Panhandle Water Planning Project
Senate Bill 2 - Task 2 Project Memorandum

Region A Task 2 Report: Agricultural Water Demand Projections

Prepared for

Freese and Nichols, Inc.
Fort Worth, Texas

Prepared by

Thomas Marek, Steve Amosson,
Leon New, Fran Bretz, and Lal Almas

Texas A&M University
Agricultural Research and Extension Center
Amarillo, Texas

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**Texas A&M – Amarillo - Region A Senate Bill 2 Task 2 Report:
Agricultural Water Demand Projections**

Executive Summary

In Senate Bill 1, it was estimated that the agricultural sector used 92.0% of all water use in Region A. Irrigated crop use accounted for 89.0% of the total, while livestock production used 3.0%. The magnitude of the water use in agriculture makes the accurate water use assessment of this sector critical for future water planning in the region. Therefore, the overall objective of Task 2 of the regional water management and planning project under Senate Bill 2 is to update/refine water use estimates. Specific objectives of Task 2 include: 1) Evaluating the data sources of irrigated crop acreage; 2) Examining the validity of single-year verses multi-year irrigated acreage estimates in determining water use; 3) Reviewing and/or revising irrigated crop water use estimates; and 4) Reviewing and/or revising livestock water use estimates for Region A.

Sources of Irrigated Acreage

Differences in the amount of irrigated acreage can significantly influence water use estimates. The irrigated acres from three different sources are analyzed to assess the variation in water use estimates. The three sources of irrigated acreage analyzed include the Natural Resource and Conservation Service (NRCS), a combination of Texas Agricultural Statistics Service (TASS) and Census of Agriculture data, and Farm Service Agency (FSA) data. Water use by crop and county was projected using each source of irrigated acreage. The North Plains Evapotranspiration network (NPET) irrigation demand model developed by Texas A&M - Amarillo (TAMA) was utilized for making the water use projections. The amount of irrigated acreage and crop composition both effect water use. FSA despite reporting 5.9% more irrigated acreage was projected to use 2.0% less water than NRCS survey. The TASS and Census approach reported 6.5% fewer acres, but water use projections were only 1.3% below NRCS survey data.

Water use estimates from the three sources of irrigated acreage, NRCS survey, TASS/Census, and FSA were within two percent of each other for the region. Even though the differences are relatively small, projecting over a 60-year time horizon magnifies the error and can mislead policy makers on future available water in the region. Variability increases when examining the amount of irrigated acreage and the crop composition reported by each source. This variability could have a significant impact when evaluating different water saving strategies that involve reducing irrigated acreage or modifying crop composition. Finally, distortion of water use projections was the greatest at the county level where most policy analyses need to be conducted.

Single Year versus Multi-year Acreage Base

The second objective included examining the validity of using single-year versus multi-year irrigated acreage estimates in determining agricultural water use. To examine the issue, TASS data for the major irrigated crops grown in Region A during a five-year period was utilized, 1997-2001. TASS data were one source of information that provided readily accessible annual data during this time period. Total irrigated acreage varied considerably during the five-year period. In 1999, irrigated acreage peaked at 1.28 million acres and hit a low at 1.08 million acres in 2001 representing a 15.6% decrease. The low acreage level reported in 2001 corresponds with extremely high natural gas prices entering into the summer crop season.

Distortions were magnified when examining acreage by crop. The major irrigated crops grown in the region, corn, wheat and sorghum had year-to-year variations in as much as 33.0%. The volatility in irrigated crop acreages suggests that the use of a single year crop acreage base

could cause dramatic distortions in projected water use estimates. These distortions whether caused by fluctuating natural gas, commodity prices or other factors can alter both acreage levels and crop composition. On the other hand, failing to account for these natural occurring events can cause additional distortions. One suggested solution to the acreage base problem could be use of an average of acreages over a number of years.

TAMA Revised Irrigation Demand Estimates

Under Task 2 of Senate Bill 2, the TAMA (Texas A&M – Amarillo) personnel are charged with updating Region A irrigated water use projections. Using the TAMA model, water demand for irrigated agriculture was estimated utilizing NRCS survey acreage numbers. This acreage basis is the same as those used currently by the TWDB, as reported on their current web site (TDWB, 2003). The total regional water demand estimates between the TWDB and the TAMA model appears to be minimal (less than 1.0%); however, the county-by-county distribution indicates that considerable differences exist. There are substantial demand differences in projected irrigation demand between the methodologies ranging from -33.4% to 23.8% in the major irrigation water use counties of Dallam, Ochiltree, Moore, and Sherman. Thus, while the total demand agrees, individual county values differ substantially. Using FSA acreages, analysis of the estimated water demand indicated that indeed five counties were again responsible for majority of water use in Region A. These counties are Dallam, Hansford, Hartley, Moore, and Sherman.

Refinements in the previously developed methodology for estimating irrigation water use demands for Region A in the Texas Panhandle have been accomplished. Subsequently, updated water demand estimates were computed using the TAMA model utilizing FSA acreages with average grower factors, soil moisture values, and quadrangle rainfall data. Available irrigation demand estimates are also presented considering deductions of increases in livestock water use. Differences between this preferred methodology and TWDB estimates range from -47.7% to 18.9%, but generally reflects a reduction from TWDB estimates. The improved methodology is viewed as being more consistent over time with increased representation of actual, regional field irrigation practices.

TAMA Revised Livestock Water Use Projections

The final objective of Task 2 is to review, update and refine, when warranted, projected growth assumptions in the livestock sector made in Senate Bill 1 for use in the Senate Bill 2 planning cycle. Resulting from this review, significant errors were discovered in TWDB inventory estimates of swine and horses. In addition, TWDB had inventory and county-level inventory distribution errors in fed beef. These errors were linked to data source problems.

No changes were recommended in the projected growth rates used in Senate Bill 1 for beef cows, horses and poultry. Growth rates for fed beef and stockers were modified slightly while major changes were recommended for swine and dairy. Overall, water use in the Region A livestock sector is predicted to increase 134.0% from 2000 to 2060. While this increase is significant, it still will only represent approximately 5.0% - 6.0% of the total water use in the region. The largest livestock water use group is projected to be the fed cattle industry with an annual usage of 34,487 ac-ft/year by 2060. The anticipated rapid expansion places the swine industry with a similar usage estimate by 2060 (32,451 ac-ft/year). In fact, water usage by the swine industry is expected to surpass the fed cattle for the 2020 to 2040 time period. These two user groups account for 75.0% of projected livestock water use in 2060. The forecasted expansion in the dairy industry increased projected annual water use from 320 ac-ft/year in 2000 to 6,729 ac-ft/year in 2060 making it the third largest livestock water group and accounting for 7.5% of total water use.

REGION A TASK 2 REPORT: AGRICULTURAL WATER DEMAND PROJECTIONS

Thomas Marek, Steve Amosson, Leon New, Fran Bretz, and Lal Almas[1]

In Senate Bill 1, it was estimated that 92.0% of all water use in Region A occurred in the agricultural sector. Irrigated crop use accounted for 89.0% of the total, while livestock production used 3.0%. The magnitude of the water use in agriculture makes accurate water use assessment of this sector critical to future water planning in the region.

The objective of this project task is to improve water use estimates for Region A agriculture. The specific objectives are:

1. Evaluate the data sources of irrigated crop acreage,
2. Examine the validity of single-year verses multi-year irrigated acreage estimates in determining crop water use,
3. Review/revise irrigated crop water use estimates for Region A, and
4. Review/revise livestock water use estimates for Region A.

1. Sources of Estimated Irrigated Acreage

Variation in the amounts of irrigated acreage can dramatically impact water use estimates. These types of errors are magnified when simulating water use over a 60-year planning horizon. The focus of this objective is to compare and discuss alternative sources of irrigated acreage estimates that are currently available. The pros and cons of these data sources are examined. The three sources of irrigated acreage analyzed are: the Natural Resource and Conservation Service (NRCS), a combination of Texas Agricultural Statistics Service (TASS) and Census of Agriculture data, and Farm Service Agency (FSA) data.

Irrigated acreage estimates are provided by NRCS through a survey conducted by their personnel. NRCS personnel are assumed to utilize a combination of TASS, Census and FSA data in compiling their acreage estimates. This approach has been, and currently is, the source of irrigated acreage estimates used by the Texas Water Development Board (TWDB) in making water use projections. However, NRCS has indicated the survey may not be continued in the future.

The combination of TASS and Census data provides another alternative for estimating county level irrigated acreage. TASS provides annual estimates by county for most major irrigated crops in the state. The Census of Agriculture provides a detailed breakdown of all irrigated crops by county every five years. However, there is up to a two-year delay before Census data is available. Both TASS and Census rely on producer surveys utilizing a sampling technique in estimating crop acreage.

The primary function of the FSA is to administer farm programs enacted by Congress. Producers are responsible for registering the amounts of irrigated acreage planted by program crops each year with FSA for program payment purposes. Recent disaster programs have not only compensated program crops, but also non-program crops. This has led to virtually every acre being certified by crop with FSA annually including grasses.

Prior to 2002, irrigated acreage delineated by crop was only kept at the county FSA level. While the data was available, a county-by-county survey of FSA offices was required to obtain it.

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[1]TAES Research Agricultural Engineer and Superintendent, TCE Professor-Economics, TCE Agricultural Engineer-Irrigation, TAES Research Associate and WTAMU Assistant Professor-Economics.

Starting in 2002, FSA compiles and maintains a centralized database of this information at the state headquarters.

1A. Methodology of Analysis

The year 2000 was selected to compare the three sources of irrigated acreage. It corresponds to the year of the last NRCS survey and is the year selected as the baseline for current Senate Bill 2 estimates. Similar 2000 data originating from FSA were collected through a survey of all county FSA offices in Region A. TASS estimates of irrigated crop acreage for 2000 were supplemented with 1997 Census of Agriculture data. Water use by crop and county was projected using each source of irrigated acreage. The irrigation demand model developed by Texas A&M – Amarillo (TAMA) was utilized for making the water use projections and uses crop evapotranspiration (ET) data from the North Plains Evapotranspiration network (NPET).

1B. Results and Discussion

Two basic questions need to be answered: Is there a significant difference between the sources of irrigated acreage relative to projected water use, and which sources of irrigated acreage are the most appropriate to be used in demand calculations?

The Region A major irrigated acreage obtained from TASS/Census, NRCS, and FSA for the year 2000 is presented in Table 1. FSA reported 5.5% or about 80,591 more total irrigated acres than did NRCS. Conversely the combination of TASS and Census data indicated a total irrigated amount of about 8.4% less acreage than NRCS reported and 195,193 acres less than FSA. Variation in irrigated acreage for specific crops at times was extreme. For example, acreages of irrigated wheat reported by FSA were 15.8% (87,727 acres) more than the 556,079 acres reported in the NRCS survey value. FSA estimates originating from the TASS and Census value of 153,879 and was 27.7% (153,900 acres) less than the survey values.

Table 1. Irrigated acreage for the major crops for Region A from TASS/Census, NRCS survey, and FSA for 2000.

Crop	TASS/Census	NRCS	FSA
Corn	648,505	595,858	571,629
Cotton	33,600	36,628	37,005
Peanuts	21,800	25,321	25,285
Sorghum	93,700	95,635	116,612
Soybeans	56,000	60,886	56,661
Wheat	402,200	556,079	643,806
Total Acreage	1,255,805	1,370,407	1,450,998

The amount of irrigated acreage and crop composition both effect water use. The projected water use by sources of the irrigated acreage data for Region A is illustrated in Figure 1. Ironically, FSA despite reporting 5.9% more acreage was projected to use 2.0% less water than NRCS survey. The TASS and Census approach reported 6.5% fewer acres, but water use projections were only 1.3% below NRCS survey data. The variation is caused by the different crop composition reported by each source since each crop has a different water use. The average water use resulting from the difference in crop composition was 15.48, 14.66 and 14.03 acre-inches per irrigated acre for TASS/Census, NRCS survey and FSA, respectively.

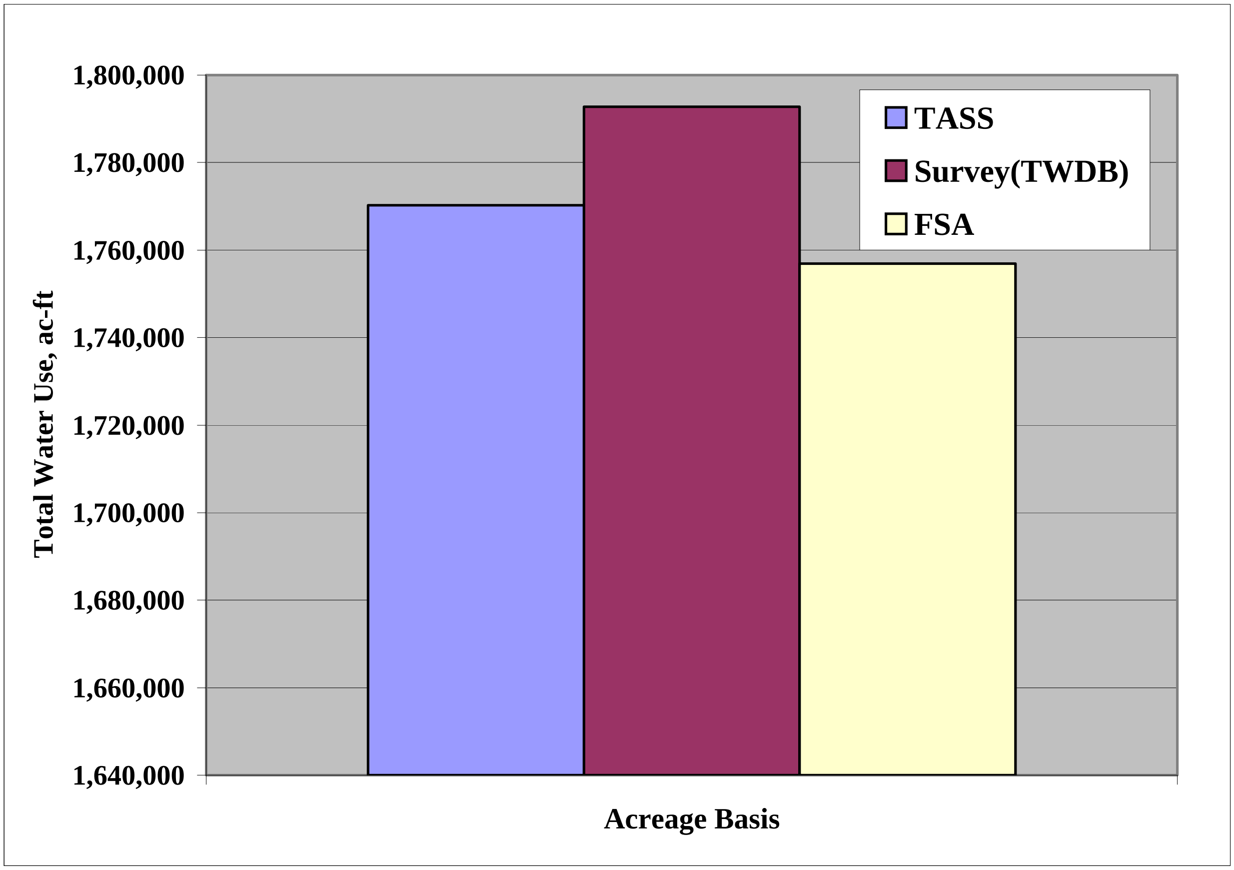

Figure 1. Projected water use for all irrigated crops in Region A for 2000 by the three sources, TASS/Census, NRCS survey, and FSA.

The variation in irrigated acreage and/or crop composition is also reflected in projected county level water use, Figure 2. The delineation of water use estimates to the county level projections increases the variability of acreage concern between projections, such as Randall County where estimates vary by more than 100.0%.

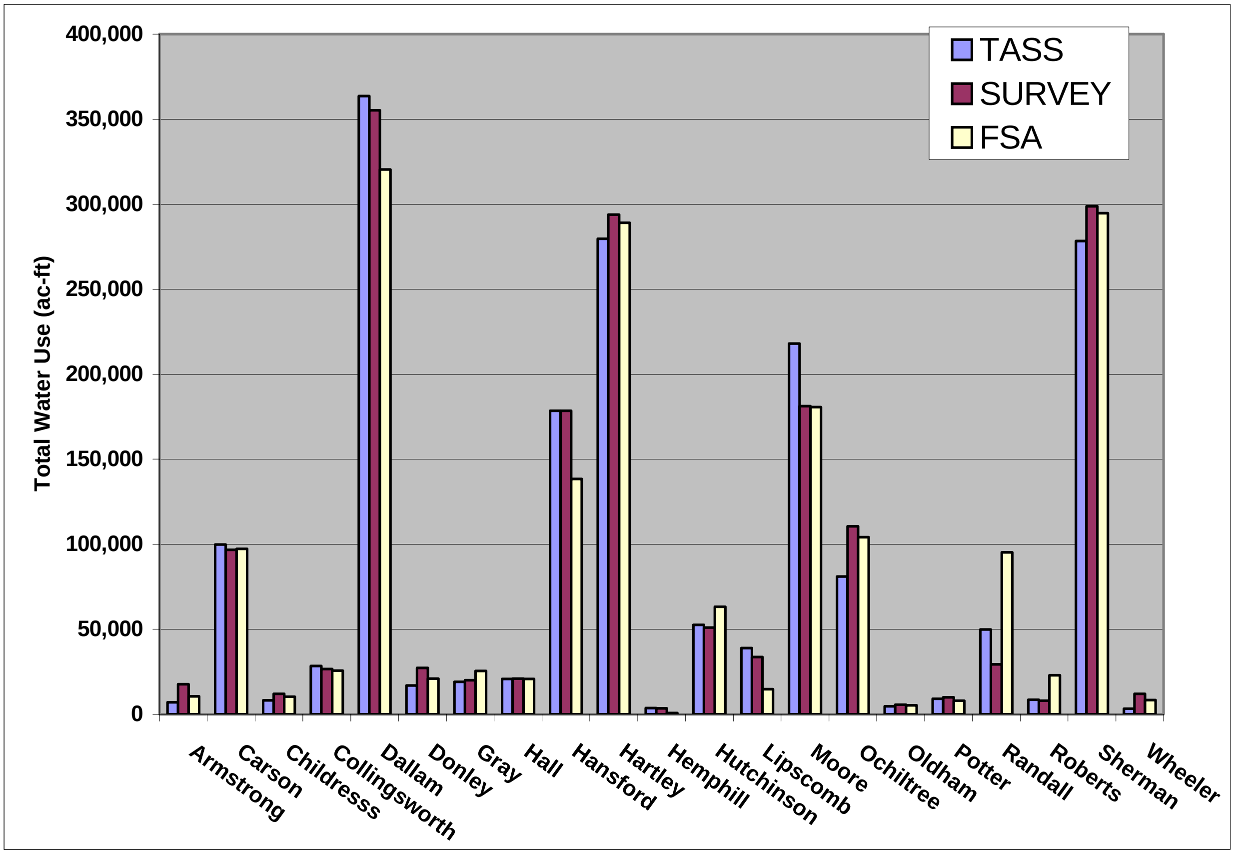

Figure 2. Delineation of total water use estimates by county in Region A for 2000 using TASS/Census, NRCS survey, and FSA irrigated acreages.

1C. Summary and Conclusions

Water use estimates made from three sources of irrigated acreage, TASS/Census, NRCS survey, and FSA were within two percent of each other for the region. Even though the differences are relatively small, projections over a 60-year time horizon magnifies the error and can mislead policy makers on future water availability in the region. Variability increases when examining the amount of irrigated acreage and the crop composition reported by each source. This variability could have a significant impact when evaluating different water saving strategies that involve reducing irrigated acreage or modifying crop composition. Finally, distortion of water use projections was greatest at the county level where most policy analyses need to be conducted.

Recent developments may make the selection of the appropriate source of irrigated acreage somewhat of a mute point. The NRCS no longer plans to conduct its survey. FSA data that includes all program crop irrigated acreage and most non-program crop acreage are intuitively the best source and preferred to the TASS/Census data that relies on a sampling of producers. The accessibility of the FSA data in the past has been the limiting problem. Recent changes made starting in 2002 by FSA have resulted in this data becoming readily accessible from a centralized database kept at the state headquarters.

2. Single versus Multi-year Baseline Acreages

Historically, a specific year's crop acreage and cropping patterns have been used as the baseline from which irrigated water use projections are generated. In recent water plans, the year selected corresponded to the year when the NRCS survey was conducted. Forecasted water use either assumed irrigated acreage and crop composition remained unchanged or modified according to future water use expectations.

Concerns have arisen in recent years over the validity of using a single year irrigated acreage data as a baseline to make projections of future water use, even for a decade. The increasing flexibility given producers in the last three farm bills to change composition between crops, and for that matter, not plant at all in response to changing commodity and input prices is leading to increased volatility in irrigated acreage and crop composition. A particular interest in the Texas High Plains is the impact of volatile natural gas prices and the distortion it may cause in irrigated acreage.

2A. Methodology

To examine the issue of a single year versus multi-year acreage base, TASS/Census data for the major irrigated crops grown in Region A during a five-year period were utilized, 1997-2001. TASS data were one source of information that provided readily accessible, annual data during this time period. A simple comparison of the variation in total irrigated acreage and irrigated acreage by crop was conducted to identify any significant changes.

2B. Results and Discussion

Total irrigated acreage varied considerably during the five-year period. In 1999, irrigated acreage peaked at 1.28 million acres and hit a low at 1.08 million acres in 2001 representing a 15.6% decrease, Table 2. The low acreage level reported in 2001 corresponds to extremely high natural gas prices entering into the summer crop season. Excluding 2001, variability was still relatively high with a range of 123,900 acres (1998 versus 1999) or 9.7%.

Table 2. Irrigated acres by major crop and year in Region A, 1997-2001.[1]

Crop/Year	1997	1998	1999	2000	2001	5 Year Average
Corn[2]	524,243	552,500	591,500	604,600	431,100	540,789
Cotton	21,025	15,200	21,900	33,600	33,000	24,945
Peanuts	16,366	23,700	30,100	21,800	21,000	22,593
Sorghum	163,042	107,900	114,900	93,700	111,700	118,248
Soybeans	24,570	43,900	55,600	56,000	8,700	37,754
Wheat	498,057	413,500	466,600	402,200	474,700	451,011
Total	1,247,303	1,156,700	1,280,600	1,211,900	1,080,200	1,195,341

[1]Source: TASS.
[2]Reported for corn grain only.

In any given year, corn, wheat and sorghum comprise 90.0% - 95.0% of the irrigated acreage among the major crops in the region. The acreage swings in these crops are far more volatile than the change in total irrigated acreage. For example, between 2000 and 2001, corn acreage dropped 28.7%, while sorghum and wheat acreage increased 19.2% and 18.2%, respectively, in response to the rising natural gas prices while overall irrigated acreage fell 10.6%

Variability in crop acreages was not limited to year 2001. Sorghum acreage fell 33.8% between 1997 and 1998. Irrigated wheat acreage has also varied at least 53,000 acres annually. The same type of annual variability is exhibited in other crops with smaller acreages such as soybeans where acreage decreased from 56,000 acres to less than 9,000 acres between 2000 and 200l.

2C. Summary and Conclusions

The volatility in irrigated crop acreages suggests the use of a single year crop acreage base could cause dramatic distortions in projected water use estimates. These distortions, whether caused by fluctuating natural gas or commodity prices or other factors, can alter both acreage levels and crop composition. On the other hand, failing to account for these events can cause its own distortion.

One possible solution to the acreage base problem is to use an average of crop acreages over a number of years. This would allow years where "events" that caused cropping patterns to be factored in, but the effects dampened when averaged with other years. The real question remaining may be, "How many years should acreages be averaged over?" For example, a five-year average may be long enough to capture and smooth the effects of some years with "events". However, five years may be too long a period to effectively capture trends in crop acreages. A three-year averaging system may over-emphasize or fail to capture certain distortions. Further study needs to be conducted to determine the optimal number of years that acreages should be averaged in determining the most suitable base acreage.

3. Senate Bill 2 Region A Crop Water Use Estimates

In the past, the Texas Water Development Board (TWDB) provided state, irrigated water use projections, principally through surveys from county and regional Natural Resource Conservation Service (NRCS) personnel. Each individual region reviewed the TWDB's estimates and could exercise the option to accept them as is or formulate an alternative methodology that more accurately reflected irrigation water demands within their respective region. Using the past methodology, large differences existed between the TWDB estimates and the measured drawdown in wells, as recorded by local water districts.

A new methodology developed for Region A by the Texas A&M – Amarillo (TAMA) group utilized calibrated crop evapotranspiration (ET) values from the North Plains Evapotranspiration (NPET) network in estimating irrigation water demands for the irrigated crops of corn, cotton, grain sorghum, hay, pasture and other, peanuts, soybeans and wheat. Calculations were based on crop ET, monthly effective rainfall, percent of potential ET pumped onto the crop, soil profile moisture utilized by the crop(s) during the growing season, and crop acreage of the respective crop(s). The results of this methodology and computation resulted in excellent agreement for the year of 1997. Irrigation demand results indicated agreement to within 97.0% of the measured well decline within the largest regional water district. Only limited data sets existed for other temporal periods and prevented additional years assessment. Nonetheless, the method appeared to be significantly better than the prior survey based approach.

Under Task 2 of Senate Bill 2, TAMA personnel are charged with updating the Region A irrigated water use estimates. This information is to be used to assist the Panhandle Regional

Planning Committee (PRPC) through the Panhandle Water Planning Group (PWPG) in evaluating the proposed TWDB irrigated water use estimates for the region. In addition, the updated model will be used to provide the planning group members a “first look” at the effectiveness of any proposed water conservation strategy.

3A. Methodology Review and Update

The TAMA methodology utilizes a categorized crop water use approach. As with most endeavors of this nature, lack of data continues to be a significant concern in a number of areas. Precise data per county were originally lacking regarding water use by crop type, rainfall, soil water holding capacity, and evapotranspiration (ET). Since that time, improved data sets and averages appear to be evolving. These include “standardized” reporting of crop acreages through the Farm Service Agency (FSA) upon which producer payments are based. Crop categories similar to those used with past reporting practices were agreed on and are as follows: corn, cotton, grain sorghum, hay, pasture and other, peanuts, soybeans and wheat. The TAMA model developed requires county-by-county input data regarding crop ET, a term now referred to as “grower factor” (which represents the amount of ET pumped and includes the percent of crop ET generally applied by producers using all irrigation system types and associated efficiencies), rainfall, soil water type and holding capacity and seasonal soil profile moisture used per crop planted. The grower factor could be synonymously labeled a “pumpage factor”. The TAMA model is based on the crop water use equation as follows:

$$P_T(ET_C) = IRR_C + ER + SSM_D \qquad (1)$$

where,

- P_T = Grower factor which represents a percentage of the crop evapotranspiration pumped on a seasonal basis (%) and includes all irrigation systems and associated efficiencies (can be more or less than 1.0 reference ET, ETo),
- ET_C = Crop evapotranspiration (or crop water use) for maximum production potential (in.),
- IRR_C = Irrigation applied on a seasonal basis to a crop (in.),
- ER = Effective rainfall computed from seasonal rainfall occurring during the crop season (in.), and
- SSM_D = Differential seasonal soil moisture used in crop production which is extracted from the soil profile during the respective growing season (in.).

Rearranging the equation and solving for an IRR_C yields:

$$IRR_C = ET_C(P_T) - ER - SSM_D \qquad (2)$$

The summary equation for all categorized crops grown per county is:

$$IRR_{CTY} = \sum_{1}^{n} IRR_C \qquad (3)$$

IRR_{CTY} = Total quantity of irrigation volume applied (pumped) to the crops grown within a county in a given year or season, (converted to ac-ft). (In Region A, n = 8 crop categorizations.)

Similarly, the summary equation for all crops within the region is:

$$IRR_{RA} = \sum_{1}^{21} IRR_{CTY} \tag{4}$$

where

IRR_{RA} = Total quantity of irrigation volume applied (pumped) to crops grown within Region A in a given year or season, (ac-ft).

Past crop ET data were utilized from the NPET network (Howell, 1998; Marek, et al., 1998) as it relates to Region A counties using a modified Penman-Monteith equation for calculation of potential evapotranspiration (PET) from the meteorological data. Recently, upgrading of the data sets (including past sets) used within the network was done using the upgraded and nationally drafted ASCE Standardized Reference Evapotranspiration Equation for Agriculture Crops (Walter, et. al., 2001). The NPET network utilizes a well-watered grass reference instead of an alfalfa-based reference. Data were specifically available for eight of the twenty-one counties in Region A. The remainder of the counties was computed using a correlation matrix attributing each NPET meteorological station's respective percentage of influence due to elevation, longitude, and latitude considering known cropping differences of particular counties. A portion of the correlation matrix indicating attribution used in the computations is presented in Table 3. Crop season and effective rainfall season used for Region A per crop are presented in Table 4. The resultant spreadsheets (including macros) turned out to be huge, but necessary.

Table 3. Selected portion of NPET meteorological station correlation (proportioning) matrix identifying station attribution used in computing county crop ET values in Region A.

NPET Meteorological Station	Dallam	Hartley	Roberts	Sherman
Dalhart	1.00	0.40	-	0.20
Dimmitt	-	-	-	-
Etter	-	0.40	-	-
JBF	-	0.20	-	0.60
Morse	-	-	0.33	0.20
Perryton	-	-	0.33	-
Wellington	-	-	-	-
White Deer	-	-	0.34	-

Another significant topic concerned the issue of effective rainfall. The procedure used is based upon the Natural Resource Conservation Service (NRCS) method (N.E.H., 1993) of computing effective rainfall. Long-term monthly quadrangle rainfall data from the TWDB website (2003) to calculate the respective seasonal crop rainfall was utilized. This was deemed acceptable given the spatial accuracy and applicable assumption of the hydrologic data. (Prior SB1 analysis indicated this approach to be satisfactory.)

Table 4. Seasonal periods and crop categories used in effective rainfall computations, Region A.

Crop	Growing Season Used in Crop ET Computations	Season Used in Effective Rainfall (ER) Computations	Number of Months Used in ER Calculations
Corn	April 15 - October 15	April 15- August 15	4
Cotton	May 15-October 15	May 15-October 15	5
Grain Sorghum	May 15-October 15	May 15-October 15	5
Hay	April 1-November 1	April 1-November 1	7
Pasture & Other	April 1-November 1	April 1-November 1	7
Peanuts	May 1-November 1	May 1-November 1	6
Soybeans	June 1-November 1	June 1-November 1	5
Wheat	October 1-July 1	October 1-July 1	9

The next variable required for the calculations was an estimation of the grower factor applied per respective crop by producers within Region A. Rather than use producers' survey type data, data were obtained from an ancillary extension/producer project that had been conducted within Region A and from parts of Region O (the adjoining region to the south). This information was compiled from 51 specific crop irrigation and production field demonstrations with 70 cooperating growers in 16 Panhandle counties (Robinson and New, 2002). These irrigated fields were monitored in terms of water applied (pumped volumes) and the associated yields. This application information is used in equation 2 and is included in Table 5.

Table 5. Five-year average (1998-2002) differential seasonal soil moisture and NPET crop ET percentage used in computations per crop category in Region A.

Crop	Differential Seasonal Soil Moisture (SSM), (inches)	Percent of NPET Crop ET Applied by Producers
Corn	2.41	0.86
Cotton	4.22	0.91
Grain Sorghum	3.62	0.84
Hay	1.50	0.95
Pasture and Other	2.50	0.80
Peanuts	2.20	1.35
Soybeans	3.11	0.91
Wheat	3.84	0.79

Differential soil profile moisture was assumed to be available to a level of 50.0% per respective crop within Region A. The respective quantities used in the calculations for the region are also included in Table 5.

The acreage attributed to each crop per county again presented concern, as addressed in the prior section. Publications from various sources reported substantially different values and subsequently would impact the irrigation demand use. Furthermore, categorizations of different reporting agencies were difficult to equate in some cases with regards to crops/categories. Ultimately, it was decided to base the acreage on FSA reported values, since this is what producers obtain crop payments on, and the new reporting system is now available on a county-by-county basis as of 2002. Water use by crop was multiplied by the planted irrigated acreage (pia) in each respective county to attain irrigation demand estimates.

3B. Irrigation Demand Results in Region A: TAMA versus TWDB

Using the TAMA model, water demand use calculations utilizing NRCS survey acreage numbers are presented in Table 6. This irrigated acreage is the same as that currently used by the TWDB, as reported on their web site (TWDB, 2003). The total regional water demand estimate between the TWDB and the TAMA model appears to be minimal; however, the county-by-county distribution indicates that considerable differences exist as viewed in Figure 2. Note the substantial demand differences exist in the major irrigation water use counties of Dallam, Ochiltree, Moore, and Sherman. TAMA projected water use to be 9.3%, 20.3% and 33.4% less than what TWDB projected in Sherman, Moore and Dallam counties, respectively. On the other hand, TAMA projected Ochiltree to use 23.8% more than TWDB estimates. Thus, while the total irrigation demand estimates for the region are virtually the same regardless of the methodology, individual county values differ substantially.

Table 6. Year 2000 irrigation water use estimates calculated with NRCS survey acreages for the 21 counties in Region A.

Region A Counties	2000 NRCS Survey Planted Irrigated Acres, pia	2000 TWDB Total Water Use, ac-ft	2000 TAMA Total Water Use, ac-ft	Estimate Difference, %
Armstrong	12,866	11,818	23,428	49.56%
Carson	96,111	79,045	140,778	43.85%
Childress	10,096	7,890	17,491	54.89%
Collingsworth	23,241	24,503	34,736	29.46%
Dallam	270,781	458,870	344,118	-33.35%
Donley	22,212	23,873	31,225	23.55%
Gray	21,494	20,525	22,869	10.25%
Hall	18,142	15,977	27,186	41.23%
Hansford	155,538	216,288	227,688	5.01%
Hartley	215,464	358,174	359,671	0.42%
Hemphill	3,065	3,373	3,590	6.04%
Hutchinson	43,331	58,766	68,502	14.21%
Lipscomb	29,010	36,005	34,414	-4.62%
Moore	155,856	291,620	242,323	-20.34%
Ochiltree	98,953	97,939	128,487	23.78%
Oldham	4,979	3,161	8,259	61.73%
Potter	6,225	9,977	12,708	21.49%
Randall	27,310	21,280	40,399	47.33%
Roberts	8,000	8,838	9,283	4.79%
Sherman	235,899	393,710	360,143	-9.32%
Wheeler	9,244	7,939	13,557	41.44%
Totals and Averages	1,467,817	2,149,571	2,150,855	0.06%

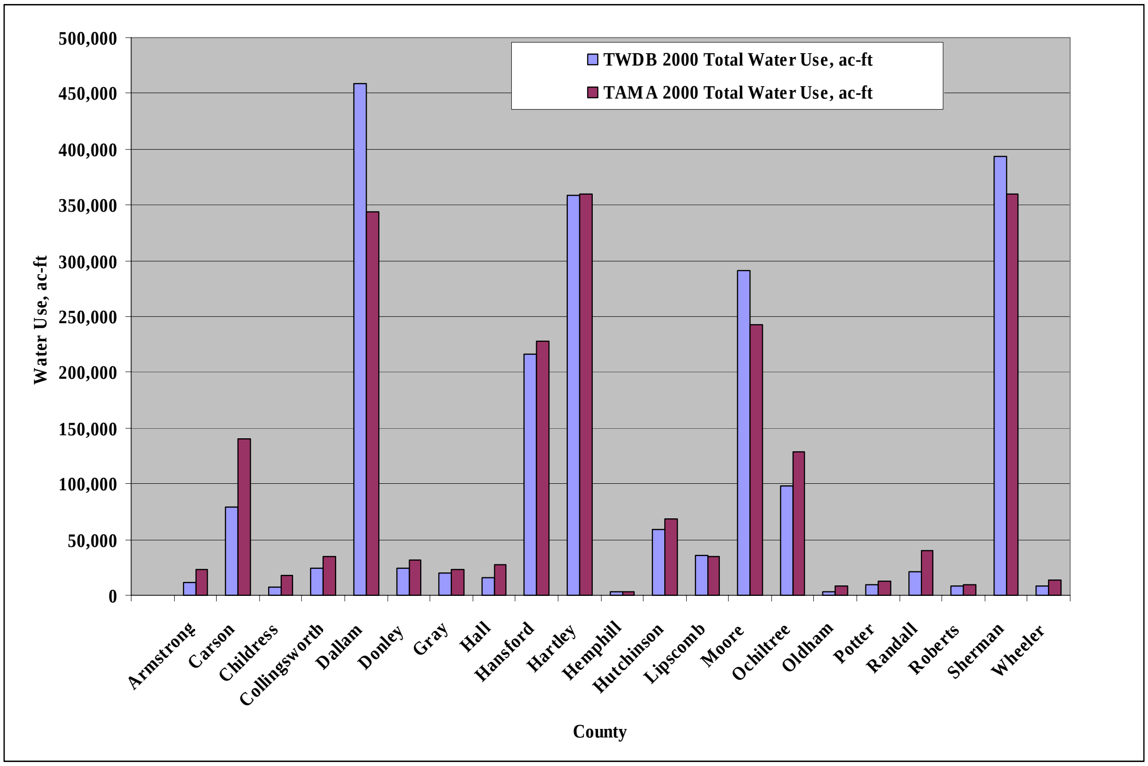

Figure 3. Total estimated irrigated water use for year 2000 by county in Region A utilizing NRCS survey acreages and values computed by TWDB and the TAMA method.

3C. Irrigation Demand Results in Region A: TAMA with FSA Acreages

As earlier discussed, a more appropriate and possibly consistent acreage estimate is that reported through the Farm Service Agency (FSA). The results of the irrigation demand calculations with FSA acreages per county for the year 2000 are presented in Table 7. The estimate difference column in Table 7 represents the percent difference between TAMA calculations with FSA acreages and estimates provided by TWDB using NRCS survey acreage estimates. Analysis of the data indicated that indeed five counties were again responsible for the majority of water use in Region A. In addition, variation in county level water use estimates increased even more between TAMA and TWDB. For example, the difference in Dallam County originally projected at 33.4% less (Table 6) increased to 47.7% less (Table7).

Table 7. Year 2000 irrigation water use estimates computed with TAMA model with FSA acreages for the 21 counties in Region A.

Region A Counties	2000 FSA Planted Irrigated Acres, pia	2000 TWDB Total Water Use, ac-ft	2000 TAMA Total Water Use, ac-ft	Estimate Difference, %
Armstrong	12,233	11,818	15,661	24.54%
Carson	96,966	79,045	141,633	44.19%
Childress	9,640	7,890	14,804	46.70%
Collingsworth	21,459	24,503	34,301	28.56%
Dallam	251,606	458,870	310,687	-47.70%
Donley	18,268	23,873	24,412	2.21%
Gray	29,409	20,525	29,031	29.30%
Hall	20,212	15,977	27,335	41.55%
Hansford	127,128	216,288	178,788	-20.97%
Hartley	216,022	358,174	352,872	-1.50%
Hemphill	1,273	3,373	833	-304.92%
Hutchinson	61,292	58,766	87,700	32.99%
Lipscomb	12,241	36,005	15,143	-137.77%
Moore	156,302	291,620	242,170	-20.42%
Ochiltree	96,929	97,939	120,733	18.88%
Oldham	4,607	3,161	7,569	58.24%
Potter	5,616	9,977	10,535	5.30%
Randall	97,595	21,280	133,807	84.10%
Roberts	18,422	8,838	25,293	65.06%
Sherman	235,347	393,710	355,837	-10.64%
Wheeler	9,572	7,939	10,468	24.16%
Totals and Averages	1,502,159	2,149,571	2,139,613	-0.47%

3D. Irrigation Demand Results in Region A: TAMA Model with FSA Acreages and Long-term Averages

Year 2000 per se was a relatively dry year compared to average or normal conditions. As such, to use actual year 2000 conditions as an irrigation estimator would significantly inflate demand for the 2000 to 2010 decade. A more suitable approach is to use the 2000 FSA acreages and utilize longer-term average (LTA) values for rainfall, grower factors, and average soil moisture conditions. Results from calculating the irrigation demand estimates in this manner are presented in Table 8 and would represent a more normal annual demand. The TAMA LTA water use projections again points out the distortion that can occur when basing water projections on single year conditions. Region A irrigated water use projections were 2,139,613 acre-feet (Table 7) when using 2000 data and 1,756,886 when using LTA data. This corresponds to 17.9% less annual water usage projection (LTA versus 2000).

Table 8. 2000 LTA irrigation water use estimates calculated with 2000 FSA irrigated acreages estimates for the 21 counties in Region A. (Note: Table includes the average LTA water use per planted irrigated acre.)

Region A Counties	2000 FSA Planted Irrigated Acres, pia	2000 LTA TAMA Total Water Use, ac-ft	2000 LTA TAMA Total Water Use per pia, in.
Armstrong	12,233	10,544	10.34
Carson	96,966	97,345	12.05
Childress	9,640	10,304	12.83
Collingsworth	21,459	25,607	14.32
Dallam	251,606	320,475	15.28
Donley	18,268	21,019	13.81
Gray	29,409	25,499	10.40
Hall	20,212	20,789	12.34
Hansford	127,128	138,389	13.06
Hartley	216,022	289,008	16.05
Hemphill	1,273	713	6.72
Hutchinson	61,292	63,208	12.38
Lipscomb	12,241	14,789	14.50
Moore	156,302	180,594	13.86
Ochiltree	96,929	104,220	12.90
Oldham	4,607	5,223	13.60
Potter	5,616	8,009	17.11
Randall	97,595	95,223	11.71
Roberts	18,422	22,890	14.89
Sherman	235,347	294,703	15.03
Wheeler	9,572	8,335	10.45
Totals and Averages	1,502,159	1,756,886	14.03

The monthly irrigation water use estimates associated with Table 8 are presented in Table 9. It should be noted the majority of the heaviest water demand occurs in the corn dominant counties of Dallam, Moore, and Sherman during the months of April through August when the corn ET requirements are the highest. Similarly, irrigation demand is essentially zero during the winter months when wheat and grasses are dormant. (These periods coincide typically with annualized groundwater district well level measurements where wells have time to recover from pumping drawdown and represent a more "equalized" level state within the area.)

Table 9. 2000 LTA monthly irrigation water use estimates calculated with 2000 FSA irrigated demand estimates for the 21 counties in Region A, acre-feet.

County	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Armstrong	0	0	608	2,493	2,006	769	1,725	1,604	123	608	608	0
Carson	0	0	4,286	19,327	17,099	10,918	18,685	16,128	2,331	4,286	4,286	0
Childress	0	0	149	660	929	1,890	3,350	2,768	261	149	149	0
Collingsworth	0	0	35	318	1,351	5,669	8,476	8,072	1,617	35	35	0
Dallam	0	0	6,525	38,971	45,093	63,030	88,519	64,176	1,112	6,525	6,525	0
Donley	0	0	228	1,847	2,504	3,972	5,528	4,922	1,563	228	228	0
Gray	0	0	889	4,439	4,254	3,546	5,346	4,405	844	889	889	0
Hall	0	0	109	526	1,308	4,314	7,234	6,291	790	109	109	0
Hansford	0	0	6,791	30,357	26,656	15,940	24,463	19,152	1,447	6,791	6,791	0
Hartley	0	0	5,502	34,304	40,333	56,662	79,169	58,668	3,366	5,502	5,502	0
Hemphill	0	0	40	176	148	57	94	94	22	40	40	0
Hutchinson	0	0	3,121	14,008	12,322	7,254	10,903	8,597	761	3,121	3,121	0
Lipscomb	0	0	261	1,884	2,227	2,782	3,547	2,838	726	261	261	0
Moore	0	0	3,331	20,171	23,700	34,763	51,423	39,014	1,532	3,331	3,331	0
Ochiltree	0	0	5,528	23,778	19,930	9,583	17,499	14,992	1,853	5,528	5,528	0
Oldham	0	0	319	1,364	1,125	374	637	633	133	319	319	0
Potter	0	0	261	1,452	1,442	1,081	1,378	1,293	579	261	261	0
Randall	0	0	5,546	22,643	18,522	7,546	15,454	14,342	78	5,546	5,546	0
Roberts	0	0	303	2,846	3,456	3,977	4,834	4,523	2,344	303	303	0
Sherman	0	0	11,708	55,010	51,679	42,377	62,422	46,939	1,152	11,708	11,708	0
Wheeler	0	0	224	1,015	1,055	1,254	2,196	1,924	220	224	224	0

3D. Irrigation Demand Results in Region A: Modifying Future Water Use Projections

Documented declines in the Ogallala Aquifer suggest long-term water use in the region will fall due to availability. In the Region A Senate Bill 1 effort, it was demonstrated that irrigated crop use per unit of water pumped had by far the lowest return compared to the other sectors. Therefore, any projected declines in water use due to limited availability are expected to occur in this sector. Furthermore, any anticipated increases in water use by the other sectors, for example, livestock, are expected to come at the expense of irrigation.

A number of options were evaluated in projecting the decline in irrigation. Initially, three constant decline rates were evaluated. These included 0.125%, 0.250% and 0.375% per year. These linear declines were abandoned as they were not felt to be realistic in term of trends experienced from past practice, technology adoption rates and diminishing water capacity in other national case history.

If the Region A Planning Group's goal to have 50.0% of the water left by the end of the planning period is to be met given current depletion rates, irrigation reductions are inevitable. As water tables decline, decreased specific capacity and lower water quality in the lower regions of the water bearing formation will result in significantly higher pumping costs resulting in lower returns for the irrigated producers. Irrigation is expected to decline by 35.0% from the current irrigation demand by the end of the 60-year planning horizon as producers comply with the proposed rule, the aquifer diminishes and accounting for growth in water use by other sectors,

The projected shape of the irrigated water use curve in the region resembles a "lazy Z", Figure 4. The logic behind the "lazy Z" curve is as follows. In the initial stages of the 60-year period, adoption of improved irrigation systems and associated developed application technologies should progress with current programs and future efforts. However, producers are not likely to rapidly change current operational practices, due to management and equipment changeover costs. A rapid decline in current irrigation demand is not foreseen from current usage values. The principal altering variable that would have the most impact in this early stage would be energy costs, but economics dictate that high production be maintained to cover current fixed system costs. In the middle decades, it is anticipated irrigation will fall sharply as systems wear out or are paid off allowing producers to either exit irrigation or adjust to lower water use crops in response to reduced irrigation profitability. It is expected that by the final decade of the planning horizon that the decline in irrigation will moderate as adjustments in acreage and crop mix reach an "equilibrium" state. The corresponding county and Region A total projected water use values for 2000 through 2060 by decade are presented in Table 10.

Recognizing again that increases in future livestock water use will be achieved through a further reduction in irrigation, estimates of the irrigation water use considering (deducting) the increases in livestock water use, results in available water use per county and total values as presented in Table 11. Graphically, these are also presented in Figure 4. Although the projected increase in livestock water use is dramatic, livestock water use is still quite small compared to irrigation demand.

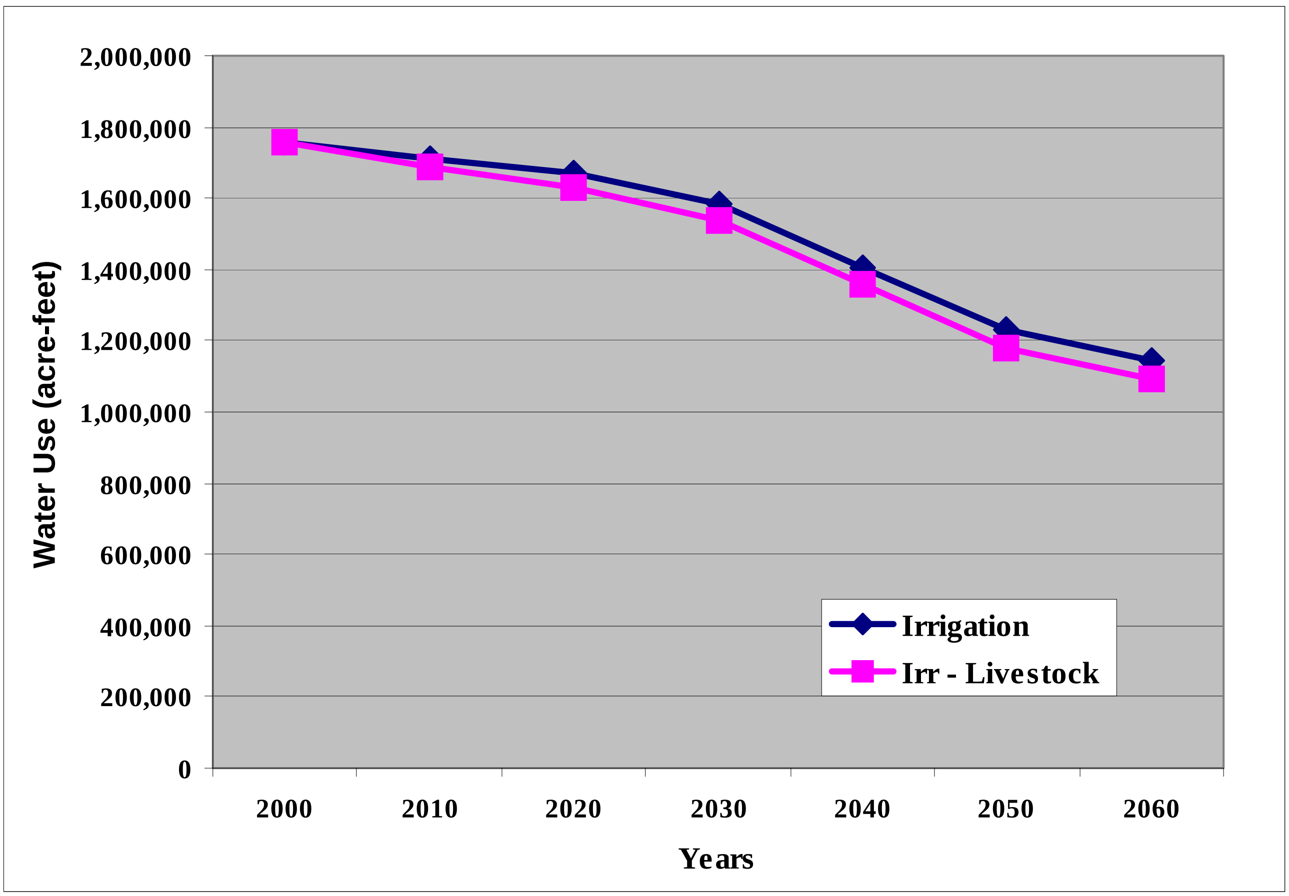

Figure 4. Region A projected irrigation water use with and without adjustments for increased livestock water use (acre-feet) by decade, 2000 – 2060.

Table 10**.** Long-term irrigation water use estimates (acre-feet) computed (with the limited data) using year 2000 FSA acreages for the 21 counties in Region A, 2000 – 2060.

Region A Counties	2000 Irr. Water Use, ac-ft	2010 Irr. Water Use, ac-ft	2020 Irr. Water Use, ac-ft	2030 Irr. Water Use, ac-ft	2040 Irr. Water Use, ac-ft	2050 Irr. Water Use, ac-ft	2060 Irr. Water Use, ac-ft
Armstrong	10,544	10,280	10,017	9,490	8,435	7,381	6,854
Carson	97,345	94,912	92,478	87,611	77,876	68,142	63,274
Childress	10,304	10,046	9,789	9,273	8,243	7,213	6,698
Collingsworth	25,607	24,967	24,327	23,046	20,486	17,925	16,645
Dallam	320,475	312,463	304,452	288,428	256,380	224,333	208,309
Donley	21,019	20,493	19,968	18,917	16,815	14,713	13,662
Gray	25,499	24,862	24,224	22,949	20,399	17,850	16,575
Hall	20,789	20,269	19,749	18,710	16,631	14,552	13,513
Hansford	138,389	134,929	131,470	124,550	110,711	96,872	89,953
Hartley	289,008	281,783	274,557	260,107	231,206	202,306	187,855
Hemphill	713	695	677	641	570	499	463
Hutchinson	63,208	61,628	60,048	56,887	50,567	44,246	41,085
Lipscomb	14,789	14,419	14,049	13,310	11,831	10,352	9,613
Moore	180,594	176,079	171,564	162,535	144,475	126,416	117,386
Ochiltree	104,220	101,615	99,009	93,798	83,376	72,954	67,743
Oldham	5,223	5,092	4,962	4,700	4,178	3,656	3,395
Potter	8,009	7,809	7,608	7,208	6,407	5,606	5,206
Randall	95,223	92,842	90,462	85,701	76,178	66,656	61,895
Roberts	22,890	22,318	21,746	20,601	18,312	16,023	14,879
Sherman	294,703	287,336	279,968	265,233	235,763	206,292	191,557
Wheeler	8,335	8,127	7,919	7,502	6,668	5,835	5,418
Totals and Averages	1,756,886	1,712,964	1,669,041	1,581,197	1,405,509	1,229,820	1,141,976

Table 11. Irrigated water use (acre-feet) by county in Region A after adjusting for increased livestock water use by decade, 2000 – 2060.

Region A Counties	2000 Irr. Water Use, ac-ft	2010 Irr. Water Use, ac-ft	2020 Irr. Water Use, ac-ft	2030 Irr. Water Use, ac-ft	2040 Irr. Water Use, ac-ft	2050 Irr. Water Use, ac-ft	2060 Irr. Water Use, ac-ft
Armstrong	10,544	10,241	9,945	9,389	8,305	7,219	6,659
Carson	97,345	94,840	92,349	87,436	77,653	67,868	62,947
Childress	10,304	10,041	9,728	9,208	8,171	7,135	6,613
Collingsworth	25,607	24,953	24,248	22,953	20,376	17,798	16,499
Dallam	320,475	305,865	291,751	275,503	243,218	210,919	194,629
Donley	21,019	20,386	19,785	18,684	16,530	14,372	13,262
Gray	25,499	24,385	23,446	22,067	19,406	16,739	15,339
Hall	20,789	20,266	19,744	18,701	16,619	14,537	13,494
Hansford	138,389	134,273	130,340	123,130	108,983	94,817	87,551
Hartley	289,008	278,266	267,893	253,173	223,986	194,782	180,009
Hemphill	713	468	275	160	6	0	0
Hutchinson	63,208	61,410	59,626	56,432	50,076	43,719	40,519
Lipscomb	14,789	14,176	13,680	12,922	11,424	9,924	9,163
Moore	180,594	174,592	168,870	159,644	141,376	123,096	113,832
Ochiltree	104,220	101,245	98,390	93,028	82,446	71,854	66,462
Oldham	5,223	4,610	4,338	3,979	3,353	2,721	2,344
Potter	8,009	7,783	7,559	7,136	6,311	5,485	5,058
Randall	95,223	92,421	89,724	84,769	75,041	65,301	60,308
Roberts	22,890	22,243	21,651	20,486	18,175	15,863	14,694
Sherman	294,703	279,451	266,263	251,325	221,639	191,941	176,964
Wheeler	8,335	7,986	7,630	7,154	6,257	5,357	4,869
Totals and Averages	1,756,886	1,689,906	1,627,233	1,537,280	1,359,354	1,181,293	1,090,932

3E. Summary and Conclusions

Refinements in the previously developed methodology for estimating irrigation water use demands for Region A in the Texas Panhandle have been accomplished. Subsequently, updated water demand estimates were computed using the Texas A&M –Amarillo (TAMA) model utilizing Farm Service Agency (FSA) acreages with average grower factors, soil moisture values and quadrangle rainfall data. The improved methodology is viewed as being more consistent over time with increased representation of actual, regional field irrigation practices.

Due to the current, limited availability of FSA data, computed water demand estimates are perceived to overstate average, longer-term irrigation demand on a decade basis. This is primarily due to the year 2000 (the year of the FSA acreage basis utilized) being drier (regionally, much less than average rainfall) than normal and imparting a greater irrigation requirement to meet overall crop ET. Thus, irrigation water demand use was derived based with a more “average” basis to more appropriately represent the decade demand. Future trends for future decades were developed using this average approach with the TAMA model (2010 – 2060).

Declining water levels in the aquifer and the marginal profitability of irrigated crop production in the region suggest future reductions in irrigation will occur. A 35.0% reduction in irrigation is assumed to occur over the 60-year planning horizon. The decrease is anticipated to happen in a “lazy Z” pattern reflecting expected trends in practice, well capacity, technology transfer and adoption considerations. The reduction in irrigation pumpage is projected to be slightly greater than the 35.0% as adjustments were made for projected increased livestock water use in the region.

4. Senate Bill 2 Region A Livestock Water Use Estimates

It was estimated in the Senate Bill 1 planning effort that livestock operations accounted for three percent of the water use in Region A. The anticipated rapid growth of the livestock industry makes on-going monitoring of this sector important. Given the importance of livestock to this region, an objective of the Senate Bill 2 Region A planning effort is to review/revise/modify where necessary regional livestock water use projections. Specific objectives were to:

1. Update livestock inventory numbers from a 1997 baseline used in Senate Bill 1 to a 2000 baseline to be used in Senate Bill 2 (Appendix B),
2. Review/revise where necessary water use estimates per species, and
3. Review/revise where necessary future livestock growth projections though 2060.

4A. 2000 Livestock Inventory Estimates

Livestock inventories by species were estimated for each county of Region A for 2000. County determination of livestock numbers is vital in the accurate estimation of water use. The Texas Agricultural Statistics Service (TASS) was used as the primary source of livestock inventory estimates. However, TASS does not provide county level livestock inventory estimates for all species. In some species, only crop reporting district or state level estimates are made. In these instances, other sources of information were used to refine/improve county level estimates.

The planning committee has identified eight livestock water use groups. They include: beef cows, fed beef, summer stockers, winter stockers, dairy cattle, horses, swine and poultry. The procedure utilized to develop the 2000 county level estimates by species varied depending on the data sources available.

<u>Beef Cows</u>

TASS inventory estimates of 2000 beef cow inventories by county were used to update the 1997 estimates used in Senate Bill 1.

<u>Fed Beef</u>

TASS only estimates fed beef by inventories on a crop reporting district basis. County level estimates were made by establishing the feedlot capacity in each county (XCEL, 2000). Inventory estimates were calculated as 85.0% of total permitted capacity. The 85.0% “occupancy rate” was determined from TASS data and feedlot turnover data provided by Jim Gill of Texas Cattle Feeders Association.

Summer Stockers

The number of summer stockers in a county was adjusted from Senate Bill 1 estimates depending on the change in beef cow inventory. If the beef inventory increased (from 1997 to 2000), it was assumed the number of summer stockers decreased because of less pasture being available. The change was calculated on the basis of 0.70 cow units being equivalent to 1 stocker unit. For example, if the number of beef cows increased by 1,000, then the number of summer stockers were decreased by 1,429.

Winter Stockers

Stockers on winter pastures were assumed to remain unchanged from the number estimated in Senate Bill 1.

Dairy Cattle

TASS 2000 dairy cow inventory numbers by county were used for Region A.

Horses

In Senate Bill 1, the 1997 Census of Agriculture that provides the only known county level estimates of horse populations was used. TASS provides annual estimates of horse populations, but only at the state level. In Senate Bill 2, the county level distribution provided by the 1997 Census was utilized and adjusted upward to reflect the 2000 inventory number reported by TASS. For example, if a county had 1,000 horses according to the 1997 Census, the 2000 inventory number was scaled up by multiplying the 2000 TASS state inventory (600,000) divided by the 1997 Census state total (241,000). In this example, the new county estimate of 2000 horse inventory would be 2,490 (1,000*600,000/241,000).

Swine

TASS only estimates swine inventory numbers on a crop reporting district basis. The distribution of hog inventories by county determined in Senate Bill 1 was utilized. The one exception was Lipscomb County where the inventory estimate was reduced from 40,000 to 10,000. These estimates were "scaled up" in a similar manner as described above for dairy cattle. Each county inventory number was adjusted by multiplying it by 1.042 (780,000/748,236 or 2000 TASS inventory/1997 Senate Bill 1 Region A inventory). These estimates by county were verified through TCEQ permits and validated by a focus group of swine producers from the region.

Poultry

Virtually no poultry currently exists in Region A. In Senate Bill 2, 2000 inventory numbers were arbitrarily set at 1,000 birds per county. This is the same assumption used in Senate Bill 1.

Beginning inventory numbers for the region by species is given in Table 12. A detailed inventory by county is located in Appendix B.

Table 12. Region A beginning and ending inventory numbers by species for Senate Bill 1 and Senate Bill 2.

Species	Senate Bill 1	Senate Bill 2	Senate Bill 1	Senate Bill 2
	1997	2000	2050	2060
(---------- Number of Head ----------)				
Beef Cows	220,000	237,000	220,000	237,000
Fed Beef	1,363,600	1,182,241	2,010,487	2,052,513
Summer Stockers	396,340	372,053	658,286	501,844
Winter Stockers	646,946	649,946	1,096,117	872,633
Dairy Cattle	877	4,400	23,364	92,425
Horses	9,964	24,806	16,882	45,006
Poultry	21,000	21,000	2,516,000	2,516,000
Swine	778,236	779,999	3,507,808	5,611,617

4B. Livestock Water Use by Species

A considerable amount of time was spent by the Region A committee in developing and documenting water use by species under Senate Bill 1. The standards developed in Region A were later adopted by the Texas Water Development Board (TWDB) for use across the state. In general, these water use estimates were adopted for use in the Region A Senate Bill 2 projections. However, the potential dramatic expansion in the swine and dairy industries merited a more detailed review of their water use.

In an effort to refine water use estimates, a focus group of swine and dairy producers, a permit specialist and industry experts was assembled. They recommended that daily water use per animal by dairies be reduced from 75 gallons/day to 65 gallons/day, Table 13. This was based on improvements employed by West Texas dairies to more efficiently use wastewater.

Swine water use was reduced from 11gallons/head/day to 5 gallons/head/day. This dramatic reduction was justified by the focus group for two reasons. The original Senate Bill 1 estimates were based on a flush type system. Only the first, large swine operation that located in the region utilized this type of system. All subsequent operations use a pull-plug system that is more efficient with respect to water use.

The second reason for the reduction in water use per head is the current composition of swine operations. While farrowing operations will use 11-gallons/head/day on average (varies by time of year), finishing operations typically use 3 - 4 gallons/head/day. Currently, the focus group felt the composition of swine operations in the region was heavily weighted toward finishing operations and 5-gallons/head/day was an appropriate water use estimate. In future water plans, the composition of swine operations will need to be re-evaluated to determine if water use needs to be adjusted.

The one exception to the 5-gallons/head/day water use estimate was Dallam County where the only flush system is located. Dallam County swine water use in 2000 was estimated using a rate of 8 gallons/head/day. Subsequent projected increases in Dallam County swine inventory were assumed to use the 5-gallons/head/day rate.

Table 13. Region A Senate Bill 1 and Senate Bill 2 livestock water use estimates per animal[a].

Species	Senate Bill 1	Senate Bill 2
Beef Cows	20	20
Fed Beef	15	15
Summer Stockers	12	12
Winter Stockers	12	12
Dairy Cattle	75	65[b]
Horses	12	12
Poultry	0.09	0.09
Swine	11	5[b][c]

[a] Personal communication with Dr. John Sweeten.
[b] Focus group of dairy and swine producers, permit specialist, and industry experts.
[c] In 2000, Dallam County water use was 8 gallons/head.

An objective of task 4 was to review and revise, when warranted, projected growth assumptions in the livestock sector made in Senate Bill 1 for use in the Senate Bill 2 planning cycle. Resulting from this review, no changes were recommended in the projected growth rates used in Senate Bill 1 for beef cows, horses and poultry, Table 14. Growth rates for fed beef and stockers were modified slightly while major changes were recommended for swine and dairy.

<u>Fed Beef</u>

An examination of Texas Commission on Environmental Quality (TCEQ) permits issued for regional feedlots indicated approximately a three percent annual growth rate has occurred from 1999-2003. While this growth is not anticipated to continue at that pace, it did warrant increasing the projected growth rate from Senate Bill 1 from 1.0% to 2.0% for the 2000-2010 decade. The growth rate from 2010-2060 was assumed to remain the same as defined in Senate Bill 1.

<u>Summer and Winter Stockers</u>

The annual projected growth rate in summer and winter stockers was reduced from 1.0% used in Senate Bill 1 to 0.5% for Senate Bill 2. In Senate Bill 1, it was thought that the continued growth of the fed cattle industry, improved pastures exiting the Conservation Reserve Program (CRP), and an increase in dryland wheat production as irrigation declined would result in the 1.0% annual growth rate. While these factors are still expected to occur, the reauthorization of the CRP and the realization that some of the growth in dryland winter wheat pasture would come at the expense of irrigated wheat pasture with higher stocking rates, it was decided to reduce the anticipated growth rate by half.

<u>Dairy Cattle</u>

An explosion in the number of TCEQ current and pending permits for dairy operations in the region since the Senate Bill 1 effort justified taking a new approach for estimating future dairy inventories. A focus group consisting of a dairy producer and industry experts was convened to provide guidance.

The focus group concluded that growth in the dairy industry would be limited and would occur west of US Highway 287. It was recommended that dairy inventories be capped at 57.5% of current and pending TCEQ permits. Half of this growth would happen by 2010 with the remainder occurring by 2020. It was assumed that 4,000 cow dairies would be added to Oldham and Sherman Counties (both west of US Highway287) where no present permit activity by 2010.

The 57.5% cap on inventory numbers originates from the fed beef industry in the region. The fed beef industry that is considered to be relatively mature, typically, has inventory levels that are approximately 57.5% of the TCEQ permitted capacity.

Swine

A similar approach utilized to update the dairy projections was employed to revise future growth estimates in the swine industry where an even more dramatic increase in TCEQ permit requests has occurred. The number of recent and pending TCEQ permit requests will increase capacity by 3.78 million head. This is in addition to the 1.78 million head capacity in existing permits.

A focus group of regional swine producers and industry experts were assembled to provide input on swine inventory projections. They determined that growth in the region would happen rapidly assuming that a proposed processing plant was constructed. The focus group concluded that inventory number would reach 57.5% of current TCEQ permit levels by 2010 and by 2020, and inventory numbers would plateau at 100.0% of current TCEQ permit level. No additional growth was assumed for the remainder of the planning horizon (2020-2060). The focus group also noted that additional growth could happen only if another processing facility was constructed.

In addition to the inventory changes suggested by the focus groups, a 10,000 head operation was added to Hemphill County in 2010. No permits currently exist in Hemphill County; however, it is anticipated since it is the only county in the northern portion of the region without a current or planned facility.

Table 14. Region A Senate Bill 1 and Senate Bill 1 projected livestock inventory growth by species, 2000 - 2060.

Species	Senate Bill 1	Senate Bill 2
(---------- Annual Growth Rates ----------)		
Beef Cows:		
2000 - 2060	0.00%	0.00%
Fed Beef:		
2000 - 2010	1.00%	2.00%
2010 - 2020	1.15%	1.15%
2020 - 2060	0.60%	0.60%
Summer/Winter Stockers:		
2000 - 2060	1.00%	0.50%
Dairy Cattle:		
2000 - 2010	8.60%	In 2010, 28.75% of TCEQ current and pending permit capacity and add 4,000 cow units in Sherman and Oldham Counties.
2010 - 2020	2.25%	In 2020, 57.50% of TCEQ current and pending capacity.
2020 - 2060	1.40%	0.00%
Horses:		
2000 - 2060	1.00%	1.00%
Poultry:	In 2020, add 500,000 capacity operations in eastern counties (Childress, Collingsworth, Hemphill, Lipcomb and Wheeler). No other growth is assumed.	
Swine:		
2000 - 2010	8.60%	57.50% of TCEQ total permit capacity and add 10,000 hog units to Hemphill County.
2010 - 2020	1.50%	100% of current TCEQ permit capacity.
2020 - 2060	1.50%	0.00%

4D. Texas A&M University Senate Bill 2 Livestock Projected Water Use

Region A annual livestock water use projections by species for selected years during the Senate Bill 2 planning horizon are presented in Table 15. Overall, water use in the Region A livestock sector is predicted to increase 134.0% from 2000 to 2060. While this increase is significant, it still will only represent approximately 5.0% - 6.0% of the total water use within Region A.

The largest livestock water use group is projected to be the fed cattle industry with an annual usage of 34,487 ac-ft/year by 2060. The anticipated, rapid expansion places the swine industry with a similar usage estimate by 2060 (32,451 ac-ft/year). In fact, water usage by the swine industry is expected to surpass the fed cattle for 2020-2040 time period. These two user groups account for 75.0% of projected livestock water use in 2060.

The forecasted expansion in the dairy industry increased projected annual water use from 320 ac-ft/year in 2000 to 6,729 ac-ft/year in 2060 making it the third largest livestock water group and accounting for 7.5% of total water use. Dairy cattle were followed closely by beef cows, winter and summer stockers which used 5,309, 4,887 and 4,497 ac-ft/year, respectively. Horses and poultry accounted for less that one percent of water use in 2060.

Table 15. TAMA Senate Bill 2 Region A estimated livestock water use (acre-feet) by species, 2000 - 2060.

Species	2000	2010	2020	2030	2040	2050	2060
(---------- acre-feet/year----------)							
Beef Cows	5,310	5,310	5,310	5,310	5,310	5,310	5,310
Fed Beef	19,864	24,215	27,148	28,821	30,598	32,484	34,487
Summer Stockers	3,334	3,505	3,684	3,872	4,070	4,278	4,497
Winter Stockers	3,623	3,809	4,004	4,208	4,423	4,650	4,887
Dairy Cattle	320	3,689	6,729	6,729	6,729	6,729	6,729
Horses	333	368	407	449	497	548	606
Poultry	2	2	254	254	254	254	254
Swine	5,390	20,339	32,451	32,451	32,451	32,451	32,451
Totals	38,176	61,237	79,987	82,094	84,332	86,704	89,221

4E. Senate Bill 1, Senate Bill 2 (TAMA) and Senate Bill 2 (TWDB) Region A Livestock Water Use

Significant refinements have been made in this project in the beginning inventories, water use by species, and projected growth rates. The new TAMA Senate Bill 2 (SB2) projections use a beginning inventory of approximately 475,000 more hogs and 100,000 more fed beef than the Senate Bill 2 TWDB projections. The SB2 TAMA projection utilizes a much lower water use per head for swine and dairy operations (5 versus 11 gallons/head/day and 65 versus 75 gallons/head/day). Projected growth rates for the swine and dairy industries were modified dramatically compared to Senate Bill 1. Ending inventories for swine and dairies are expected to be 5,611,617 and 92,425 head, respectively, compared to ending inventories in Senate Bill 1 of 3,507,818 and 16,882 head.

Total livestock water uses projected in Senate Bill 1, TAMA Senate Bill 2, and TWDB Senate Bill 2 are graphically presented in Figure 5. Ironically, the Senate Bill 2 annual water use estimates by TAMA and TWDB are very close in the beginning and in the end of the planning horizon, despite all the changes. However, significant differences of up to 33.0% exist during the interim years of the planning horizon. More importantly may be at the county level, differences in inventories between TAMA and TWDB combined with projected growth rates could substantially distort future water supply availability. A detailed breakdown of SB2 TAMA county level livestock water use projections is given in Appendix B.

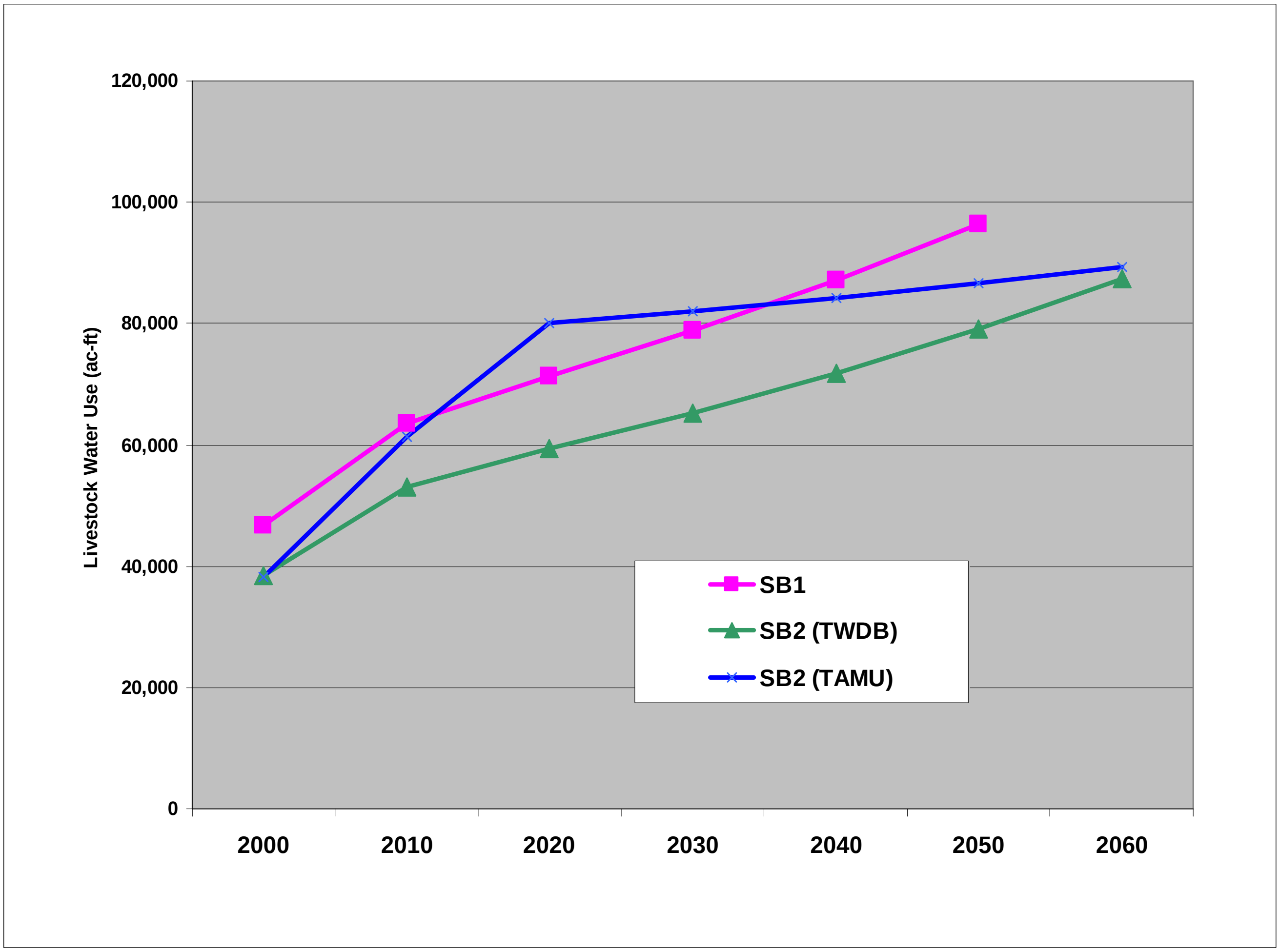

Figure 5. Comparison livestock water use (acre-feet) , Senate Bill 1, Senate Bill 2 (TWDB), and Senate Bill 2 (TAMA) by decade, 2000 – 2060.

4F. Summary and Conclusions

The final objective of Task 2 is to review, update and refine, when warranted, projected growth assumptions in the livestock sector made in Senate Bill 1 for use in the Senate Bill 2 planning cycle. Resulting from this review, significant errors were discovered in TWDB inventory estimates of swine and horses. In addition, TWDB had inventory and county-level inventory distribution errors in fed beef. Therefore, errors were linked to data source problems.

No changes were recommended in the projected growth rates used in Senate Bill 1 for beef cows, horses and poultry. Growth rates for fed beef and stockers were modified slightly while major changes were recommended for swine and dairy. Overall, water use in the Region A livestock sector is predicted to increase 134.0% from 2000 to 2060. While this increase is significant, it still will only represent approximately 5.0% - 6.0% of the total water use in the region. The largest livestock water use group is projected to be the fed cattle industry with an annual usage of 34,487 ac-ft/year by 2060. The anticipated rapid expansion places the swine industry with a similar usage estimate by 2060 (32,451.1 ac-ft/year). In fact, water usage by the swine industry is expected to surpass the fed cattle for the 2020 to 2040 time period. These two user groups account for 75.0% of projected livestock water use in 2060. The forecasted expansion in the dairy industry increased projected annual water use from 320 ac-ft/year in 2000 to 6,729ac-ft/year in 2060 making it the third largest livestock water group and accounting for 7.5% of total water use.

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APPENDIX A

TEXAS A&M UNIVERSITY SENATE BILL 2-
TASK 2 REPORT PRESENTATION

Senate Bill 2
Region A-Task 2

Preliminary Findings

Amarillo Research and Extension Center

TAMU Project Team

Steve Amosson
Thomas Marek
Leon New
Fran Bretz
Lal Almas

Amarillo Research and Extension Center

Senate Bill 2 -TAMU
Task 2 Objectives

- Evaluate sources of irrigated acreage.
- Evaluate validity of single year versus multi-year average of acreage estimates.
- Review/compare TWDB/TAMU Region A irrigation estimates.
- Review/compare TWDB/TAMU Region A livestock water use estimates.

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Sources of Irrigated Acreage

- TWDB/NRCS
  - Every 5 years (TASS/FSA ??)
- TASS/Ag Census
  - TASS-Every year. Ag Census-Every 5 years.
  - Done by producer survey.
- FSA
  - Every year.
  - Done by program sign-up.

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Sources of Irrigated Acreage
Procedure

- Compare acreage estimates by source for the same year (2000).
- Compare water use estimates using TAMU methodology for each source.
- Seek subcommittee recommendation to TWDB for future source of irrigated acreage data used in estimating Region A water demand.

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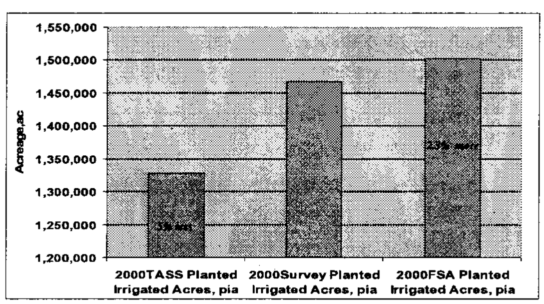
SB2 2000 Acreage Comparisons Using TASS, TWDB & FSA



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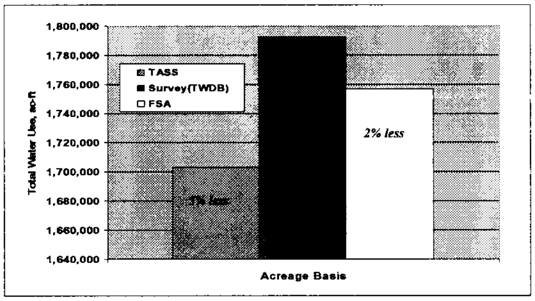
SB2 2000 Total Irr. Water Use Comparisons Using TASS, TWDB & FSA Acreages



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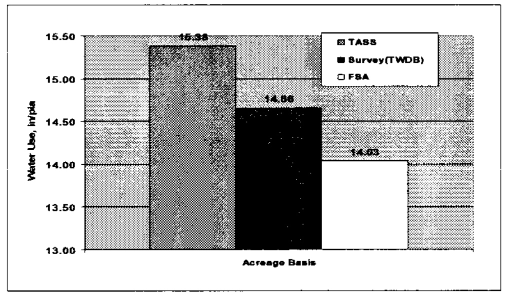
SB2 2000 Water Use (in/pia) Comparisons, TASS, TWDB & FSA



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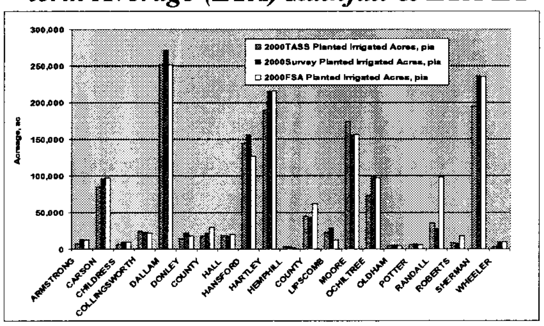
SB2 2000 Acreage Comparisons using Long-term Average (LTA) Rainfall & LTA ET



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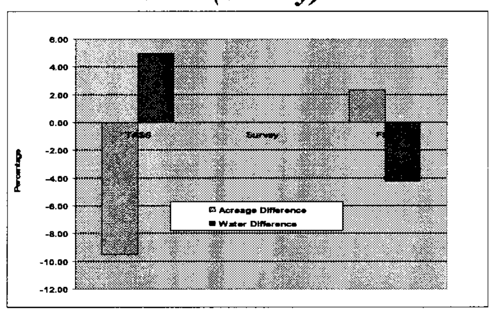
Acreage & Water Percentage Change, TWDB (Survey) Base



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Single versus Multi-year Average Procedure

- Compile Region A annual irrigated acreage estimate for a 5 year period (1997-2001).
- Evaluate variation in irrigated acreage over the years by crop.
- Seek subcommittee recommendation to TWDB on use of a single versus multi-year average irrigated acreage base for estimating water demands.

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Time Series Analysis

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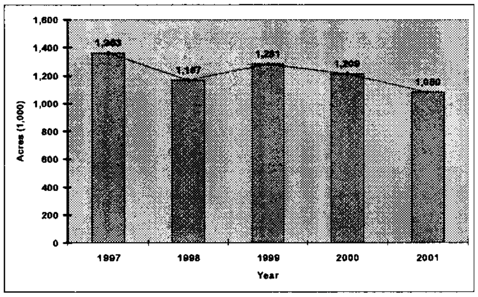
Total Irrigated Acreage in Region A 1997-2001



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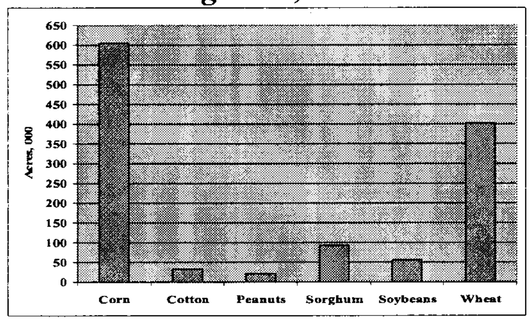
Irrigated Acres of Major Crops in Region A, 2000



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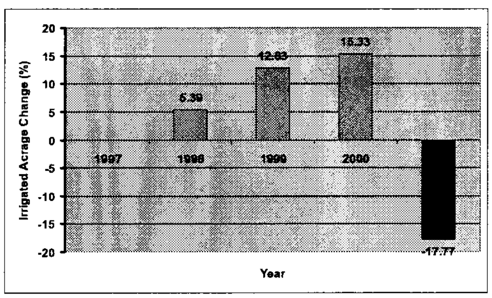
Trend of Corn Irrigated Acreage in Region A 1997-2001



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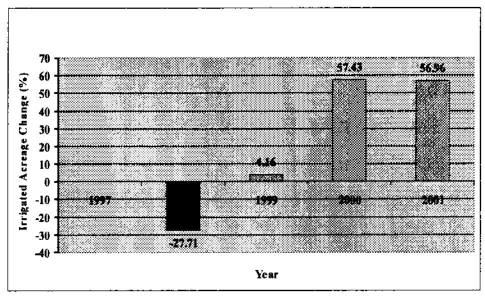
Trend of Cotton Irrigated Acreage in Region A 1997-2001



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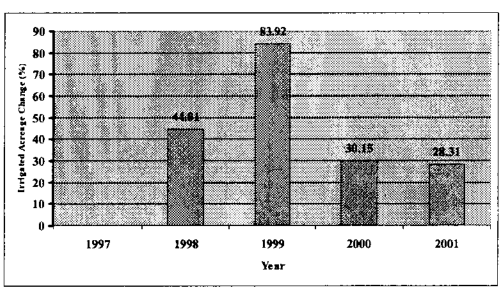
Trend Peanuts Irrigated Acreage in Region A 1997-2001



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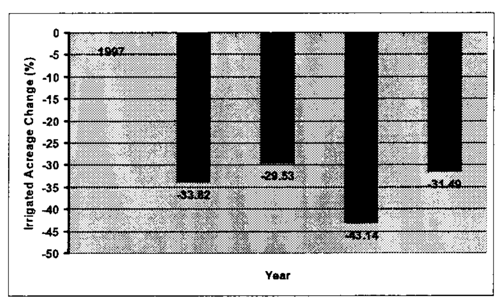
Trend of Sorghum Irrigated Acreage in Region A 1997-2001



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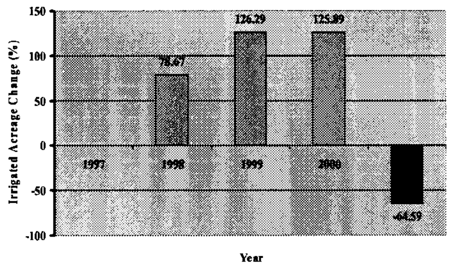
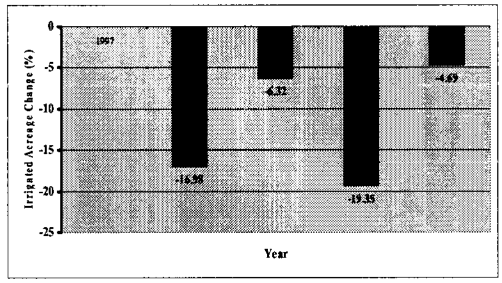
Trend of Soybeans Irrigated Acreage in Region A 1997-2001



Trend of Wheat Irrigated Acreage in Region A 1997-2001



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Recommendations Needed from Committee:

- **Determine source of irrigated acreage to be used.**
- **Determine the use of single year or multi-year average of acreage estimates.**
- **Determine water use estimates using TWDB versus TAMU irrigation estimates.**

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- Senate Bill 1 was mandated by the Texas Legislature in 1997 to review the State's Water Plan. SB2 was initiated in 2001.
- Texas was divided into 16 regions.
- The Texas Panhandle was designated as the Panhandle Water Planning Area (Region A) and was comprised of 21 counties.

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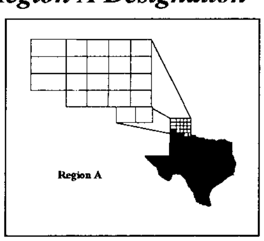
Region A Designation



Texas counties designated in Texas' Senate Bill 1 & 2 as Region A. The region is comprised of 21 counties.

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Region A

- Costs: Region A is the largest water-consuming region in Texas with 89% of the water used for agriculture.
- Benefits: Water use in Region A produces:

  46% of the wheat,
  62% of the corn,
  23% of the grain sorghum,
  80% of the cattle on feed,
  82% of the swine, and
  45% of the beef slaughter capacity in Texas.

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Prior Water Use Calculations in Texas

- In the past, TWDB water use calculations tended to dramatically over estimate irrigation water use when compared to the measured drawdown in groundwater wells.
- TWDB irrigation water use estimates are based on survey data collected from regional Natural Resource Conservation Service personnel.

Texas A&M University System (TAMUS) Crop Water Use Approach

- The Texas A&M University irrigation water use estimates are based on a categorized crop water use approach for corn, cotton, sorghum, hay, pasture, peanuts, soybeans and wheat.

Methodology is Based On:

- Crop Evapotranspiration (ET). Actual crop ET was derived and updated from the large, monolithic lysimeters at Bushland, Texas and obtained through the NPET.
- Monthly Effective Rainfall. A modified monthly effective rainfall was utilized from the procedure described in the NRCS National Engineering Handbook.

Methodology is Based On:

- Grower Factor. The percent crop ET pumped was based on Texas Cooperative Extension data gathered from actual producers' fields by Agri-Partner Demonstrations.
- Soil Moisture. Soil moisture levels in the soil, which is used by the plant.

Methodology is Based On:

- Crop Acreage. Crop acreages used in SB2 were the TWDB survey numbers. This ensures that we are comparing water use estimates from TAMU and TWDB on an "apple to apple" basis.

Methodology is Based On:

- 2000 is the primary year used in SB2 because this is the latest acreage year available. It also uses data from the North Plains Evapotranspiration Network (NPET) and the Agri-Partners Demonstrations (TAEX).

Texas A&M University System (TAMUS) Crop Water Use Approach

Irrigation Water Pumped =
Crop PET x (% Applied)
- Effective Rainfall
- Soil Profile Water Used

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Effective Rainfall??

Calculated by method from NRCS , Chapter 2, National Engineering Handbook on Irrigation Water Requirements

Technique was mean monthly precipitation, average crop ET, and soil water storage factor to calculate effective precipitation.

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Actual Effective Rainfall Equations are:

$$SF = (0.531747 + 0.295164\,D - 0.057697\,D^2 + 0.003804\,D^3)$$

$$P_e = SF(0.70917P_t^{0.82416} - 0.11556)(10^{0.02426ET_c})$$

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TAMUS Model

$$P_T(ET_C) = IRR_C + ER + SSM_D$$

where:

P_T =Percentage of crop ET pumped on a seasonal basis, (in),

ET_C =Crop ET (or water use) for maximum production potential, (in),

IRR_C =Irrigation applied (pumped) on a seasonal basis to a crop, (in),

ER =Effective rainfall computed from seasonal rainfall occurring during the crop season, (in),

SMM_D=Differential seasonal soil moisture used in crop production which is extracted from the soil profile, (in).

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TAMUS Model

$$IRR_{CTY} = \sum_{1}^{n} IRR_C$$

where:

IRR_{CTY}=Total quantity of irrigation volume applied (pumped) to the crops grown within a in a given year or growing season, (ac-ft), per county .

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TAMUS Model

$$IRR_{REG} = \sum_{1}^{n} IRR_{CTY}$$

where:

IRR_{REG}=Total quantity of irrigation volume applied (pumped) to the region per given year or growing season, (ac-ft).

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- A modified Penman-Monteith equation is used by the NPET Network to calculate the PET from meteorological data.
- Data was available from 8 meteorological stations. The remainder of the counties were computed using the following correlation matrix.

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NPET Meteorological Station Correlation Matrix Identifying Station Attribution in Computing ET

County Met Station	Armstrong	Collingsworth	Donley	Roberts
Dalhart	-	-	-	-
Dimmitt	0.25	-	0.07	-
Etter	-	-	-	-
JBF	0.50	-	0.13	-
Morse	-	-	-	0.33
Perryton	-	-	-	0.33
Wellington	0.25	1.00	0.80	-
White Deer	-	-	-	0.34

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SB1 (1997) Seasonal SM and Crop ET%

Crop	Differential Seasonal Soil Moisture (in)	Percent ET Applied
Corn	2.00	0.84
Cotton	5.00	0.93
Sorghum	2.50	0.77
Hay	1.50	0.95
Pasture	2.50	0.80
Peanuts	2.50	1.00
Soybeans	3.00	0.78
Wheat	3.50	0.60

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SB2 (2000) Seasonal Soil Moisture and Crop ET

Crop	Differential Seasonal Soil Moisture (in)	Percent ET Applied
Corn	3.54	0.83
Cotton	4.37	0.92
Sorghum	3.48	0.80
Hay	1.50	0.95
Pasture	2.50	0.80
Peanuts	3.94	1.72
Soybeans	3.99	1.07
Wheat	2.34	0.85

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1998-2002 Seasonal Soil Moisture and Crop ET (Long-term Average)

Crop	Differential Seasonal Soil Moisture (in)	Percent ET Applied
Corn	2.41	0.86
Cotton	4.22	0.91
Sorghum	3.62	0.84
Hay	1.50	0.95
Pasture	2.50	0.80
Peanuts	2.20	1.35
Soybeans	3.11	0.91
Wheat	3.84	0.79

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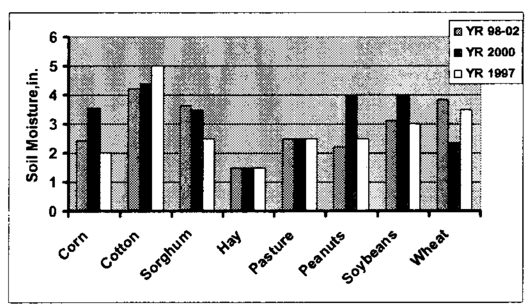
Comparison of Soil Moisture Values



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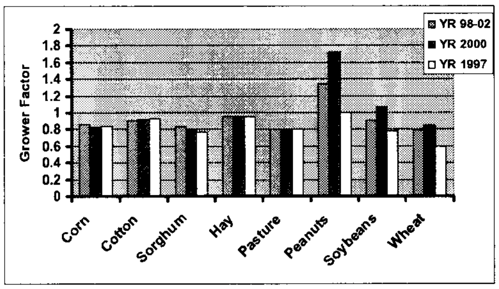
Comparison of Grower Factor Values



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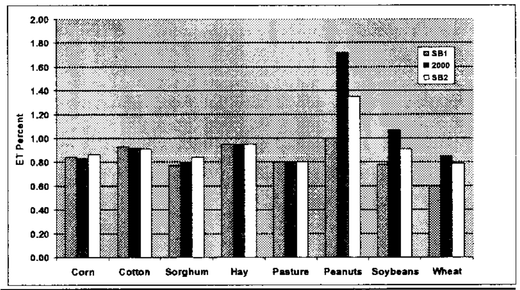
ET Percentages, SB1, 2000 & SB2



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Seasonal Periods and Crop Categories Used in Effective Rainfall Calculations

Crop	Season Used in Crop ET Calculations	Season Used in Effective Rainfall (ER)	# of Months Used in ER Calculations
Corn	April 15-October 15	April 15-August 15	4
Cotton	May 15-October 15	May 15-October 15	5
Sorghum	May 15-October 15	May 15-October 15	5
Hay	April 1-November 1	April 1-November 1	7
Pasture	April 1-November 1	April 1-November 1	7
Peanuts	May 1-November 1	May 1-November 1	6
Soybeans	June 1-November 1	June 1-November 1	5
Wheat	October 1-July 1	October 1-July 1	9

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2000 Yr. Water Demand Estimates

County	2000 Survey PIA, acres	2000 Survey Total Irr Demand,ac-ft	County App. Avg, in/pia
ARMSTRONG	12,866	23,428	21.85
CARSON	96,111	140,778	17.58
CHILDRESS	10,096	17,491	20.79
COLLINGSWORTH	23,241	34,736	17.94
DALLAM	270,781	344,118	15.25
DONLEY	22,212	31,225	16.87
GRAY	21,494	22,869	12.77
HALL	18,142	27,186	17.98
HANSFORD	155,538	227,688	17.57
HARTLEY	215,464	359,671	20.03
HEMPHILL	3,065	3,590	14.06
HUTCHINSON	43,331	68,502	18.97
LIPSCOMB	29,010	34,414	14.24
MOORE	155,856	242,323	18.66
OCHILTREE	98,953	128,487	15.58
OLDHAM	4,979	8,259	19.90
POTTER	6,225	12,708	24.50
RANDALL	27,310	40,399	17.75
ROBERTS	8,000	9,283	13.92
SHERMAN	235,899	360,143	18.32
WHEELER	9,244	13,557	17.60
Total	1,467,817	2,150,854	17.58

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2000 "LTA" Water Demand Estimates

County	2000 Survey PIA, acres	2000 Survey Total Irr Demand,ac-ft	County App. Avg, in/pia
ARMSTRONG	12,866	17,738	16.54
CARSON	96,111	96,750	12.08
CHILDRESS	10,096	12,011	14.28
COLLINGSWORTH	23,241	26,744	13.81
DALLAM	270,781	355,287	15.74
DONLEY	22,212	27,192	14.69
GRAY	21,494	20,133	11.24
HALL	18,142	20,936	13.85
HANSFORD	155,538	178,453	13.77
HARTLEY	215,464	293,884	16.37
HEMPHILL	3,065	3,504	13.72
HUTCHINSON	43,331	51,039	14.13
LIPSCOMB	29,010	33,679	13.93
MOORE	155,856	181,154	13.95
OCHILTREE	98,953	110,555	13.41
OLDHAM	4,979	5,717	13.78
POTTER	6,225	9,919	19.12
RANDALL	27,310	29,332	12.89
ROBERTS	8,000	7,910	11.87
SHERMAN	235,899	298,819	15.20
WHEELER	9,244	12,003	15.58
Total	1,467,817	1,792,757	14.66

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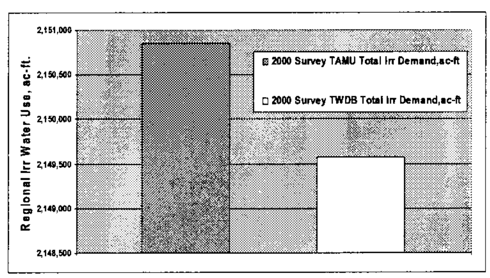
Regional Irrigation Water Use Demand Estimates



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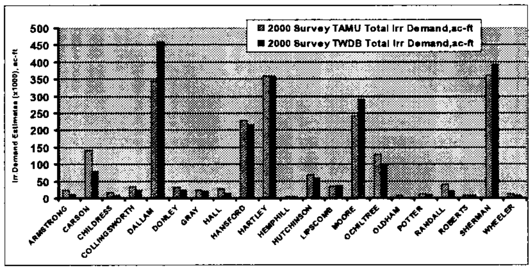
Comparison of Irrigation Water Use Demand Estimates



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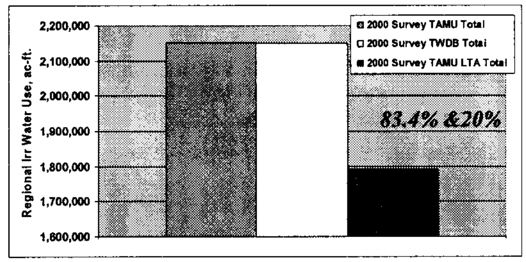
Regional (Total) Irrigation Water Use Demand Estimates



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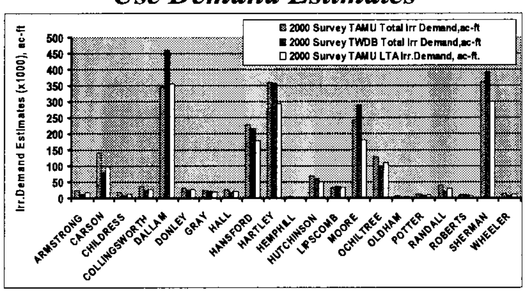
Comparison of Irrigation Water Use Demand Estimates



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Region A Livestock Water Use

Ag Sub Sub Committee

John Sweeten
Ben Weinheimer

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Region A Livestock Water Use Objective

Review/revise as needed in SB1---

Current inventory numbers
Water use per animal
Future Projections

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Region A Livestock Water Use 2000 Inventory Numbers

Significant differences exist between TAMU & TWDB in 2000 Region A & county inventories:

Hogs

Fed Cattle

Horses

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Region A Livestock Water Use
TAMU Inventory Calculations

2000 Hog Inventory

Problem: No county level estimates available from TASS/NASS.

SB1 inventory by county adjusted for the increase in hog numbers reported by TASS in the 1-N crop reporting region.

$SB1_C$ * TASS 2000 1-N / $SB1_A$ = $SB2_C$

Validated by: TASS/TCEQ Permits
Hog Producer Focus Group

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Region A Livestock Water Use
TAMU Inventory Calculations

2000 Fed Cattle Inventory

Problem: No county level fed cattle inventory estimates available from TASS/NASS.

1999 feedlot capacity by county was inflated 2% to estimate 2000 capacity and then adjusted by the "occupancy rate" (85%) to estimate fed cattle inventory by county.

Sources/validation: Xcel, TASS, TCEQ, TCE, John Sweeten, Ben Weinheimer

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Region A Livestock Water Use
TAMU Inventory Calculations

2000 Horse Inventory

Problem: Only state level horse inventories are estimated by TASS.

County estimates of horse inventory provided in the 1997 Census of Agriculture were adjusted by multiplying the TASS 2000 state inventory divided by the Census state inventory to arrive at the 2000 Region A county horse estimates.

Validation: None

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Region A Livestock Water Use
TAMU Inventory Calculations
Water Use per Animal

Water use estimates developed in Region A under SB1 (and by the rest of the state) were left the same for SB2 with the exception of hogs and dairy.

A focus group of hog and dairy representatives was utilized to evaluate water use and projection numbers.

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Region A Livestock Water Use
Hog/Dairy Focus Group Participants

Participant	Organization
Greg Goode	Texas Farm
Pete Gibbs	Dairy Farmers of America
Norman Mullin	Permit Consultant
Craig Rohrbach	PSF
Jodi Sterle	TAMU-Swine Specialist
Ken Horton	TPPA
John Sweeten	TAES
Ben Weinheimer	TCFA

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Region A Livestock Water Use
Water Use Per Animal

	SB1	SB2
	(gal/animal/day)	
Swine	11	5*
Dairy	75	65

*Dallam county calculated at 8.5 gal/hog/day for 2000 inventory due to flushing systems. Future inventory additions are assumed to utilize 5 gal/hog/day due to pull plug systems.

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Region A Livestock Water Use SB2 Projections

Timeframe: 2000 – 2060.

Projections for beef cows, horses and poultry remain unchanged from SB1.

Projections for stocker cattle, fed cattle, hogs and dairy were modified.

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Region A Livestock Water Use SB2 Projections

	SB1	SB2
Stocker Cattle:	—annual growth rate—	
2000-2060	1.00%	0.50%
Fed Cattle:		
1999-2010	1.00%	2.00%
2010-2020	1.15%	1.15%
2020-2060	0.60%	0.60%

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2002 Swine Head Count

County	TCEQ	Existing	Permitted	Pending	Total
Armstrong					
Carson					
Childress					
Collingsworth					
Dallam		1,145,000	220,000	939,826	2,304,826
Donley					
Gray			50,000		50,000
Hall					
Hansford		44,576			44,576
Hartley				197,670	197,670
Hemphill					
Hutchinson					
Lipscomb					
Moore		17,800	264,600		282,400
Ochiltree		371,974			371,974
Oldham					
Potter					
Randall		4,320	(inactive)		4,320
Roberts					
Sherman		191,880	1,012,000	1,099,600	2,303,480
Wheeler					
Total		1,775,550	1,546,600	2,237,096	5,559,246

*Source: TCEQ. Counties left blank were not listed in the TCEQ swine reports.

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Region A Livestock Water Use SB2 Projections

Swine Focus Group Results: If processing facility is built, growth will be rapid & then flatten out - unless another processing facility is built. Estimate inventory to level out at current permit capacity.

Swine

	SB1	SB2
1999-2010	8.60% AGR	57.50% of the permit capacity plus 10,000 unit in Hemphill County
2010-2020	1.50% AGR	100% of all permits
2020-2060	1.50% AGR	0.00%

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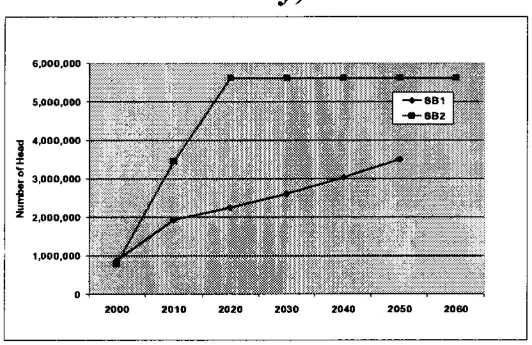
Swine Inventory, SB1 & SB2



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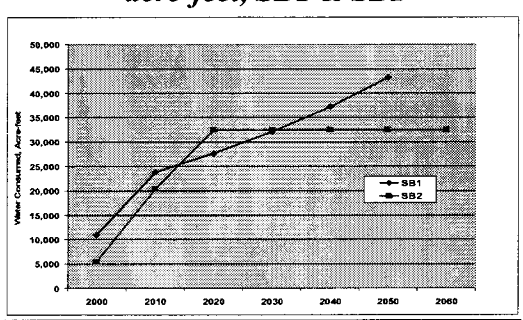
Swine Water Consumption Estimate, acre-feet, SB1 & SB2



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2002 Dairy Head Count

County	TCEQ	Existing	Permitted	Pending	Total
Armstrong					
Carson					
Childress					
Collingsworth					
Dallam		700	11,400		12,100
Donley					
Gray		6,400			6,400
Hall					
Hansford					
Hartley		25,000	26,400	60,000	111,400
Hemphill					
Hutchinson		7,560			7,560
Lipscomb				2,800	2,800
Moore			10,000		10,000
Ochiltree					
Oldham					
Potter					
Randall		1,150			1,150
Roberts					
Sherman					
Wheeler					
Total		40,810	47,800	62,800	151,410

*Source: TCEQ. Counties left blank were not listed in the dairy reports.

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Region A Livestock Water Use SB2 Projections

Focus Group Results: Dairy growth will be limited to areas west of Highway 287 & not as strong as the growth south of I-40.

Dairies

	SB1	SB2
1999-2010	8.60%	28.75% of permit capacity; add 4,000 cow units to Sherman & Oldham.
2010-2020	2.25%	57.50% of current permit numbers.
2020-2060	1.40%	0.00%

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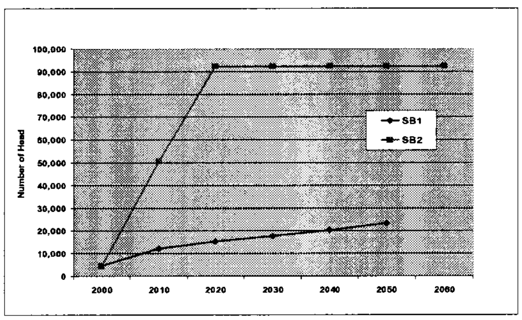
Dairy Inventory, SB1 & SB2



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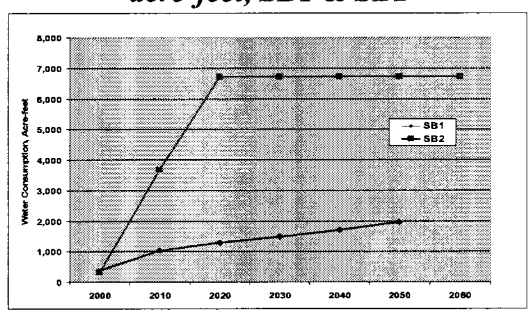
Dairy Water Consumption Estimate, acre-feet, SB1 & SB2



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Region A Livestock Inventory Projections for SB1 (2050) & SB2 (2060)

	SB1	SB2
Beef: Cows	220,000	237,000
Beef: Fed Cattle	2,010,487	2,052,513
Beef: Stockers	1,754,403	1,374,477
Dairy Cattle	23,364	92,425
Horses	16,882	45,066
Poultry	2,516,000	2,516,000
Swine	3,507,818	5,611,617

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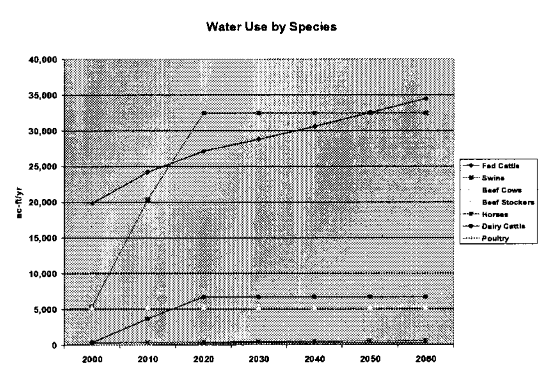

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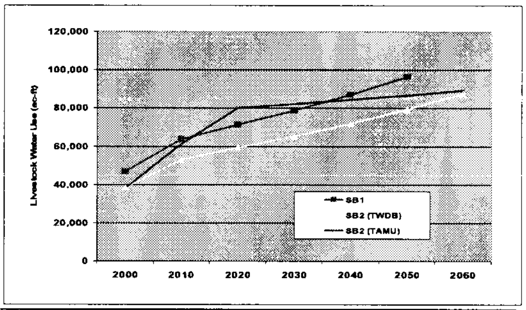
Comparison Livestock Water Use, SB1, SB2 (TWDB) & SB2 (TAMU)



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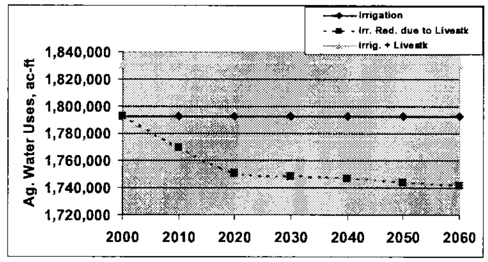
Constant Ag. Aquifer Withdrawal Analysis



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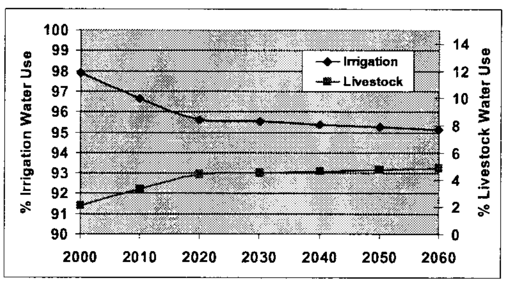
Irrigation versus Livestock Water Use Percentages of Ag. Water



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Recommendations Needed from Committee:

- **Determine/accept procedure for calculating inventory numbers.**
- **Determine/accept water use per animal.**
- **Future projections.**

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APPENDIX B

TEXAS A&M UNIVERSITY SENATE BILL 2
REGION A PROJECTED LIVESTOCK INVENTORY AND WATER USE
BY COUNTY AND REGION, 2000-2060

Table 9. PROJECTED FUTURE LIVESTOCK NUMBERS & WATER USE--Stocker Beef Cattle, Winter Pasture Operations (5 months/year)

	Stocker Cattle -- Winter Pasture							2000				2010					2020				
								Stockers	Water Use, Stocker Cattle--->			Stockers	Water use,	Water Use, Stocker Cattle--->			Stockers	Water use,	Water Use, Stocker Cattle--->		
County	2000	2010	2020	2030	2040	2050	2060	Head	gal/day	gal/hd/yr	ac-ft/yr	Head	gal/hd/day	gal/day	gal/hd/yr	ac-ft/yr	Head	gal/hd/day	gal/day	gal/hd/yr	ac-ft/yr
1 Armstrong	15,420	16,209	17,037	17,909	18,825	19,787	20,799	15,420	185,040.0	1,825	86.4	16,209	12	194,503.0	1,825	90.8	17,037	12	204,449.9	1,825	95.4
2 Carson	46,445	48,820	51,317	53,941	56,700	59,599	62,647	46,445	557,340.0	1,825	260.1	48,820	12	585,842.4	1,825	273.4	51,317	12	615,802.5	1,825	287.4
3 Childress	11,357	11,938	12,548	13,190	13,865	14,574	15,319	11,357	136,284.0	1,825	63.6	11,938	12	143,253.6	1,825	66.9	12,548	12	150,579.6	1,825	70.3
4 Collingsworth	18,567	19,517	20,515	21,564	22,666	23,826	25,044	18,567	222,804.0	1,825	104.0	19,517	12	234,198.2	1,825	109.3	20,515	12	246,175.2	1,825	114.9
5 Dallam	77,692	81,665	85,842	90,231	94,846	99,696	104,795	77,692	932,304.0	1,825	435.1	81,665	12	979,982.1	1,825	457.4	85,842	12	1,030,098.6	1,825	480.8
6 Donley	3,410	3,584	3,768	3,960	4,163	4,376	4,600	3,410	40,920.0	1,825	19.1	3,584	12	43,012.7	1,825	20.1	3,768	12	45,212.3	1,825	21.1
7 Gray	29,585	31,098	32,688	34,360	36,117	37,964	39,906	29,585	355,020.0	1,825	165.7	31,098	12	373,175.8	1,825	174.2	32,688	12	392,260.0	1,825	183.1
8 Hall	3,245	3,411	3,585	3,769	3,961	4,164	4,377	3,245	38,940.0	1,825	18.2	3,411	12	40,931.4	1,825	19.1	3,585	12	43,024.6	1,825	20.1
9 Hansford	105,594	110,994	116,670	122,637	128,909	135,501	142,430	105,594	1,267,128.0	1,825	591.4	110,994	12	1,331,929.1	1,825	621.7	116,670	12	1,400,044.1	1,825	653.4
10 Hartley	27,263	28,657	30,123	31,663	33,283	34,985	36,774	27,263	327,156.0	1,825	152.7	28,657	12	343,886.8	1,825	160.5	30,123	12	361,473.2	1,825	168.7
11 Hemphill	6,469	6,800	7,148	7,513	7,897	8,301	8,726	6,469	77,628.0	1,825	36.2	6,800	12	81,597.9	1,825	38.1	7,148	12	85,770.8	1,825	40.0
12 Hutchinson	17,107	17,982	18,901	19,868	20,884	21,952	23,075	17,107	205,284.0	1,825	95.8	17,982	12	215,782.3	1,825	100.7	18,901	12	226,817.4	1,825	105.9
13 Lipscomb	25,801	27,120	28,507	29,965	31,498	33,109	34,802	25,801	309,612.0	1,825	144.5	27,120	12	325,445.6	1,825	151.9	28,507	12	342,088.9	1,825	159.7
14 Moore	43,892	46,137	48,496	50,976	53,583	56,323	59,204	43,892	526,704.0	1,825	245.8	46,137	12	553,639.7	1,825	258.4	48,496	12	581,952.9	1,825	271.6
15 Ochiltree	51,464	54,096	56,862	59,770	62,827	66,040	69,417	51,464	617,568.0	1,825	288.2	54,096	12	649,150.5	1,825	303.0	56,862	12	682,348.2	1,825	318.5
16 Oldham	37,327	39,236	41,242	43,352	45,569	47,899	50,349	37,327	447,924.0	1,825	209.1	39,236	12	470,830.9	1,825	219.8	41,242	12	494,909.2	1,825	231.0
17 Potter	9,909	10,416	10,948	11,508	12,097	12,715	13,366	9,909	118,908.0	1,825	55.5	10,416	12	124,989.0	1,825	58.3	10,948	12	131,380.9	1,825	61.3
18 Randall	44,959	47,258	49,675	52,215	54,886	57,693	60,643	44,959	539,508.0	1,825	251.8	47,258	12	567,098.5	1,825	264.7	49,675	12	596,100.0	1,825	278.2
19 Roberts	7,240	7,610	7,999	8,409	8,839	9,291	9,766	7,240	86,880.0	1,825	40.5	7,610	12	91,323.1	1,825	42.6	7,999	12	95,993.3	1,825	44.8
20 Sherman	57,215	60,141	63,217	66,450	69,848	73,420	77,174	57,215	686,580.0	1,825	320.4	60,141	12	721,691.8	1,825	336.8	63,217	12	758,599.2	1,825	354.1
21 Wheeler	6,985	7,342	7,718	8,112	8,527	8,963	9,422	6,985	83,820.0	1,825	39.1	7,342	12	88,106.6	1,825	41.1	7,718	12	92,612.3	1,825	43.2
																0.0					
Total	646,946	680,031	714,808	751,363	789,788	830,178	872,633	646,946	7,763,352.0		3,623.4	680,031		8,160,370.8		3,808.7	714,808		8,577,693.3		4,003.5

Note: Assumes 0.5 %/year growth in this beef cattle industry sector, 2000-2060.

Table 10. PROJECTED FUTURE LIVESTOCK NUMBERS & WATER USE--Poultry, Laying Hens or Broilers

	Poultry							2000					2010					2020			
								Poultry	Water use,	Water Use, Poultry			Poultry	Water use,	Water Use, Poultry			Poultry	Water use,	Water Use, Poultry	
County	2000	2010	2020	2030	2040	2050	2060	Head	gal/hd/day	gal/day	gal/hd/yr	ac-ft/yr	Head	gal/hd/day	gal/day	gal/hd/yr	ac-ft/yr	Head	gal/hd/day	gal/day	ac-ft/yr
1 Armstrong	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
2 Carson	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
3 Childress	1,000	1,000	500,000	500,000	500,000	500,000	500,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	500,000	0.09	45,000.0	50.4
4 Collingsworth	1,000	1,000	500,000	500,000	500,000	500,000	500,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	500,000	0.09	45,000.0	50.4
5 Dallam	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
6 Donley	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
7 Gray	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
8 Hall	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
9 Hansford	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
10 Hartley	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
11 Hemphill	1,000	1,000	500,000	500,000	500,000	500,000	500,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	500,000	0.09	45,000.0	50.4
12 Hutchinson	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
13 Lipscomb	1,000	1,000	500,000	500,000	500,000	500,000	500,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	500,000	0.09	45,000.0	50.4
14 Moore	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
15 Ochiltree	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
16 Oldham	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
17 Potter	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
18 Randall	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
19 Roberts	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
20 Sherman	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	0.1
21 Wheeler	1,000	1,000	500,000	500,000	500,000	500,000	500,000	1,000	0.09	90.0	32.85	0.1	1,000	0.09	90.0	32.85	0.1	500,000	0.09	45,000.0	50.4
																	0.0				
Total	21,000	21,000	2,516,000	2,516,000	2,516,000	2,516,000	2,516,000	21,000		1,890.0		2.1	21,000		1,890.0		2.1	2,516,000		226,440.0	253.6

Note: Assumed growth in counties on the eastern side of the Panhandle, closest to urban markets.
Modular growth in economic units of half-million birds or larger would be expected.

TABLE 11. SUMMARY OF LIVESTOCK WATER USE PROJECTIONS, 2000-2060, PANHANDLE WATER PLANNING GROUP (21 Counties). (Cont'd)

2050

Cattle Feedlots ac-ft/yr	Swine ac-ft/yr	Beef Cows ac-ft/yr	Beef Stockers----- Summer ac-ft/yr	Beef Stockers----- Winter ac-ft/yr	Horses ac-ft/yr	Dairy Cattle ac-ft/yr	Poultry ac-ft/yr	Total, all Species ac-ft/yr
157.2	0.9	134.4	313.9	110.8	17.0	0.0	0.1	734.4
345.4	2.8	246.4	279.3	333.8	10.7	0.0	0.1	1,218.6
0.0	0.0	201.6	16.4	81.6	15.4	0.0	50.4	365.5
0.0	0.5	336.0	146.2	133.4	38.4	0.0	50.4	705.0
3,644.8	13,930.5	224.0	213.4	558.4	24.5	506.6	0.1	19,102.4
714.7	0.9	470.5	188.9	24.5	40.8	0.0	0.1	1,440.4
1,667.6	224.0	268.8	139.6	212.6	36.4	267.9	0.1	2,817.2
0.0	3.0	246.4	31.9	23.3	7.2	0.0	0.1	311.9
4,788.3	249.7	134.4	181.3	758.9	30.7	0.0	0.1	6,143.4
4,693.0	1,107.1	224.0	397.4	195.9	23.3	4,454.5	0.1	11,095.5
1,214.9	56.0	403.3	253.8	46.5	36.4	0.0	50.4	2,061.3
345.4	0.2	134.4	178.1	122.9	25.5	316.5	0.1	1,123.2
19.1	224.0	224.0	179.5	185.4	16.4	117.2	50.4	1,016.1
3,385.2	1,581.7	134.4	153.4	315.5	15.1	418.7	0.1	6,004.0
2,549.0	2,083.3	201.6	43.4	369.9	21.3	0.0	0.1	5,268.6
1,167.3	0.6	268.8	547.2	268.3	25.8	291.2	0.1	2,569.4
61.9	3.5	112.0	326.2	71.2	23.9	0.0	0.1	598.9
3,216.0	24.2	224.0	180.7	323.1	72.6	65.5	0.1	4,106.4
0.0	56.0	179.2	391.2	52.0	15.5	0.0	0.1	694.1
3,513.8	12,901.3	156.8	59.1	411.2	13.0	291.2	0.1	17,346.5
1,000.5	0.9	784.1	57.5	50.2	38.3	0.0	50.4	1,981.9
32,484.4	32,451.1	5,309.5	4,278.3	4,649.6	548.4	6,729.4	253.6	86,704.5

2060

Cattle Feedlots ac-ft/yr	Swine ac-ft/yr	Beef Cows ac-ft/yr	Beef Stockers----- Summer ac-ft/yr	Beef Stockers----- Winter ac-ft/yr	Horses ac-ft/yr	Dairy Cattle ac-ft/yr	Poultry ac-ft/yr	Total, all Species ac-ft/yr
166.9	0.9	134.4	330.0	116.5	18.8	0.0	0.1	767.6
366.7	2.8	246.4	293.6	350.9	11.8	0.0	0.1	1,272.3
0.0	0.0	201.6	17.3	85.8	17.0	0.0	50.4	372.1
0.0	0.5	336.0	153.7	140.3	42.4	0.0	50.4	723.3
3,869.5	13,930.5	224.0	224.3	586.9	27.1	506.6	0.1	19,369.1
758.7	0.9	470.5	198.6	25.8	45.0	0.0	0.1	1,499.6
1,770.4	224.0	268.8	146.8	223.5	40.2	267.9	0.1	2,941.8
0.0	3.0	246.4	33.5	24.5	8.0	0.0	0.1	315.5
5,083.5	249.7	134.4	190.5	797.7	33.9	0.0	0.1	6,489.8
4,982.3	1,107.1	224.0	417.7	206.0	25.8	4,454.5	0.1	11,417.5
1,289.8	56.0	403.3	266.8	48.9	40.2	0.0	50.4	2,155.4
366.7	0.2	134.4	187.2	129.2	28.2	316.5	0.1	1,162.6
20.2	224.0	224.0	188.7	194.9	18.1	117.2	50.4	1,037.7
3,593.9	1,581.7	134.4	161.2	331.6	16.7	418.7	0.1	6,238.2
2,706.1	2,083.3	201.6	45.6	388.8	23.5	0.0	0.1	5,449.1
1,239.3	0.6	268.8	575.2	282.0	28.5	291.2	0.1	2,685.7
65.8	3.5	112.0	342.9	74.9	26.4	0.0	0.1	625.6
3,414.3	24.2	224.0	189.9	339.6	80.2	65.5	0.1	4,338.0
0.0	56.0	179.2	411.2	54.7	17.1	0.0	0.1	718.4
3,730.4	12,901.3	156.8	62.1	432.2	14.3	291.2	0.1	17,588.5
1,062.2	0.9	784.1	60.4	52.8	42.3	0.0	50.4	2,053.1
34,487.0	32,451.1	5,309.5	4,497.1	4,887.4	605.8	6,729.4	253.6	89,221.0