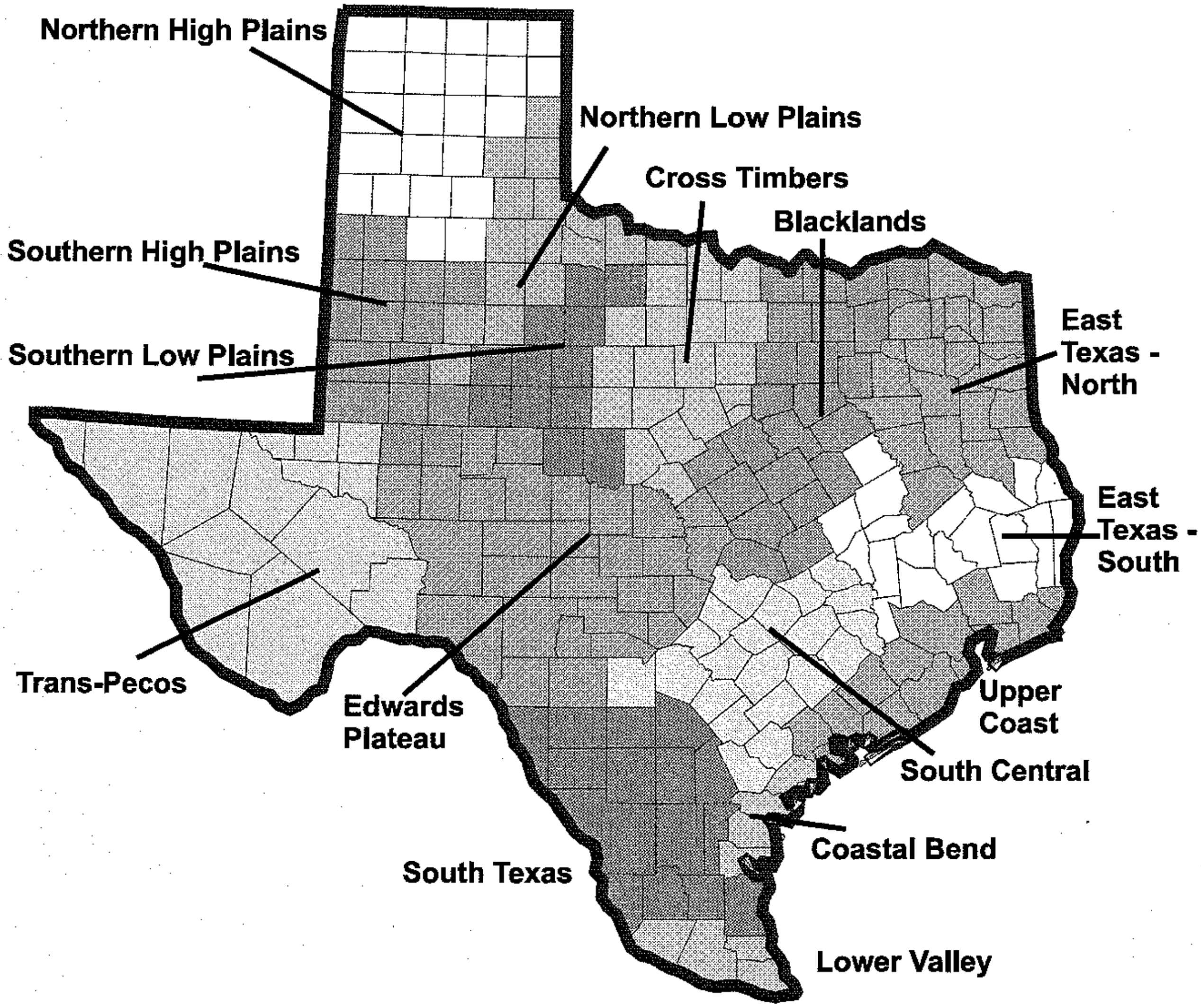
TABLE 7
Top 10 Crops in Texas and Their Cash Receipts for 1997

Rank	Crop	Cash Receipts (% of Total Crops)
1	Cotton lint	$1,385,689,000 (26.2)
2	Corn	$657,716,000 (12.4)
3	Sorghum grain	$450,156,000 (8.5)
4	Wheat	$362,366,000 (6.9)
5	Hay	$230,095,000 (4.4)
6	Cottonseed	$196,358,000 (3.7)
7	Peanuts	$193,205,000 (3.7)
8	Rice	$168,126,000 (3.2)
9	Pecans	$68,500,000 (1.3)
10	Soybeans	$58,854,000 (1.1)
TOTAL		**$3,771,065,000 (71.4)**

Source: Texas Agricultural Statistics, 1997

For purposes of analysis, the Texas Agricultural Statistics Service breaks the state into 10 districts. These districts share common features with respect to their physical characteristics and the crops that are grown there. Figure 3 shows these districts graphically and they are listed in Appendix A. Five of the 10 districts are further separated into "north" and "south" sections, therefore yielding 15 separate geographical areas used in the discussion. The areas are:

- Northern High Plains (1-N)
- Southern High Plains (1-S)
- Northern Low Plains (2-N)
- Southern Low Plains (2-S)
- Cross Timbers (3)
- Blacklands (4)
- East Texas-North (5-N)
- East Texas-South (5-S)
- Trans-Pecos (6)
- Edwards Plateau (7)
- South Central (8-N)
- Coastal Bend (8-S)
- Upper Coast (9)
- South Texas (10-N)
- Lower Valley (10-S)



Source: Texas Agricultural Statistics Service, 1997

FIGURE 3. Texas Agricultural Statistics Districts

These districts all have crops that are typically produced within their boundaries and they vary from citrus crops in the south to corn and wheat in the north. The following sections discuss the districts where the major crops are found. They also show the percentage of the state's production that is located in the district as well as an approximate value of the crops based on 1997 production and market numbers. The crop value was derived using the ratio of crop production in the district to the total in the state and applying it to the state total of cash receipts for that crop. It should be noted that many factors can impact production and economic values and that a typical year to use in the study is only a theoretical one as weather and other factors can impact crops across the state. Nevertheless, 1997 statistics were used as they are the latest available and show no major fluctuations across the last several years that would cause concern regarding their true meaning or relevance.

While 1997 may not necessarily be a "typical" year when considering the problems encountered in the industry, the difficulties and yearly differences or variances realized across the state were not much different than the previous years in terms of economic output. Table 8 shows agricultural cash receipt and crop share values for 1993 through 1997. This data demonstrates that while there are some fluctuations in the crop production and values, they have been fairly stable. The major crops have remained the mainstay of agricultural field production in the state to the extent they were several years ago and in the same order. In addition, the major crops have also maintained their share of overall agricultural production which includes livestock. This number has been stable at the mid-20% range with the major field crops accounting for 26% of the state's total agricultural cash receipt value and 66% of the state's total field crop value in 1997. The major crops accounted for between 66% and 70% of the total field crop value from 1993 to 1997.

The crops included in the table center around the seven major crops produced in the state that generate the vast majority of aerial application activity. They include cotton, corn, sorghum grain, wheat, peanuts, rice, and soybeans. Hay and greenhouse/nursery products are not included in this analysis. As mentioned earlier, the seven crops account for approximately 66% of the state's total field crop production in 1997. This figure jumps to 87% when you remove hay and greenhouse/nursery products from the calculation.

TABLE 8
Summary of Agricultural Cash Receipts (1,000s) and Share by Major Crop (%)

Crop	1993		1994		1995		1996		1997	
	$	%	$	%	$	%	$	%	$	%
Cotton	$1,622,010	53%	$1,837,139	54%	$1,357,721	44%	$1,743,740	49%	$1,582,048	46%
Corn	$447,698	15%	$610,281	18%	$700,160	23%	$607,044	17%	$657,716	19%
Sorghum Grain	$391,514	13%	$334,084	10%	$384,977	13%	$473,238	13%	$450,156	13%
Wheat	$334,258	11%	$225,344	7%	$283,661	9%	$326,983	9%	$362,366	10%
Peanuts	$162,852	5%	$172,587	5%	$154,980	5%	$170,872	5%	$193,205	6%
Rice	$79,481	3%	$173,231	5%	$137,011	4%	$192,555	5%	$168,126	5%
Soybeans	$26,210	1%	$26,454	1%	$38,438	1%	$46,739	1%	$58,854	2%
Total of 7 Major Crops	$3,064,023	100%	$3,379,120	100%	$3,056,948	100%	$3,561,171	100%	$3,472,471	100%
Total of All Crops and % of Major Crops	$4,519,471	68%	$4,819,997	70%	$4,646,497	66%	$5,139,187	69%	$5,287,031	66%
Total of All Agriculture and the % of Major Crops	$12,730,745	24%	$12,932,250	26%	$13,097,100	23%	$12,959,924	27%	$13,470,966	26%

Source: Texas Agricultural Statistics, 1997

HIGH PLAINS DISTRICT

Cotton, the most valuable crop produced in Texas, is most widely found in the High Plains. It dominates the southern High Plains with more than 5% of the state's total cotton production found in each of Gaines, Lubbock, and Hale counties. More than half of the corn in the state is also found in the High Plains. The top three corn-producing counties are Dallam, Castro, and Hartley all located in the High Plains. Wheat is also very prevalent in the High Plains. Approximately half of the state's production of wheat is found in the High Plains specifically in Dallam, Deaf Smith, and Hansford counties. Nearly a third of the state's sorghum is produced in the High Plains District, more than any other district. Most of that is in the northern High Plains region. And as if the region isn't prolific enough, the southern High Plains also lays claim to the largest production of peanuts with nearly 57% of the states total. Table 9 shows the major crops and their value for the region.

TABLE 9
Major Crops in the High Plains District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Cotton	67%	$1,051,415
Corn	66%	$432,695
Wheat	54%	$194,379
Sorghum Grain	31%	$139,113
Peanuts	57%	$110,927
Soybeans	26%	$15,395
Total Cash Receipt Value		**$1,943,924**

Source: Texas Agricultural Statistics Service, 1997

LOW PLAINS DISTRICT

While cotton is king in the High Plains, it ranks high in the Low Plains as well. The Low Plains is second to the High Plains in cotton production. It is also second in wheat production and peanut production behind the High Plains. Like the High Plains, the Low Plains is home to a significant amount of agricultural production. Table 10 shows the major crops and their value found in the region.

TABLE 10
Major Crops in the Low Plains District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Cotton	13%	$202,834
Wheat	20%	$72,159
Peanuts	17%	$32,993
Sorghum Grain	3%	$15,355
Corn	<1%	$1,266
Soybeans	<1%	$431
Total Cash Receipt Value		**$325,038**

Source: Texas Agricultural Statistics Service, 1997

CROSS TIMBERS DISTRICT

The Cross Timbers district includes 18 counties in the north central part of the state south of Wichita Falls from Clay County to Mills County and Shackelford to Parker. Wheat and peanut crops account for 6% of the state's production while cotton, sorghum grain, and corn account for less than 1%. The total cash receipt value is approximately $40 million as illustrated in Table 11.

TABLE 11
Major Crops in the Cross Timbers District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Wheat	6%	$22,931
Peanuts	6%	$11,604
Cotton	<1%	$3,386
Sorghum Grain	<1%	$1,401
Corn	<1%	$318
Total Cash Receipt Value		**$39,640**

Source: Texas Agricultural Statistics Service, 1997

BLACKLANDS DISTRICT

The Blacklands are located in north central Texas and run from the Oklahoma border at Cooke, Grayson, and Fannin counties south to Williamson and Milam counties north of Austin. They are home to large amounts of corn and soybean production. The district ranks second behind the High Plains in corn production and second in soybean production behind the Upper Coast District. The district also is third in sorghum grain production behind the High Plains and the South Central/Upper Coast District. Overall, it is the fifth most productive district in the state behind the High and Low Plains. Table 12 shows the crops grown in the district, the percent with respect to the state total, and the cash receipt values.

TABLE 12
Major Crops in the Blacklands District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Corn	14%	$89,951
Sorghum Grain	16%	$71,946
Cotton	3%	$47,708
Wheat	13%	$47,220
Soybeans	25%	$14,627
Peanuts	2%	$3,247
Total Cash Receipt Value		**$274,699**

Source: Texas Agricultural Statistics Service, 1997

EAST TEXAS DISTRICT

The East Texas District stretches from Hardin, Jasper, and Newton counties to the Oklahoma border extending as far west as Brazos and Robertson counties in the southern part of the district and Henderson and Hopkins counties in the northern part of the district. Although home to a wide array of field crops, as shown in Table 13, it is not known as one of the more agriculturally prolific regions of the state. Cash receipt values approach $50 million with soybeans being the leading field crop. It is, however, home to significant acreage of commercial timberlands which contribute to the economy as well as generate aerial application activity as these commercial timberlands need spraying and fertilizing. While the pesticide spraying continues to be conducted from the air by helicopter, fertilizing has more recently been accomplished by fixed-wing aircraft used by the traditional aerial applicator.

TABLE 13
Major Crops in the East Texas District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Cotton	1%	$13,851
Corn	2%	$13,244
Rice	5%	$8,501
Soybeans	11%	$6,653
Sorghum Grain	1%	$3,525
Wheat	1%	$2,045
Peanuts	1%	$1,241
Total Cash Receipt Value		**$49,060**

Source: Texas Agricultural Statistics Service, 1997

COMMERCIAL TIMBERLANDS

A discussion of Texas crops that could potentially impact aerial application activity in Texas would not be complete without mentioning the commercial timberlands of East Texas. These timberlands comprise nearly 12 million acres (6). Recently, timber companies have begun using aerial applicators for crop fertilization work. Considering the size of these timberlands, the potential aerial activity generated could be significant. According to the Texas Forest Service, the East Texas economy depends on these timberlands and this industry. "In 31 of 43 counties, forest industry is the first or second largest manufacturing employer. Wood-based industry is the ninth largest manufacturing employer in the state, producing $6 billion worth of products each year (6)." Its economic importance to Texas and the country are widely known as Texas is a net exporter of timber product (7). Directly and indirectly, this industry is responsible for billions of dollars in products and thousands of jobs.

TRANS-PECOS DISTRICT

Perhaps the least productive of all the agricultural districts, the Trans-Pecos District extends from El Paso County east to Terrell, Pecos, Crane, and Ector counties. Although it is not as agriculturally significant as the other districts, this region is rich in oil and gas. It is home to 1% of the state's cotton production with total cash receipt values of just over $15 million as shown in Table 14.

TABLE 14
Major Crops in the Trans-Pecos District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Cotton	1%	$13,851
Sorghum Grain	<1%	$1,060
Wheat	<1%	$268
Corn	<1%	$236
Total Cash Receipt Value		**$15,415**

Source: Texas Agricultural Statistics Service, 1997

EDWARDS PLATEAU DISTRICT

The Edwards Plateau extends from Sterling and Coke counties southward toward the coast to Kinney County and east to Lampasas and Burnet counties. Cotton is its most valuable crop followed by wheat and sorghum grain. Table 15 shows these crops, the percent of the state's total, and their economic value.

TABLE 15
Major Crops in the Edwards Plateau District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Cotton	3%	$43,706
Wheat	4%	$15,254
Sorghum Grain	3%	$11,293
Corn	1%	$9,853
Peanuts	1%	$2,580
Total Cash Receipt Value		**$82,686**

Source: Texas Agricultural Statistics Service, 1997

SOUTH CENTRAL/COASTAL BEND DISTRICT

The South Central/Coastal Bend District includes Kleberg, Nueces, San Patricio, Aransas, and Refugio counties and stretches north from there to Travis, Bastrop, Lee, and Burleson counties. It extends as far west as Medina County and as far east as Austin and Washington counties. The district is home to cotton where it ranks behind the High and Low Plains. It also produces nearly 20% of the state's rice crop ranking it second to the Upper Coast District. It ranks second in the state in sorghum grain production and, as Table 16 shows, it is the fourth most productive region in the state.

TABLE 16
Major Crops in the South Central/Coastal Bend District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Sorghum Grain	21%	$94,265
Cotton	5%	$82,180
Corn	9%	$57,754
Rice	19%	$31,252
Peanuts	4%	$7,247
Wheat	1%	$5,370
Soybeans	2%	$1,394
Total Cash Receipt Value		**$279,462**

Source: Texas Agricultural Statistics Service, 1997

UPPER COAST DISTRICT

The Upper Coast District encompasses the coastal region from north of the Corpus Christi metropolitan area in Calhoun County to Orange County along the Louisiana border. It includes all of the city of Houston and Harris County. The district produces 76% of the state's rice. Approximately 40% of the production can be found in Wharton and Colorado counties with Matagorda, Jefferson, Brazoria, and Jackson counties also producing large amounts of rice. It is also the state's leading region for soybean production at 33%. As Table 17 indicates, the region is important as it also produces cotton, corn and sorghum grain ranking it third among agricultural districts in cash receipt values.

TABLE 17
Major Crops in the Upper Coast District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Rice	76%	$128,373
Cotton	4%	$63,097
Sorghum Grain	11%	$49,667
Corn	4%	$27,873
Soybeans	33%	$19,429
Peanuts	<1%	$329
Wheat	<1%	$259
Total Cash Receipt Value		**$289,027**

Source: Texas Agricultural Statistics Service, 1997

SOUTH TEXAS/LOWER VALLEY DISTRICT

Although often considered the state's hub of citrus production, the South Texas/Lower Valley agricultural district is much more diverse. The district includes the area south of Zavala and Frio counties south to the Mexican border encompassing the coastal counties from Kenedy south. Sorghum grain is the leading field crop followed by cotton. As a comparison, the total cash receipts for citrus products, grapefruits and oranges, exceeded $18 million in 1997. Although these numbers were down somewhat compared to previous years, they were approximately $28 million in 1995, the peak for the 1993-1997 period. Table 18 shows the major crops located in the South Texas/Lower Valley agricultural district along with their corresponding share of the state total and their cash receipt value.

TABLE 18
Major Crops in the South Texas/Lower Valley District

Crop	Percent of State Total	Cash Receipt Value (1,000s)
Sorghum Grain	14%	$62,530
Cotton	4%	$60,019
Corn	4%	$24,527
Peanuts	12%	$23,037
Wheat	1%	$2,481
Soybeans	2%	$926
Total Cash Receipt Value		**$173,520**

Source: Texas Agricultural Statistics Service, 1997

The data discussed above are summarized in both Tables 19 and 20 providing a "big picture"overview of the major crops in Texas, their location, and a measure of their economic value. Table 19 shows how the High Plains District is unparalleled in its level of agricultural production and value. Approximately 56% of the seven major crops discussed are produced in the district. The Low Plains, Blacklands, Upper Coast, and South Central/Coastal Bend districts are next with between 8% and 9% of the state's total. Table 20 shows the High Plains leading the state in the production of five of the seven major crops including cotton, corn, sorghum grain, wheat, and peanuts. The table also illustrates the diversity of crops grown across the state with the exception of rice, which is fairly localized along the coastal regions.

TABLE 19
Summary of Agricultural Districts by Cash Value

Agricultural District	Cash Receipt Value of Major Crops (1000s)	Percent of Total for Seven Major Crops	Percent of Total for All Field Crops *
High Plains	$1,943,924	56%	48%
Low Plains	$325,038	9%	8%
Upper Coast	$289,027	8%	7%
South Central/Coastal Bend	$279,462	8%	7%
Blacklands	$274,699	8%	7%
South Texas/Lower Valley	$173,520	5%	4%
Edwards Plateau	$82,686	2%	2%
Cross Timbers	$39,640	1%	1%
East Texas	$49,060	1%	1%
Trans-Pecos	$15,415	<1%	<1%
TOTAL	**$3,472,470**	**100%**	**87%**

Source: Texas Agricultural Statistics Service, 1997

*** Does not include hay and greenhouse/nursery products in the statistics. Percentages may not add due to rounding.**

TABLE 20
Summary of Agricultural Districts By Major Crops

Agricultural District	Cotton	Corn	Sorghum Grain	Wheat	Peanuts	Rice	Soybeans
High Plains	67%	66%	31%	54%	57%	-	26%
Low Plains	13%	<1%	3%	20%	17%	-	<1%
Blacklands	3%	14%	16%	13%	2%	-	25%
Upper Coast	4%	4%	11%	<1%	<1%	76%	33%
South Central/Coastal Bend	5%	9%	21%	1%	4%	19%	2%
South Texas/Lower Valley	4%	4%	14%	1%	12%	-	2%
Edwards Plateau	3%	1%	3%	4%	1%	-	-
Cross Timbers	<1%	<1%	<1%	6%	6%	-	-
East Texas	1%	2%	1%	1%	1%	5%	11%
Trans-Pecos	1%	<1%	<1%	<1%	-	-	-
TOTAL	100%	100%	100%	100%	100%	100%	100%

Source: Texas Agricultural Statistics Service, 1997

To provide additional meaning and perspective, Table 21 shows how Texas' production of these major crops fits into the national picture. Texas' rank in terms of crop production for the seven major crops discussed above is shown in the table. This will help place the importance or significance of Texas agriculture into a more meaningful national context.

TABLE 21
National Rank of Texas Crops by Production

	Cotton	Corn	Sorghum Grain	Wheat	Peanuts	Rice	Soybeans
Rank	1	12	2	4	2	4	22

Source: Texas Agricultural Statistics Service, 1997

Understanding the location and value of these crops provides a good understanding of the level of aerial application activity that may follow. The type of crop, the level of aerial activity that it requires for production, the economic value of the particular crop, the amount produced, and the seasons of the year it is produced all provide insight into the expected aerial application activity. While other factors, including the weather, may impact agricultural production and values from time to time, production and values have been strong and stable over the years and there is no reason to believe that this trend will not continue. And similarly, the aerial application activity that accompanies agricultural production will continue to be an integral part of the industry as it continues to play a role in safe and efficient food production. The next chapter examines the aerial activity in the state for these major crops in the major agricultural districts.

V. AERIAL APPLICATION ACTIVITY IN TEXAS

The level of aerial application activity varies across the state depending on the crop being worked and the weather patterns during the season. Cotton, the state's largest crop, generates the most aerial application activity. This is due in large part to the boll weevil eradication program currently underway in the plains regions of the state. However, other crops grown in the state also generate a large amount of aerial application activity both from public-use airports and from private airstrips. Figure 4 shows aerial application activity from a public-use airport while Figure 5 shows activity at a private strip. Figure 4 shows rice fertilizing activity and Figure 5 shows rice planting activity. While quantifying the level of activity has proved difficult and inaccurate at best, this chapter provides some insight into the level of activity that does exist, where it exists, and during what times of the year it can be expected.

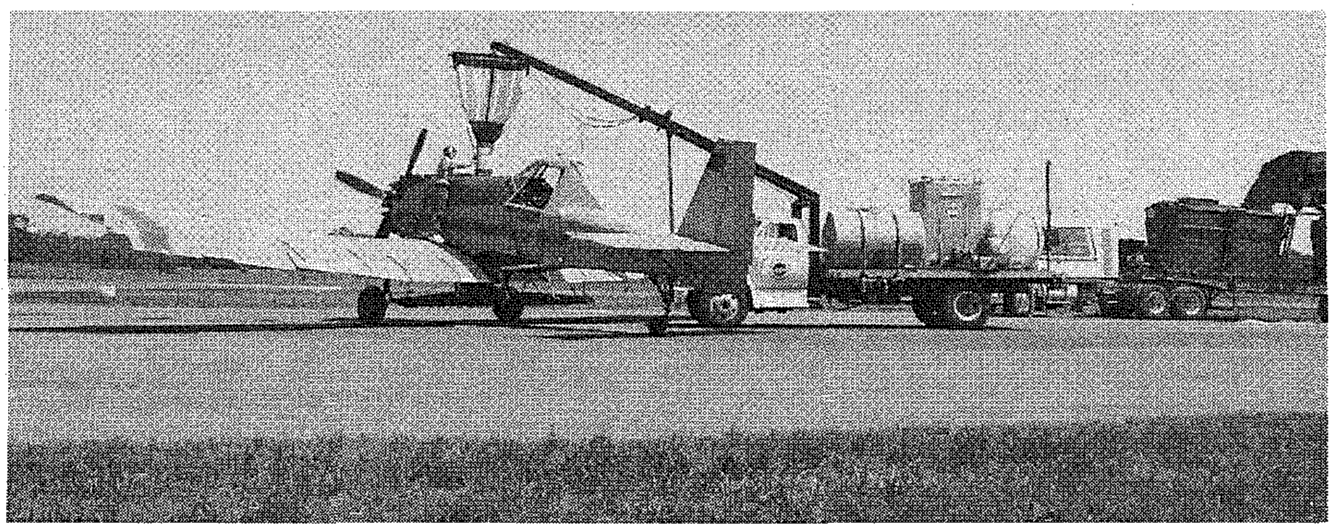


FIGURE 4. Aerial Application Activity at a Public-Use Airport

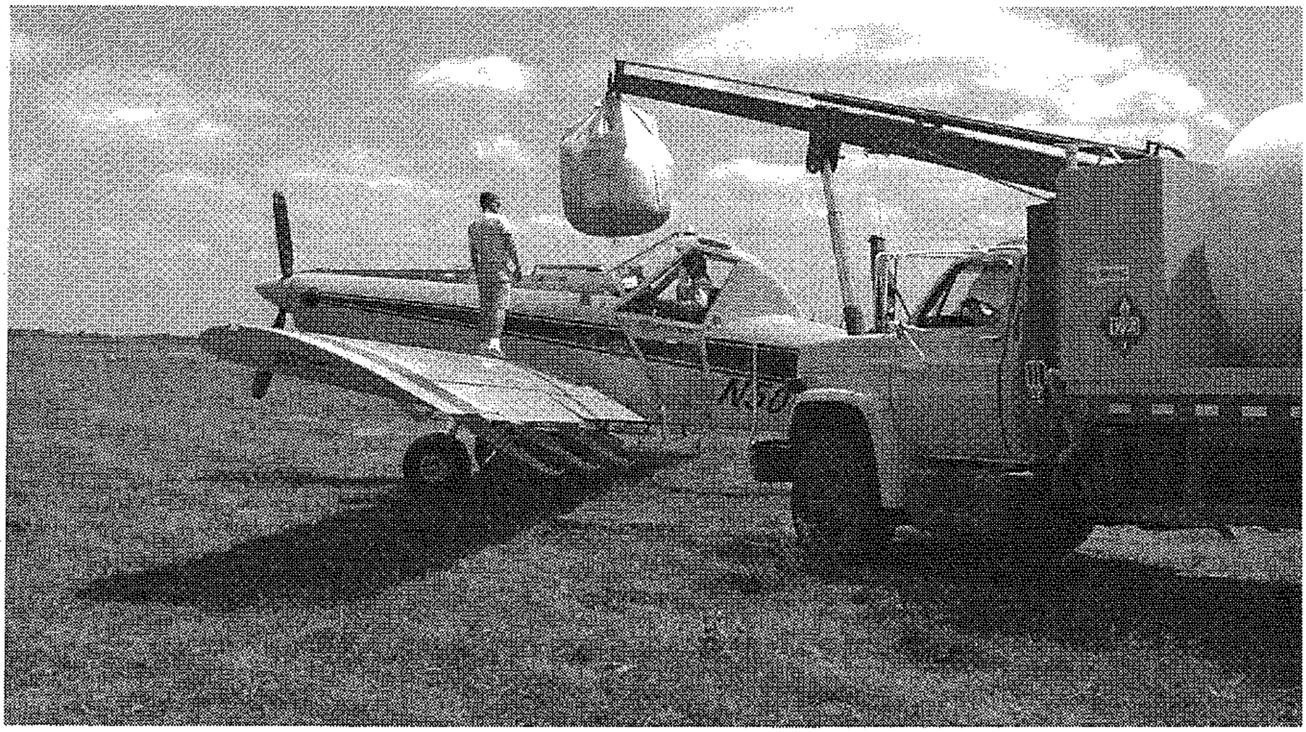


FIGURE 5. Aerial Application Activity at a Private Airstrip

COTTON AND THE TEXAS BOLL WEEVIL ERADICATION PROGRAM

Perhaps the largest and most concentrated aerial application activity in the state is related to its most lucrative crop, cotton. The Texas Boll Weevil Eradication Foundation oversees a significant amount of aerial application activity during the cotton growing season. Although the program has been in operation around the state for some time, it is expected that it will continue in various regions around the state for years to come. The weather and effectiveness of the program, among other factors, will influence this timeline. Nevertheless, it is an important program to the state's agricultural bottom line as illustrated previously.

The following tables show the number of planes used in the eradication program and their locations for 1996 through 1998. While total numbers of aircraft utilized have decreased, it does not necessarily mean that the decline will continue in the years to come. The number of turbine-powered aircraft being used has also increased. This shows that productivity gains associated with turbine-powered aircraft may be accounting for smaller numbers of total aircraft. It also reinforces the trend of increased use of turbine-powered aircraft in the industry.

Table 22 shows the airports and the number of aircraft at those airports used in the Boll Weevil Eradication Program for 1996.

TABLE 22
Texas Boll Weevil Eradication Program Airports and Number of Aircraft - 1996

Location	Total Aircraft	Turbine Engine	Piston Engine
Alice International Airport	12	7	5
Stonewall County Airport (Aspermont)	10	4	6
Bruce Field (Ballinger)	20	12	8
Bay City Municipal Airport	20	2	18
Beeville Municipal Airport	4	0	4
Colorado City Municipal Airport	12	7	5
Eagle Lake Airport	4	1	3
Eldorado Airport (Eldorado)	3	0	3
Elmdale Airport (Abilene)	3	1	2
Hamlin Municipal Airport	6	4	2
Haskell Municipal Airport	6	6	0
Hondo Municipal Airport	12	6	6
Knox City Municipal Airport	4	4	0
La Ward (Private Strip)	8	6	2
Long Mott (Private Strip)	4	3	1
Munday Municipal Airport	4	4	0
Olney Municipal Airport	6	6	0
Palacios Municipal Airport	7	6	1
Nueces County Airport (Robstown)	6	6	0
Rosenberg Airport	12	7	5
Fisher County Airport (Rotan/Roby)	15	5	10
San Angelo (Private Strip)	3	0	3
San Patricio County Airport (Sinton)	10	8	2
Winston Field Municipal Airport (Snyder)	10	7	3

Location	Total Aircraft	Turbine Engine	Piston Engine
Arledge Field (Stamford)	25	5	20
Avenger Field (Sweetwater)	9	5	4
Taft (Private Strip)	16	13	3
Uvalde Municipal Airport	8	1	7
Victoria Regional Airport	12	8	4
Wharton (Private Strip)	9	9	0
TOTAL - 30 Locations	**280**	**153**	**127**

Source: Texas Boll Weevil Eradication Foundation, Inc.

As shown in the table, 280 aircraft were used in 1996 for boll weevil eradication across the state. Turbine-powered aircraft made up 55% of the aircraft used. Table 23 shows the same information for 1997.

TABLE 23
Texas Boll Weevil Eradication Program Airports and Number of Aircraft - 1997

Location	Total Aircraft	Turbine Aircraft	Piston Aircraft
Alice International Airport	11	8	3
Bruce Field (Ballinger)	10	6	4
Batesville Airport	3	0	3
Colorado City Municipal Airport	20	0	20
Eldorado Airport	5	0	5
Elmdale Airpark (Abilene)	3	1	2
Hamlin Municipal Airport	8	6	2
Haskell Municipal Airport	14	14	0
Hondo Municipal Airport	2	0	2
Kleberg County Airport (Kingsville)	2	2	0
Knox City Municipal Airport	6	6	0
Long Mott (Private Strip)	3	2	1
Munday Municipal Airport	4	3	1
Olney Municipal Airport	5	5	0
Robstown (Private Strip)	16	15	1
Nueces County Airport (Robstown)	6	6	0
Fisher County Airport (Rotan/Roby)	8	6	2
San Angelo (Private Strip)	11	6	5
San Patricio County Airport (Sinton)	11	8	3
Winston Field Municipal Airport (Snyder)	14	10	4
Arledge Field (Stamford)	3	0	3
Avenger Field (Sweetwater)	8	1	7
Taft (Private Strip)	9	9	0

Location	Total Aircraft	Turbine Aircraft	Piston Aircraft
Uvalde Municipal Airport	3	2	1
Veribest (Private Strip)	5	3	2
Victoria Regional Airport	8	1	7
Total - 26 Locations	**198**	**120**	**78**

Source: Texas Boll Weevil Eradication Foundation, Inc.

In 1997, boll weevil eradication program aircraft were somewhat less in number than in 1996 and the percentage of turbine-powered aircraft used increased to 61% of the total. Table 24 shows the same information for 1998.

TABLE 24
Texas Boll Weevil Eradication Program Airports and Number of Aircraft - 1998

Location	Total Aircraft	Turbine Aircraft	Piston Aircraft
Alice International Airport	11	8	3
Bruce Field (Ballinger)	2	1	1
Batesville Airport	3	3	0
Beeville Municipal Airport	4	1	3
Castroville Municipal Airport	2	0	2
Colorado City Municipal Airport	16	1	15
Eldorado Airport	1	0	1
Elmdale Airport (Abilene)	3	1	2
Hamlin Municipal Airport	6	6	0
Haskell Municipal Airport	7	5	2
Kingsville (Private Strip)	2	2	0
Knox City Municipal Airport	5	5	0
Long Mott (Private Strip)	5	5	0
Munday Municipal Airport	3	3	0
Olney Municipal Airport	3	3	0
Robstown (Private Strip)	3	3	0
Nueces County Airport (Robstown)	4	4	0
Fisher County Airport (Rotan/Roby)	5	5	0
San Angelo (Private Strip)	3	1	2
Seymour Municipal Airport	2	2	0
San Patricio County Airport (Sinton)	11	11	0
Winston Field Municipal Airport (Snyder)	8	6	2
Arledge Field (Stamford)	2	2	0

Location	Total Aircraft	Turbine Aircraft	Piston Aircraft
Avenger Field (Sweetwater)	6	2	4
Taft (Private Strip)	11	11	0
Uvalde Municipal Airport	5	2	3
Veribest (Private Strip)	2	1	1
Victoria Regional Airport	4	0	4
TOTAL - 28 Locations	**139**	**94**	**45**

Source: Texas Boll Weevil Eradication Foundation, Inc.

In 1998, fewer aircraft were utilized for this program but no conclusions should be prematurely drawn regarding the level of activity or productivity of aerial application. The trend toward more efficient and productive turbine-powered aircraft continued as 68% of the program aircraft were turbine-powered aircraft. In addition, over this three-year period, the number of locations (airports) has remained stable, ranging from 26 to 30 locations across the state for the current program areas.

Table 25 summarizes this information for 1996 to 1998 to more clearly show the aircraft trends and airports utilized in this program which is designed to maintain and preserve the state's most important crop.

TABLE 25
Summary of Boll Weevil-Related Aerial Application Activity, 1996-1998

Year	Total Locations (Airports)	Public-Use Airports	Private Strips	Total Aircraft	Turbine Aircraft	Piston Aircraft
1996	30	25	5	280	153 / 55%	127 / 45%
1997	26	21	5	198	120 / 61%	78 / 39%
1998	28	22	6	139	94 / 68%	45 / 32%

Source: Texas Boll Weevil Eradication Foundation, Inc.

The percentage of turbine-powered aircraft used in the program increased every year while the number of airports being used for the program remained relatively constant. Some difficulty remains in determining the extent of future activity to be generated in the boll weevil program. The success of the current programs across the state is a large factor. Nevertheless, it remains clear that the eradication programs generate significant activity at public-use airports and do so for multiple years at a time. The boll weevil zones are not identical to the agricultural districts mentioned earlier, but are generally synonymous with them. Although there is no exact overlap with respect to the counties involved and their boundaries in these geographic definitions, the boll weevil zones are in the same general area of the state as their agricultural district counterparts.

Currently there are three active zones that include the Southern Rolling Plains, the Central Rolling Plains, and the South Texas/Winter Garden. In addition, five zones have been expanded. These include the Western High Plains, the Permian Basin, the Northern Rolling Plains, the Northwest Plains, and the El Paso/Trans Pecos.

Because of these new and expanded zones, it is likely that this level of aerial activity will continue in the foreseeable future. Further, this pesticide application program is not the only aerial application work associated with cotton. Aerial applications are also made on the crop for defoliation that aids the harvesting process.

Determining the timeline for boll weevil-related aerial application is not a precise process. As stated in the general conditions and specifications of the Texas Boll Weevil Eradication Foundation, Inc. contract, "there are numerous biological, entomological, and environmental factors that determine the time and sequence of treatments (7)." This refers to the exact timing when the aerial applications take place. According to program documents, a full season for the program includes three segments: spring, mid-season, and fall (7). It can be expected that substantial aerial application activity will take place during these times in regions with active zones with insecticide work performed from June through October for northern and central zones and April through August in South Texas zones.

But boll weevil applications are not the only applications being made for cotton. Interviews with aerial applicators revealed that some herbicide applications are made before the cotton is planted. In south Texas, where planting begins during the first part of March, herbicide applications are performed in the latter part of February. In the Panhandle, cotton is planted during the first part of May. As always, many factors, including weather, can influence these timelines. Pesticide applications then occur accordingly followed by the aerial application of defoliants before harvest. Some aerial activity may occur in the late fall for fertilization but most of this is accomplished by ground equipment.

Although aerial application activity for cotton is not year-round, it certainly accounts for a significant portion. Depending on the region of the state and the prevailing weather patterns, aerial applications occur from February into November on a regular basis including applications of herbicide, pesticide, and defoliants.

MAJOR CROPS AND AERIAL APPLICATION ACTIVITY

While cotton production accounts for a large percentage of aerial application activity in Texas, production of other crops generates significant activity as well. These crops include corn, sorghum grain or milo, wheat, peanuts, rice, and soybeans. Researchers conducted interviews with several aerial applicators across the state to compile the following accounts of aerial activity.

Corn

Nearly half of the two million acres of corn planted in Texas in 1997 could be found in the Panhandle. Corn is typically planted in March and April in the Texas Panhandle and harvested in the latter part of September. Aerial applications related to corn are generally limited to pesticide work that typically occurs in July. Aerial applicators in more southern parts of the state indicate that they spray herbicide for corn crops in the latter half of March to the first week of April. Limited application activity related to corn in south Texas results from the fact that not as much corn is grown in the area as is in other areas of the state. Also corn is not the dominant crop in the region surrounding Nueces County where more sorghum grain is grown than any other crop. Corn-related aerial application does exist in south Texas but not on the same level as found in the more northern parts of the state.

Sorghum Grain

South Texas is home to the largest sorghum grain producing counties in the state led by Nueces and San Patricio counties. Nearly 12% of the sorghum produced in the state comes from these two counties. So, as would be expected, aerial application activity is present in this area. In the Southern parts of the state, sorghum grain related application may begin with herbicide applications in March and April followed by insecticide applications in May and June. The crop is usually planted before cotton in February and March and is typically harvested in early July. On occasion, additional herbicide applications may be warranted in October and November depending on the rainfall. The application is performed to prevent unwanted growth from occurring outside of the main growing season. This leaves the moisture in the ground for the main season. Also, some fertilizing work may be done in November. In southeast Texas, some insecticide may be applied in July and August. In northern parts of the state, the sorghum grain is planted after cotton with insecticide applications running concurrent with corn in July. Across the state, aerial applications for sorghum grain can run from March through August and in October and November depending on the weather and other factors.

Wheat

Wheat is largely grown in the Panhandle and the Rolling Plains regions of the state. Interviews with applicators in the Plains revealed that wheat is typically planted in August and September and that aerial application work typically runs from October to February. Weather and market prices also influence this timeline as researchers found that a lot of wheat was not being sprayed this year due to sagging commodity prices making it financially unfeasible to treat. Nevertheless, the application season can run for several months. Interviews with a Panhandle applicator showed that they did not do any work on wheat. In that region, wheat is typically planted in September and October and harvested the first part of June. Following this timeline, it is expected that aerial application work in that area might prevail from November into the spring.

Peanuts

While it is known that some aerial application work is done on peanuts, not a significant amount of activity was found. One applicator operating out of Knox City did some peanut applications but it was not very much of his total work. With 320,000 acres of peanuts in the state, it is not believed to be a major generator of aerial applications. Table 26 shows the major crops in the state and the number of acres planted in 1997. Using Table 29 as a guide, it is expected that any peanut-related aerial activity would take place in the late spring and summer months.

Rice
Although rice is not a very large crop in terms of acreage, it ranks number seventh out of seven of the major crops in the state in terms of acres planted and eighth in cash receipts. However, rice relies on aerial application perhaps more than any other crop in the state. Approximately 90% of rice in the state is sown by air making it unique with respect to other crops. Fertilizing is also done by air. Grown primarily in the Upper Coast and Coastal Bend districts of the state, nearly 40% of the state's production comes from Wharton and Colorado counties. Rice is generally planted in March and April with fertilizing applications being made from April to June. Rice is an aerial-intensive crop creating a very busy four-month period in the spring. Rice production also has special needs in terms of infrastructure required to support such aerial application operations. These needs will be discussed in more detail later in this report.

Soybeans
Few of the aerial applicators interviewed made specific mention of work done on soybeans other than to say that they do not do any soybean applications. This is not to say that no soybean-related aerial applications are made. One operator in the southeastern part of the state does do some insecticide work in August and September. Soybean crops in Texas make up a small part of total acreage and account for approximately 1% of the total crops in terms of cash receipts. Soybean production is not an aerial-intensive crop like rice. Table 26 shows the major crops in Texas and the acreage planted in 1997 for each one.

TABLE 26
Total Acreage Planted By Major Crop, 1997

Crop	Total Acreage (1,000s)	Percent of 7 Major Crops
Wheat	6,300	35%
Cotton	5,500	31%
Sorghum Grain	3,300	18%
Corn	2,000	11%
Soybeans	420	2%
Peanuts	320	2%
Rice	260	1%
TOTAL	**18,100**	**100%**

Source: Texas Agricultural Statistics, 1997

Timberland
A significant amount of commercial timberland acreage is located in the eastern part of Texas. The Temple-Inland Corp., based in Diboll, Texas, has approximately 1.2 million acres of commercial timberland in the state. The Timber Company, a Georgia-Pacific subsidiary, has 24,000 acres of

timberlands. The Louisiana-Pacific Corp., which owns nearly one million acres of timberland companywide, also has a presence in Texas. Collectively, Texas is home to approximately 12 million acres of commercial timberlands capable of growing timber crops (6). "East Texas timberlands are located near the neighboring states of Oklahoma, Arkansas, and Louisiana and are often referred to collectively as the 'Piney Woods' (6)."

Interviews with Temple-Inland personnel in Diboll revealed some insight into the aerial application work conducted by the company in Texas. Temple-Inland's aerial application work includes both applying herbicide and fertilizer. Because of the controversial nature of the herbicide application, the company contracts the work to rotary-wing operators. By choosing helicopters to do the work, the company removes a lot of potential for conflict over herbicide application because of the greater precision involved. The contractor uses a truck with a helipad mounted on top for refueling, thus eliminating trips to the airport and allowing the helicopter to spray more acres per hour than a fixed wing aircraft. This is not a recommendation but simply one of the current practices in the industry. The company does use fixed-wing aircraft for their heavy load fertilizer applications. As with the herbicide applications, the fertilizer applications are contracted out to independent operators. Officials stated that, in previous years, the Texas applications were given to one operator for fertilizer work while another operator was contracted for the herbicide work.

One operator interviewed for this project, indicated that they had been involved in the fertilization work in the past and that most of it typically occurs in the winter, but may be more than just seasonal. There were some indications that timber-related aerial applications could be year-round.

While some of these applications are made using public-use general aviation airports, others use private airstrips owned and operated by the timber companies. Temple-Inland has used public-use airports in Jasper, Lufkin, and Center, and private strips in Evadale and the Toledo Bend region.

Vegetables

In 1997 Texas remained one of the top five states in the nation in vegetable production (1). These vegetables are primarily produced in the South Texas, Lower Valley, and Trans-Pecos agricultural districts. Table 27 shows the planted acreage and cash value for some selected vegetable crops as outlined by the Texas Agricultural Statistics Service for 1997 (1). It should be noted that most of the acreage statistics for these crops have remained relatively stable during the 1993-1997 period. The cash values, however, have seen more volatility. Both can influence the level of aerial activity generated by a particular crop as witnessed by reduced aerial application work on wheat this year due to falling commodity prices. Table 27 begins to paint a picture as to why Texas, in 1997, ranked fifth in the nation in harvested acreage, or 4.9% of the U.S. total. "Texas also ranked fifth in production, with 4% of the total, and fifth in value, accounting for 3.1% of the total (1)."

Input from aerial applicators provided information on the spraying of vegetables in the state. In the Lower Valley where significant vegetable crops are found, aerial applications could be possible throughout most of the year. For example, peppers require multiple applications of insecticide, fungicide and fertilizer which occur from August into December. In addition, onions, which are typically planted in October, will require applications of fungicide and fertilizer beginning in November and continuing through March. Greens and cabbage are typically planted in October and spring peppers and squash in March. With other vegetables being planted at different times of the year, it is easy to see that crop protection treatments made shortly after planting up until harvest time may generate significant aerial application activity.

TABLE 27
Acreage and Cash Value of Selected Vegetable Crops For Fresh Market - 1997

Crop	Acreage Planted	Cash Value (1,000s)	State Production Rank
Cabbage	9,300	$33,813	5
Cantaloupe	12,500	$27,160	3
Carrots	3,700	$9,999	7
Celery	900	$6,744	3
Sweet Corn	3,800	$1,998	20
Cucumbers	1,800	$4,191	9
Honeydew Melons	3,300	$9,492	3
Onions	16,300	$41,539	6
Peppers, Bell	5,400	$30,898	4
Spinach	3,100	$5,522	3
Tomatoes	3,400	$21,760	9
Watermelons	42,000	$50,490	4
TOTALS	**105,500**	**$243,606**	

Source: Texas Agricultural Statistics, 1997

For the most part, vegetable-related aerial activity is found in the Lower Valley where these crops are typically localized and concentrated. One operator in the Valley indicated that he worked year-round including applications on many types of vegetables.

The largest of these vegetables in terms of both acreage planted and cash value are watermelons. Although they are grown in several parts of the state, there are primarily three regions where they are grown in larger quantities. The largest producing region is South Texas/Lower Valley followed by East Texas and the southern part of the High Plains. Together, these three regions accounted for approximately two-thirds of all the watermelon acreage harvested in 1997 (1).

The dependence of watermelons on aerial application varies by region. Both aerial applications and ground rig applications are made on the crop with the South Texas/Lower Valley region seeing a higher rate of aerial application. In that region, about half of the watermelon crops are treated by air. Approximately 60% of the crops are sprayed by air at least once. In East Texas, aerial application is less frequent. Reasons for this include the topography of the region that makes it difficult to spray small fields by air when they are surrounded by large trees. In west Texas, specifically the Southern High Plains region, the drier weather precludes the development of some of the diseases and other problems found elsewhere. Consequently, there is not as much need for applications including aerial applications.

Other factors influence the demand for aerial application and these are worth noting. Although the acreage for watermelons and other vegetables is small compared to other crops, watermelons are what the industry refers to as high gallon work. Watermelons require approximately 10 gallons per acre where many other crops are substantially less than that at a few gallons per acre. This translates to more trips being made with fewer acres per trip being sprayed. This intensity in conjunction with the short spraying season for watermelons can generate significant aerial activity in some regions during certain times of the year. For watermelons, this activity can be expected from April to June with the most intense activity occurring from mid-April to mid-May. Incidentally, this time frame is the same for cantaloupes and honeydew melons. Additionally, when fields are too wet or when vines get to be too large, applications will need to be made by air since using ground rigs may be too difficult or too damaging to the crop. As with any other crop, when time becomes an important factor, aerial application is the best alternative for quick, efficient, and effective treatment.

Miscellaneous

Interviews with aerial applicators also revealed aerial activity around the state generated by other crops or by needs not related to producing the top seven cash crops. In southeast Texas, winter pasture land/rye grass requires aerial activity that consists of planting in September and October and fertilization anywhere from September to January. In the Rolling Plains region, as well as in other parts of the state where mesquite is present, operators are involved in spraying for mesquite and brush control in May and on prickly pear cactus control in April. The Rolling Plains region is within the Northern and Southern Low Plains Agricultural Statistics Districts.

Lastly, as briefly mentioned above, a fair amount of aerial activity is generated in the South Texas/Lower Valley district for cantaloupes and honeydew melons from April through June with more intense operations occurring from mid-April to mid-May.

SUMMARY

As evidenced from the above discussion, agriculture in Texas is a very significant part of the state economy as well as the national economy. Preserving this interest includes preserving and protecting crops through both conventional and state-of-the-art methods and technology. Aerial applications help accomplish this. The value of the crops they protect is staggering as is the number of jobs tied to the agricultural industry in general. Without aerial application, the state risks huge economic losses that move well into the billions of dollars. This is clearly illustrated by understanding that boll weevils alone can destroy cotton fields, the state's largest cash-producing crop, in a matter of weeks.

Before discussing the needs of aerial applicators, it is first beneficial to understand the level of aerial activity in the state as a whole. The activity is generated across the state with higher concentrations found in certain areas. Table 28 attempts to summarize the level of activity throughout the year by crop or other vegetation. It should be noted that these approximations can vary somewhat due to weather patterns and circumstances specific to some regions and farmers. In addition, information for some crops may not be complete. Also, some crops are planted earlier in some parts of the state, and in these cases, the regional differences are not necessarily noted in the table but are represented by crop. While the types of application are not noted in this table, they are mentioned above. Table 28 can be used to assess levels of aerial activity and potential activity when combined with other information such as weather, regional location within the state, density and area/acreage of the crop grown, crop prices, and the extent the crop relies on aerial applications.

TABLE 28
Summary of Aerial Activity in Texas

Crop/Vegetation	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Cotton		■	■	■	■	■	■	■	■	■	■	
Corn			■	■			■					
Sorghum Grain			■	■	■	■	■	■		■	■	
Wheat	■	■	■							■	■	■
Rice			■	■	■	■						
Soybeans								■	■			
Timberland										■	■	■
Winter Pasture/Rye Grass									■	■	■	■
Mesquite/Brush					■							
Prickly Pear Cactus				■								
Peppers								■	■	■	■	■
Onions	■	■	■								■	■
Watermelons				■	■	■						
Cantaloupes/Honeydew				■	■	■						

While this analysis is not exhaustive, it includes the input of aerial applicators across the state and represents the level of aerial application activity across the state. It substantiates the input of several applicators who indicated that they work year-round. Others indicated that while they do not work throughout the year, they only have a month or two of downtime in the course of a year. It should be noted that this table does not represent work done for other crops and purposes not listed but does include the major crops in the state. Some vegetables are included in the table because they generate significant activity throughout most of the year. To help validate this information and to provide additional helpful information in assessing the level of activity or its potential, it is beneficial to examine the planting and harvesting calendar of major U.S. crops published by the U.S. Department of Agriculture. Table 29 presents this information.

TABLE 29
Planting (P) and Harvesting (H) Calendar for Most Major U.S. Crops

Crop	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Hard Red Winter Wheat					H	H	H		P	P		
Soft Red Winter Wheat					H	H	H		P	P	P	
White Winter Wheat						H	H	H/P	P	P	P	
Hard Red Spring Wheat				P	P		H	H	H			
Durum Spring Wheat				P	P		H	H	H			
Corn				P	P				H	H	H	
Sorghum Grain					P	P			H	H	H	
Barley				P	P		H	H				
Oats			P	P	P		H	H				
Soybeans				P	P	P			H	H	H	H
Peanuts				P	P			H	H	H		
Sunflower Seed					P	P			H	H	H	
Cotton			P	P	P				H	H	H	H
Sugar Beets				P	P				H	H	H	
Sugar Cane	H/P	H/P	H/P	H/P						H/P	H/P	H/P
Tobacco				P	P	P/H	H	H	H			

Source: Agricultural Fact Book, 1997. U.S. Department of Agriculture, Office of Communications

When considering the potential timeline for aerial applications for crop protection and harvesting, the above calendar can provide insightful information. It also largely agrees with the information collected from applicators in Texas. The next chapter moves from understanding the nature of the activity to understanding the needs of aerial applicators who use the state's general aviation public-use airports.

VI. AGRICULTURAL AIRPORT NEEDS AND RECOMMENDATIONS

With the role and importance of agricultural aviation now well established, this chapter focuses on the needs of the state's airports that serve the aerial application community. Recommendations on how agricultural airports can be supported through the planning and programming process are also included.

NEEDS

Based on numerous interviews and site visits, certain needs of aerial applicators have been identified and are documented below. A discussion of these identified needs follows.

Agricultural Pads

The primary need among aerial applicators operating from the state's public-use airports is for self-contained agricultural pads. These pads allow operators to load aircraft in a safe and efficient manner. Located away from other general aviation traffic and operations, these pads allow space for the aircraft and supporting equipment necessary for loading the aircraft. These activities can include mixing and loading fertilizer, and utilizing fuel trucks to fuel the aircraft. It is not uncommon to find some of these trucks weighing around 100,000 lbs. The impacts of these heavy trucks operating on airport grounds can be substantial if the appropriate infrastructure is not in place. Typically, general aviation airports are not suited and designed for such heavy equipment. The weight of these trucks can cause damage to pavements requiring them to be fixed or replaced more frequently causing greater expense. Additionally, these agricultural pads allow for the safe and quick clean-up of any spills that may occur in the loading process thus allowing for compliance with state and federal environmental regulations and standards. Planners should consider whether or not a particular pad will also be used as a washdown facility because it could influence the design.

Many of the pads at agricultural airports do not have any containment features, i.e., they lack containment walls and/or sumps. Both of these are important for containing any spills that may occur. Guidelines in *Designing Facilities for Pesticide and Fertilizer Containment* published by the MidWest Plan Service call for loading pads to include several key features. This is done to "improve operational and worker efficiency while reducing personnel and environmental safety risks (8)." These features include: 1) sealed, liquid-tight, reinforced concrete pad to form an impervious barrier. Loading pads should be sloped towards shallow sumps; 2) sloped pad surfaces plus watertight walls and curbs around the perimeter to form a shallow depression for containment should there be a leak or spill; 3) independent shallow sumps for containment; and 4) approach ramps to the pad to minimize dust and trash accumulation. The same guidelines also recommend roofs for these pads, especially in areas where there is significant rainfall. Precipitation can cause problems on pads that are not kept clean.

Currently, aerial applicators are operating from public-use airports under a variety of conditions. Some are using agricultural pads that are gravel, asphalt, or concrete. The size varies as well but are often too small to accommodate their needs. Asphalt pads are more likely to erode and wear as they are not capable of supporting their intended use. Further, some of the pads at public-use airports are under exclusive lease agreements to airport tenants and cannot be used by the general public.

At least one operator has built his own pad and another operator is in the planning process to fund and build his own pad. This situation points out issues concerning equity, compliance, and government involvement. However, a large mitigating factor is the fact that the pads that are built will be open to the public and even those operators that build their own pad at their home airport will be able to use and benefit from the new pads built at other airports.

Figures 6 and 7 illustrate the needs for adequate space considering the support trucks required for aerial application activity. Figure 6 shows a fuel truck that is often used while Figure 7 shows a fertilizer truck used in rice application work.

Figure 8 shows an example of an agricultural pad that has often served as a model. It is approximately 60 feet square and constructed of concrete including retaining walls. It has an access road in the back for fuel trucks and chemical drop-offs to prevent the large trucks from driving on aircraft apron areas not capable of supporting the weight. This pad has chemical and fuel storage areas adjacent to the pad that would not be necessary for pads at public-use airports serving multiple users. However, the availability of storage areas could result in minimizing truck activity, including heavy trucks capable of causing damage on and around the pad area. This is particularly true for airports with significant activity throughout the year as well as those with intense aerial application seasons as with the boll weevil program. Finally, this pad was designed and built with much smaller aircraft in mind than are currently used. While it is still useful, it was not designed for aircraft with 60-foot wingspans nor was consideration given to the support trucks necessary as all of the fuel, chemicals, and mixing equipment are located adjacent to the pad. Therefore, planners must give careful consideration to the size of the pad. Pads on public-use airports will serve multiple users and therefore should include any necessary permanent storage and mixing equipment. All of the necessary equipment will be on support trucks, making space to operate safely important. The pad shown in Figure 7 is at a public-use airport, and, though it is not concrete, is 200 feet long and 100 feet wide.

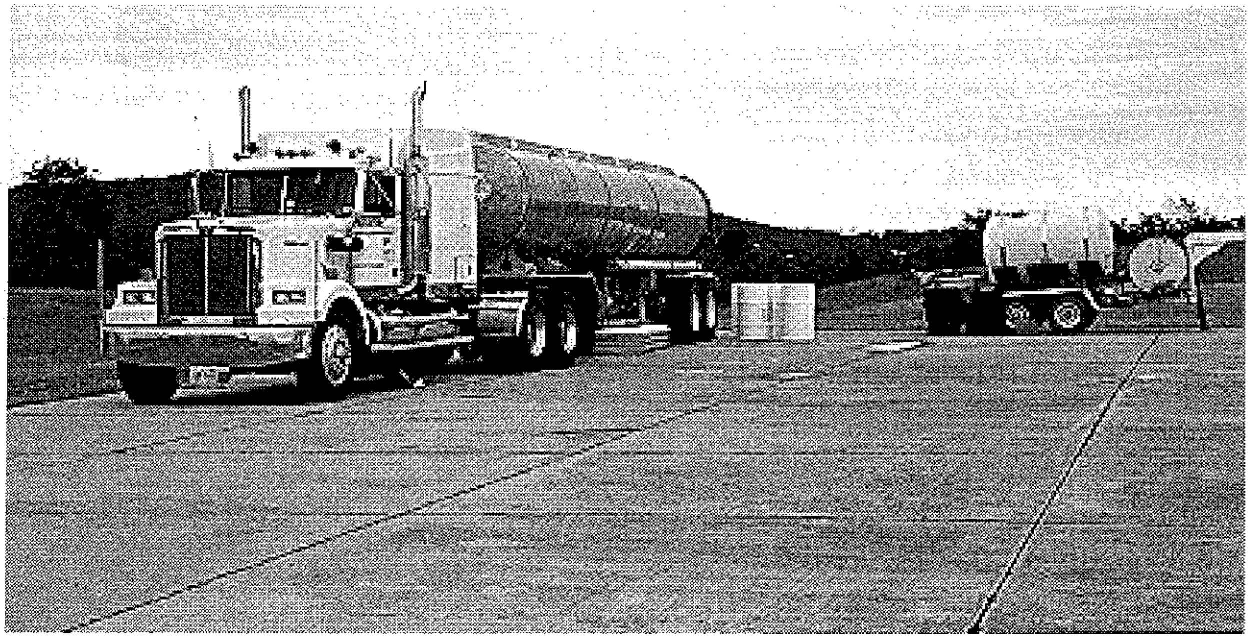


FIGURE 6. Fuel Truck Used for Aerial Application

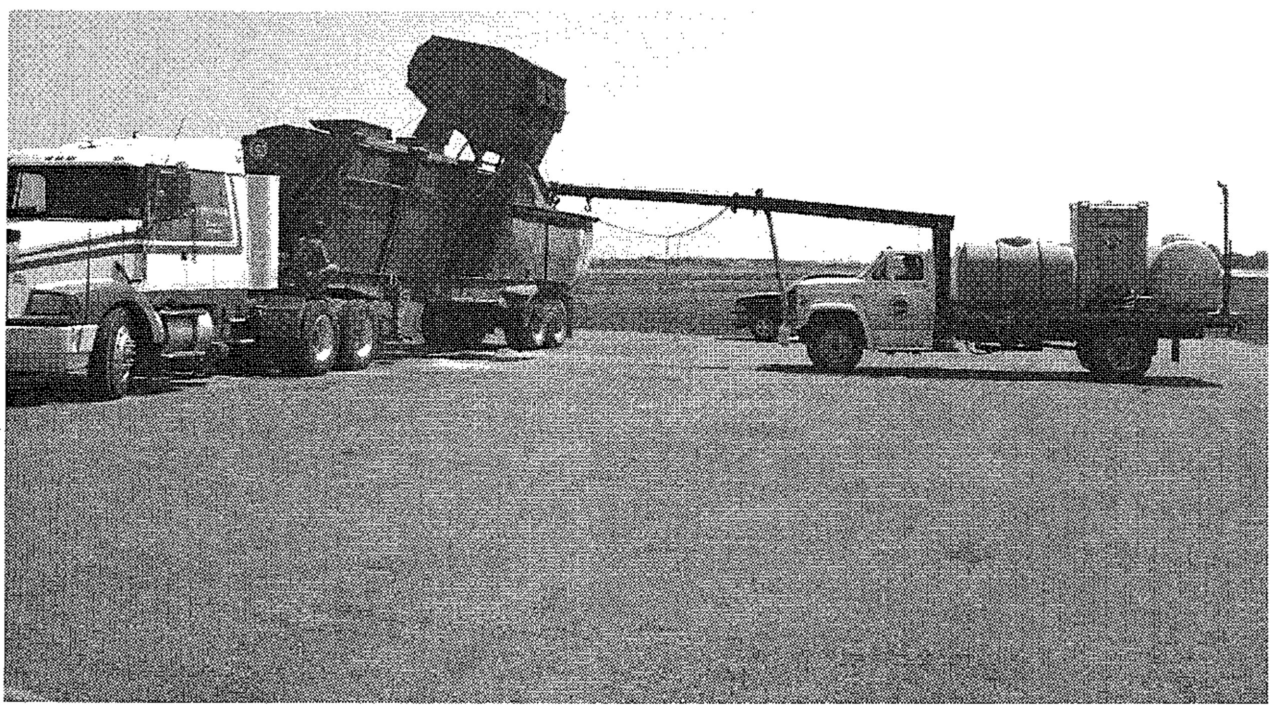


FIGURE 7. Fertilizer Truck Used for Aerial Application

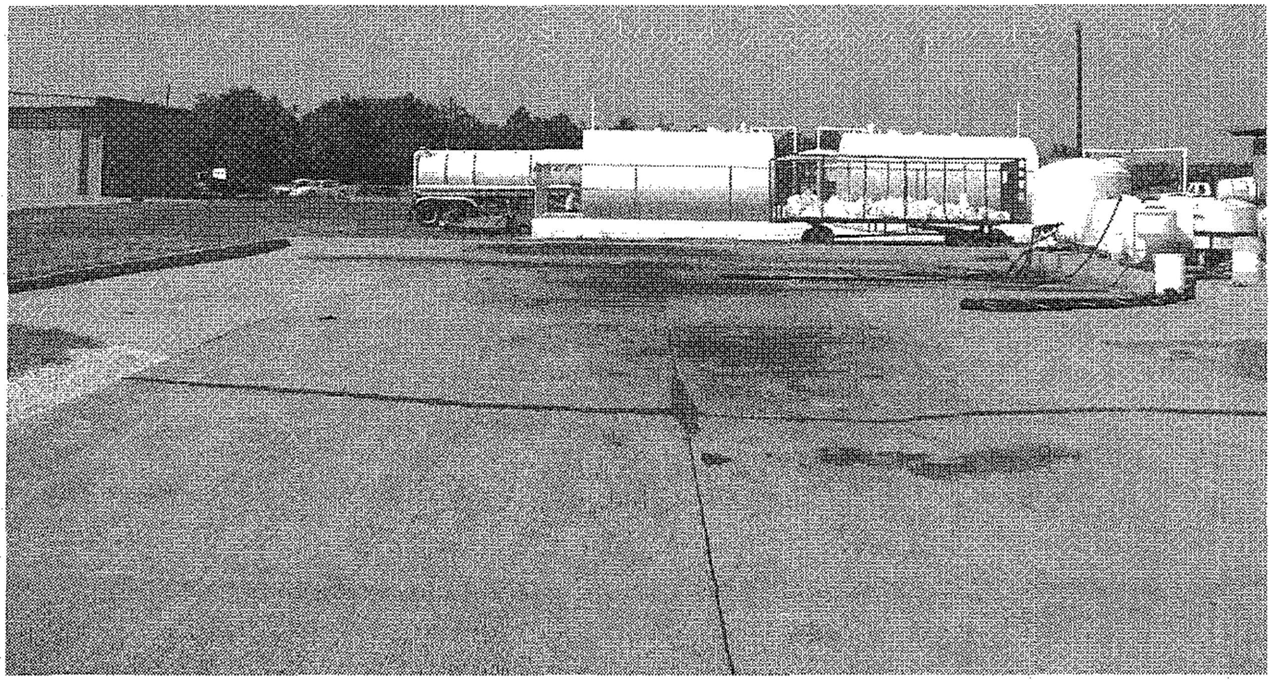


FIGURE 8. Model Agricultural Pad

Access Roads

Access roads provide a means for the fuel and equipment trucks mentioned previously to travel to the agricultural pad. Because of their size and weight, it is necessary for them to avoid the main airport roads. The possible damage to facilities not designed to handle such weight could be substantial. By avoiding the main airport roads, support vehicles are kept away from aircraft apron areas that are easily damaged. Additionally, establishing separate roads will prevent the agricultural operations from restricting or interfering with normal general aviation operations at the airport. Figure 9 shows an example of an access road to an agricultural pad. It is a gravel road and serves the needs of the primarily agricultural airport quite well.

FIGURE 9. Access Road to Agricultural Pad

Figure 10 shows the same access road from a different perspective. The same road also serves another pad at the other end of the runway shown here. The entrance to this road is separate from the main airport entrance. The pad shown in Figure 9 is at the far end of the road shown in Figure 10. Most of the pads visited shared some access with the airport roads or aprons. There were generally no segregated access roads separate from the main airport entrance.

FIGURE 10. Segregated Access Road To Agricultural Pad

The pad shown above is 300 feet long and 100 feet wide. Figure 11 shows an example of the type of pavement failure that can occur when appropriate pavements are not used or when heavy support trucks are allowed to share main airport entrance roads and apron areas not capable of supporting heavy loads.

FIGURE 11. Example of an Apron Pavement Failure

Figure 12 further illustrates the damage to asphalt surfaces used in agricultural aviation operations or other operations where adequate facilities are not available for the given needs or use. Weather is capable of quickly eroding an already degrading surface.

FIGURE 12. Additional Asphalt-Damaged Surface

Stub Taxiways

In some cases, there is, or may be, a need for a stub taxiway to connect the agricultural pad area to the runway and taxiway system. This prevents loaded agricultural aircraft from taxiing around the airport or across other apron areas to access the runway. This keeps the agricultural operations segregated from the other activity at the airport. This is particularly important in areas where there is significant aerial applicator activity such as is found with the boll weevil program. Stub taxiways can help minimize the movement of loaded aircraft, reduce the risk of runway incursions, and allow for a pattern of activity at the airport reducing congestion at busier airports and during busier seasons where large numbers of aircraft are operating at the same time. Figure 13 shows an example of such a stub taxiway.

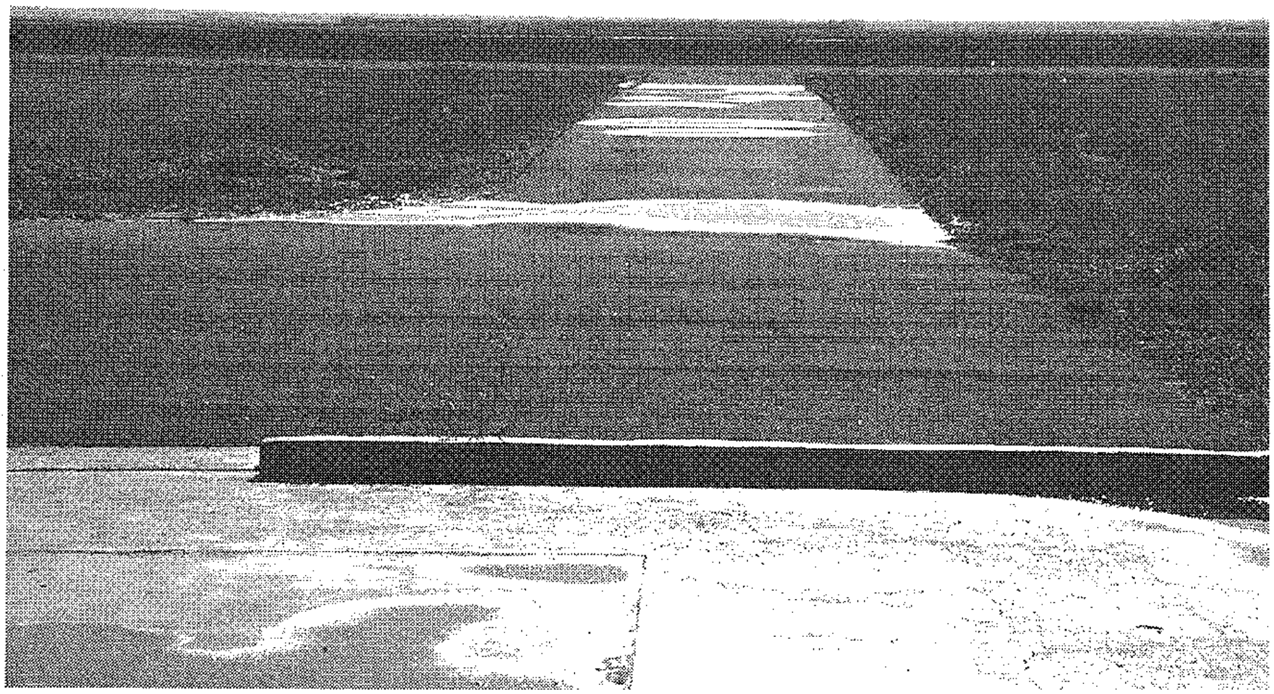


FIGURE 13. Example of a Stub Taxiway

As shown in the figure, the stub taxiway connects the pad to the runway/taxiway system while separating the agricultural traffic from the general aviation apron areas and not forcing aircraft to taxi more than necessary.

Aircraft Tie-Downs

A need exists for aircraft tie-downs at airports that accommodate overnight stays of agricultural aircraft. These are typically associated with the boll weevil program or other intensive programs where it is not uncommon to find numerous aircraft working over a period of several days. Some airports have had more than a dozen aircraft operating during the same day. By creating more tie-down space adjacent to the agricultural pad, more aircraft can be accommodated without interfering with the other activity on the airport. Also, it prevents aircraft from parking on the pad thus potentially hindering operations the next morning.

RECOMMENDATIONS

The recommendations that follow are the result of the examination of the role and needs of agricultural airports that have been detailed in this report. Agriculture in Texas carries with it significant economic benefits not only for the state, but also for the nation. Aerial applicators service the agricultural industry in important ways that help protect and preserve Texas' crops and their economic impact. The following recommendations are made to better support agricultural airports through the airport planning and programming process. These recommendations fit into four general categories. They are: 1) agricultural loading pads and pad improvements; 2) agricultural pad access roads; 3) stub-taxiways; and 4) aircraft tie-downs. Each of these recommendations are discussed in detail below. Lastly, the subject of design standards and how they relate to agricultural airports is discussed and included in this section.

Agricultural Loading Pads and Pad Improvements

These pads are used for loading pesticides, herbicides, insecticides, fertilizers, and seed into agricultural aircraft. They can also be used as a wash-down facility. They should be large enough and strong enough to accommodate the aircraft and any support equipment including large trucks. When loading fertilizer, it is not uncommon that large, 18-wheel trucks that weigh 80,000 lbs. to 100,000 lbs. are needed. There may also be a need for large fuel trucks as well. Additionally, these pads should be made of impervious concrete and self-contained, allowing workers to clean-up agricultural chemicals should a spill occur without causing harmful effects. This includes liquid-tight containment walls and sloped pads that include a sump to clean-up leaks or spills. However, the nature and extent of the aerial application operation as well as the region of the state may dictate the extent to which these facilities are necessary. Applications consisting of seed and dry fertilizer require fewer safeguards than liquid chemicals.

With agricultural aircraft wingspans approaching 60 feet, an ideal agricultural pad size would be a 100-foot by 100-foot concrete pad with an additional 50 feet of asphalt on either side. This 200-foot by 200-foot pad should accommodate the largest of aircraft with the necessary space for large support trucks if needed. The use of asphalt for the main part of the pad is not recommended as it deteriorates more quickly and its integrity is more susceptible to chemicals often used in the industry. In addition, large trucks should park on the concrete portion of the pad and not on the adjacent asphalt.

It is anticipated that the concrete pad will have a thickness of six to ten inches depending on the expected use and operation of the pad and especially the type of sub-grade that exists. The type of sub-grade varies across the state and is much stronger for example in the Austin area than it is in the Houston area. A weak sub-grade may require ten inches of pavement and a strong sub-grade may only require six. This, more than anything else will determine the strength and thickness of the pavement. In addition, the types of operation should be considered. Applications on some crops require more and heavier support equipment and more trips per acre. All of these factors give us an idea of the amount of use the facility can expect.

With respect to the adjacent asphalt surface, it may be beneficial to taper the thickness of the asphalt with a greater thickness closer to the concrete. This allows for the heavier trucks operating on the facility that may need some additional maneuvering space that exceeds the confines of the concrete pad. This can ultimately extend the life of the pad and reduce future maintenance costs. Considering the size of the concrete pad, it is expected that it would be jointed to control cracking, reduce maintenance costs, and promote the life of the pavement. With that said, it is critical that the local area be examined for soil type and that the nature of the aerial applications to be made from the facility be understood when designing the facility.

Some existing agricultural pads serve their airports well in terms of size and location. However, they could benefit from adding berms or walls to contain the area for the same reasons mentioned above. In addition, sizes could be expanded to better serve the users.

Costs of these pads can vary depending on specifications that include its size, thickness, and other features that may be included. It is expected that the time needed to construct these pads would be a minimum of 90 days. Detailed drawings of an agricultural loading pad are presented in Appendix D and E.

Access Roads

Access roads to the agricultural loading pads are necessary to provide access for large trucks that are capable of causing damage to asphalt apron space or other airport pavement not suitable for 100,000 pound trucks. These roads would ideally have entrances separate from the main airport entrance. It is not necessary that they be concrete. Asphalt, gravel, crushed aggregate, or limestone roads can be quite suitable. For this particular use, gravel, crushed aggregate, and limestone roads have some advantages. Construction and maintenance costs are less and they can be designed and built to accommodate the heavy trucks that will be using the road. They can be maintained more easily and at less cost. While asphalt is smoother and can be used in wet weather, the trucks using the road will not be operating at speeds where that will become a factor. Neither is aerial activity expected to occur during inclement weather. Additional roads may be needed to provide access to storage areas if the geometry of the area warrants. Further, these separate access roads are important to segregate the agricultural aviation activity which includes the myriad of trucks often associated with supporting agricultural aviation. This is important for both operational and safety reasons.

The length of these roads will depend on access to the roadway system leading to or around the airport and the costs will vary depending on the type of surface used and the length of the road. The width of the road should be no less than that of a standard highway lane which is 12 feet. The access road shown in Figure 9 is 13 feet wide and is designed with a crown and a two percent grade from the center of the road for drainage. It is constructed with ten inches of crushed stone and is located in a region known for weaker sub-grades. Detailed drawings of this access road are presented in Appendix E.

A significant consideration, as mentioned earlier with the loading pads, is the type of sub-grade present at the airport. The types of sub-grades can vary considerably across the state and are an important factor when designing pavements and surfaces. For a gravel or crushed aggregate road, it is expected that the thickness will be approximately four to six inches depending on the sub-grade. Some regions that have especially soft soil may require more. With proper design, including adequate drainage, a gravel or crushed aggregate road can be quite sufficient.

Stub Taxiways

Often it is necessary to provide a link to the runway system from the agricultural pad. This is critical at airports that have a fair amount of general aviation traffic that could be negatively impacted during the busy agricultural application season. Nevertheless, it is important that the loaded agricultural aircraft have as direct access as possible to the runway to prevent unnecessary taxiing.

Aircraft Tie-Downs

Many of the aerial applicators interviewed expressed a need for tie-down facilities. Significant generators of aerial activity such as the boll weevil eradication program, create a lot of traffic at small airports. Parking these aircraft overnight can become a problem in some places. During busy seasons for certain crops, some airports will attract more than a dozen aircraft. Tie-downs, however, should not be built on the loading pads. This can hinder the operations of others who may need to use the pad where aircraft are parked. Nevertheless, there are some facilities that need tie-downs to accommodate their agricultural aircraft. The number of tie-downs depends on the nature of the work performed at that airport. Clearly, airports that accommodate boll weevil-related work will require more tie-downs than airports not serving such intensive programs. It is not necessary that these tie-downs be concrete or even asphalt.

Design Standards

Functional categories were recently developed by the TxDOT Aviation Division to help better address airport planning and programming issues. Tied closely with an airport's function is its role and level of service and the associated design standards. There currently exists an agricultural airport functional category that includes airports serving areas of intense agricultural production. Agricultural spraying services are required to support the production capability of many small communities. As outlined above, the facilities that serve these communities have a need for additional facilities and standards that will contribute to safe and efficient airport operations.

A recent review of the current design standards with respect to agricultural airports was recently performed as part of another Texas Transportation Institute (TTI) study (9). Changes to the current design standards for airports with the same role and airport reference code (ARC) as the agricultural airports were recommended for those airports classified as agricultural. Tables 30 and 31 show the applicable design standards and the recommended design element changes, respectively, for those facilities functionally categorized as agricultural airports. Terminal facilities and runway lights are not always required.

TABLE 30
Applicable Design Standards for Agricultural Airports

Airport Role	Airport Reference Code (ARC)	Airplane Type/Size
Basic Utility Stage I or II	B-I	Small Airplanes

The only recommended design element changes for agricultural airports not included in the recommendations of this report pertain to minimum runway widths. Minimum runway widths of 50 feet or 75 feet of stabilized turf in lieu of the 60 feet outlined in the applicable design standards are appropriate for agricultural airports.

TABLE 31
Recommended Design Element Changes for Agricultural Airports

Design Element	Recommended Changes
Minimum runway	Minimum runway width 50 feet or 75 feet stabilized turf
Minimum apron	Add agricultural apron (self-contained), 80,000-pound PCC agricultural chemical truck parking pad adjacent to PCC agricultural aircraft loading apron designed for chemical washdown and containment
Other	Access road, paved or gravel, suitable for carrying an 80,000-pound chemical truck from the public road to the agricultural chemical truck parking pad

The recommendations and results of this report demonstrate the appropriateness of the design standards and pertinent recommended changes outlined above for agricultural airports. The recommended changes only help to ensure the safe and efficient operation of an airport during periods of agriculture-related aerial activity. As previously stated, terminal facilities and runway lights are not necessarily recommended but are also not excluded or deleted as part of the recommendations. Agricultural operators typically do not fly at night in Texas but that alone is not enough to remove them from the standards. Generally speaking, additional development is not required for the airport to carry out its function as an agricultural airport but those items are not specifically identified for removal from the standards as they may be important for other users of a particular public airport.

It should also be noted that the truck and loading design elements outlined in the recommendations are appropriate at any airport with significant agricultural operations regardless of the functional classification of the airport.

CONCLUSION

The recommendations made above do not fit every circumstance that may exist. Planners should use these recommendations in conjunction with proper consideration of each agricultural airport, its layout, and the volume and type of aerial application activity at that airport as well as the agricultural activity in the region. When used accordingly and in conjunction with appropriate engineering design standards (grading, drainage, etc.), these recommendations can provide for the safe and efficient operation of agricultural aviation activity at Texas airports.

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APPENDIX A
TEXAS AGRICULTURAL STATISTICS DISTRICTS

Texas Agricultural Statistics Districts

Texas Agricultural Statistics Service

Northern High Plains(1-N)
Armstrong
Briscoe
Carson
Castro
Dallam
Deaf Smith
Floyd
Gray
Hale
Hansford
Hartley
Hemphill
Hutchinson
Lipscomb
Moore
Ochiltree
Oldham
Parmer
Potter
Randall
Roberts
Sherman
Swisher

Southern High Plains (1-S)
Andrews
Bailey
Cochran
Crosby
Dawson
Gaines
Glasscock
Hockley
Howard
Lamb
Lubbock
Lynn
Martin
Midland
Terry
Yoakum

Northern Low Plains (2-N)
Borden
Childress
Collingsworth
Cottle
Dickens
Donley
Foard
Garza
Hall
Hardeman
Kent
King
Motley
Wheeler
Wichita
Wilbarger

Southern Low Plains (2-S)
Baylor
Coleman
Fisher
Haskell
Jones
Knox
Mitchell
Nolan
Runnels
Scurry
Stonewall
Taylor

Cross Timbers (3)
Archer
Brown
Callahan
Clay
Comanche
Eastland
Erath
Hood
Jack
Mills
Montague
Palo Pinto
Parker
Shackelford
Somervell
Stephens
Throckmorton
Wise
Young

Blacklands (4)
Bell
Bosque
Collin
Cooke
Coryell
Dallas
Delta
Denton
Ellis
Falls
Fannin
Grayson
Hamilton
Hill
Hunt
Johnson
Kaufman
Lamar
Limestone
McLennan
Milam
Navarro
Rockwall
Tarrant
Williamson

East Texas - North (5-N)
Anderson
Bowie
Camp
Cass
Cherokee
Franklin
Gregg
Harrison
Henderson
Hopkins
Houston
Marion
Morris
Nacogdoches
Panola
Rains
Red River

Rusk
Shelby
Smith
Titus
Upshur
Van Zandt
Wood

East Texas - South (5-S)
Angelina
Brazos
Freestone
Grimes
Hardin
Jasper
Leon
Madison
Montgomery
Newton
Polk
Robertson
Sabine
San Augustine
San Jacinto
Trinity
Tyler
Walker
Waller

Trans-Pecos (6)
Brewster
Crane
Culberson
Ector
El Paso
Hudspeth
Jeff Davis
Loving
Pecos
Presidio
Reeves
Terrell
Ward
Winkler

Edwards Plateau (7)
Bandera
Blanco
Burnet
Coke
Concho
Crockett
Edwards
Gillespie
Irion
Kendall
Kerr
Kimble
Kinney
Lampasas
Llano
Mason
McCulloch
Menard
Reagan
Real
San Saba
Schleicher
Sterling
Sutton
Tom Green
Upton
Uvalde
Val Verde

South Central (8-N)
Austin
Bastrop
Bee
Bexar
Burleson
Caldwell
Colorado
Comal
DeWitt
Fayette
Goliad
Gonzales
Guadalupe
Hays
Karnes
Lavaca
Lee
Medina
Travis
Washington
Wilson

Coastal Bend (8-S)
Aransas
Kleberg
Nueces
Refugio
San Patricio

Upper Coast (9)
Brazoria
Calhoun
Chambers
Fort Bend
Galveston
Harris
Jackson
Jefferson
Liberty
Matagorda
Orange
Victoria
Wharton

South Texas (10-N)
Atascosa
Brooks
Dimmit
Duval
Frio
Jim Hogg
Jim Wells
Kenedy
La Salle
Live Oak
Maverick
McMullen
Webb
Zapata
Zavila

Lower Valley (10-S)
Starr
Hidalgo
Willacy
Cameron

APPENDIX B
TEXAS AGRICULTURAL AIRPORTS

TABLE B-1
Texas Agricultural Airports

Airport	Number of Pads	Size	Material	Public Use
Alice International Airport	1	8 x 10	Plastic	No
Stonewall County Airport (Aspermont)				
Bruce Field (Ballinger)	2		Concrete	1 Public, 1 Private
Bay City Municipal Airport	1	200 x 200	Asphalt/Limestone	No
Beeville Municipal Airport				
Benger Air Park (Friona)				
Cameron Municipal Airpark				
Castroville Municipal Airport				
Chambers County Airport (Winnie/Stowell)	1		Asphalt	Yes
Colorado City Municipal Airport	1	20 x 40		No
Dimmitt Municipal Airport	3		Concrete	
Eagle Lake Airport				
Eldorado Airport	1	75 x 50	Asphalt/Caliche	No
Elmdale Airpark (Abilene)	1	20 x 65	Plastic/Caliche	No
Fabens Airport				
Fisher County Airport (Rotan/Roby)	2		Concrete	No
Foard county Airport (Crowell)				
Hamlin Municipal Airport	1		Concrete	No
Haskell Municipal Airport	1		Concrete	No
Hondo Municipal Airport				
Kent County Airport (Jayton)	4			
Kleberg County Airport (Kingsville)				

Airport	Number of Pads	Size	Material	Public Use
Knox City Municipal Airport	1	40 x 50	Concrete	No
La Porte Municipal Airport				
Lamesa Municipal Airport	2	75 x 75	Concrete	No
Littlefield Municipal Airport	5			
Munday Municipal Airport	2		Concrete	No
Oldham County Airport (Vega)	1		Concrete	No
Olney Municipal Airport	1		Asphalt	No
Palacios Municipal Airport				
Nueces County Airport (Robstown)				
Rosenberg Airport				
Seymour Municipal Airport	1		Asphalt	No
San Patricio County Airport (Sinton)				
Winston Field Municipal Airport (Snyder)			Asphalt	Yes
Spearman Municipal Airport				
Arledge Field (Stamford)	3	60 x 30 50 x 90 80 x 65	All Concrete	2 Private, 1 Public
Stratford Field	N/A			
Sunray Airport	N/A			
Avenger Field (Sweetwater)	1	50 x 50	Concrete	No
T-Bar Airport (Tahoka)	1	40 x 60	Concrete	Yes
Uvalde Municipal Airport	1	60 x 40	Concrete	No
Victoria Regional Airport			Concrete Ramp	Yes

Note: Some of the information missing above was not provided by the airport upon inquiry

APPENDIX C
EXAMPLE AERIAL APPLICATOR'S APRON LOAN PROGRAM

AERIAL APPLICATOR'S APRON LOAN PROGRAM

Nebraska Department of Aeronautics

I. Program Intent. The Nebraska Department of Aeronautics (NDA) and the Nebraska Aeronautics Commission have developed this program to help municipalities construct aerial applicator's apron. Assistance is available through a revolving fund established by the Commission in 1994, which provides no-interest loans. This program is intended to aid and foster aviation interests and activities within the state.

II. Eligibility.

A. Who is eligible? Any municipality that operates a public-use airport or persons owning privately owned public-use airports. A municipality can be an airport authority, city, county or village. A privately owned public-use airports must have at least one paved runway, retail sale of aviation fuel and facilities for sheltering, servicing or repair of aircraft.

B. What items are eligible?

1. Aerial applicator's apron and the taxiway to serve the apron.

2. Pipes, water supply and other necessary appurtenances.

3. Engineering and surveying costs.

C. Other conditions that must be met.

1. The location must be shown on the approved Airport Layout Plan.

2. The construction must comply with the Nebraska Department of Environmental Quality (DEQ) regulations, NDA's minimum standards and all applicable laws, regulations and building codes.

3. The airport must meet the department's minimum standards for primary surface, approach surface (20:1), and transitional or lateral surface (7:1); or must have an FAA determination of no hazard.

III. Funding and Payments.

A. NDA will loan 70% of the eligible costs up to the amount approved by the Commission.

B. The maximum per airport is $10,000 for the total of all loans outstanding under this program.

C. Repayment Period. The repayment period will be five years.

D. Monthly payments will be billed to the sponsor. The payment amount will be the amount of the agreement divided by 60 months. No interest or carrying charges will be charged.

IV. Application. The airport sponsor must apply in writing; a letter from the chairman or secretary is sufficient. The letter must include:

A. Written description, including dimensions.

B. Sketch showing the location and details of the proposed construction.

C. Estimated cost.

D. Reason for the project.

E. Funding assurance. A statement from the sponsor or their lender showing the amount of local money available for the project.

The engineering division can help the sponsor develop the project scope and estimate the cost.

V. How the Program Works.

A. Commission Approval. The airport sponsor or the state airport engineer may present the application to the Aeronautics Commission. The Commission can take one of the following actions.

1. Approve the project and reserve funds for it. The project then moves on to section B described below.

2. Approve the project and place it on the list for future funding. The list will be used when there is not enough money in the revolving fund to allocate funds for the project. When funds become available, NDA will notify the sponsor that it is next on the list. The sponsor can then prepare for bids.

3. Disapprove the project.

Funds reserved for a municipality will be withdrawn, without prejudice, if the municipality has not signed a construction contract within six months of the Commission's approval or of notification that funds are available.

B. Soliciting Bids. The airport sponsor may use either the formal bid process or solicit informal proposals. NDA must concur in the contract award.

1. Informal proposals. The sponsor must use the generic plans approved by DEQ to simultaneously obtain two or more written proposals or quotes and submit these to NDA with an indication of the sponsor's preference. The proposals should include a detailed list of materials and services.

2. Formal Bids. The sponsor must hire an engineer to prepare the plans and specifications. NDA must accept the plans and specifications before bids are advertised. NDA recommends that the project be advertised three times. The sponsor opens the bids, then sends the bid tabulation and indication of contract award to NDA.

C. Aerial Applicator's Apron Program Agreement. After NDA concurs with the award and the sponsor sends in a signed construction contract, NDA will prepare an agreement providing for the transfer of funds to the sponsor. The agreement will include the exact amount of money that will be advanced and the repayment schedule.

D. Construction and Funding. The sponsor pays the contractor as construction progresses and sends a copy of the billings to NDA. NDA will reimburse the sponsor for 70% of incurred costs. The NDA will retain 10% from each reimbursement until the sponsor has completed the "Project Close Out" list described below.

E. Project Close Out. The following steps are required.

1. The construction is completed and the final bills have been submitted.

2. The sponsor accepts the construction and advises NDA in writing.

3. The sponsor submits a management program as required in the DEQ regulations.

When all items are done, NDA will forward the final 10% due.

F. Repayment. The agreement will include the repayment schedule. NDA will begin billing the sponsor when the project is closed or when the facility is used for aviation purposes, whichever is first.

G. Termination. If the project is not closed or used for aviation purposes within two years of executing a construction contract, the agreement will terminate upon written notice from NDA to the sponsor. All funds advanced to the sponsor under the agreement must be promptly refunded to NDA.

APPENDIX D
EXAMPLE AERIAL APPLICATOR APRON SPECIFICATIONS

AERIAL APPLICATOR APRON SPECIFICATIONS
Nebraska Department of Aeronautics

TRENCHING FOR PIPING

Trenching may be done using any standard construction method such as backhoe or trencher. A 2" sand base shall be used for pipe bedding. The pipe shall be laid on the sand bedding and sand will be used to surround the pipe and fill to the top of the pipe. Earth fill may be used above the pipe to the top of the trench. The fill should be carefully compacted or water soaked to compact.

SOIL PREPARATION

the topsoil including all vegetation should be removed. The surrounding area should be graded to drain away from the apron, preferably at a 5:1 slope. A disc shall be used on the subgrade to a depth of six inches and recompacted by use of standard construction compaction equipment or wheel packed by rubber tire implement. Adequate moisture should be added to the subgrade material to allow proper compaction. A 4" base should be placed and compacted on top of the compacted subgrade.

CONCRETE COMPOSITION

Concrete shall consist of aggregate, Type I Portland Cement, water, and air-entraining admixture. Class of concrete shall be "47B" and shall comply with Section 1002 Nebraska Department of Roads Standard Specifications. The proportions of cement and aggregate shall be as shown below.

lbs. of cement. per C.Y.	air content	lbs. of aggreg. per 100 lbs. of cement (total)	ratio of limestone aggregate to total aggreg.	max. water-cement ratio (lbs. of water) / 100 lbs. of cement
564	5.0-7.5%	510-555	27-33%	0.53

CONCRETE PLACEMENT

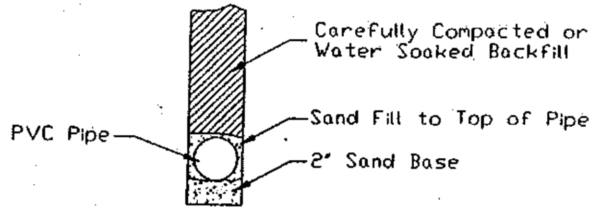
the concrete shall be placed in forms and an electric or pneumatic vibrator used to consolidate the mixture. The surface shall be smoothed to match the forms by use of a screed or other standard construction method. The surface finish shall be obtained by use of a metal trowel or float, and broom or burlap finish applied. A concrete curing compound will be applied and the material will be allowed to cure for 7 days, with no traffic.

REINFORCING STEEL

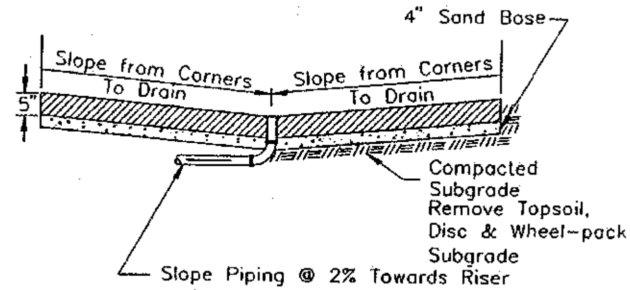
Reinforcing steel will be #4 bars, in 4 foot lengths at the designed joints. The bars may be pre set using metal chairs set at a depth of 2" or may be inserted into the concrete at a uniform depth of 2", prior to the screeding process.

CONTROL JOINTS

After the concrete has gained sufficient strength to support a worker, control joints shall be cut in the slab at a depth of 1/4 the thickness of the concrete slab. The cuts shall be made in straight lines conforming to the planned joint pattern. The surface of the joints shall be tool finished and filled with sealant. Sealant shall be "Sonometric 1 Sealant" or equal. Any joints resulting from the construction process shall also be billed with sealant.



PIPE DITCH SECTION
No Scale



APRON SECTION
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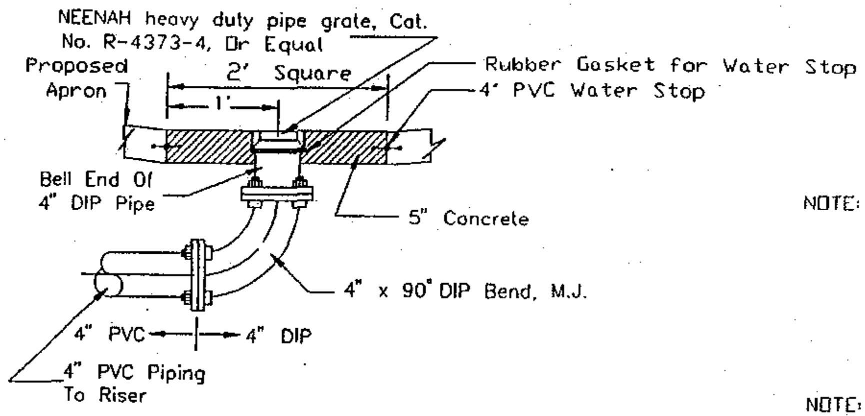
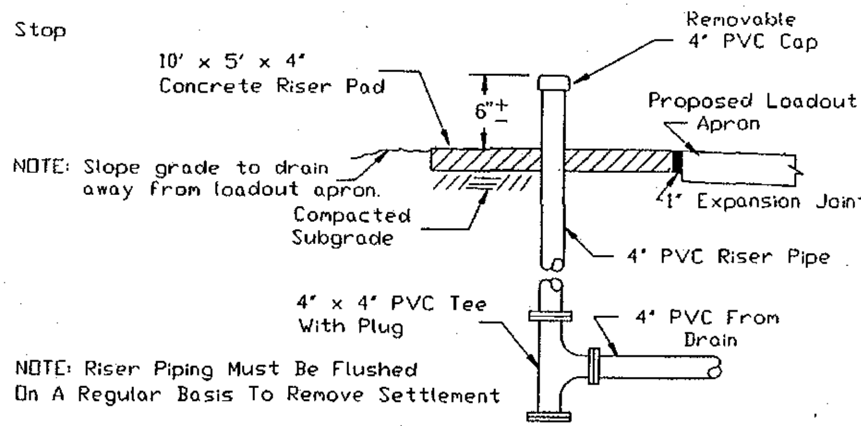


NOTE: Drain piping must be pumped and drain must be plugged as part of off season maintenance. Use Chicago Speciality Plug #3412 or Equal

DRAIN SECTION
No Scale



NOTE: Riser Piping Must Be Flushed On A Regular Basis To Remove Settlement

RISER DETAIL
No Scale

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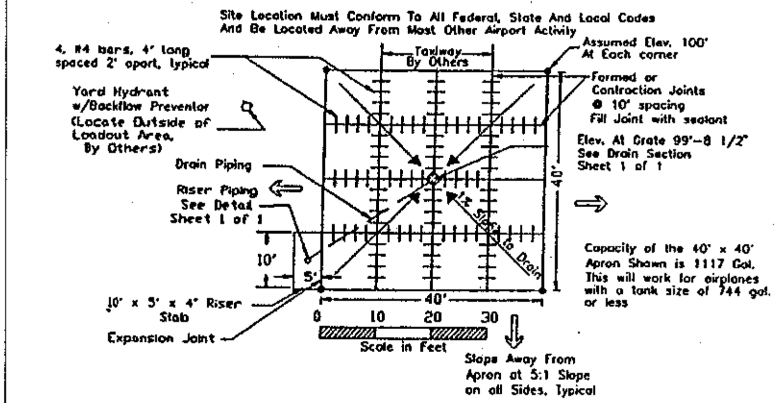
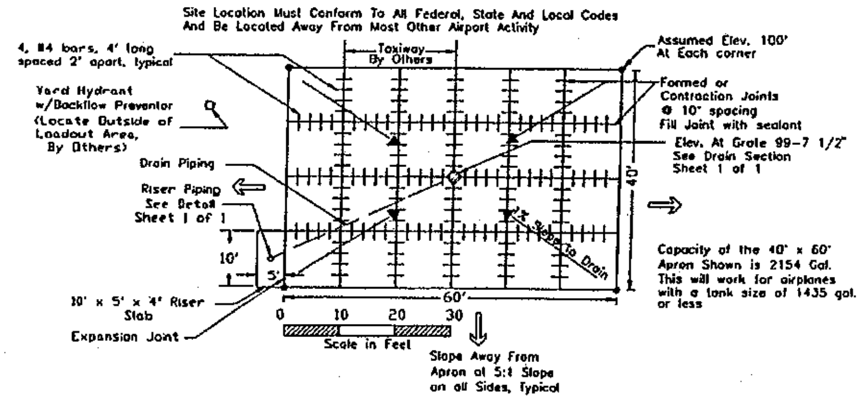
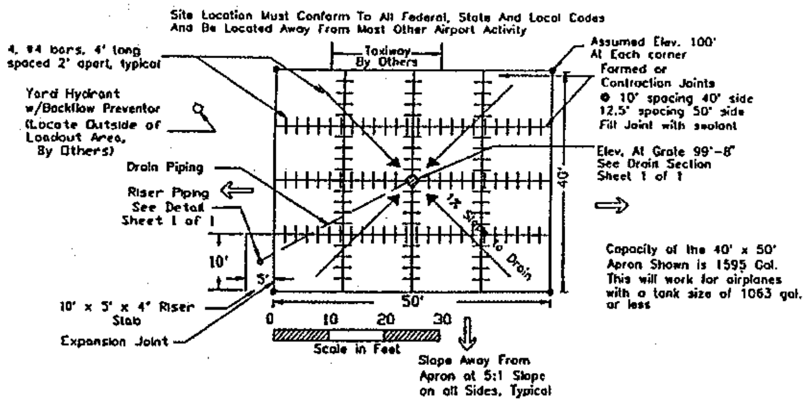
New Aerial Applicators Apron	Sheet 1 of 3



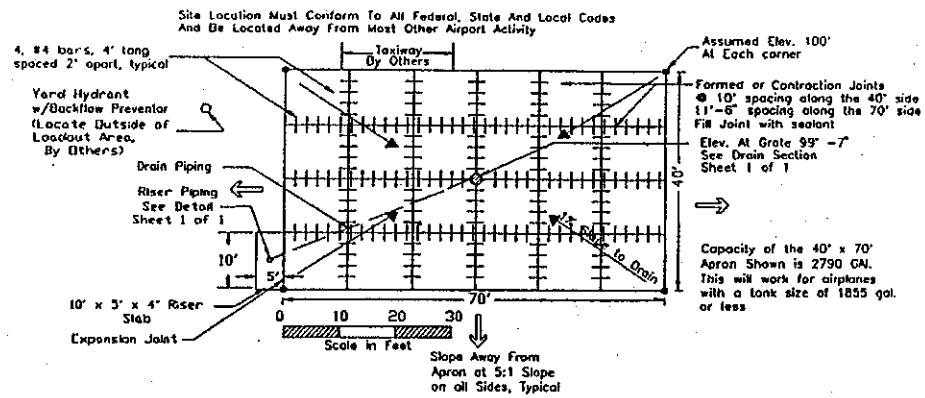
40' x 40'
APRON PLAN



40' x 60'
APRON PLAN



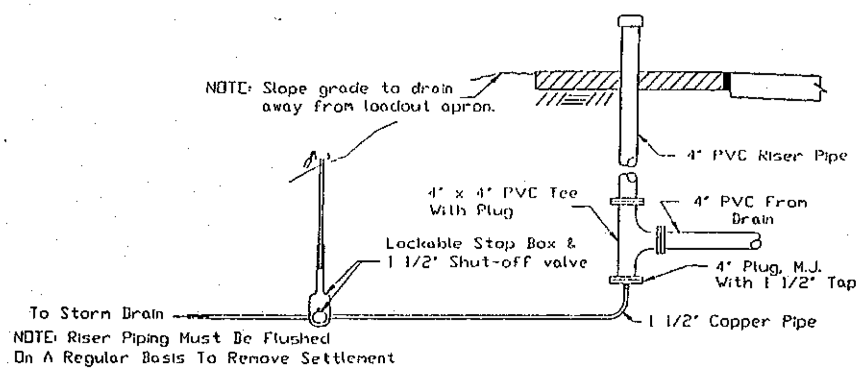
40' x 50'
APRON PLAN



40' x 70'
APRON PLAN

Nebraska Department of Aeronautics P.O. Box 82088 Lincoln, NE 68501-2088	DWG. NO. 1399 8 FEB 94 DRAWN BY: RVR
New Aerial Applicators Apron	Sheet 2 of 3

Winter Bypass Operational Instructions:
The surface of the loadout facility and drain line will be cleaned before the winter bypass drain is opened at the start of the off-season. Loadout facilities will not be conducted when the storm drain is open. Prior to the start of the season the winter bypass drain valve will be closed and locked in the closed position.



RISER DETAIL WITH OPTIONAL WINTER BYPASS
No Scale

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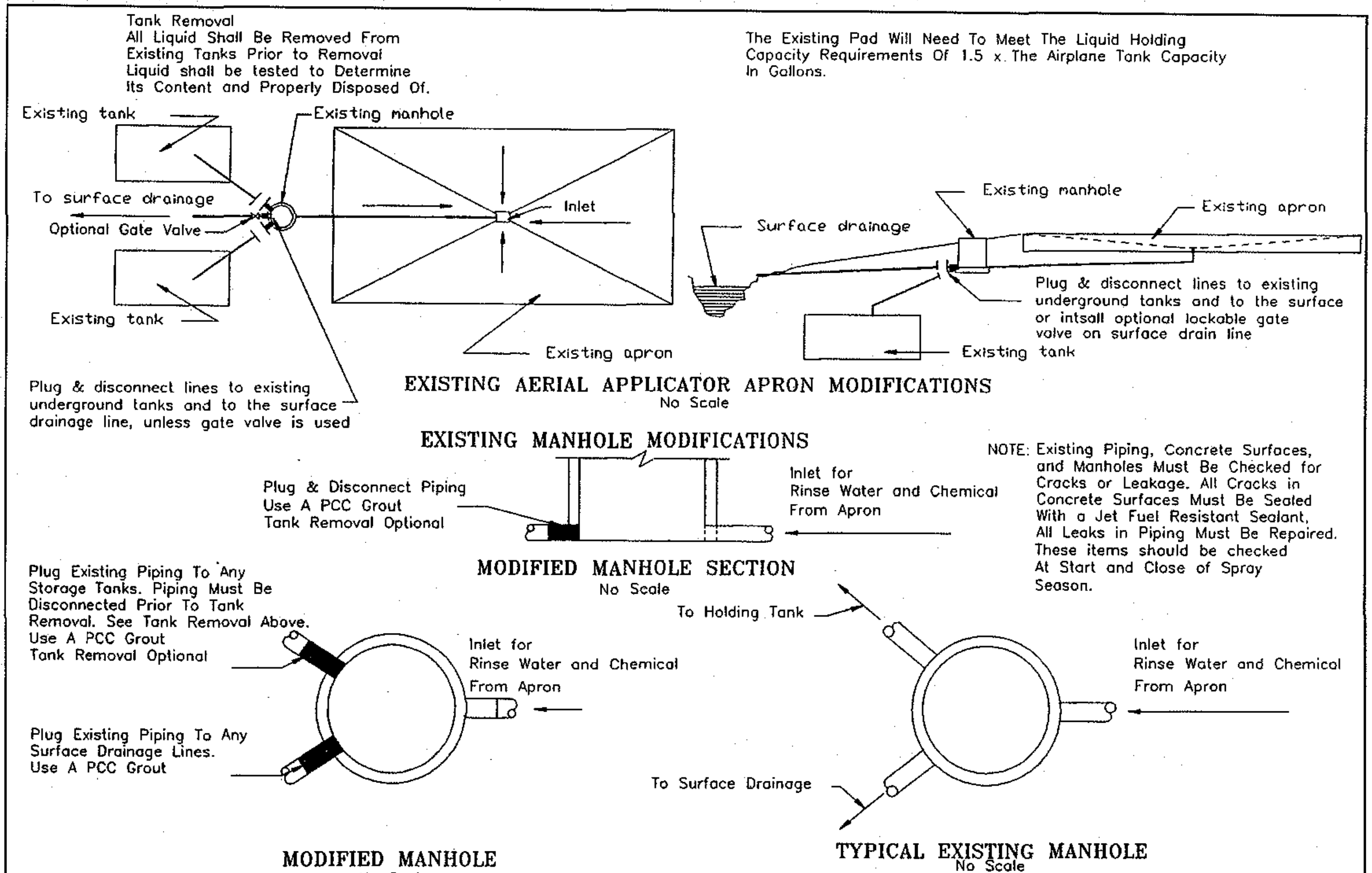
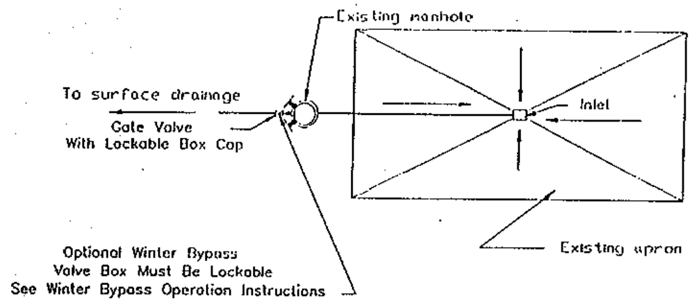
New Aerial Applicators Apron	Sheet 3 of 3

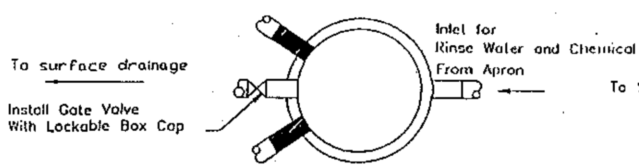


Nebraska Department of Aeronautics P.O. Box 82088 Lincoln, NE 68501-2088	DWG. NO. 1398 8 FEB 94 DRAWN BY: RVR
New Aerial Applicators Apron	Sheet 1 of 2

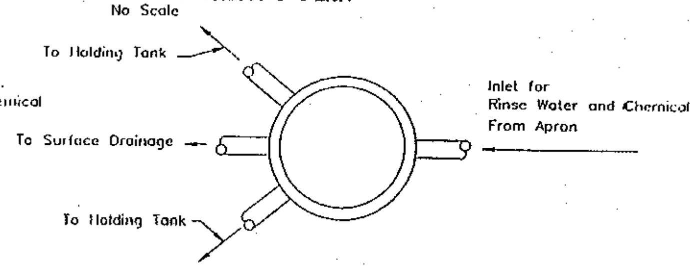
Winter Bypass Operational Instructions:
The surface of the loadout facility and drain line will be cleaned before the winter bypass drain is opened at the start of the off-season. Loadout facilities will not be conducted when the storm drain is open. Prior to the start of the season the winter bypass drain valve will be closed and locked in the closed position.



WINTER BYPASS MODIFICATIONS PLAN
No Scale



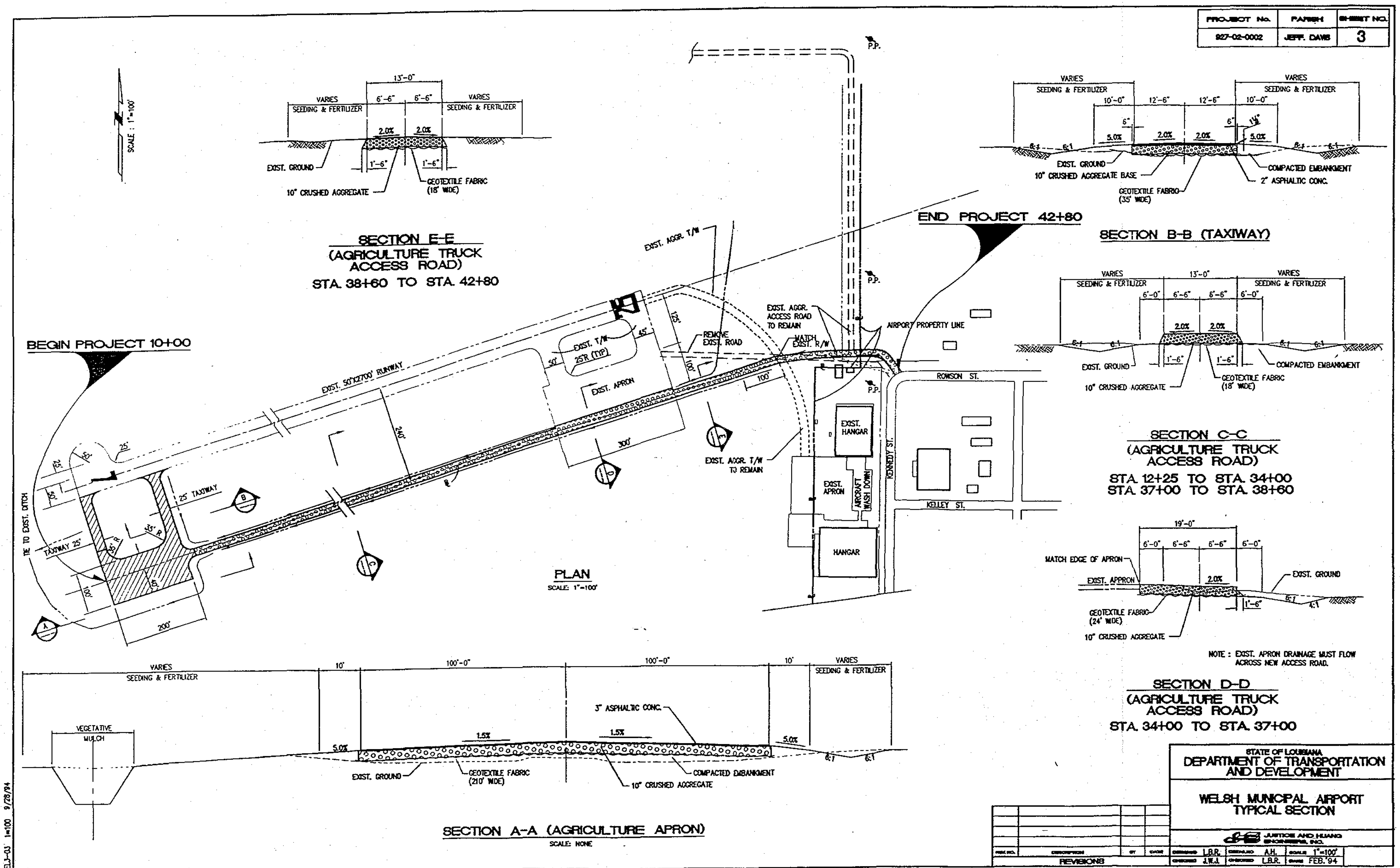
MODIFIED MANHOLE
No Scale



TYPICAL EXISTING MANHOLE
No Scale

Nebraska Department of Aeronautics P.O. Box 82088 Lincoln, NE 68501-2088	DWG. NO. 1398 8 FEB 94 DRAWN BY: RVR
New Aerial Applicators Apron	Sheet 2 of 2

Appendix E
Example Agricultural Airport
Engineering Drawings



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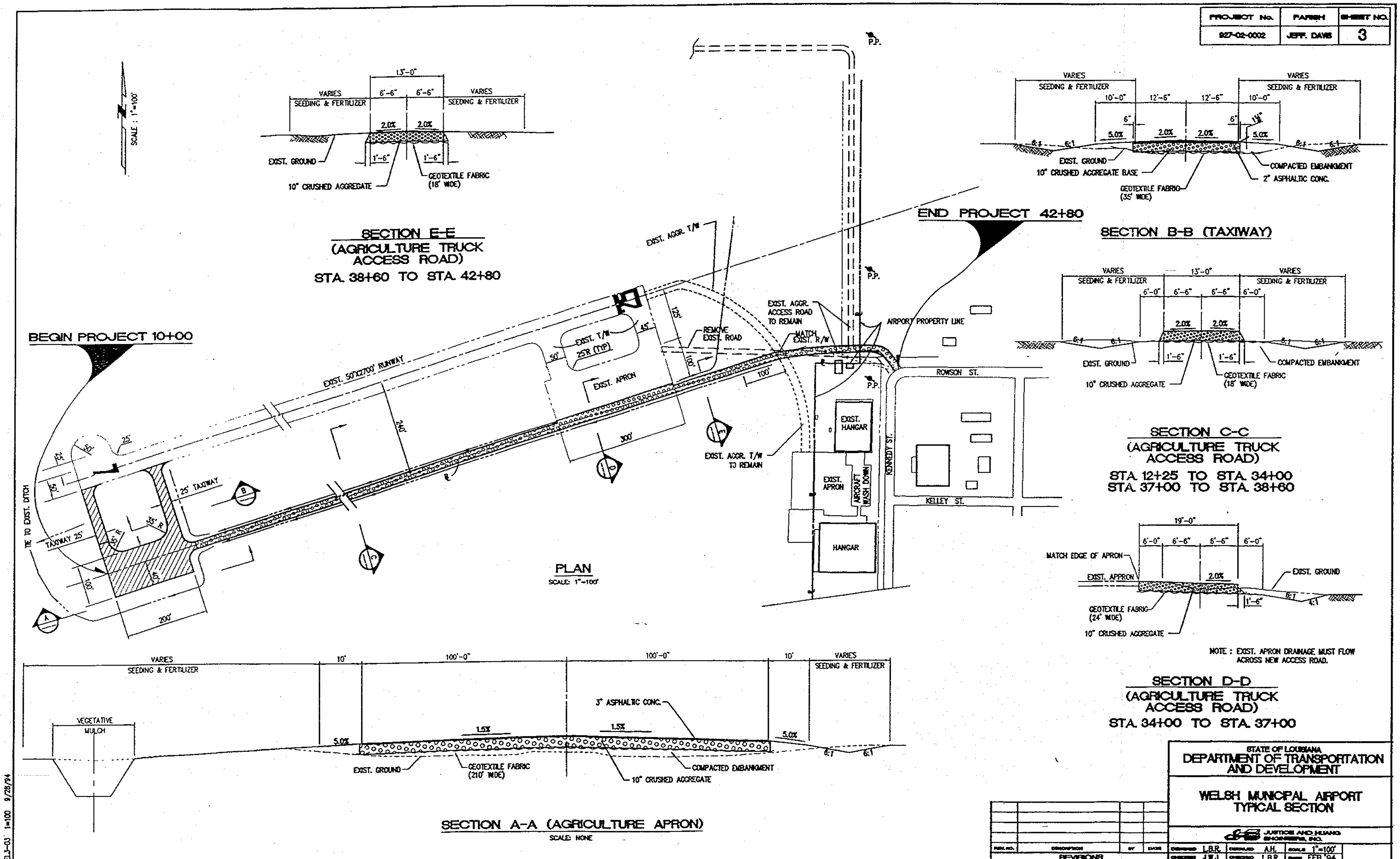
927-02-0002 | JEFF. DAVIS | 3
SCALE: 1"=100'
SECTION E-E
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 38+60 TO STA. 42+80
13'-0"
6'-6" 6'-6"
VARIES SEEDING & FERTILIZER
2.0% 2.0%
1'-6" 1'-6"
EXIST. GROUND
10" CRUSHED AGGREGATE
GEOTEXTILE FABRIC (18' WIDE)
SECTION B-B (TAXIWAY)
VARIES SEEDING & FERTILIZER
10'-0" 12'-6" 12'-6" 10'-0"
5.0% 2.0% 2.0% 5.0%
6:1 6:1
EXIST. GROUND
10" CRUSHED AGGREGATE BASE
GEOTEXTILE FABRIC (35' WIDE)
COMPACTED EMBANKMENT
2" ASPHALTIC CONC.
END PROJECT 42+80
BEGIN PROJECT 10+00
EXIST. AGGR. T/W
EXIST. 50'X2700' RUNWAY
EXIST. T/W 25'R (TYP)
EXIST. APRON
REMOVE EXIST. ROAD
MATCH EXIST. R/W
EXIST. AGGR. ACCESS ROAD TO REMAIN
AIRPORT PROPERTY LINE
EXIST. AGGR. T/W TO REMAIN
25' TAXIWAY
TAXIWAY 25'
TIE TO EXIST. DITCH
35' R
200'
100'
300'
240'
125'
P.P.
ROWSON ST.
KENNEDY ST.
KELLEY ST.
EXIST. HANGAR
EXIST. APRON
AIRCRAFT WASH DOWN
HANGAR
PLAN
SCALE: 1"=100'
SECTION C-C
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 12+25 TO STA. 34+00
STA. 37+00 TO STA. 38+60
VARIES SEEDING & FERTILIZER
13'-0"
6'-0" 6'-6" 6'-6" 6'-0"
2.0% 2.0%
1'-6" 1'-6"
EXIST. GROUND
10" CRUSHED AGGREGATE
GEOTEXTILE FABRIC (18' WIDE)
COMPACTED EMBANKMENT
SECTION D-D
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 34+00 TO STA. 37+00
19'-0"
6'-0" 6'-6" 6'-6" 6'-0"
MATCH EDGE OF APRON
EXIST. APPRON
2.0%
EXIST. GROUND
GEOTEXTILE FABRIC (24' WIDE)
10" CRUSHED AGGREGATE
6:1 4:1
NOTE: EXIST. APRON DRAINAGE MUST FLOW ACROSS NEW ACCESS ROAD.
SECTION A-A (AGRICULTURE APRON)
SCALE: NONE
VARIES SEEDING & FERTILIZER
10' 100'-0" 100'-0" 10'
VEGETATIVE MULCH
3" ASPHALTIC CONC.
5.0% 1.5% 1.5% 5.0%
EXIST. GROUND
GEOTEXTILE FABRIC (210' WIDE)
10" CRUSHED AGGREGATE
COMPACTED EMBANKMENT
STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
WELSH MUNICIPAL AIRPORT
TYPICAL SECTION
JUSTICE AND HUANG ENGINEERS, INC.
REVISIONS
L.B.R. A.H. 1"=100'
J.W.J. L.B.R. FEB. '94
WELJ-03 1=100 9/28/94



PROJECT No. | PARISH | SHEET NO.
927-02-0002 | JEFF. DAVIS | 3
SCALE: 1"=100'
SECTION E-E
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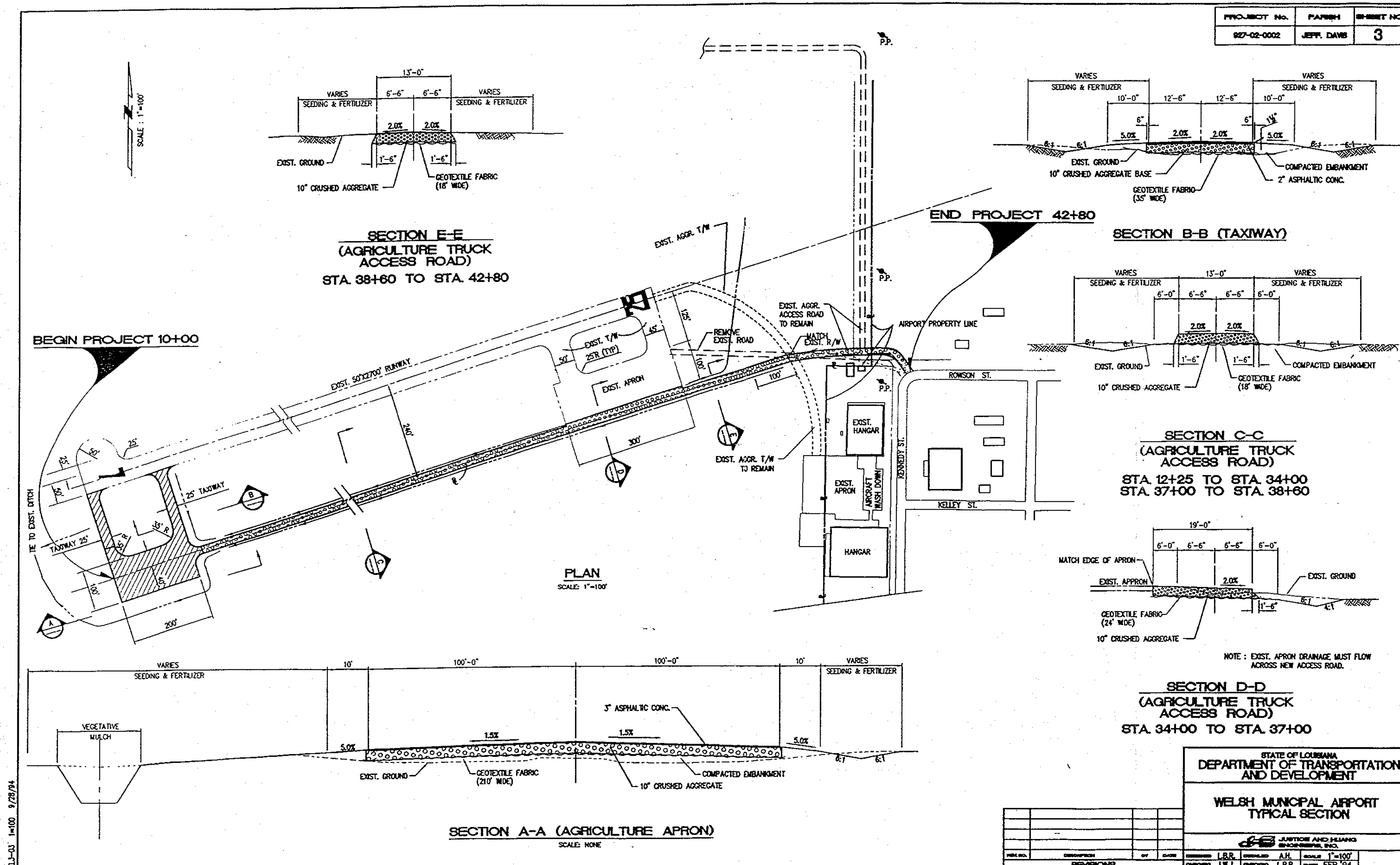
STA. 38+60 TO STA. 42+80
13'-0"
6'-6"
VARIES
SEEDING & FERTILIZER
2.0%
1'-6"
EXIST. GROUND
10" CRUSHED AGGREGATE
GEOTEXTILE FABRIC (18' WIDE)
END PROJECT 42+80
SECTION B-B (TAXIWAY)
10'-0"
12'-6"
5.0%
6:1
EXIST. GROUND
10" CRUSHED AGGREGATE BASE
GEOTEXTILE FABRIC (35' WIDE)
COMPACTED EMBANKMENT
2" ASPHALTIC CONC.
BEGIN PROJECT 10+00
EXIST. 50'X2700' RUNWAY
EXIST. AGGR. T/W
EXIST. T/W
25'R (TYP)
EXIST. APRON
REMOVE EXIST. ROAD
EXIST. AGGR. ACCESS ROAD TO REMAIN
MATCH EXIST. R/W
AIRPORT PROPERTY LINE
P.P.
ROWSON ST.
KENNEDY ST.
KELLEY ST.
EXIST. HANGAR
EXIST. APRON
AIRCRAFT WASH DOWN
HANGAR
EXIST. AGGR. T/W TO REMAIN
25' TAXIWAY
TAXIWAY 25'
TIE TO EXIST. DITCH
35'R
240'
300'
200'
100'
125'
PLAN
SCALE: 1"=100'
SECTION C-C
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 12+25 TO STA. 34+00
STA. 37+00 TO STA. 38+60
6'-0"
COMPACTED EMBANKMENT
19'-0"
MATCH EDGE OF APRON
EXIST. APPRON
EXIST. GROUND
4:1
GEOTEXTILE FABRIC (24' WIDE)
10" CRUSHED AGGREGATE
NOTE : EXIST. APRON DRAINAGE MUST FLOW ACROSS NEW ACCESS ROAD.
SECTION D-D
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 34+00 TO STA. 37+00
10'
100'-0"
VEGETATIVE MULCH
3" ASPHALTIC CONC.
1.5%
GEOTEXTILE FABRIC (210' WIDE)
COMPACTED EMBANKMENT
10" CRUSHED AGGREGATE
SECTION A-A (AGRICULTURE APRON)
SCALE: NONE
STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
WELSH MUNICIPAL AIRPORT
TYPICAL SECTION
JUSTICE AND HUANG ENGINEERS, INC.
L.B.R.
A.H.
1"=100'
J.W.J.
L.B.R.
FEB. '94
REVISIONS
WELJ-03 1=100 9/28/94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SHEET NO. 3
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END PROJECT 42+80
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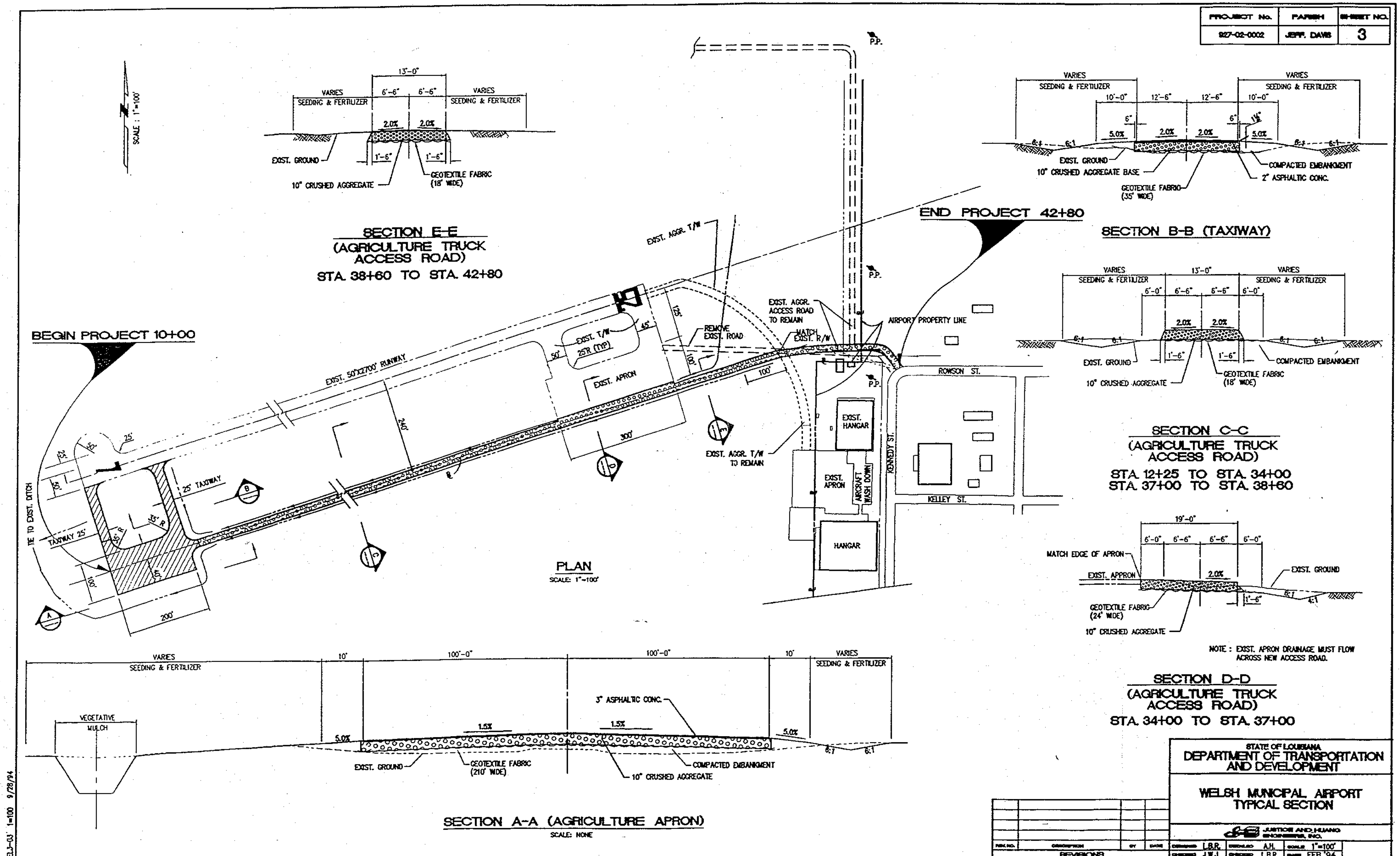
SECTION B-B (TAXIWAY)
SECTION C-C (AGRICULTURE TRUCK ACCESS ROAD) STA. 12+25 TO STA. 34+00 STA. 37+00 TO STA. 38+60
SECTION D-D (AGRICULTURE TRUCK ACCESS ROAD) STA. 34+00 TO STA. 37+00
NOTE : EXIST. APRON DRAINAGE MUST FLOW ACROSS NEW ACCESS ROAD.
SECTION A-A (AGRICULTURE APRON)
SCALE: NONE
PLAN
SCALE: 1"=100'
SCALE : 1"=100'
VARIES
SEEDING & FERTILIZER
EXIST. GROUND
10" CRUSHED AGGREGATE
10" CRUSHED AGGREGATE BASE
GEOTEXTILE FABRIC (18' WIDE)
GEOTEXTILE FABRIC (35' WIDE)
GEOTEXTILE FABRIC (24' WIDE)
GEOTEXTILE FABRIC (210' WIDE)
COMPACTED EMBANKMENT
2" ASPHALTIC CONC.
3" ASPHALTIC CONC.
MATCH EDGE OF APRON
EXIST. APPRON
VEGETATIVE MULCH
EXIST. 50'X2700' RUNWAY
EXIST. APRON
EXIST. T/W 25'R (TYP)
25' TAXIWAY
TAXIWAY 25'
TIE TO EXIST. DITCH
EXIST. AGGR. T/W
EXIST. AGGR. T/W TO REMAIN
EXIST. AGGR. ACCESS ROAD TO REMAIN
REMOVE EXIST. ROAD
MATCH EXIST. R/W
AIRPORT PROPERTY LINE
P.P.
ROWSON ST.
KENNEDY ST.
KELLEY ST.
EXIST. HANGAR
EXIST. APRON
AIRCRAFT WASH DOWN
HANGAR
REVISIONS
STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
WELSH MUNICIPAL AIRPORT
TYPICAL SECTION
JUSTICE AND HUANG ENGINEERS, INC.
L.B.R.
A.H.
1"=100'
J.W.J.
L.B.R.
FEB.'94
WELJ-03 1=100 9/28/94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PARISH JEFF. DAVIS
SHEET NO. 3
SCALE: 1"=100'
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END PROJECT 42+80
EXIST. 50'X2700' RUNWAY
EXIST. T/W
25'R (TYP)
EXIST. APRON
EXIST. AGGR. T/W
REMOVE EXIST. ROAD
MATCH EXIST. R/W
EXIST. AGGR. ACCESS ROAD TO REMAIN
AIRPORT PROPERTY LINE
EXIST. AGGR. T/W TO REMAIN
EXIST. HANGAR
EXIST. APRON
AIRCRAFT WASH DOWN
HANGAR
ROWSON ST.
KENNEDY ST.
KELLEY ST.
P.P.
25' TAXIWAY
TAXIWAY 25'
TIE TO EXIST. DITCH
PLAN
SCALE: 1"=100'
SECTION E-E
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 38+60 TO STA. 42+80
13'-0"
6'-6" 6'-6"
VARIES SEEDING & FERTILIZER
2.0% 2.0%
1'-6" 1'-6"
EXIST. GROUND
10" CRUSHED AGGREGATE
GEOTEXTILE FABRIC (18' WIDE)
SECTION B-B (TAXIWAY)
10'-0" 12'-6" 12'-6" 10'-0"
6" 5.0% 2.0% 2.0% 5.0%
6:1
EXIST. GROUND
10" CRUSHED AGGREGATE BASE
GEOTEXTILE FABRIC (35' WIDE)
COMPACTED EMBANKMENT
2" ASPHALTIC CONC.
SECTION C-C
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 12+25 TO STA. 34+00
STA. 37+00 TO STA. 38+60
6'-0" 6'-6" 6'-6" 6'-0"
COMPACTED EMBANKMENT
SECTION D-D
(AGRICULTURE TRUCK ACCESS ROAD)
STA. 34+00 TO STA. 37+00
19'-0"
MATCH EDGE OF APRON
EXIST. APPRON
EXIST. GROUND
GEOTEXTILE FABRIC (24' WIDE)
10" CRUSHED AGGREGATE
4:1
NOTE: EXIST. APRON DRAINAGE MUST FLOW ACROSS NEW ACCESS ROAD.
SECTION A-A (AGRICULTURE APRON)
SCALE: NONE
VARIES SEEDING & FERTILIZER
10' 100'-0" 100'-0" 10'
VEGETATIVE MULCH
3" ASPHALTIC CONC.
5.0% 1.5% 1.5% 5.0%
EXIST. GROUND
GEOTEXTILE FABRIC (210' WIDE)
10" CRUSHED AGGREGATE
COMPACTED EMBANKMENT
STATE OF LOUISIANA
DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
WELSH MUNICIPAL AIRPORT
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J.W.J. L.B.R. FEB. '94
WEL3-03 1=100 9/28/94