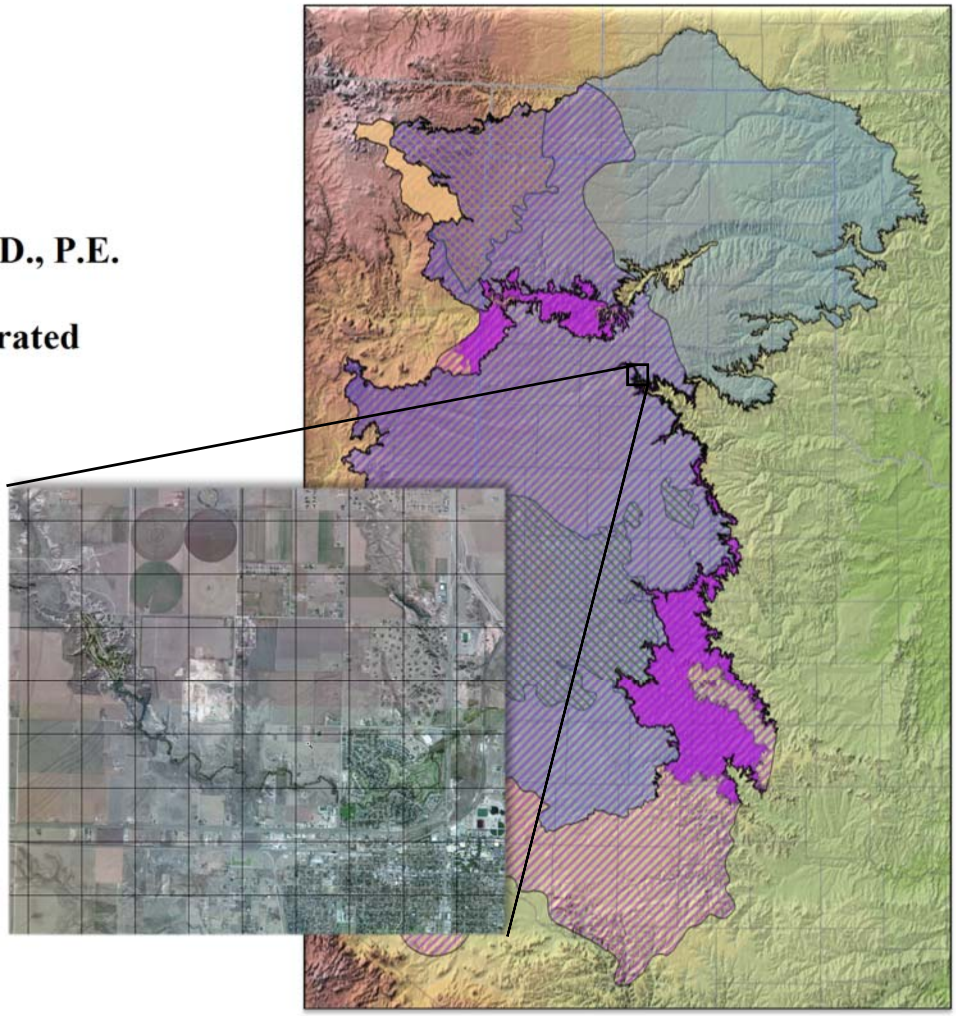
Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model



Prepared by

Neil E. Deeds, Ph.D., P.E.
Marius Jigmond
INTERA Incorporated

Prepared for:

Texas Water Development Board
P.O. Box 13231, Capitol Station
Austin, Texas 78711-3231

August 2015

Texas Water Development Board

Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model

Editors

Neil E. Deeds, Ph.D., P.E.
Marius Jigmond
INTERA Incorporated

August 2015

This page is intentionally blank.

Geoscientist and Engineer Seals

This report documents the work of the following Licensed Texas Professional Engineer:

NEIL E. DEEDS
92741

Neil E. Deeds, P.E.

Dr. Deeds was the Project Manager for this work and was responsible for development of the numerical model.

Neil Deeds

Signature

2015/8/27

Date

This page intentionally left blank.

Table of Contents

List of Appendices

List of Figures

List of Tables

This page intentionally left blank

Executive Summary

This report documents the construction and calibration of the numerical groundwater availability model for the High Plains Aquifer System, and is targeted primarily to those with experience constructing and/or using groundwater models. The numerical model was developed as part of the Texas Water Development Board's groundwater availability model program. The purpose of the High Plains Aquifer System model is to provide a tool for managing the groundwater resources in the study area.

The High Plains Aquifer System in Texas consists of the southern and northern portions of the major Ogallala Aquifer (including the minor Rita Blanca Aquifer), the minor Edwards-Trinity (High Plains) Aquifer, and the minor Dockum Aquifer. In the south, the Dockum Aquifer is overlain by portions of the Pecos Valley and Edwards-Trinity (Plateau) aquifers. The Pecos Valley and Edwards-Trinity (Plateau) aquifers are not explicitly modeled as part of the High Plains Aquifer System.

The code used to implement the numerical model was MODFLOW-NWT. The model consists of four layers, and the model grid is composed of uniformly spaced half-mile square grid cells. The model simulates the time period from 1930 to 2012, with an initial steady-state stress period that represents pre-development conditions. The model was primarily calibrated to observed heads in the four aquifers. It was calibrated to both steady-state and transient conditions. Both the steady-state and transient calibration statistics are well within acceptable ranges.

In the steady-state calibration, recharge is the major source of inflow to the Ogallala Aquifer, and discharge to rivers is the largest source of outflow. In the transient model, by 1940 pumping has become the largest outflow component, and by 1942 removal of water from storage has become the largest inflow component. Discharge to rivers decreases from over 500,000 acre-feet per year to less than 300,000 acre-feet per year over the course of the transient simulation. Although recharge increases through time due to agricultural activity, this does not significantly offset the increased production. Cross-formational flow is not a significant component of the Ogallala Aquifer water budget.

In contrast, cross-formational flow is a significant component of the minor aquifer water budgets. Cross-formational flow from the Ogallala Aquifer is the largest inflow component for

both the Rita Blanca and Edwards-Trinity (High Plains) aquifers, both pre- and post-development. Removal of water from storage is the largest inflow component of the upper and lower Dockum Aquifer water budgets post-development, although it is nearly matched by recharge in the lower Dockum Aquifer.

A sensitivity analysis was performed, which indicated the horizontal hydraulic conductivity was an important parameter for all of the aquifers except the upper Dockum Aquifer, which was more sensitive to vertical hydraulic conductivity. Heads in the unconfined Ogallala Aquifer were sensitive to pumping rate and specific yield in places where significant pumping has occurred. Drawdown in the minor aquifers was more sensitive to hydraulic conductivity. Steady-state heads in the Ogallala Aquifer are sensitive to recharge rate.

All groundwater models have limitations with respect to data support, scale, and the assumptions used in their development. However, the development documented in this report resulted in a well-calibrated model of the High Plains Aquifer System in Texas that can be used to support water availability planning at a regional scale.

1.0 Introduction and Purpose of Model

1.1 Introduction

The Texas Water Development Board (TWDB) has identified the major and minor aquifers in Texas on the basis of regional extent and amount of water produced. The major and minor aquifers are shown in Figures 1.0.1 and 1.0.2, respectively. General discussion of the major and minor aquifers is given in Ashworth and Hopkins (1995). Aquifers that supply large quantities of water over large areas of the state are defined as major aquifers and those that supply relatively small quantities of water over large areas of the state or supply large quantities of water over small areas of the state are defined as minor aquifers.

The boundaries of the aquifers comprising the High Plains Aquifer System are shown in Figure 1.0.3. The High Plains Aquifer System in Texas consists of the southern and northern portions of the major Ogallala Aquifer (including the minor Rita Blanca Aquifer), the minor Edwards-Trinity (High Plains) Aquifer, and the minor Dockum Aquifer. In the south, the Dockum Aquifer is overlain by portions of the Pecos Valley and Edwards-Trinity (Plateau) aquifers. The Pecos Valley and Edwards-Trinity (Plateau) aquifers are not explicitly modeled as part of the High Plains Aquifer System.

This report documents the construction and calibration of the numerical groundwater availability model for the High Plains Aquifer System. A previous report (Deeds and others, 2015) documented the conceptual model development for the High Plains Aquifer System groundwater availability model. While the conceptual model report is written in a style that should be accessible to most interested stakeholders, this numerical model report is targeted primarily to those with experience constructing and/or using groundwater models.

1.2 Purpose of the Model

The Texas Water Code codified the requirement for generation of a State Water Plan that allows for the development, management, and conservation of water resources and the preparation and response to drought, while maintaining sufficient water available for the citizens of Texas (TWDB, 2007). Senate Bill 1 (75th Texas Legislative Session, 1997) and subsequent legislation directed the TWDB to coordinate regional water planning with a process based upon public participation. Also, as a result of Senate Bill 1, the approach to water planning in the state of

Texas has shifted from a water-demand based allocation approach to an availability-based approach.

Groundwater models provide a tool to estimate groundwater availability for various water use strategies and to determine the cumulative effects of increased water use and drought. A groundwater model is a numerical representation of the aquifer system capable of simulating historical conditions and predicting future aquifer conditions. Inherent to the groundwater model are a set of equations that are developed and applied to describe the primary or dominant physical processes considered to be controlling groundwater flow in the aquifer system. Groundwater models are essential for performing complex analyses and making informed predictions and related decisions (Anderson and Woessner, 1992).

Development of groundwater availability models for the major and minor Texas aquifers is integral to the state water planning process. The purpose of the groundwater availability model program is to provide a tool that can be used to develop reliable and timely information on groundwater availability for the citizens of Texas and to ensure adequate supplies or recognize inadequate supplies over a 50-year planning period. The groundwater availability models also serve as an integral part of the process of determining modeled available groundwater based on desired future conditions, as required by House Bill 1763 (79th Texas Legislative Session, 2005). The High Plains Aquifer System groundwater availability model will thus serve as a critical tool for groundwater planning in the state.

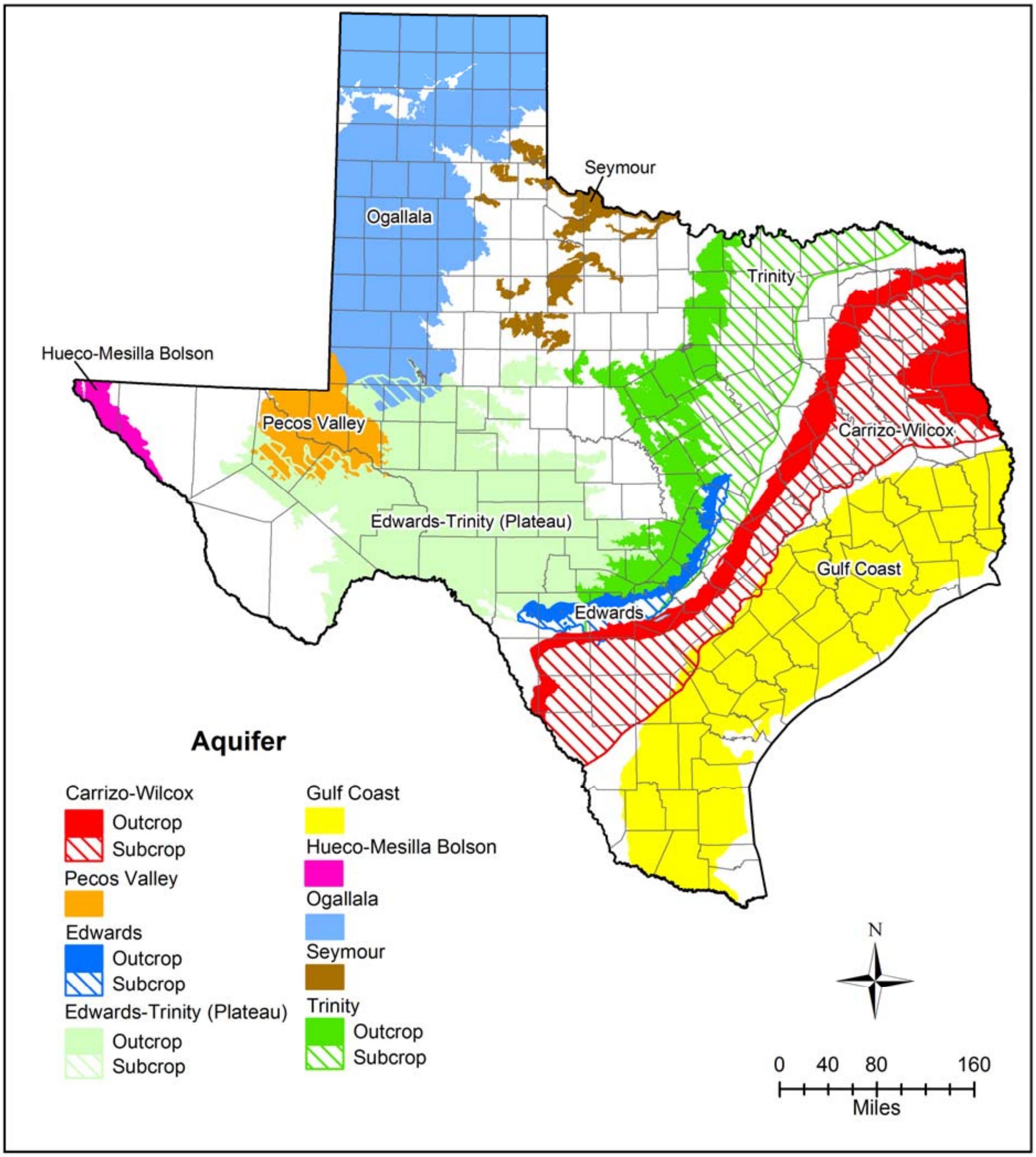


Figure 1.0.1 Location of major aquifers in Texas (TWDB, 2006a).

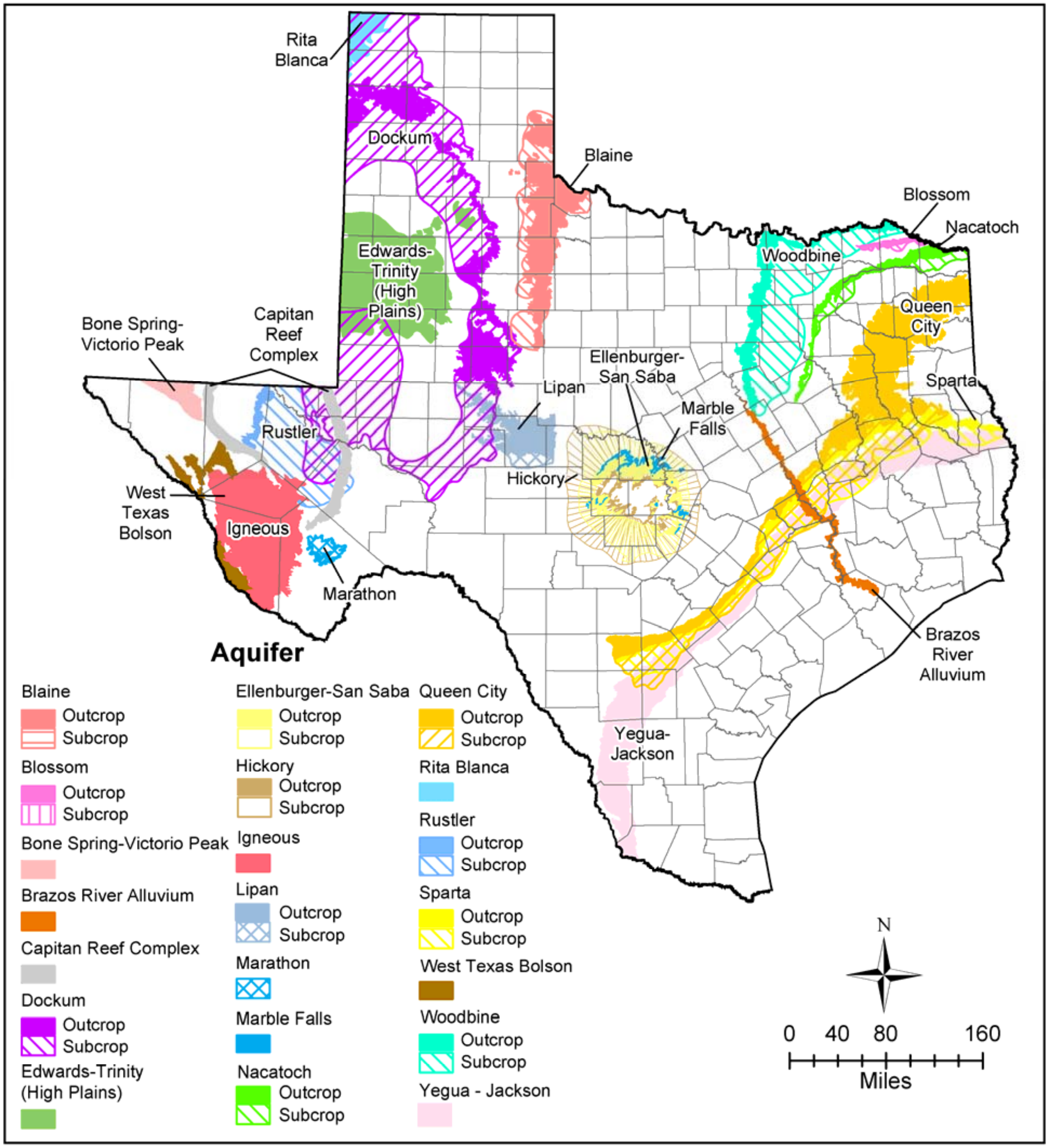


Figure 1.0.2 Location of minor aquifers in Texas (TWDB, 2006b).

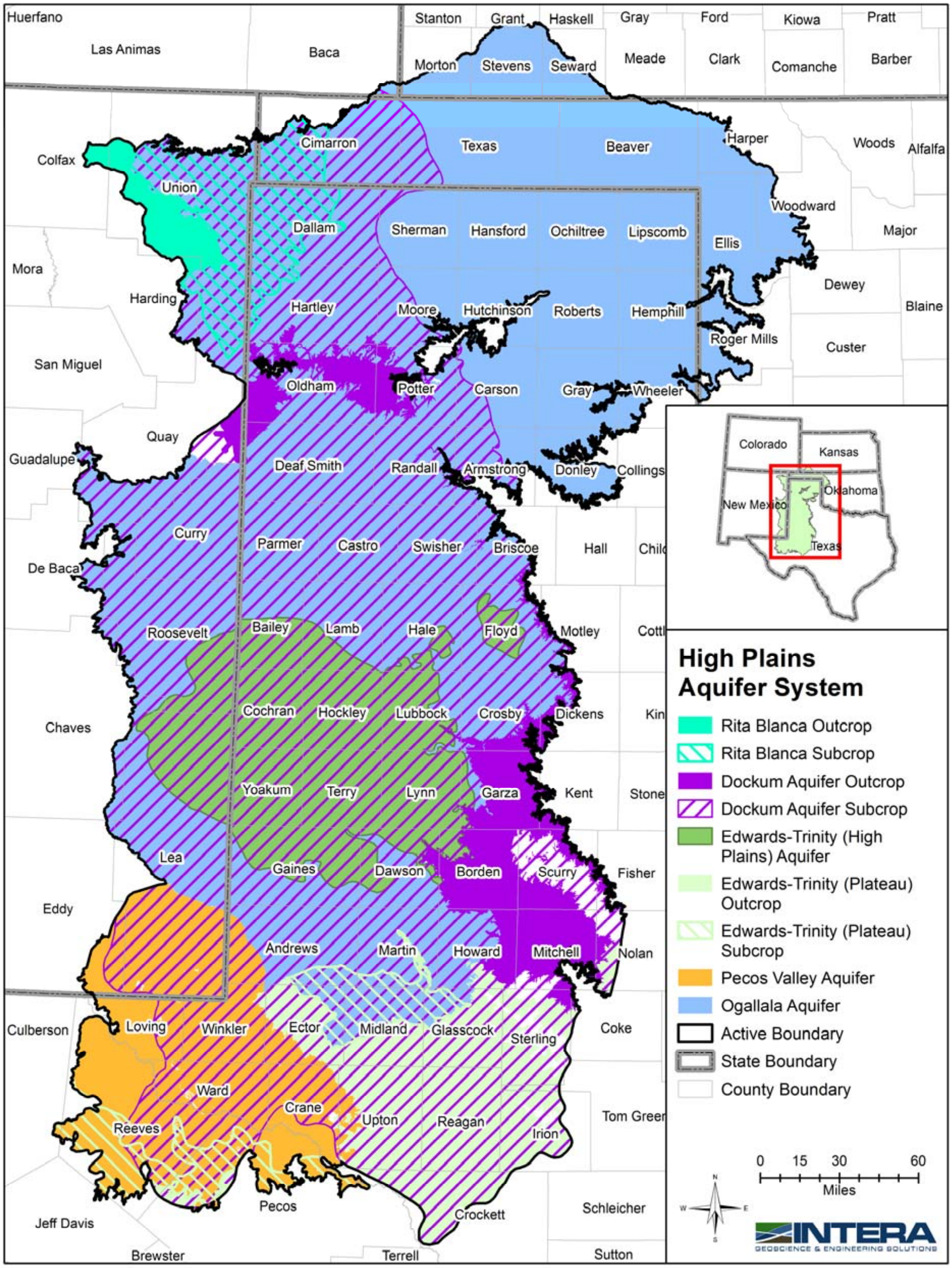


Figure 1.0.3 **Aquifers included in the High Plains Aquifer System groundwater availability model.**

This page intentionally left blank

2.0 Model Overview and Packages

The code selected for the groundwater model is MODFLOW-NWT (Niswonger and others, 2011). MODFLOW is a three-dimensional finite difference groundwater flow code which is supported by boundary condition packages to handle recharge, evapotranspiration, streams, springs and reservoirs. MODFLOW-NWT is an enhanced version of the MODFLOW family of codes developed and supported by the United States Geological Survey. The benefits of using MODFLOW for the current effort include: 1) MODFLOW incorporates the necessary physics of groundwater flow, 2) MODFLOW is the most widely accepted groundwater flow code in use today, 3) MODFLOW was written and is supported by the United States Geological Survey and is public domain, 4) MODFLOW is well documented (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996; Harbaugh and others, 2000; Harbaugh, 2005; Niswonger and others, 2011), and 5) MODFLOW has a large user group. Additionally, there are numerous graphical user interfaces that can be used to develop MODFLOW models and process model results.

The graphical user interface chosen in this case is Groundwater Vistas Version 6.1. The model was developed outside of the graphical user interface and then imported to Groundwater Vistas after calibration was complete, so the workflow for model creation did not necessarily follow any workflow prescribed by the use of that graphical user interface.

A MODFLOW model consists of grouping of input text files (also called “packages”) that describe various components of the groundwater flow system. The input packages and their corresponding filenames are shown in Table 2.0.1 below. The output files written by MODFLOW contain water levels (HDS), drawdown (DDN), water budget information (CBB) and a listing of the characteristics of the run (LST) as shown in Table 2.0.2. A description of the contents and changes to each of the input packages shown in Table 2.0.1 are included in the sections that follow.

Table 2.0.1 Summary of model input packages and filenames.

File Type Abbreviation	File Type	Input File Name
BAS6	Basic Package	hpas.bas
DIS	Discretization File	hpas.dis
DRN	Drain Package	hpas.drn
EVT	Evapotranspiration Package	hpas.evt
NWT	Newton Solver Package	hpas.nwt
OC	Output Control Option	hpas.oc
RCH	Recharge Package	hpas.rch
RIV	River Package	hpas.riv
UPW	Upstream-Weighting Package	hpas.upw
WEL	Well Package	hpas.wel

Table 2.0.2 Summary of model output packages and filenames.

File Type	Output File Name
Binary flow file	hpas.cbb
Binary drawdown file	hpas.ddn
Binary head file	hpas.hds
List file	hpas.lst

2.1 Basic Package

The MODFLOW Basic (suffix BAS) package is used to 1) specify which cells in each model layer are active or inactive, and 2) specify the starting water levels in the aquifers for the simulation. The Basic package can also be used to specify constant head cells.

The groundwater model of the High Plains Aquifer System in Texas represents the major Ogallala Aquifer, the minor Rita Blanca Aquifer, the minor Edwards-Trinity (High Plains) Aquifer, and the minor Dockum Aquifer. In the southern portion of the model domain, the Dockum Aquifer is overlain by portions of the Pecos Valley and Edwards-Trinity (Plateau) aquifers. The model has four layers: the Ogallala Aquifer and the Pecos Valley Aquifer compose layer 1, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer and the Edwards-Trinity (Plateau) Aquifer compose layer 2, the upper Dockum Group is represented by layer 3, and the lower Dockum Group is represented by layer 4.

The active and inactive model cells for each of the four layers are shown in Figure 2.1.1 through Figure 2.1.4. Active model cells are indicated with a positive value of the variable IBOUND, an input to the Basic package. Additional information about what each model cell represents was specified using the IBOUND values in Table 2.1.1. For example, the outcrop portion of an aquifer is indicated with a “1” in the second digit of the IBOUND value, and the downdip portion of an aquifer is indicated with a “2” in the second digit of the IBOUND value. Pass throughs were required where the Ogallala Aquifer (layer 1) directly overlays upper (layer 3) or lower Dockum Group (layer 4). Pass throughs are vertically thin model layers with little storage potential that allow for aquifer continuity where layers pinch out. Pass throughs by model layer are noted with a value of “3” or “4” in the second digit of the IBOUND value.

Grid cells were associated with each aquifer using the aquifer outlines and by selecting the grid centroids that fell within the aquifer outline. For any aquifer, cells that were connected through corner connections and small clusters of cells along the edges of the active model boundary were removed to enhance model convergence and improve stability of the model. Also, to improve model stability, starting heads for the steady-state model were set to land surface elevation to allow all model grid cells to start wet.

The types of model cells are shown in Figure 2.1.5a and Figure 2.1.5b. Model cell types include springs, escarpments, and draws represented with the drain package; rivers and general head boundaries represented with the river package; and evapotranspiration. All of these model cell types are forms of head-dependent flow boundaries, and are each discussed in the sections that follow. The bottom of the model represents the top of Permian, and is a no-flow boundary.

Table 2.1.1 Model stratigraphy and layering.

System	Formation		Aquifer	Model Layer		
				North	Central	South
Quaternary	Pecos Valley Alluvium		Pecos Valley			1(1)
Tertiary	Ogallala		Ogallala	1	1	
Cretaceous	Duck Creek (2)	Boracho(3)	Edwards – Trinity		2(2)	2(1, 3)
	Kiamichi (2)	Finlay(3)				
	Edwards (2)					
	Comanche Peak (2)					
	Walnut (2)					
	Antlers					
Jurassic	Morrison		Rita Blanca	2		
	Exeter					
Triassic	Cooper Canyon		Upper Dockum		3	3
	Trujillo					
	Tecovas		Lower Dockum	4	4	4
	Santa Rosa					
Permian	Dewey Lake			No Flow		
	Rustler		Rustler			

(1) While represented by model layers, the Edwards-Trinity (Plateau) and Pecos Valley aquifers contain head boundaries in all cells, and thus are not explicitly simulated in the model.
(2) Edwards-Trinity (High Plains) Aquifer is represented by layer 2 in the central portion of the domain.
(3) Edwards-Trinity (Plateau) Aquifer is represented by layer 2 in the southern portion of the domain.

Table 2.1.2 Summary of IBOUND values in the Basic package.

IBOUND Value	Model Layer	Aquifer	Subset of Aquifer	Comment
11	1	Ogallala	-	
21	1	Pecos Valley	-	Head boundary
31	2	Rita Blanca	Outcrop	
32	2	Rita Blanca	Downdip	
42	2	Edwards-Trinity (High Plains)	-	
51	2	Edwards-Trinity (Plateau)	Outcrop	Head boundary
52	2	Edwards-Trinity (Plateau)	Downdip	Head boundary
13	2	-	-	Pass throughs
14	2	-	-	Pass throughs
61	3	Upper Dockum	Outcrop	
62	3	Upper Dockum	Downdip	
24	3	-	-	Pass throughs
14	3	-	-	Pass throughs
71	4	Lower Dockum	Outcrop	
72	4	Lower Dockum	Downdip	

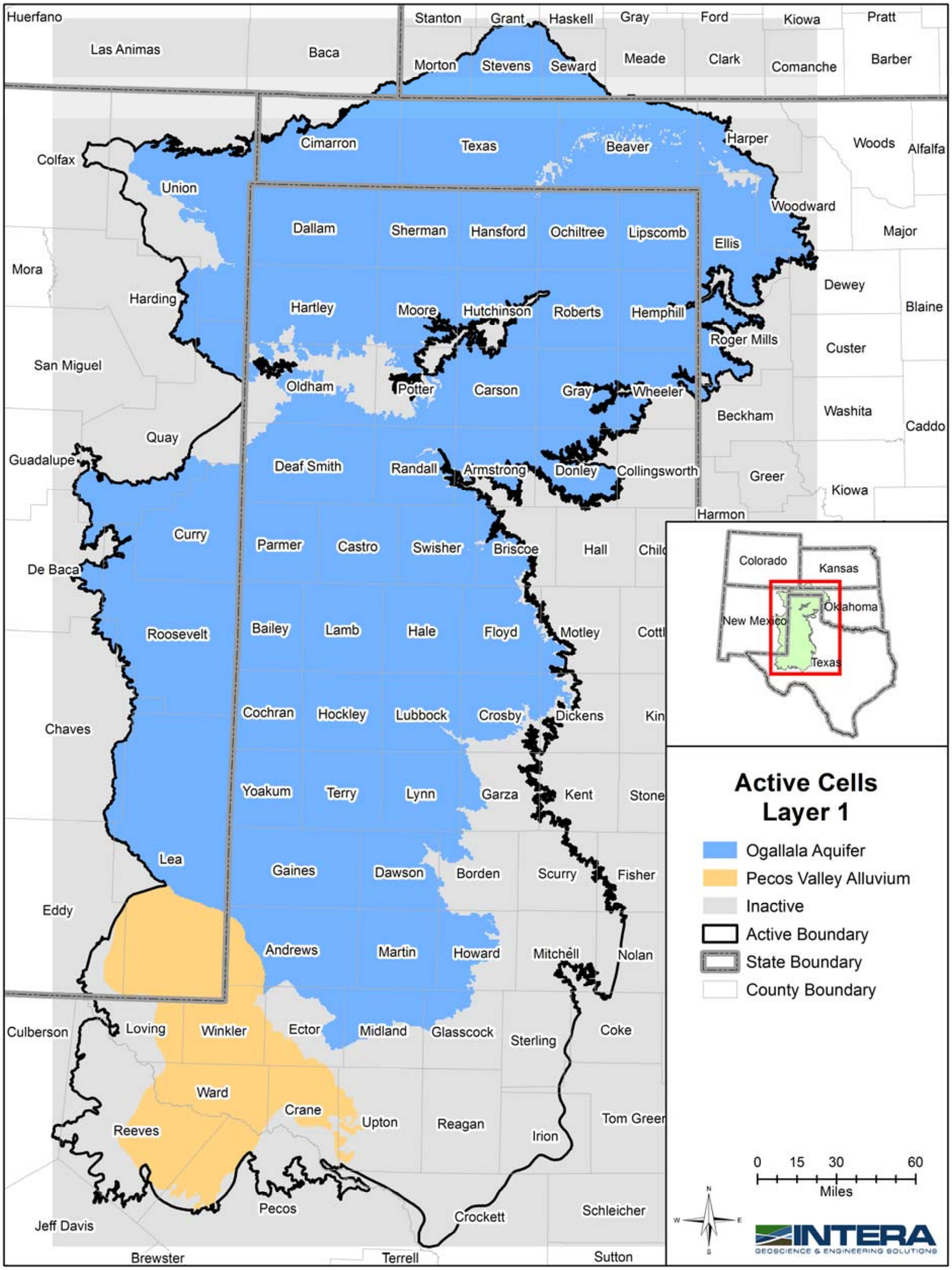


Figure 2.1.1 Layer 1 active/inactive model cells.

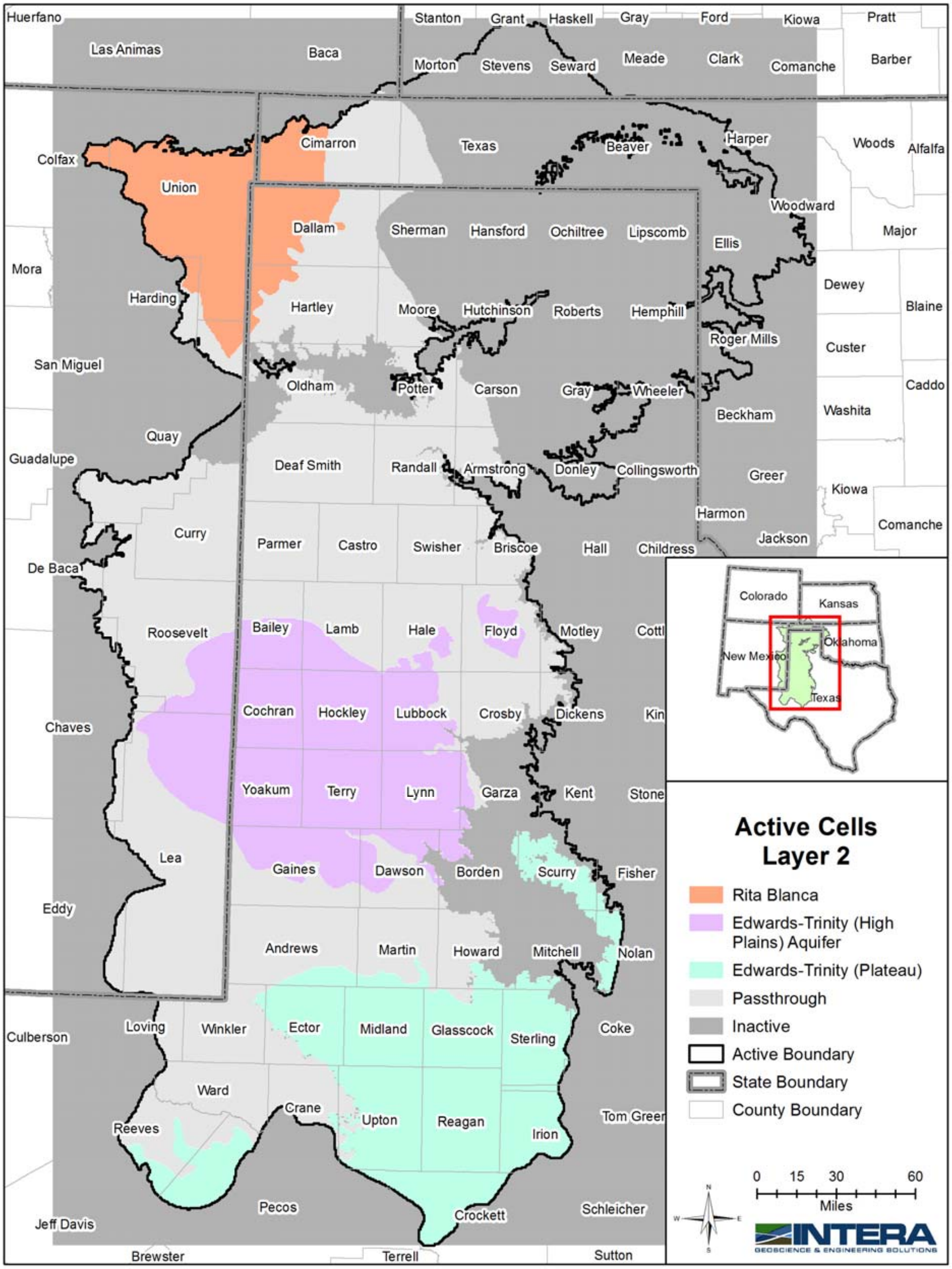


Figure 2.1.2 Layer 2 active/inactive model cells.

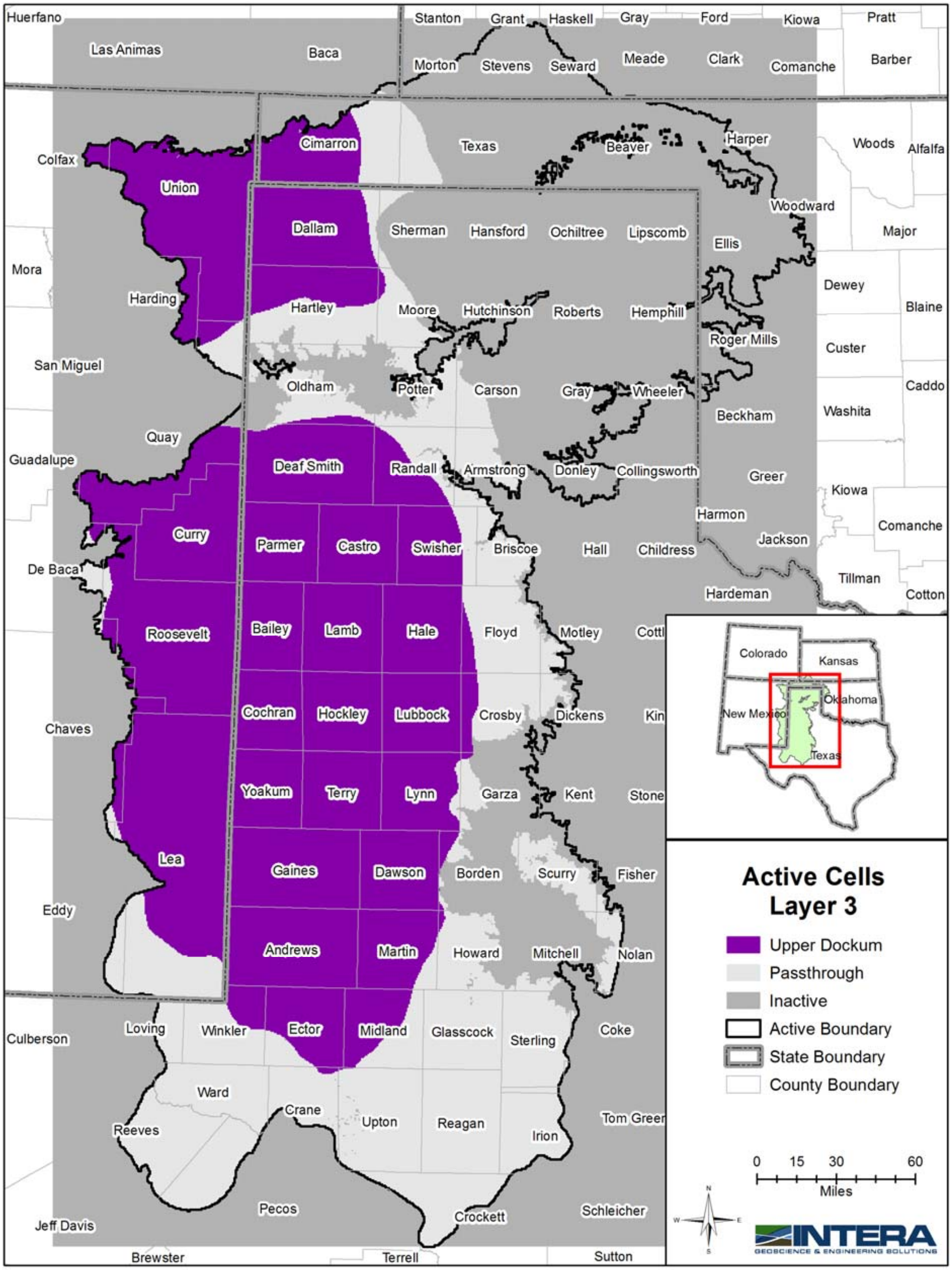


Figure 2.1.3 Layer 3 active/inactive model cells.

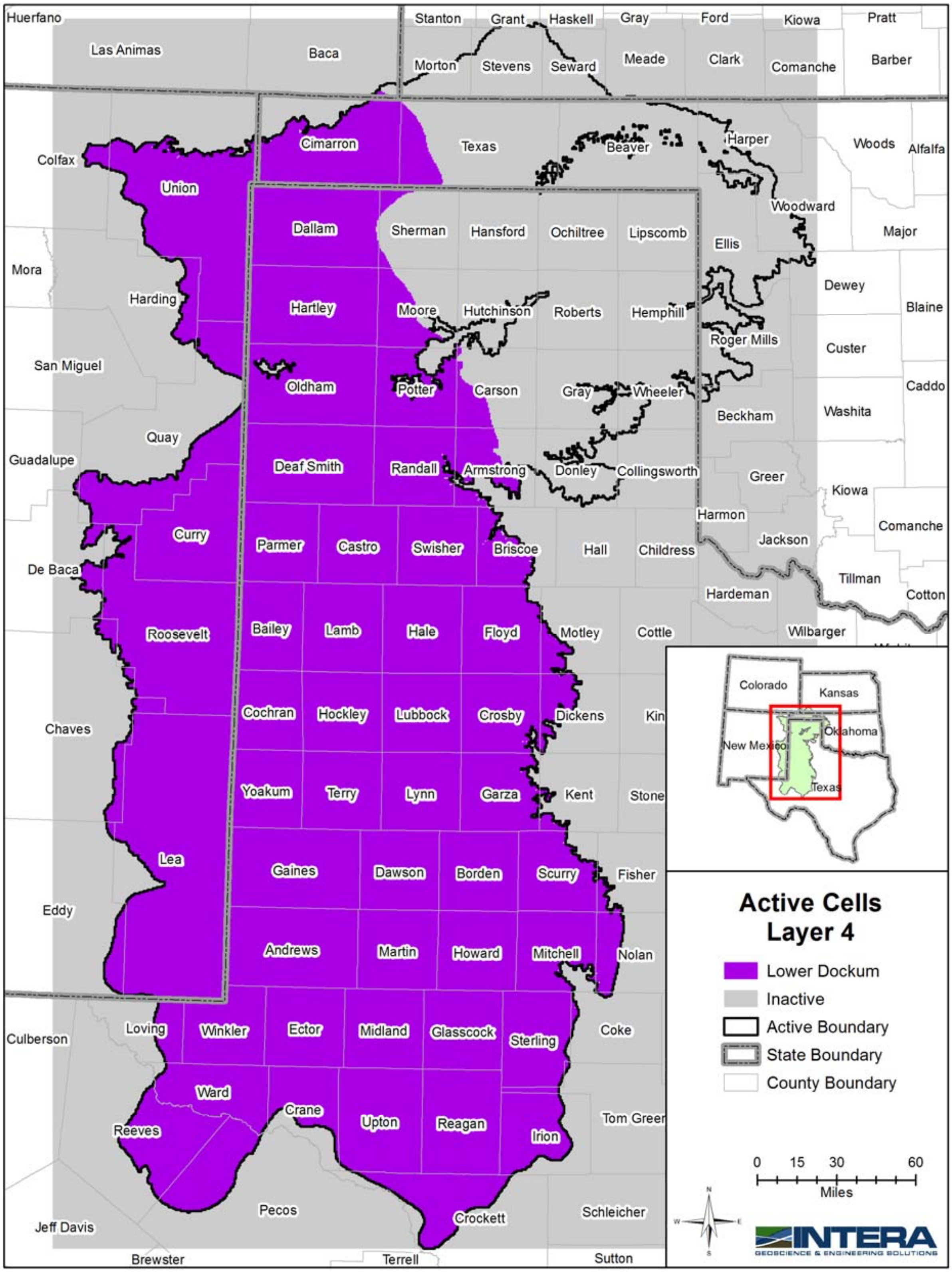


Figure 2.1.4 Layer 4 active/inactive model cells.

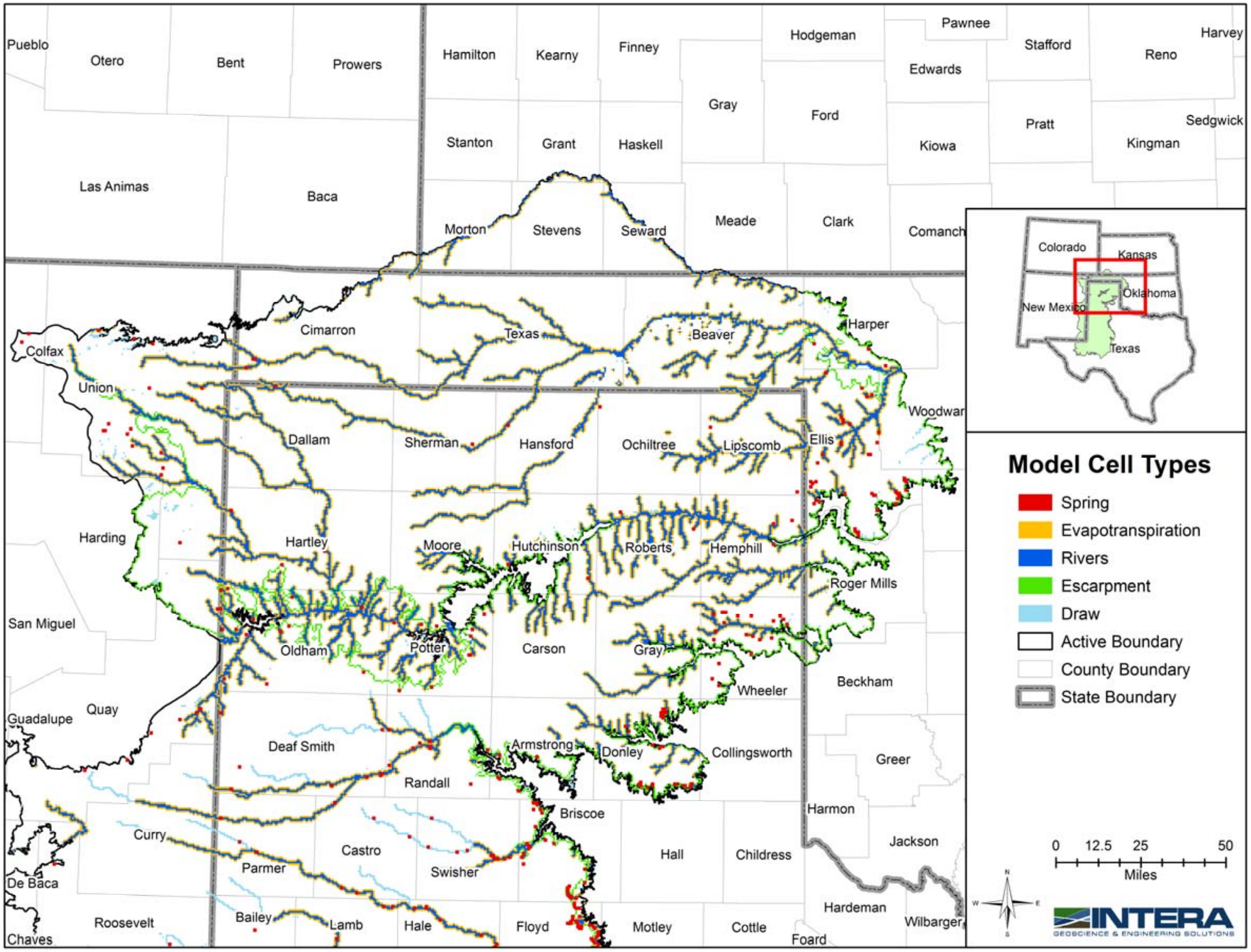


Figure 2.1.5a Uppermost active layer model cell types in the northern portion of the study area.

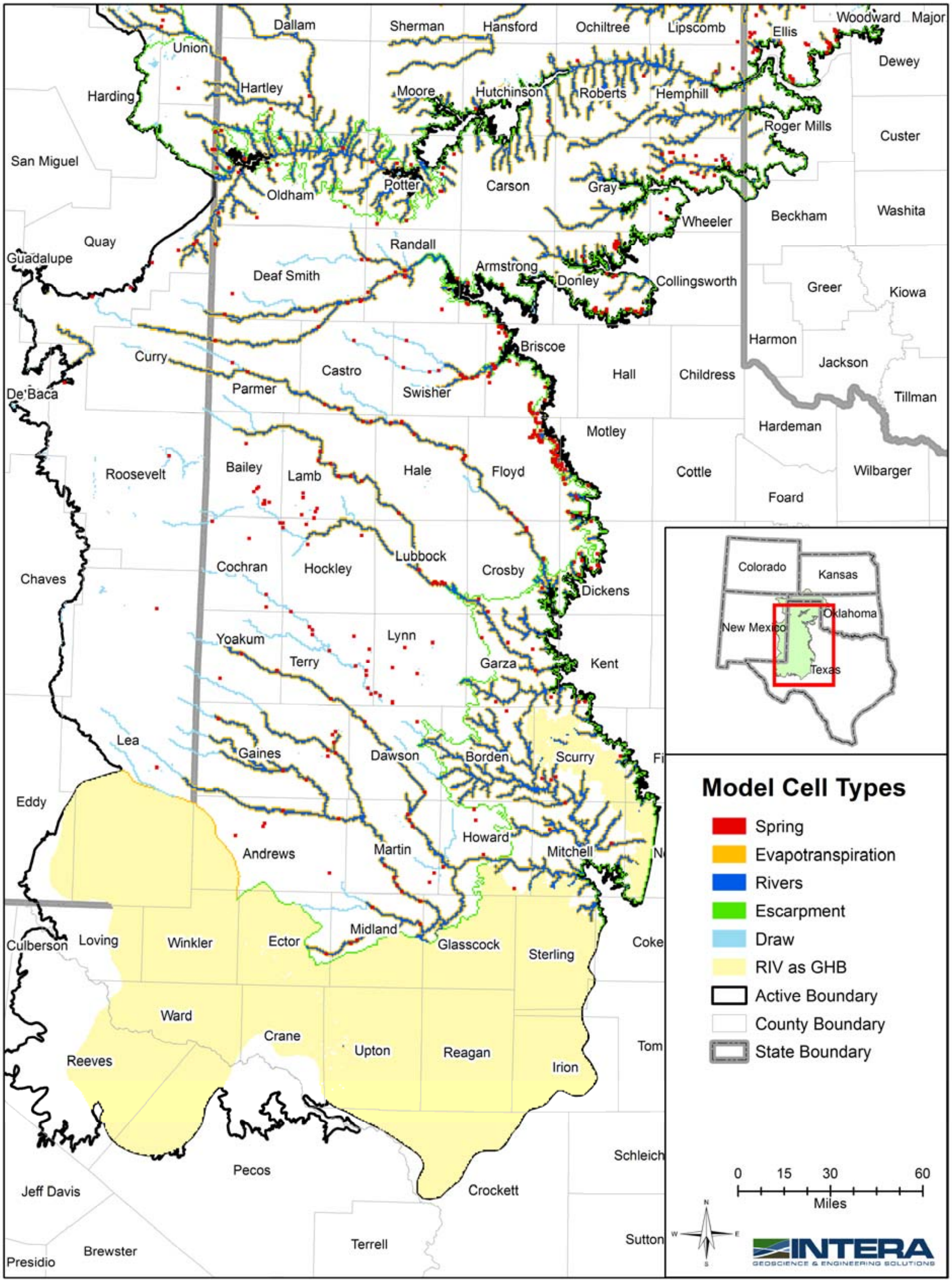


Figure 2.1.5b Uppermost active layer model cell types in the southern portion of the study area.

2.2 Name File

The name file simply contains the names and unit numbers of the input and output files that comprise the numerical model, shown previously in Tables 2.0.1 and 2.0.2.

2.3 Discretization Package

The MODFLOW discretization (suffix DIS) package contains the model grid dimensions, the cell-by-cell elevations of the model layers, and a definition of the model stress periods.

2.3.1 Model Grid Specifications

The High Plains Aquifer System groundwater availability model grid contains 4 layers, 932 rows, and 580 columns. The grid is uniform, with cells that are 2640 feet square. Figure 2.3.1 shows an example of the model grid at a county scale. The grid cell dimension is similar in scale to a quarter-section, which is the area covered by a typical center pivot irrigation system.

The grid is oriented directly north-south in the TWDB's designated coordinate system for groundwater availability models described in Anaya (2001). The cells are aligned with the previous southern Ogallala Aquifer groundwater availability model (Blandford and others, 2008) and the previous Dockum Aquifer groundwater availability model (Ewing and others, 2008), with four of the new model grid cells fitting inside one of the previous model one-mile-square grid cells. The lower left corner of the grid is positioned at groundwater availability model coordinate system coordinates 3628793.0 easting, 19479909.0 northing, and has no rotation.

Layer elevations were sampled from the surfaces created during the conceptual model development. Because the grid is uniform and oriented directly north-south, the conceptual model surfaces were created at a raster orientation and resolution that exactly coincided with the model grid cells, therefore no resampling was required. Minimum cell thicknesses were enforced during grid creation. For cells representing an aquifer, the minimum was 30 feet, whereas the thickness was set to 1 foot for cells representing pass-throughs. The top of the model represents land surface. When minimum thicknesses were enforced, elevations were pushed down from above, since land surface elevation has more certainty than the structural bottoms of the aquifers. Figure 2.3.2a and Figure 2.3.2b show representative cross sections of the model grid, for west-east sections in the northern and southern portions of the model.

In some areas of the model, especially along the escarpment to the east, large elevation changes in land surface occur in adjoining grid cells. No smoothing of these offsets was implemented, so some model cross sections may reflect these large offsets, with the appearance of "gaps." In some cases, the assignment of an aquifer to a cell, based on the aquifer outline, was inconsistent with the variation in land surface elevation. The cell elevations and aquifer assignments were examined, and the aquifer assignments were modified from their initial values, when such inconsistencies were identified.

2.3.2 Stress Period Setup

The High Plains Aquifer System groundwater availability model has 84 stress periods, starting with a steady-state stress period that represents predevelopment conditions. The second, and all subsequent stress periods are transient. The second stress period represents year 1930, with all transient stress periods lasting one year until stress period 84, which represents year 2012. Table 2.3.1 shows the stress period types, times, and durations. Note that leap years were considered in the stress period setup, so transient stress periods may be either 365 or 366 days long.

Table 2.3.1 Table of stress period times and durations.

Stress Period	Stress Period Length (Days)	Stress Period Represents	Steady-State (SS)/Transient (TR) Stress Period	Stress Period	Stress Period Length (Days)	Stress Period Represents	Steady-State (SS)/Transient (TR) Stress Period
1	1	Pre-Development	SS	43	365	1971	TR
2	365	1930	TR	44	366	1972	TR
3	365	1931	TR	45	365	1973	TR
4	366	1932	TR	46	365	1974	TR
5	365	1933	TR	47	365	1975	TR
6	365	1934	TR	48	366	1976	TR
7	365	1935	TR	49	365	1977	TR
8	366	1936	TR	50	365	1978	TR
9	365	1937	TR	51	365	1979	TR
10	365	1938	TR	52	366	1980	TR
11	365	1939	TR	53	365	1981	TR
12	366	1940	TR	54	365	1982	TR
13	365	1941	TR	55	365	1983	TR
14	365	1942	TR	56	366	1984	TR
15	365	1943	TR	57	365	1985	TR
16	366	1944	TR	58	365	1986	TR
17	365	1945	TR	59	365	1987	TR
18	365	1946	TR	60	366	1988	TR
19	365	1947	TR	61	365	1989	TR
20	366	1948	TR	62	365	1990	TR
21	365	1949	TR	63	365	1991	TR
22	365	1950	TR	64	366	1992	TR
23	365	1951	TR	65	365	1993	TR
24	366	1952	TR	66	365	1994	TR
25	365	1953	TR	67	365	1995	TR
26	365	1954	TR	68	366	1996	TR
27	365	1955	TR	69	365	1997	TR
28	366	1956	TR	70	365	1998	TR
29	365	1957	TR	71	365	1999	TR
30	365	1958	TR	72	366	2000	TR
31	365	1959	TR	73	365	2001	TR
32	366	1960	TR	74	365	2002	TR
33	365	1961	TR	75	365	2003	TR
34	365	1962	TR	76	366	2004	TR

Table 2.3.1, continued

Stress Period	Stress Period Length (Days)	Stress Period Represents	Steady-State (SS)/Transient (TR) Stress Period	Stress Period	Stress Period Length (Days)	Stress Period Represents	Steady-State (SS)/Transient (TR) Stress Period
35	365	1963	TR	77	365	2005	TR
36	366	1964	TR	78	365	2006	TR
37	365	1965	TR	79	365	2007	TR
38	365	1966	TR	80	366	2008	TR
39	365	1967	TR	81	365	2009	TR
40	366	1968	TR	82	365	2010	TR
41	365	1969	TR	83	365	2011	TR
42	365	1970	TR	84	366	2012	TR

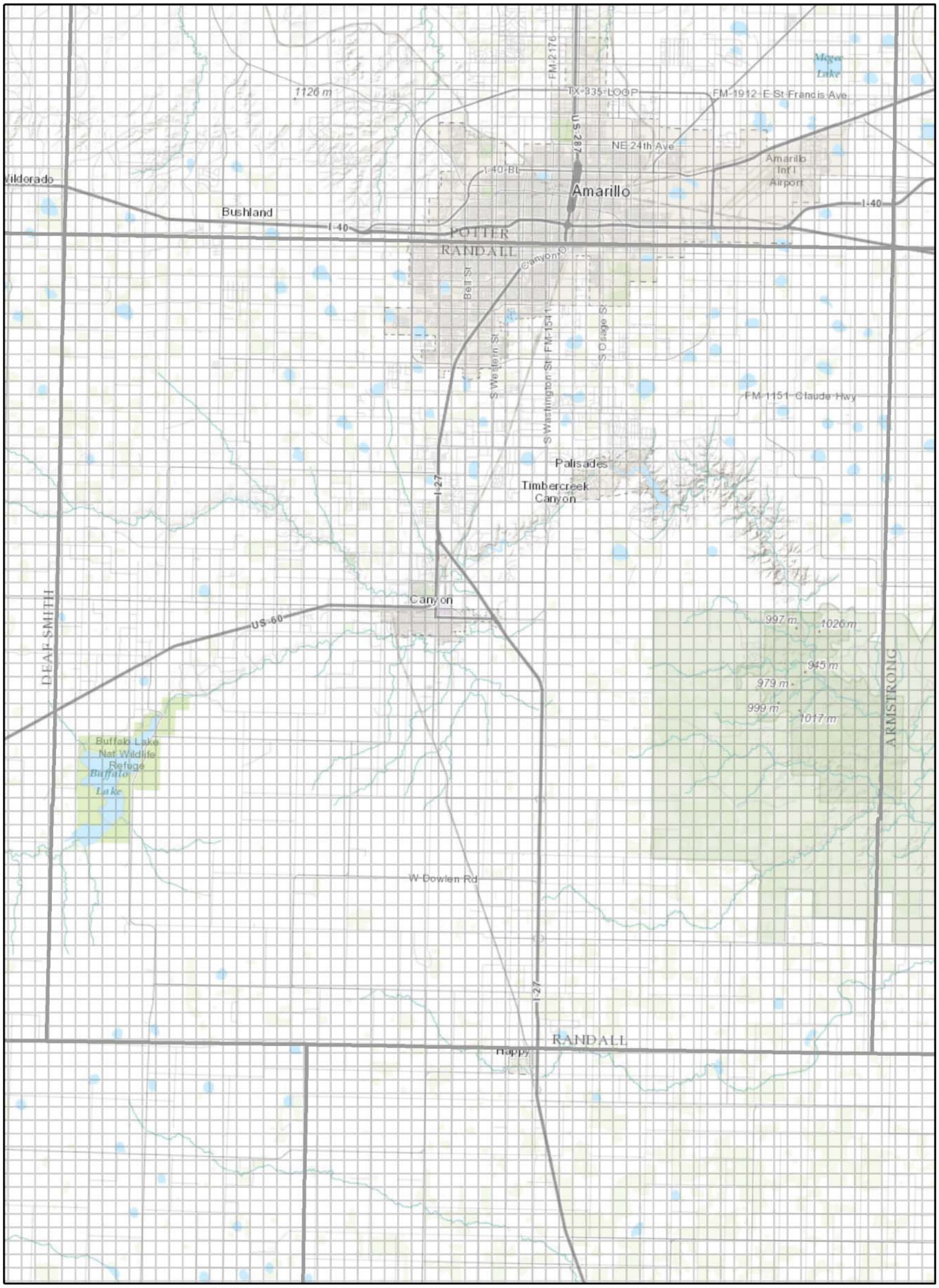


Figure 2.3.1 Example of model grid scale shown for Randall County.

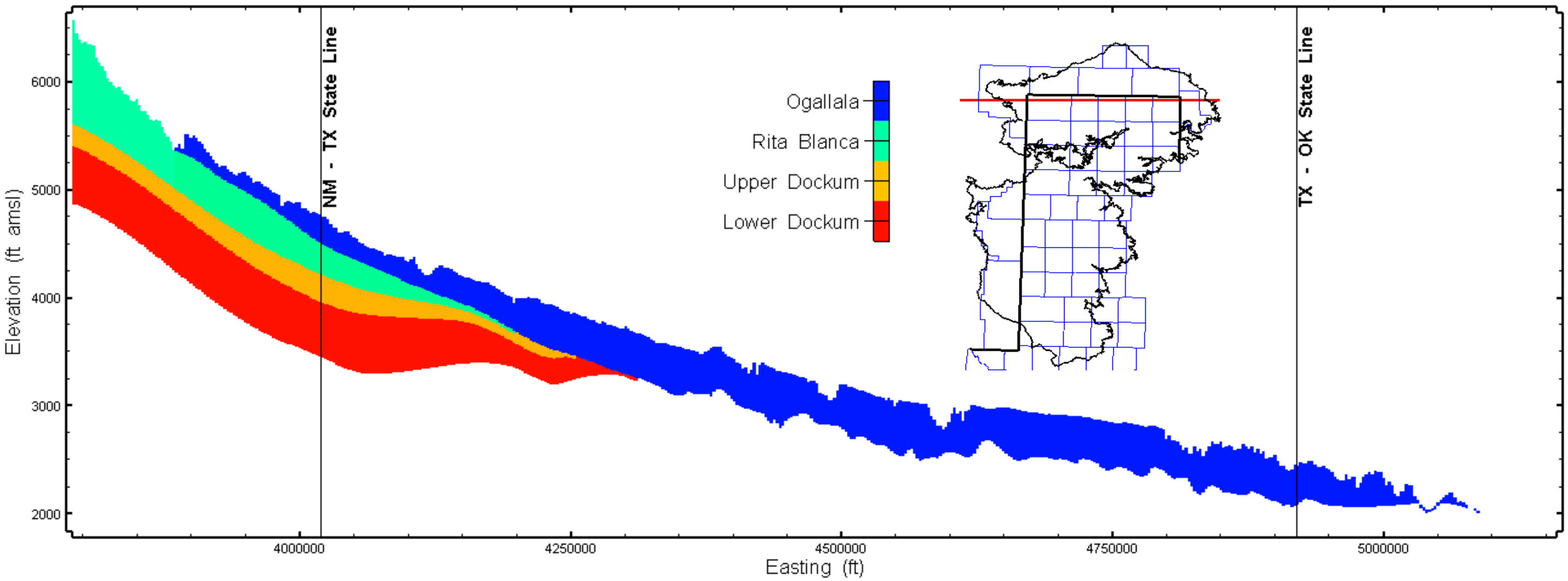


Figure 2.3.2a West-east cross section for row 140 showing model grid plotted from Discretization package (100x vertical exaggeration).

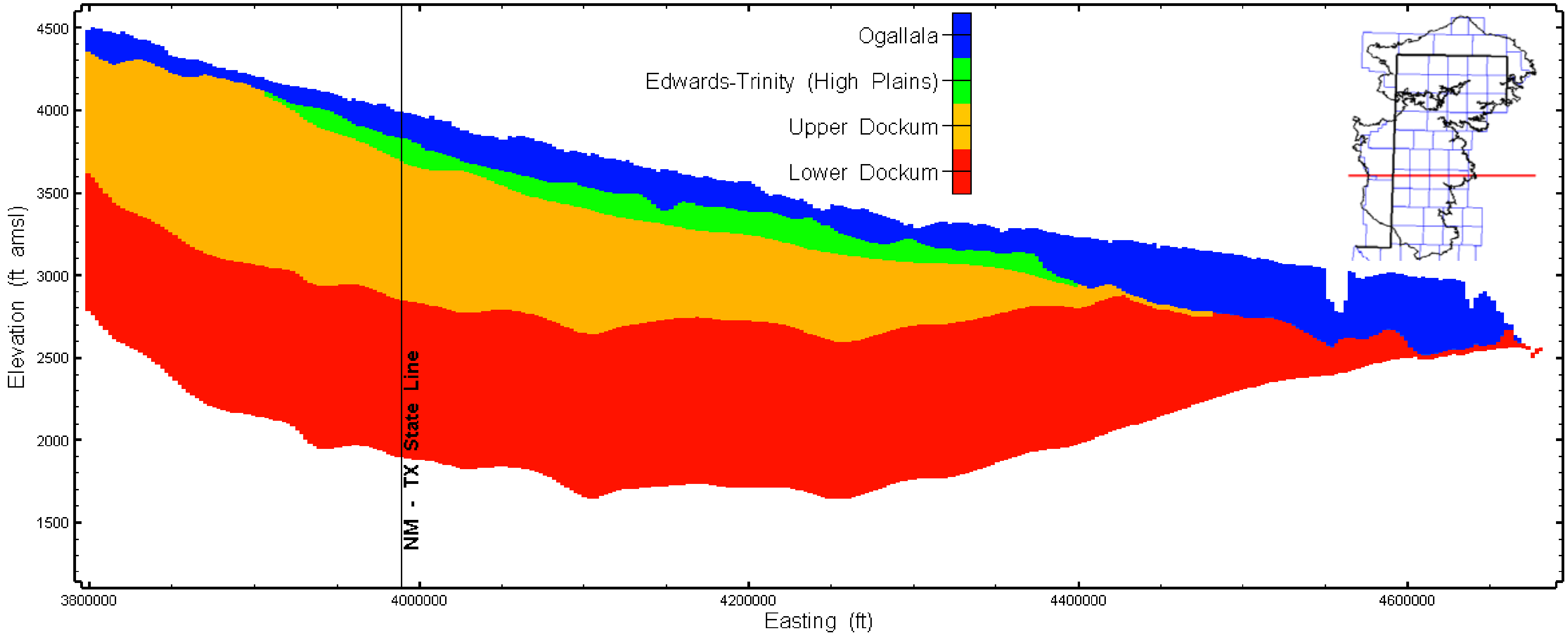


Figure 2.3.2b West-east cross section for row 514 showing model grid structure plotted from Discretization package (100x vertical exaggeration).

2.4 Upstream Weighting Flow Package

The Upstream Weighting (suffix UPW) package is used to specify hydraulic properties for MODFLOW-NWT. These properties control how easily groundwater can flow through the aquifer and how it responds to pumping. These properties include hydraulic conductivity (both horizontal and vertical), specific yield, and specific storage.

2.4.1 External Files

For the High Plains Aquifer System groundwater availability model, property matrices for each layer were created as external files, with one file for each property/layer combination. These external files, which are stored in a subdirectory called "UPWref", are then referenced in the UPW file.

2.4.2 Property Zones

During model calibration (Section 3.1), some of the hydraulic properties were adjusted. For the Ogallala Aquifer, pilot points were used to create a multiplier matrix that was applied to the initial hydraulic conductivity field during parameter estimation. "Pilot points" are locations where, during parameter estimation, point values are varied from their initial estimates. The multiplier matrix is generated by kriging the values at the pilot points. This multiplier matrix is then multiplied by the initial hydraulic conductivity field on a cell-by-cell basis to result in a calibrated hydraulic conductivity field. Figure 2.4.1 shows the location of the pilot points used to generate the multiplier matrix that was applied to the Ogallala Aquifer horizontal hydraulic conductivity. Because each pilot point represents a parameter, and each parameter requires a forward simulation during the calculation of the Jacobian matrix (an outer iteration in PEST), the modeler must try to achieve a balance between pilot point density (higher densities allow more refinement of the property field) and parameter estimation run times. In general, we placed pilot points on an approximate county-level density, with a few areas receiving more pilot points, where warranted by calibration.

For the non-Ogallala aquifers, and the rest of the hydraulic properties, property zones were primarily coincident with each active aquifer outline. That is, the initial hydraulic property field for each aquifer was modified using a single multiplier for the entire aquifer. Figures 2.4.2 through 2.4.4 show the property zones as they correspond to each aquifer outline. In addition, a depth decay multiplier was used to modify horizontal and vertical hydraulic conductivity in the confined portions of the aquifers. This multiplier does not apply to the Ogallala Aquifer, which is not confined. The multiplier was calculated as a function of depth following the exponential decay model of Louis (1974):

$$multiplier = e^{-A\,(Depth - D_0)} \tag{2.4.1}$$

where A is a calibration parameter and D_0 is the depth beyond which the multiplier takes on a value less than unity. A value of 150 feet was used for D_0 for all of the aquifers to which the multiplier was applied.

Two additional property zones were used in calibration. The first, shown in Figure 2.4.5, is a zone that defines the approximate region where the Ogallala Aquifer is in direct contact with the underlying Santa Rosa formation, as described in Deeds and others (2015), Section 4.6. The second was a zone used to modify the specific yield of the Ogallala Aquifer. The zone is shown in Figure 2.4.6. This zone corresponded with an area where simulated water level declines were too rapid compared to measured declines at initial estimates of specific yield, as discussed in Section 3.1.3. Summary statistics for hydraulic properties can be found in Section 3.1.

Table 2.4.1 Table of aquifer properties defined in the Upstream Weighting package and filenames containing matrix of each property value.

File Name	Property
Kh1.ref	Horizontal hydraulic conductivity for layer 1
Kv1.ref	Vertical hydraulic conductivity for layer 1
Ss1.ref	Specific storage for layer 1
Sy1.ref	Specific yield for layer 1
Kh2.ref	Horizontal hydraulic conductivity for layer 2
Kv2.ref	Vertical hydraulic conductivity for layer 2
Ss2.ref	Specific storage for layer 2
Sy2.ref	Specific yield for layer 2
Kh3.ref	Horizontal hydraulic conductivity for layer 3
Kv3.ref	Vertical hydraulic conductivity for layer 3
Ss3.ref	Specific storage for layer 3
Sy3.ref	Specific yield for layer 3
Kh4.ref	Horizontal hydraulic conductivity for layer 4
Kv4.ref	Vertical hydraulic conductivity for layer 4
Ss4.ref	Specific storage for layer 4
Sy4.ref	Specific yield for layer 4

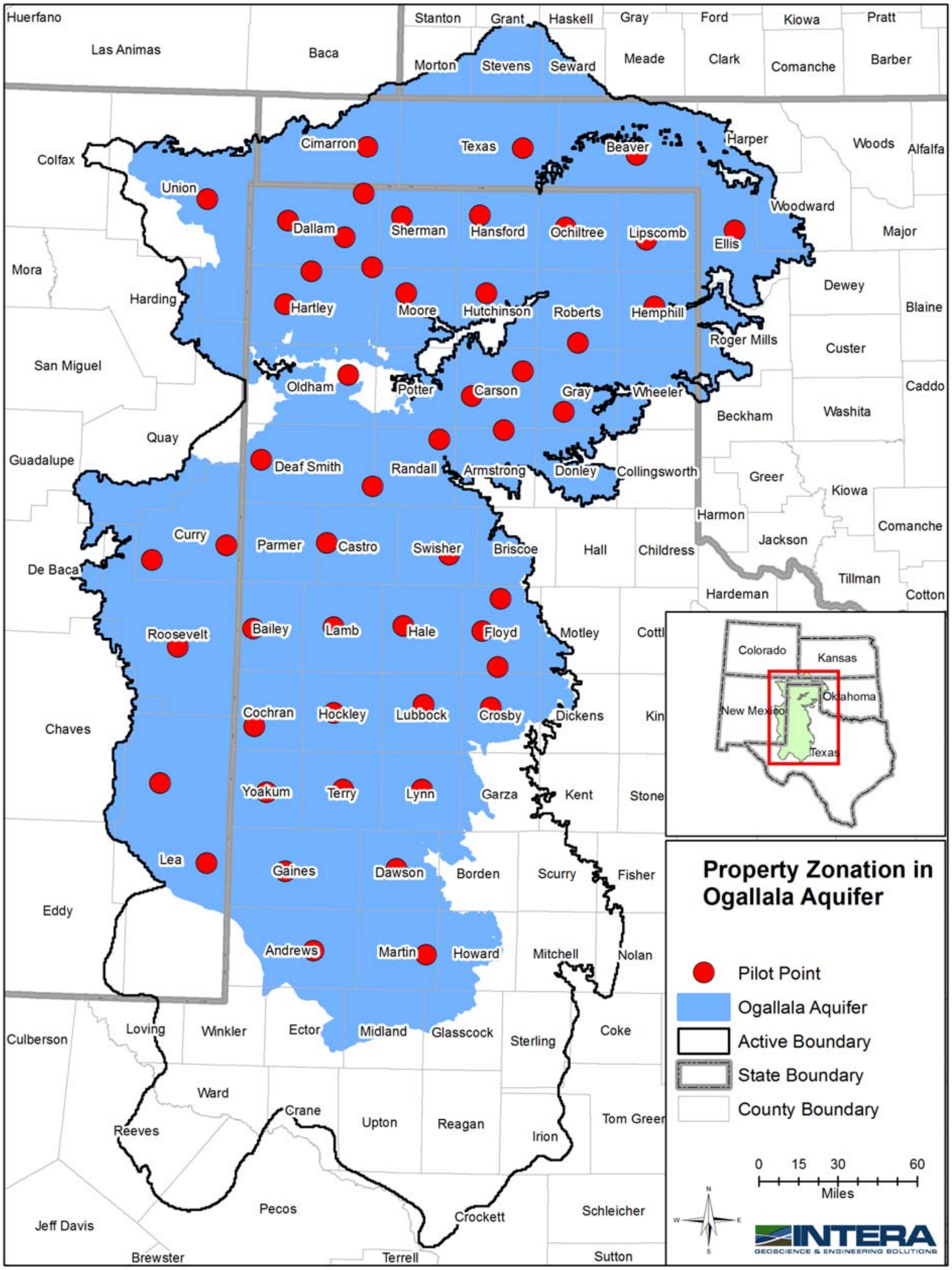


Figure 2.4.1 Locations of pilot points for property calibration zonation in the Ogallala Aquifer.

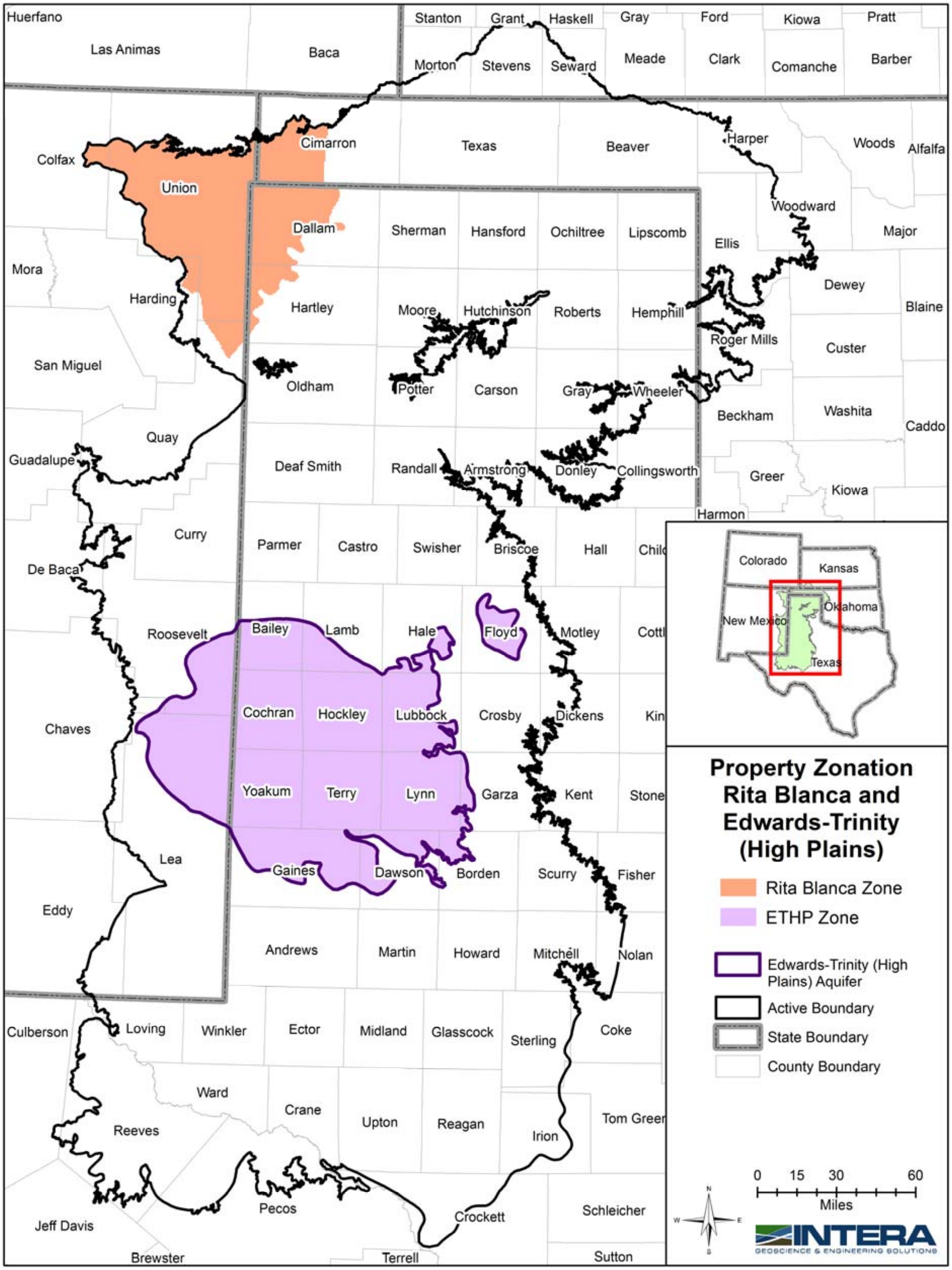


Figure 2.4.2 Property calibration zonation in the Rita Blanca and Edwards-Trinity (High Plains) aquifers.

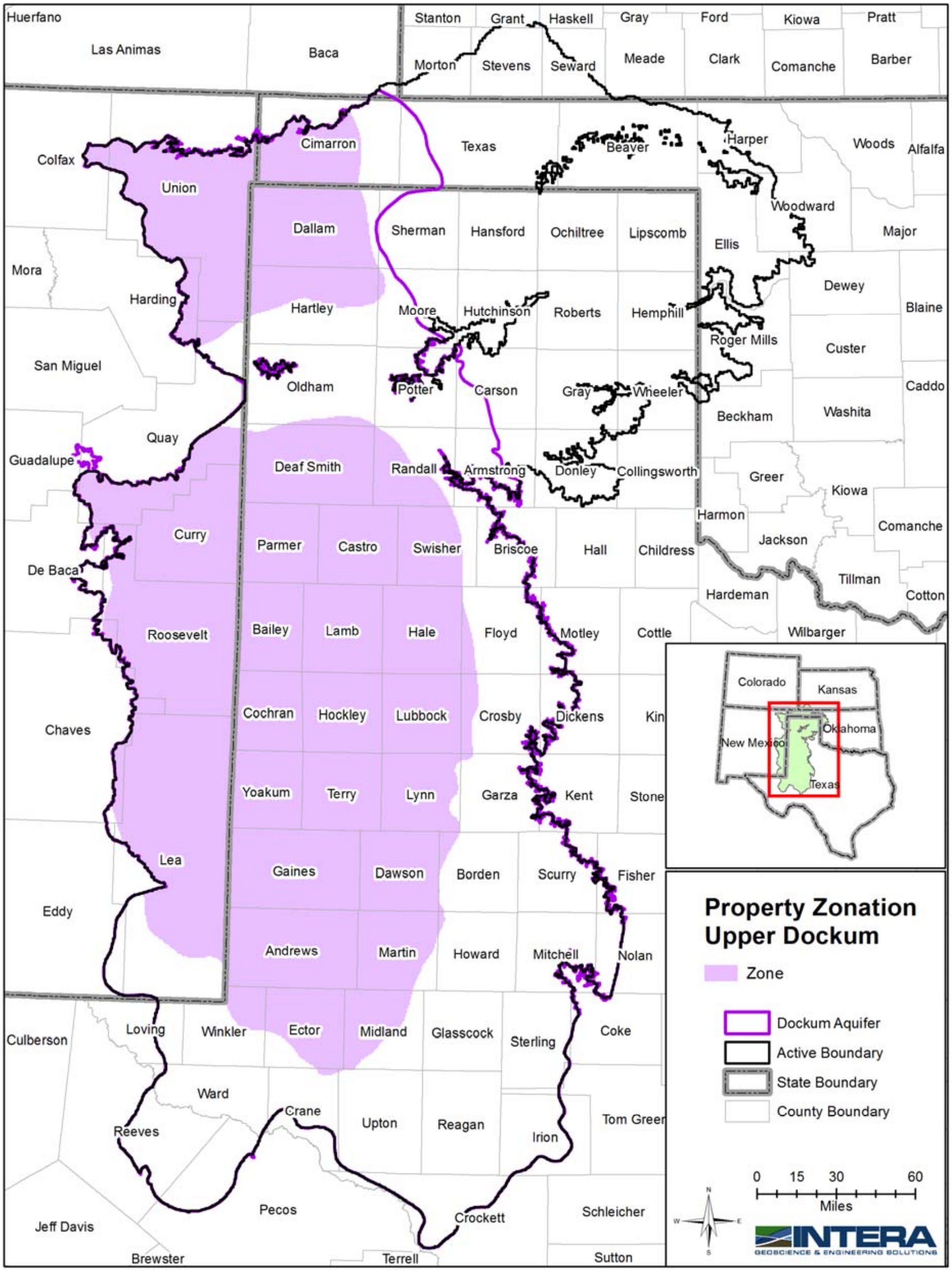


Figure 2.4.3 Property calibration zonation in the upper Dockum Group.

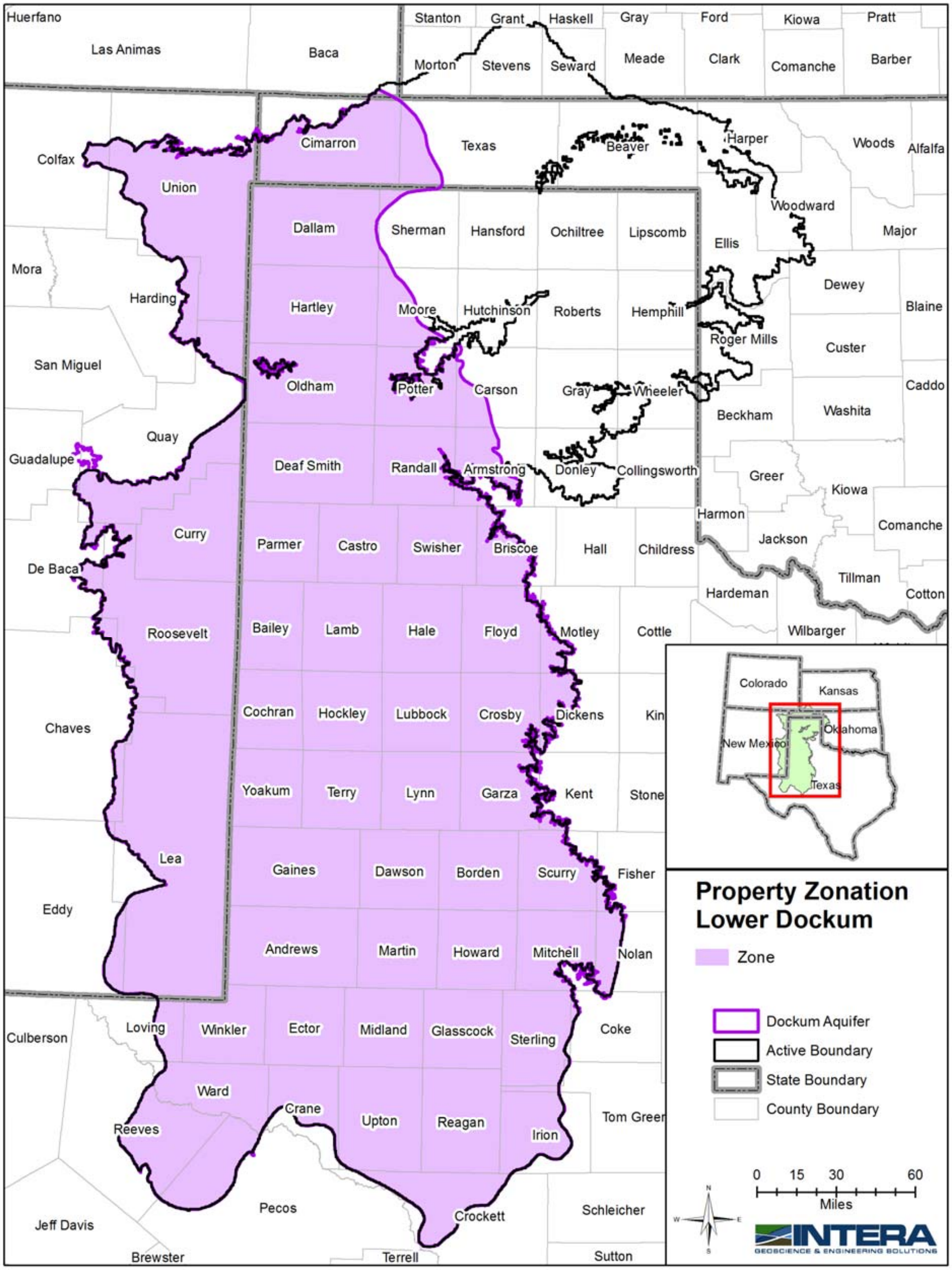


Figure 2.4.4 Property calibration zonation in the lower Dockum Group.

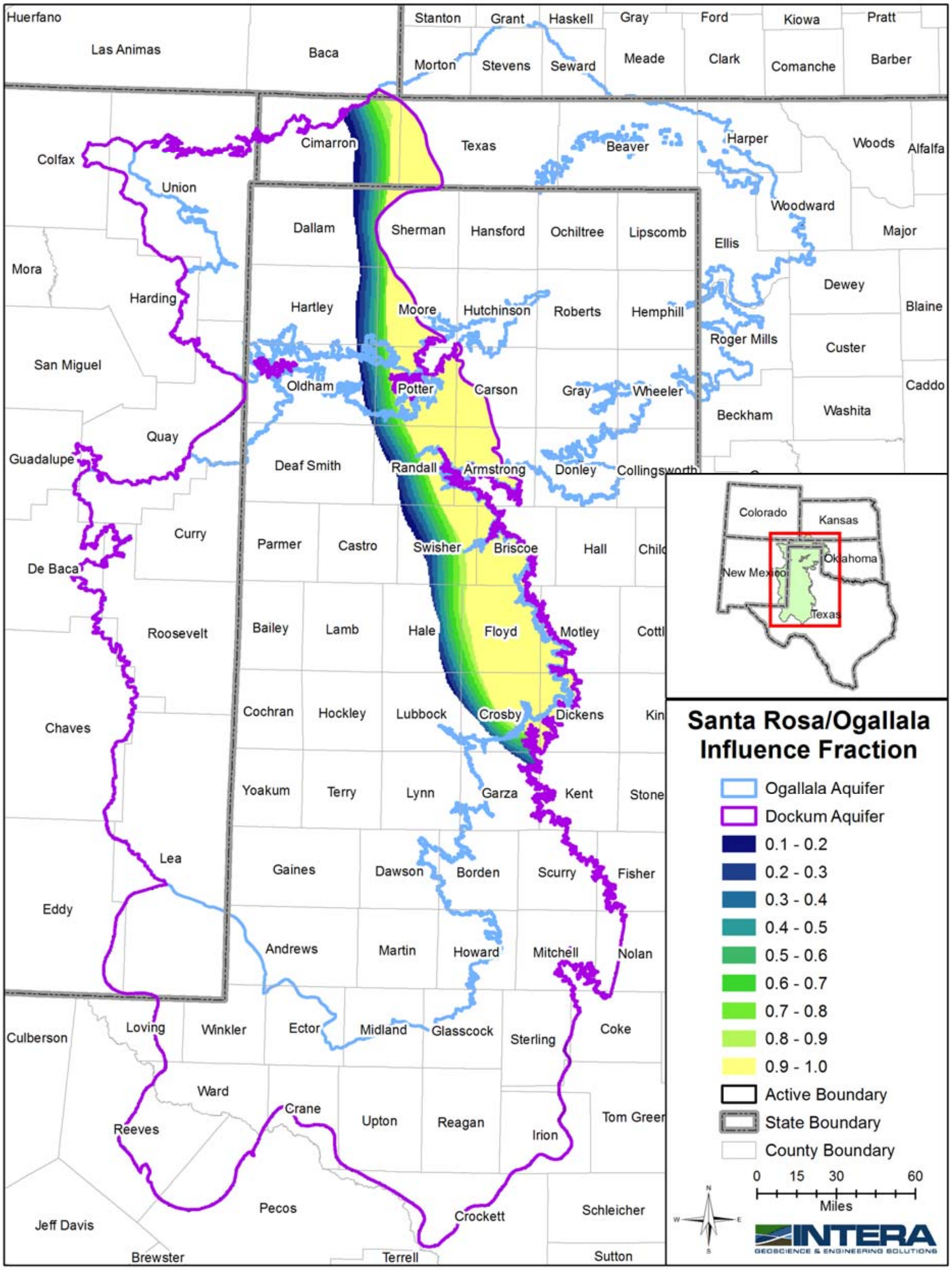


Figure 2.4.5 Santa Rosa/Ogallala influence fraction.

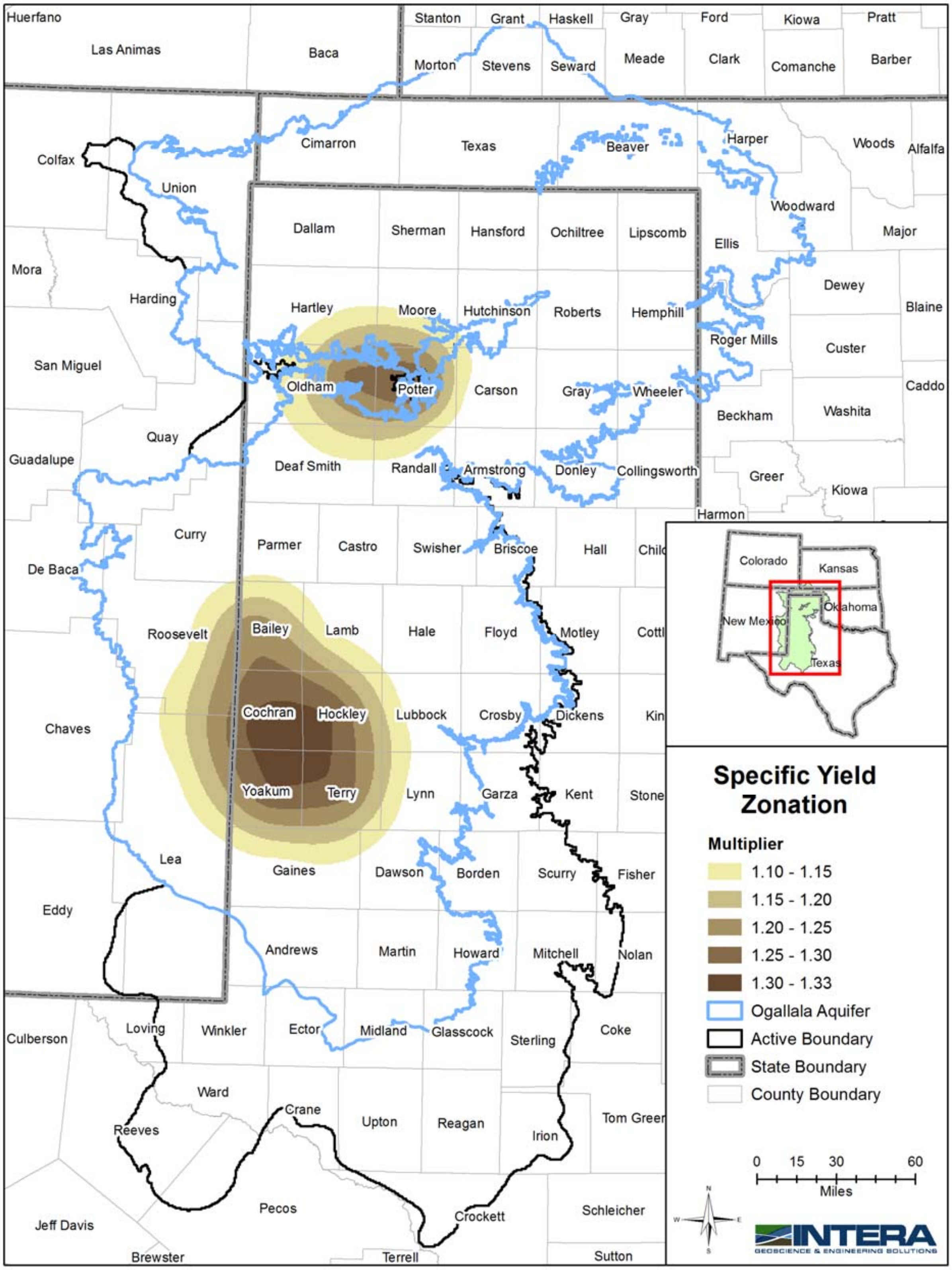


Figure 2.4.6 Specific yield calibration zone.

2.5 Well Package

The MODFLOW Well (suffix WEL) package was used to simulate groundwater production. The Well package requires specification of a model cell location and a prescribed flow for each stress period.

2.5.1 Treatment of Minimum Saturated Thickness

One feature of MODFLOW-NWT that is different from previous versions of MODFLOW is the ability for the user to specify a minimum layer thickness fraction at which production in a cell will be automatically scaled back. This simulates a decline in production that occurs in many cases when saturated thickness declines.

A minor modification was made to the source code for the Well package to change the way that this minimum thickness fraction is specified. In the original code, the minimum thickness fraction is specified as a fraction of the cell thickness. This means that for a given specified fraction, very thick cells will be curtailed sooner in absolute terms than thinner cells. For example, take two cells, one that is 500 feet thick, and one that is 50 feet thick. If the minimum fraction is set to 0.1, then pumping in the first cell will be curtailed when saturated thickness reaches 50 feet, while in the second cell pumping will be curtailed when saturated thickness reaches 5 feet, a physically unreasonable thickness for production.

The modification to the code simply allows the user to enter an absolute minimum thickness, in feet, at which pumping will be curtailed. The same variable PHIRAMP is used to represent this minimum thickness in the Well file. However, if PHIRAMP is greater than 1.0 (the maximum value for PHIRAMP in the original source code), then PHIRAMP is treated as an absolute thickness in length units, rather than as a fraction of cell thickness. If PHIRAMP is between 0 and 1, then it is treated identically as it was in the original code.

PHIRAMP was initially set to 30 feet, consistent with the estimate of when irrigation production is likely to decline significantly as stated in Brune (1969).

2.5.2 Data Sources

Two primary data sources were used in the creation of the pumping distribution. The first is a well dataset, which allows the assignment of pumping to a reported well location. The second is pumping volume estimates by water use category. These estimates were available at the county level, as determined during the development of the conceptual model (Deeds and others, 2015). In addition, the TWDB water use survey contains a further breakdown by survey name.

The master list of well locations used in the model was created by combining all available well datasets for the study area and, as much as possible, identifying and removing duplicate well records. Wells lacking depth information were excluded since they could not be assigned to an aquifer. In addition to using any available identifying information (for example, state well number) to identify duplicates, a well could also be identified as a duplicate record if it fell within a certain distance of another well and had a similar total well depth. The additional metric requiring a matching depth means that this method likely leaves behind many duplicate well records. However, given the uncertainty in location data (some wells are only given approximate locations in drilling logs), it seemed unwise to rely completely on spatial proximity to determine duplicates.

In Texas, the following datasets were analyzed and incorporated, as appropriate, into the master well list:

1. Texas Water Development Board groundwater database (TWDB, 2014a). This dataset yielded 25,517 unique wells.
2. Submitted Drillers Reports database (TWDB, 2014b). If a well fell within 20 feet of a well in (1) and the well depth matched (within +/- 10 feet), the well was removed as a duplicate. This dataset yielded 77,815 additional unique wells.
3. Texas Commission on Environmental Quality Public Water Supply Database. If a well had the same state well number as a well in (1), the well was removed as a duplicate. Of the remaining wells, if one fell within 20 feet of a well in (1) or (2) and well depth matched (within +/- 10 feet), the well was also removed as a duplicate. This dataset yielded 1,440 additional unique wells.
4. Data received from groundwater conservation districts for the current model
    a. High Plains Water District: If a well had the same state well number as a well in (1), the well was removed as a duplicate. Of the remaining wells, if one fell within 20 feet of a well in (1), (2), or (3) and well depth matched (within +/- 10 feet), the well was also removed as a duplicate. This dataset yielded 1,167 additional unique wells.

b. North Plains Groundwater Conservation District: If a well had the same state well number as a well in (1), the same log number as a well in (2), or the same well number as a well in (3), the well was removed as a duplicate. Of the remaining wells, if one fell within 20 feet of a well in (1), (2), or (3) and well depth matched (within +/- 10 feet), the well was also removed as a duplicate. This dataset yielded 414 additional unique wells.

c. Hemphill County Underground Water Conservation District : If a well fell within 20 feet of a well in (1), (2), or (3) and well depth matched (within +/- 10 feet), the well was also removed as a duplicate. This dataset yielded 367 additional unique wells.

d. South Plains Underground Water Conservation District: If a well fell within 20 feet of a well in (1), (2), or (3) and well depth matched (within +/- 10 feet), the well was also removed as a duplicate. This dataset yielded 158 additional unique wells.

e. Panhandle Groundwater Conservation District: If a well had the same state well number as a well in (1), the well was removed as a duplicate. Of the remaining wells, if one fell within 20 feet of a well in (1) , (2), or (3) and well depth matched (within +/- 10 feet), the well was also removed as a duplicate. This dataset yielded 4,184 additional unique wells.

Outside of Texas, the following datasets were analyzed and incorporated, as appropriate, into the master well list:

1. United States Geological Survey National Water Information System (United States Geological Survey, 2013). This dataset yielded 9,758 additional unique wells.
2. Oklahoma Water Resources Board Groundwater database (Oklahoma Water Resources Board Groundwater, 2014). If a well fell within 20 feet of a well in (1) and well depth matched (within +/- 10 feet), the well was removed as a duplicate. This dataset yielded 9,666 additional unique wells.
3. New Mexico Office of the State Engineer wells dataset (New Mexico Office of the State Engineer, 2014). If a well fell within 20 feet of a well in (1) and well depth matched (within +/- 10 feet), the well was removed as a duplicate. This dataset yielded 18,267 additional unique wells.

Wells were assigned to aquifers based on their depth and known screen information. If no screen information was known, screen information of nearby wells of similar type was used to estimate the screen length. When screens intersected multiple aquifers, the potential production from each aquifer for that well was distributed based on transmissivity weighting.

2.5.3 Initial Construction and Well Assignment

The assignment of pumping to wells followed a basic hierarchy, as follows:

1. Wells with meter data were assigned the metered values. The majority of metered data was in Roberts County, where the Canadian River Municipal Water Authority has metered wells. While North Plains Groundwater Conservation District has a groundwater metering program that provides good estimates of total pumping per county, they do not record per-well metering that could be used for direct assignment.
2. Where possible, water use survey records with survey names were matched to similar owner names in the well database. When this assignment was made, if the well had a reported water use category it was given priority for matching with a similar water use survey water use category. Many wells did not have primary water use categories, and were assigned based on owner name only. The well owner name and water use survey name matching process was aided using a fuzzy string matching algorithm. Per-well production limits were established by aquifer, so that a single well would not be assigned more production than was plausible at the grid-cell scale. Production limits for the Ogallala Aquifer were estimated based on Hecox and others (2002), which relates initial saturated thickness to well yield. Production limits for the minor aquifers were set to 750 gallons per minute, based on records of large well productivity for the Dockum Aquifer. The number of records for wells completed only in the Rita Blanca or Edwards-Trinity (High Plains) aquifers was not sufficient for a good population sample, so the 750 gallons per minute limit was assumed adequate unless we found a reason to change it during calibration.
3. Reported pumping that could not be assigned to wells based on owner or survey name was considered to be “unallocated”. This remaining pumping was assigned to remaining wells based on use category, when available. Wells without use categories were used to assign any remaining pumping.

Because irrigation pumping constitutes most of the pumping in the region, and the TWDB water use survey does not contain records for irrigation pumping, all of it was assigned using the "unallocated" strategy of #3. That is, irrigation pumping was assigned to wells with an irrigation use category. However, even with the large well dataset, some pumping totals exceeded the number of wells for a county available in the well database, under the estimated maximum production rates per well. When that occurred, additional locations for pumping were identified as discussed in the following section.

2.5.4 Addition of Pumping Locations

Additional pumping locations were assigned based on two strategies. First, the High Plains Water District and the Panhandle Groundwater Conservation District had both hand-digitized irrigated lands in their districts. These combined coverages are shown in Figure 2.5.1. The model grid was intersected with these coverages, and those intersected cells that did not already have allocated groundwater production were identified as potential production locations.

After the initial allocation, some wells had production rates that proved to exceed the capacity of the aquifer (that is, the saturated thickness was reduced to the minimum (30 feet) prior to the end of the simulation). For these cases, pumping was reallocated to other wells of the same category that had excess production capacity at specific wells. For a few cases, no existing well locations remained at which to apply the excess production capacity, and additional locations were identified based on remaining saturated thickness. The presence of focused groundwater production in high-yielding areas with large saturated thickness, such as the paleovalleys, is a well-established phenomenon (Scanlon and others, 2010) and the basis of this strategy.

2.5.5 Modification of Pre-1980 Pumping Totals

During the development of the conceptual model, several counties were identified where pre-1980 pumping totals appeared to significantly exceed the estimated change in volume in the aquifer, when considering specific yield and recharge. The approach to reducing pre-1980 totals was to scale all well rates by a factor. This factor was constant between 1930 and 1970, and then linearly increased from 1970 to 1980, so that the transition to 1980 volumes would be somewhat smooth. Discussion of the how the value of this factor was estimated for each of the affected counties is contained in Section 3.1.

Well package totals by county and aquifer are provided as part of the electronic submittal that accompanies this report in *geodatabase/xlsx/well_file_totals.xlsx*.

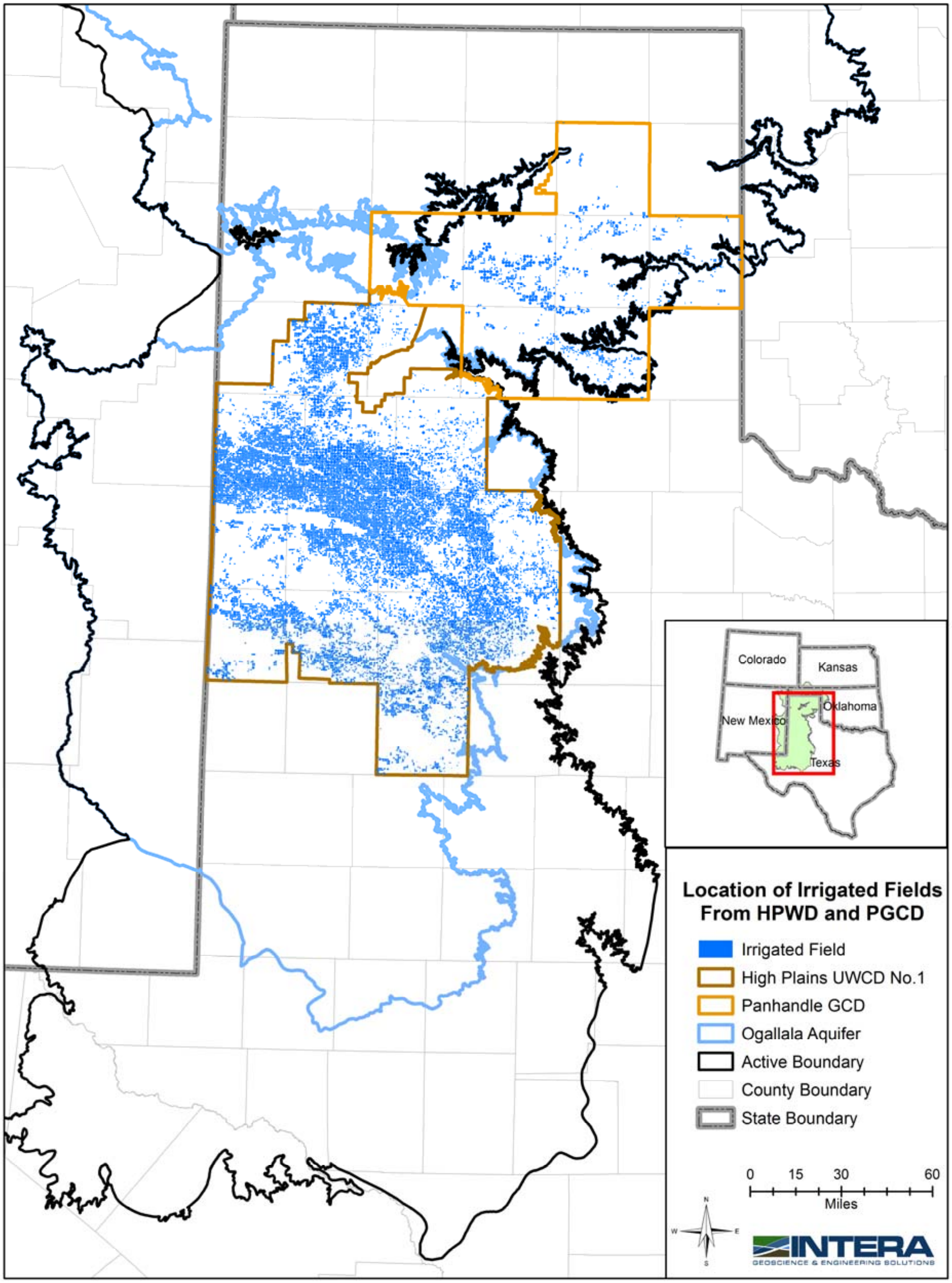


Figure 2.5.1 Locations of irrigated fields from High Plains Water District and Panhandle Groundwater Conservation District.

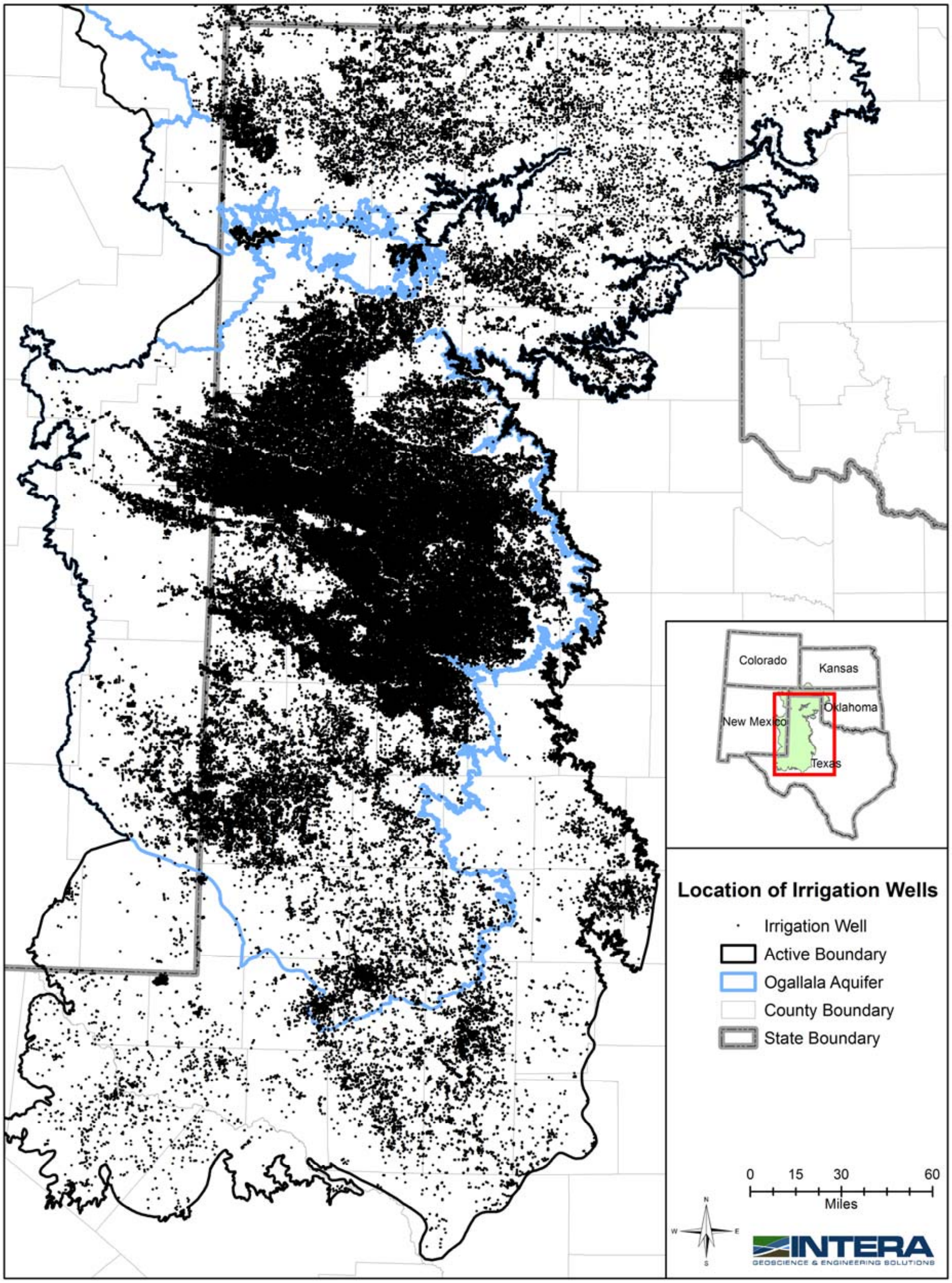


Figure 2.5.2 **Irrigation well distribution used to allocate irrigation pumping.**

2.6 Drain Package

The MODFLOW Drain (suffix DRN) package was used to simulate outflow from aquifer outcrops to springs, seeps, and draws. Perennial rivers and reservoirs were simulated separately using the River Package (Section 2.9). Drain cells throughout the model are shown in Figure 2.1.5. Locations of spring and draw drain cells were based on documented spring and draw locations (Deeds and others, 2015). In the case of springs, a drain cell was added in the cell that contained the estimated location of the spring. For draws, grid cells were selected based on their intersection with the polyline coverage that represented the estimated draw locations.

In addition to the springs and draws, drains cells were added along the escarpments to represent potential seepage face conditions. This approach is consistent with previous models of the Ogallala Aquifer (Blandford and others, 2008; Dutton and others, 2001). A few drain cells were also added during calibration to represent seepage in low-lying areas, as described in Section 3.1. In the Drain package file, “hpas.drn,” annotation at the end of each line in the file indicates whether the drain cell represents a spring, draw, escarpment, or seepage in low-lying areas.

Outflow to drains occurs whenever the water level elevation in the aquifer is higher than the elevation of the drain, which represents the stage of the spring, seep, or draw. Elevations of the drains were based on the minimum elevation from the digital elevation model raster values contained in the model grid cell corresponding to the drain. In addition, drain elevations were constrained such that all drain elevations were a minimum of 10 feet above the bottom of the model layer in which the drains were placed. The value of 10 feet was used because it was found to be the approximate minimum that would not cause stability issues with respect to dry cells.

The resistance to the outflow to a drain can be controlled by the drain conductance. The drain conductances were initially set to 1,000 feet squared per day for all drains. This conductance is high enough that the underlying aquifer properties will provide the limiting factor for outflow. Drain location, elevation, and conductance remained constant for all stress periods.

2.7 Evapotranspiration Package

The MODFLOW Evapotranspiration (suffix EVT) package was used to simulate groundwater evapotranspiration from the model. Note the distinction between overall evapotranspiration, that may occur either in the vadose or saturated zone, and groundwater evapotranspiration, the portion that occurs in the saturated zone. Groundwater evapotranspiration occurs primarily in riparian areas. To simulate evapotranspiration that may occur in riparian areas, evapotranspiration cells were added adjacent to cells representing perennial streams (Section 2.9). Evapotranspiration cells were not added to cells that contained drain boundaries, due to the presence of a spring or draw.

The Evapotranspiration package as implemented required specification of the elevation of the evapotranspiration surface, the maximum evapotranspiration rate, and the extinction depth. If the elevation of the water table exceeds the elevation of the evapotranspiration surface, evapotranspiration occurs at the maximum rate. As the water table drops below the elevation of the evapotranspiration surface, the rate decreases linearly until the extinction depth is reached, at which point the rate is zero.

The evapotranspiration surface was set to the average ground surface elevation in a model grid cell, which is coincident with the top of the uppermost active model layer. The maximum evapotranspiration rate in the Texas portion of the model was based on the coverage provided in the TWDB study (Scanlon and others, 2005). Outside of Texas, the maximum evapotranspiration rate was based on the potential evapotranspiration from Borelli and others (1998) multiplied by the “Shrubland” vegetation coefficient of 0.44. The extinction depth was set to 14 feet, which is the rooting depth for the “Shrubland” vegetation type, common to the region. The model was only minimally sensitive to rooting depth (Section 4).

2.8 Recharge Package

The MODFLOW Recharge (suffix RCH) package was used so simulate recharge to groundwater in the model. Recharge was applied in the outcrops of the Ogallala, Rita Blanca, and Dockum aquifers. The option was used to apply recharge in the uppermost active layer. Because MODFLOW-NWT does not inactivate cells where the head falls below the layer bottom, the layer to which recharge was applied does not vary during the course of a simulation.

2.8.1 Steady-State Recharge

Steady-state recharge was based on the predevelopment distribution from Deeds and others (2015) and modified during calibration using a pilot point multiplier approach. The pilot point locations are shown in Figure 2.8.1. Recharge was set to zero in river cells (Section 2.9). Under gaining conditions, rivers represent a discharge boundary. Under losing conditions, the river package provides recharge. So adding recharge flux to these cells was not warranted.

2.8.2 Transient Recharge

Transient recharge was based primarily on the post-development recharge estimate from Deeds and others (2015). In the southern portion of the model, transient recharge increases through time due to changes in soil conditions from agricultural activities, and irrigation return flow. The transition from steady-state recharge to "present-day" recharge was based on the estimated breakthrough years shown in Figure 4.4.15 of Deeds and others (2015).

The breakthrough years were county-based, but using county boundaries to define variation in recharge was not desirable because of the abrupt (and unnatural) transition that would occur across the boundaries. Instead, a coverage of point values for the breakthrough years located at county centers was created. When year ranges were indicated in the source data, the midpoint value of the range was used in the coverage. The point coverage was then interpolated onto the model grid, and masked to include only the portion of the southern area where recharge changed from predevelopment. The resulting matrix was then used as a cell-by-cell indicator for when the transition from steady-state recharge to "present-day" recharge would occur. The transition was linearly interpolated in time over a ten-year period, starting with the breakthrough year.

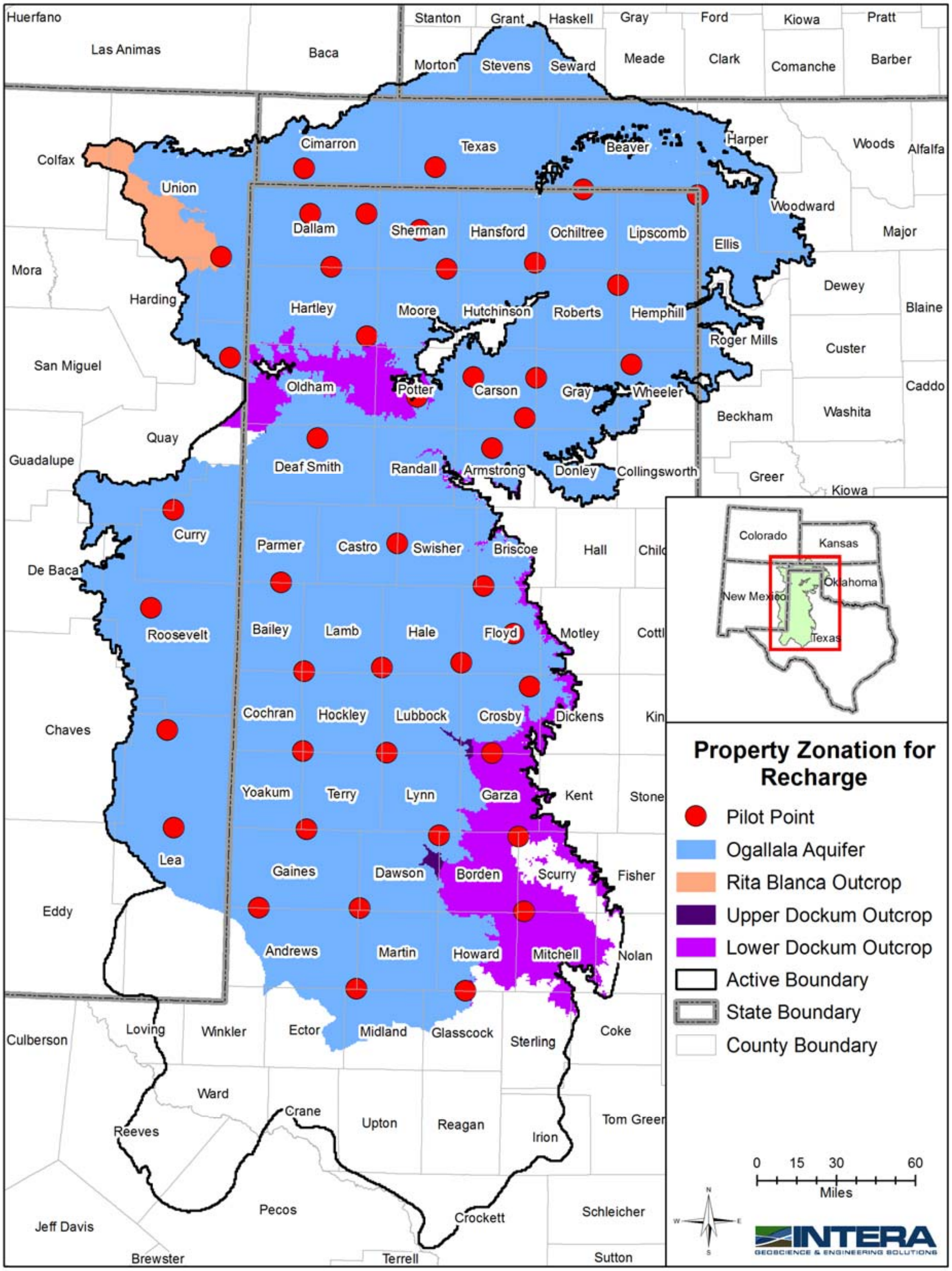


Figure 2.8.1 Locations of pilot points for recharge zones.

2.9 River Package

The MODFLOW River (suffix RIV) package was used to simulate the interaction of the aquifers with perennial streams and reservoirs. In addition, the River package was used as a general-head boundary condition in the cells representing portions of the Pecos Valley and Edwards-Trinity (Plateau) aquifers. In the River package file, “hpas.riv”, annotation on each line indicates whether the cell represents a river, reservoir, or general-head boundary.

2.9.1 Streams

River cells were selected based on the intersection of the model grid with the polyline feature class representing streams from Deeds and others (2015). River cells were placed only in outcrop cells. The stage was set based on the minimum land surface elevation in the grid cell, determined from the 10-meter digital elevation model. The stage was further constrained such that the height between the stage and the model cell bottom was a minimum of 10 feet. As with the drains, the 10 foot minimum was used to improve model stability with respect to cells drying out. The river bottom was set at 5 feet below the river stage. The 5 foot difference between the river stage and the river bottom was an approximation of river depth, and is used by MODFLOW in the calculation of river leakage rate to the aquifer when aquifer heads drop below the river bottom.

The conductance for each river cell was scaled by the length of the polyline feature that intersected the cell. For example, a cell with only a small corner intersected by the polyline feature would have a lower conductance than a cell where the polyline runs diagonally from corner to corner, because the smaller intersection indicates that the cell represents less river length and therefore should have less interaction with the aquifer. The initial riverbed conductance was set based on a hydraulic conductivity of 1.0 feet per day multiplied by the intersecting length. The overall conductance was adjusted during calibration.

2.9.2 Reservoirs

River cells representing reservoirs were selected by intersecting the model grid with the polygon feature class representing reservoirs from Deeds and others (2015). River cells representing reservoirs were placed only in outcrop cells. The stage of the reservoirs was based on reported elevations, when available, and on 10-meter digital elevation model, when the stage was not available. Because the number of reservoirs in the model area increased throughout the transient period, each reservoir was made active in the reported year of impoundment. The conductance of each river cell representing a reservoir was initially set to 1,000 feet squared per day.

2.9.3 Head-Dependent Flow Boundaries

As noted previously, while portions of the Pecos Valley and Edwards-Trinity (Plateau) aquifers are represented in the model, the model is not intended to be used as a planning tool for these aquifers. An existing Edwards-Trinity (Plateau) and Pecos Valley aquifers groundwater availability model (Hutchinson and others, 2011) was used to estimate head elevations through time that were then applied as a stage to the River package in those cells. The difference between the river stage and river bottom was set to 5 feet. Because these cells are not actually coincident with rivers, the 5 foot value does not have physical meaning, but is used by MODFLOW in the calculation of flow to the aquifer when aquifer heads drop below the river bottom. The conductance in these cells was set to 100 feet squared per day. Examination of cross formational flow during calibration indicated that vertical conductance limited the flux between the Dockum Aquifer and the Edwards-Trinity (Plateau) and Pecos Valley aquifers.

The River package was used rather than the General-Head-Boundary package (Harbaugh and others, 2000) to limit the magnitude of simulated inflow from this boundary that could occur as water levels decrease due to pumping in underlying aquifers. While the General-Head-Boundary package limits flow based on conductance, it does not limit flow based on increased downward gradients. In previous models, this has led to difficulties in simulating the effects of maximized pumping in these underlying aquifers. In contrast to the General-Head-Boundary package, the River package limits the downward gradient while also limiting flow via the conductance. This approach avoids increased flow due to increased gradients when maximal pumping is applied to the underlying aquifers.

2.10 Output Control File

The MODFLOW Output Control file specifies when, during the simulation, water level, drawdown, and water budget information are saved to disk. The Output Control file was set up to save these results at the end of each stress period (that is, at the end of the pre-development period and annually between 1930 and 2012).

2.11 Solver

The MODFLOW-NWT Newton-Raphson solver parameters are entered in the NWT file. The head closure criteria was set to 0.01 feet, and the flux closure criteria was set to 1,000 feet cubed per day. Trial-and-error showed that convergence was most likely achieved when the COMPLEX option was specified, which triggers the use of a set of parameters defined by the code authors for highly nonlinear problems. Convergence was also somewhat sensitive to the value of MINTHICK, which was eventually set to 0.00001.

This page intentionally left blank

3.0 Model Calibration and Results

Once a model has been designed and constructed, it is usually calibrated to match observed characteristics of the aquifer. Typically these calibration targets consist of observed water levels in wells, but can also include discharge to surface water or other processes. The calibration process involves adjusting the hydraulic properties and flux boundaries of the model, within pre-defined constraints, in order that simulated output metrics better match observed metrics. This section describes that process of calibration, and presents the simulated results in terms of heads and fluxes. In addition, the simulated water budgets, which account for all of the water flowing in and out of an aquifer, are presented.

3.1 Calibration Procedure

3.1.1 Targets

The steady-state model represents the condition prior to significant development of the aquifer system, which was considered to be prior to 1930. Selection of water-level measurements representative of predevelopment conditions is a challenge for most groundwater modeling studies and was discussed in Section 4.3 of the conceptual model (Deeds and others, 2015). There were 1,097 steady-state targets for all of the aquifers combined. These totals are in contrast to the 16,214 well locations and 183,266 measurements in the transient target dataset. However, because the steady-state simulation sets the starting heads for the transient simulation, early time transient targets have a strong influence on the steady-state calibration, which adds additional constraint to the steady-state calibration. The locations of the targets in the various aquifers are presented in Section 3.2, when discussing the average head residuals.

Some estimates of spring flow and stream gain/loss were available from the conceptual model development. However, because these measurements were over very short time periods (the spring flow measurements were single estimates, and the stream gain/loss estimates were from synoptic studies of 1 or 2 days), they were not considered to be quantitative targets for transient calibration, but rather qualitative indicators of the presence of recharge or discharge at surface locations.

3.1.2 Calibration Metrics

Traditional calibration measures (Anderson and Woessner, 1992), such as the mean error and the mean absolute error, quantify the average error in the calibration process. The mean error is the mean of the differences between measured hydraulic heads and simulated hydraulic heads:

$$meanerror = \frac{1}{n} \sum_{i=1}^{n} \left(h_m - h_s\right)_i \tag{3.1.1}$$

where

h_m = measured hydraulic head (feet above mean sea level)

h_s = simulated hydraulic head (feet above mean sea level)

n = number of calibration measurements

The mean absolute error is the mean of the absolute value of the differences between simulated hydraulic heads and measured hydraulic heads:

$$mean\,absoluteerror = \frac{1}{n} \sum_{i=1}^{n} \left|\left(h_m - h_s\right)_i\right| \tag{3.1.2}$$

The difference between a measured hydraulic head and a simulated hydraulic head is termed a residual.

The mean absolute error was used as the basic calibration metric for hydraulic heads. A typical calibration criterion for hydraulic heads is a mean absolute error that is less than or equal to 10 percent of the observed hydraulic head range in the aquifer being simulated. However, because of the wide variation in topography in the active model area and the corresponding large vertical range over which measured heads vary, this relative criterion was not considered to be sufficient for this modeling effort. The mean absolute errors from previous groundwater availability models of the aquifers were also reviewed to provide an approximate criterion during calibration.

The mean absolute error is useful for describing model error on an average basis but, as a single measure, does not provide insight into spatial trends in the distribution of residuals. Examination of the distribution of residuals is necessary to determine if they are randomly distributed over the model grid and not spatially biased. Post plots of hydraulic head residuals for both the steady-state and transient portions of the model were used to check for spatial bias. These plots indicate the magnitude and direction of the differences between observed and simulated hydraulic heads.

Finally, crossplots of simulated versus observed hydraulic heads and residual versus observed hydraulic heads were used to determine if bias varies with the magnitude of the observed hydraulic heads.

3.1.3 Calibration of Hydraulic Properties

Section 2.4 includes a description of the zones used when adjusting hydraulic properties during calibration. The parameter estimation software, PEST, was used to assist in the calibration of hydraulic properties. Of the 51 pilot point multipliers used in adjusting the Ogallala Aquifer horizontal hydraulic conductivity, 47 were constrained to vary within a range from 0.3 to 3, and 4 were constrained to a range from 0.3 to 10. The increase in the range for four of the pilot points was to help lower steady-state water levels in a portion of Dallam and Sherman counties. The initial value of every pilot point was 1.0, so if PEST did not adjust the pilot point value, then the resulting conductivity field near that pilot point would be identical to the initial conductivity field created during conceptual model development.

The remaining conductivities were adjusted through the aquifer-wide multipliers and depth-decay coefficients. Table 3.1.1 shows a summary of the initial and calibrated hydraulic properties for each of the aquifers. The overall trend for adjustment of conductivities was one of decrease from initial, with the exception of an increase for the Ogallala Aquifer horizontal hydraulic conductivity. Figures 3.1.1 through 3.1.4 show the calibrated horizontal hydraulic conductivities for the aquifers represented by the four model layers. The average horizontal conductivity in the Ogallala Aquifer was increased from 18 to 33 feet per day during calibration. However, because a multiplier matrix was constrained within a reasonable range, the relative distribution of hydraulic conductivity, with the expression of the paleochannels and other features, was maintained.

The Rita Blanca Aquifer horizontal hydraulic conductivity was decreased significantly from the initial estimate. This decrease was due to the original estimate being based on the Ogallala Aquifer hydraulic conductivity. Calibration indicated that the higher clay percentage of the Rita Blanca Aquifer contributes to a lower horizontal hydraulic conductivity in that unit. In fact, a higher horizontal hydraulic conductivity in the Rita Blanca Aquifer was found to cause dewatering of the overlying Ogallala Aquifer. The horizontal hydraulic conductivity in the Edwards-Trinity (High Plains) Aquifer was also decreased from the initial estimate during calibration. As with the Rita Blanca Aquifer, this decrease was necessary to sustain adequate heads in the Ogallala Aquifer in the western part of the model. Similar to the previous Dockum Aquifer modeling effort (Ewing and others, 2008), the upper and lower Dockum Aquifer horizontal hydraulic conductivities were decreased in calibration. For the lower Dockum Aquifer, the conductivities were only decreased in the deeper areas based on the depth decay approach, that is, the conductivities in the shallower areas are nearly identical to the initial estimated Dockum Aquifer hydraulic conductivity. The final calibrated distribution for the lower Dockum Aquifer shows the expected decreasing trend in conductivity in the center of the basin, where water quality degrades significantly.

Figures 3.1.5 through 3.1.8 show the calibrated vertical hydraulic conductivities for the aquifers represented by the four model layers. The vertical conductivity of the Ogallala Aquifer was not sensitive in calibration, since the vertical conductivities of the underlying units were all significantly lower. Because the overall vertical conductance between two layers is typically calculated as a harmonic mean, the lower of the two values will tend to dominate the calculation. While the Rita Blanca Aquifer vertical hydraulic conductivity remained at its initial value, the Edwards-Trinity (High Plains) Aquifer vertical conductivity was decreased somewhat, as were the upper and lower Dockum Aquifer vertical conductivities. In all cases, a reasonable overall vertical to horizontal anisotropy ratio was maintained, of between 0.01 and 0.0001.

Section 2.4.2 discussed the property zone for the estimated region where the Ogallala Aquifer is in close contact with the Santa Rosa Formation sandstone that exists at the bottom of the Dockum Aquifer. Sensitivity analyses were performed with the vertical conductivity of this zone, to determine whether calibration could be improved by increasing the vertical conductivity. Section 3.4 shows some of the results of this sensitivity analysis. The results of this analysis indicated that no special approach was required for parameterizing the vertical conductivity of this zone. The basic approach for estimating the vertical conductivity of the lower Dockum Aquifer was driven by clay percentage in the unit and depth of burial. The conductance term calculated by MODFLOW between two layers is dependent on vertical conductivity of the two layers and layer thickness. Because the lower Dockum Aquifer in this zone is relatively sandy, is shallow, and thin compared to areas more basinward, the vertical connection calculated from the basic approach results in a vertical conductance that creates satisfactory calibration to heads in the area.

Changes in specific storage from initial estimates were not found to improve calibration results significantly, so the calibrated specific storage values are identical to the initial estimates. The specific yield of the Ogallala Aquifer was increased in an area the size of approximately six counties, mostly in Potter County in the north, and Bailey, Cochran, Hockley, Yoakum and Terry counties in the south. The specific yield was increased in order to help maintain saturated thickness in those counties in the transient simulation. The final distribution of specific yield, as shown in Figure 3.1.9, remained similar in appearance to the initial distribution, with a slight increase in the mean from 0.163 to 0.171. Figures 3.1.10 through 3.1.12 show the calibrated storativity for the Rita Blanca and Edwards-Trinity (High Plains) aquifers, the upper Dockum Aquifer, and the lower Dockum Aquifer respectively.

3.1.4 Calibration of Recharge

Section 2.8 describes the distribution of pilot points used in generating the multiplier matrix for calibrating recharge. The multiplier pilot points were constrained to a range of 0.3 to 3. Figure 3.1.13 shows the calibrated steady-state recharge distribution. The mean steady-state recharge increased slightly from 0.25 inches per year to 0.30 inches per year. The calibrated recharge distribution shows an increase in recharge to the northeast, which is consistent with higher precipitation and an increased number of surface water features common to counties such as Hemphill. The calibrated steady-state recharge was propagated through the transient period. In other words, the initial variation in recharge from steady-state to transient was maintained for the calibrated case. Figure 3.1.14 shows the calibrated transient recharge distribution for year 2012. The model sensitivity to recharge was dominated by the steady-state stress period, where heads at the end of the steady-state stress period were very sensitive to the recharge rate. The model was much less sensitive to changes in recharge during the transient stress periods.

The decrease in horizontal and vertical conductivity in the upper Dockum Aquifer outcrop resulted in significant flooding (outcrop heads far above layer top) at the initial recharge rate. The calibrated upper Dockum Aquifer recharge rate was decreased by a factor of 0.1. The calibrated lower Dockum Aquifer recharge rate was kept at the initial rate.

A final change to recharge included addition of focused recharge near the City of Lubbock. The rate and location was based on the approach in Blandford and others (2008). The only change from their approach was to add the flux to the Recharge package, rather than the Well package, and to continue the final rate of approximately 12,000 acre-feet per year through year 2012. The 12,000 acre-feet per year rate was based on an earlier study (Daniel B. Stephens & Associates, 2007). The additional recharge does improve simulation of some of the rising hydrographs near the City of Lubbock.

3.1.5 Calibration of Head Boundary Conductances

The conductances of the head boundaries, including those in the Drain and River packages were not changed from initial to final calibration. As discussed in Section 3.1.1, the spring and stream gain/loss estimates were not considered to be quantitative targets, so conductances were not adjusted locally to attempt to match simulated values to the estimates. For the steady-state model, recharge is balanced by discharge to rivers, drains, and evapotranspiration. We did compare the spring flows in steady-state to the range of measured rates for springs in the region, to ensure that none of the rates were unrealistic. For example, if many springs were simulated to flow at a constant 10,000 gallons per minute, this would be considered high compared to the range of recorded values (Deeds and others, 2015: Table 4.5.5), where the very highest reported flows (not average, but maximum) are in the 1,000 to 2,000 gallons per minute range. The highest simulated springflows were about 1,000 gallons per minute, so we considered that to be within the realistic range.

The other component of discharge with a conductance parameter was rivers. For rivers, we compared the fraction of discharge to rivers to the fraction of discharge to evapotranspiration and drains (springs, draws, and seepage in low-lying areas). The following values are expressed as a percent of recharge in the Ogallala Aquifer. For the steady-state model, 33 percent of net discharge was to rivers, while drains were 31 percent and evapotranspiration accounted for 32 percent. While we did not have good prior estimates of what these percents should be, their relatively similar magnitude was considered reasonable, since each of these components is recognized in the conceptual model as an important component of discharge in the system.

In the transient model, we checked to make sure that as reservoirs came online, they did not constitute a large portion of the water balance, since reservoirs represent a small relative area compared to other surface water components. For example, in 1980 reservoirs contribute less than 1 percent of net inflow to the water balance.

3.1.6 Reduction in Pumping

The approach for reduction of pre-1980 pumping in the Ogallala Aquifer is discussed in Section 2.5.5. This reduction was only applied to the Ogallala Aquifer, not to the minor aquifers. Pre-1980 pumping was reduced from initial estimates based both on the results of the volume change analysis from the conceptual model development, and the response of the model during calibration. The total annual pumping values by county and aquifer are included in Appendix C.

Two characteristics of model performance were used as indicators of excessive pumping in a county. The first indicator was a large difference between the amount of pumping that was in the WEL file and the amount of pumping that was actually occurring in the model. When the NWT Well package curtailed a significant amount of the pumping compared to the input quantity, the pumping in the county was further analyzed. This mismatch will be termed “deficit pumping” for the purposes of this discussion.

As was described in Section 2.5.5, iterative attempts were made to redistribute deficit pumping from these wells that had reached the saturated thickness limit. For some counties, this redistribution was sufficient so that the deficit pumping was reduced to some small fraction of the county total. The initial goal was that post-1980 deficit pumping be less than 10 percent of post-1980 pumping overall. After that goal was achieved, the deficit pumping in individual years was verified to be less than approximately 10 percent of the total. This was achieved for most individual years in the Texas counties, with the exception of a few years where pumping estimates spike dramatically before returning to typical levels in the following year. Outside Texas, where the pumping estimates are more uncertain, the 10 percent constraint was relaxed somewhat. No Texas counties with significant pumping in the Ogallala (that is, over 10,000 acre-feet per year) had post-1980 deficit pumping that exceeded 10 percent of the total. The deficit pumping in all counties for all years is provided as part of the electronic submission that accompanies this report, and can be found at *geodatabase/xlsx/deficit_pumping.xlsx*.

After deficit pumping was managed through reduction in pre-1980 pumping and spatial reallocation, the mean error for affected counties was examined. A large positive mean error (where simulated heads are much lower than measured heads) that increased through time was the second indicator of excess pumping. Mean error was examined through time, starting in the 1940s (if measurements were available), to ensure that the large positive mean error was not due to early time calibration (that is, that steady-state heads were far too low).

This process was not completed for every county to try to achieve a perfect statistical result at the local scale, but was rather completed for those few counties that stood out with large, late-time bias in heads, that would affect the model's use as a planning tool.

Table 3.1.2 shows the fraction of initial pumping that was used for counties where pumping was adjusted. The maximum reduction involved a pre-1980 factor of 30 percent for Bailey County. Bailey still showed a mean error of more than 30 feet in the last decade, even with this decrease in pre-1980 pumping. Therefore, Bailey County was the one county where post-1980 pumping was also decreased in the input files (not just curtailed by NWT as deficit pumping). The decrease was 10 percent, which is identical to the reduction that was applied to all counties for later years in the previous Southern Ogallala Aquifer groundwater availability model (Blandford and others, 2008). The decrease in pumping and increase in specific yield in Bailey County described in Section 2.4 reduced the mean error in Bailey County from over 50 feet to between 20 and 30 feet.

After pumping rates were generally established, and sufficient statistical model calibration had been achieved through parameter estimation, hydrograph trends were examined versus observed trends. In some cases, especially in the minor aquifers, obvious spatial mismatches occurred between the location of drawdown trends and the location of pumping within a county. The hydrograph trends were used in some cases to guide the location of pumping within a county, while still maintaining county totals by use category. The goal of this exercise was not to create perfect hydrograph fits in all cases, but rather to provide a check of whether hydrograph trends could be improved under the existing hydraulic property calibration, with the stated constraint that pumping totals by county and category be maintained.

Table 3.1.1 Table of initial and calibrated statistics for hydraulic properties.

Parameter	Aquifer	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
		Min	**Min**	**Max**	**Max**	**Mean**	**Mean**	**Geometric Mean**	**Geometric Mean**	**Median**	**Median**
Kh	Ogallala Aquifer	1.00E+00	4.22E-01	5.27E+02	5.50E+02	1.83E+01	3.31E+01	1.07E+01	1.96E+01	1.03E+01	2.03E+01
Kh	Rita Blanca	1.00E+00	2.45E-02	5.36E+01	1.31E+00	1.56E+01	3.82E-01	1.31E+01	3.22E-01	1.30E+01	3.19E-01
Kh	Edwards-Trinity (High Plains)	1.17E-01	2.55E-01	1.06E+01	2.30E+01	5.57E+00	1.21E+01	4.79E+00	1.04E+01	4.66E+00	1.01E+01
Kh	Edwards-Trinity (Plateau)	9.41E+00	9.41E-01	8.11E+01	8.11E+00	4.16E+01	4.16E+00	3.78E+01	3.78E+00	3.83E+01	3.83E+00
Kh	Upper Dockum	2.47E-01	1.00E-03	5.51E+00	3.43E-02	1.47E+00	7.11E-03	1.37E+00	6.03E-03	1.40E+00	6.05E-03
Kh	Lower Dockum	6.74E-02	1.00E-03	2.23E+01	2.23E+01	1.97E+00	4.45E-01	1.26E+00	3.95E-02	1.34E+00	4.24E-02
Kv	Ogallala Aquifer	6.47E-04	6.47E-04	9.98E-03	9.98E-03	1.72E-03	1.72E-03	1.44E-03	1.44E-03	1.25E-03	1.25E-03
Kv	Rita Blanca	5.87E-04	5.87E-04	1.05E-03	1.05E-03	7.53E-04	7.53E-04	7.47E-04	7.47E-04	7.31E-04	7.31E-04
Kv	Edwards-Trinity (High Plains)	1.12E-03	1.17E-05	1.00E-01	1.04E-03	3.39E-02	3.54E-04	6.70E-03	7.00E-05	2.04E-03	2.13E-05
Kv	Edwards-Trinity (Plateau)	9.41E-03	9.41E-05	8.11E-02	8.11E-04	4.16E-02	4.16E-04	3.78E-02	3.78E-04	3.83E-02	3.83E-04
Kv	Upper Dockum	5.09E-04	1.00E-05	1.03E-03	7.94E-05	6.62E-04	4.09E-05	6.56E-04	4.03E-05	6.27E-04	3.99E-05
Kv	Lower Dockum	5.12E-04	3.14E-05	2.17E-03	1.74E-04	7.45E-04	5.59E-05	7.25E-04	5.37E-05	6.88E-04	5.08E-05
Ss	Ogallala Aquifer	9.57E-06	9.57E-06	3.33E-04	3.33E-04	7.00E-05	7.00E-05	5.15E-05	5.15E-05	4.93E-05	4.93E-05
Ss	Rita Blanca Outcrop	5.14E-06	5.14E-06	6.65E-06	6.65E-06	5.76E-06	5.76E-06	5.74E-06	5.74E-06	5.66E-06	5.66E-06
Ss	Rita Blanca Downdip	5.18E-06	5.18E-06	6.83E-06	6.83E-06	6.10E-06	6.10E-06	6.09E-06	6.09E-06	6.12E-06	6.12E-06
Ss	Edwards-Trinity (High Plains)	3.00E-06	3.00E-06	3.00E-06	3.00E-06	3.00E-06	3.00E-06	3.00E-06	3.00E-06	3.00E-06	3.00E-06
Ss	Edwards-Trinity (Plateau) Outcrop	5.03E-07	5.03E-07	2.40E-03	2.40E-03	1.32E-04	1.32E-04	7.99E-05	7.99E-05	6.89E-05	6.89E-05
Ss	Edwards-Trinity (Plateau) Downdip	6.85E-06	6.85E-06	9.03E-04	9.03E-04	8.12E-05	8.12E-05	4.73E-05	4.73E-05	3.29E-05	3.29E-05
Ss	Upper Dockum Outcrop	5.62E-06	5.62E-06	7.25E-06	7.25E-06	6.75E-06	6.75E-06	6.74E-06	6.74E-06	6.80E-06	6.80E-06

Table 3.1.1, continued

Parameter	Aquifer	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
		Min	**Min**	**Max**	**Max**	**Mean**	**Mean**	**Geometric Mean**	**Geometric Mean**	**Median**	**Median**
Ss	Upper Dockum Downdip	5.18E-06	5.18E-06	7.42E-06	7.42E-06	6.45E-06	6.45E-06	6.44E-06	6.44E-06	6.58E-06	6.58E-06
Ss	Lower Dockum Outcrop	4.49E-06	4.49E-06	6.87E-06	6.87E-06	6.38E-06	6.38E-06	6.37E-06	6.37E-06	6.40E-06	6.40E-06
Sy	Ogallala Aquifer	0.03	0.03	0.27	0.27	0.17	0.17	0.16	0.17	0.16	0.17
Sy	Rita Blanca Outcrop	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Sy	Rita Blanca Downdip	0.05	0.05	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Sy	Edwards-Trinity (High Plains)	0.05	0.05	0.14	0.14	0.09	0.09	0.09	0.09	0.09	0.09
Sy	Edwards-Trinity (Plateau) Outcrop	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sy	Edwards-Trinity (Plateau) Downdip	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sy	Upper Dockum Outcrop	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Sy	Upper Dockum Downdip	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Sy	Lower Dockum Outcrop	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Shading indicates that values were not changed from their initial estimates during calibration.

Kh = horizontal hydraulic conductivity
Kv = vertical hydraulic conductivity
Ss = specific storage
Sy = specific yield

Table 3.1.2 Fraction of initial pre-1980 Ogallala Aquifer pumping by county.

County	Pre-1980 Fraction	Percent Reduction
Bailey	0.30	70%
Briscoe	0.75	25%
Castro	0.39	61%
Cochran	0.36	64%
Crosby	0.55	45%
Deaf Smith	0.43	57%
Hale	0.42	58%
Hockley	0.33	67%
Lamb	0.37	63%
Lubbock	0.40	60%
Midland	0.83	17%
Moore	0.80	20%
Oldham	0.48	52%
Parmer	0.38	62%
Potter	0.66	34%
Randall	0.56	44%
Swisher	0.43	57%
Terry	0.38	62%
Yoakum	0.42	58%

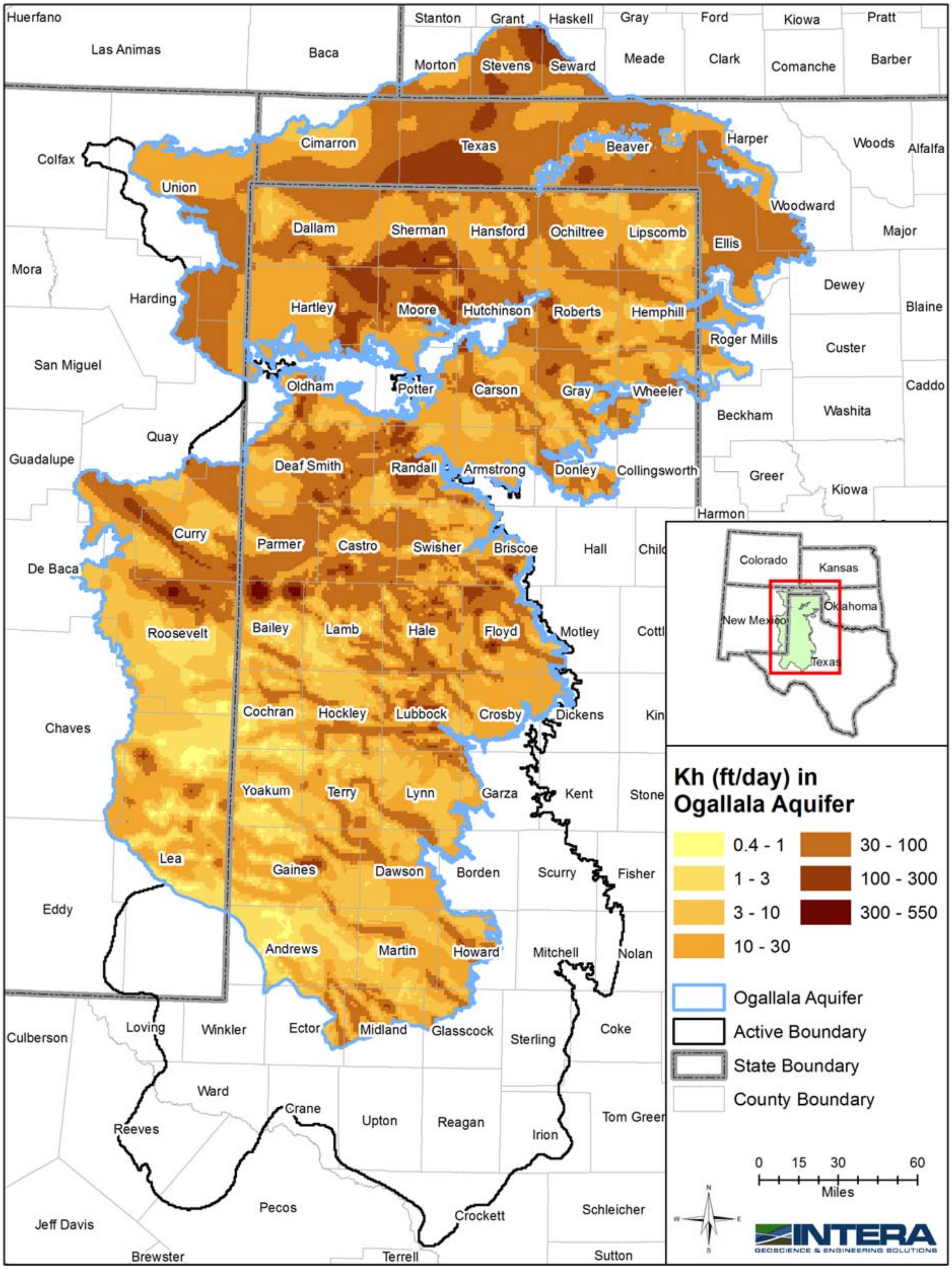


Figure 3.1.1 Calibrated horizontal hydraulic conductivity in feet per day in the Ogallala Aquifer.

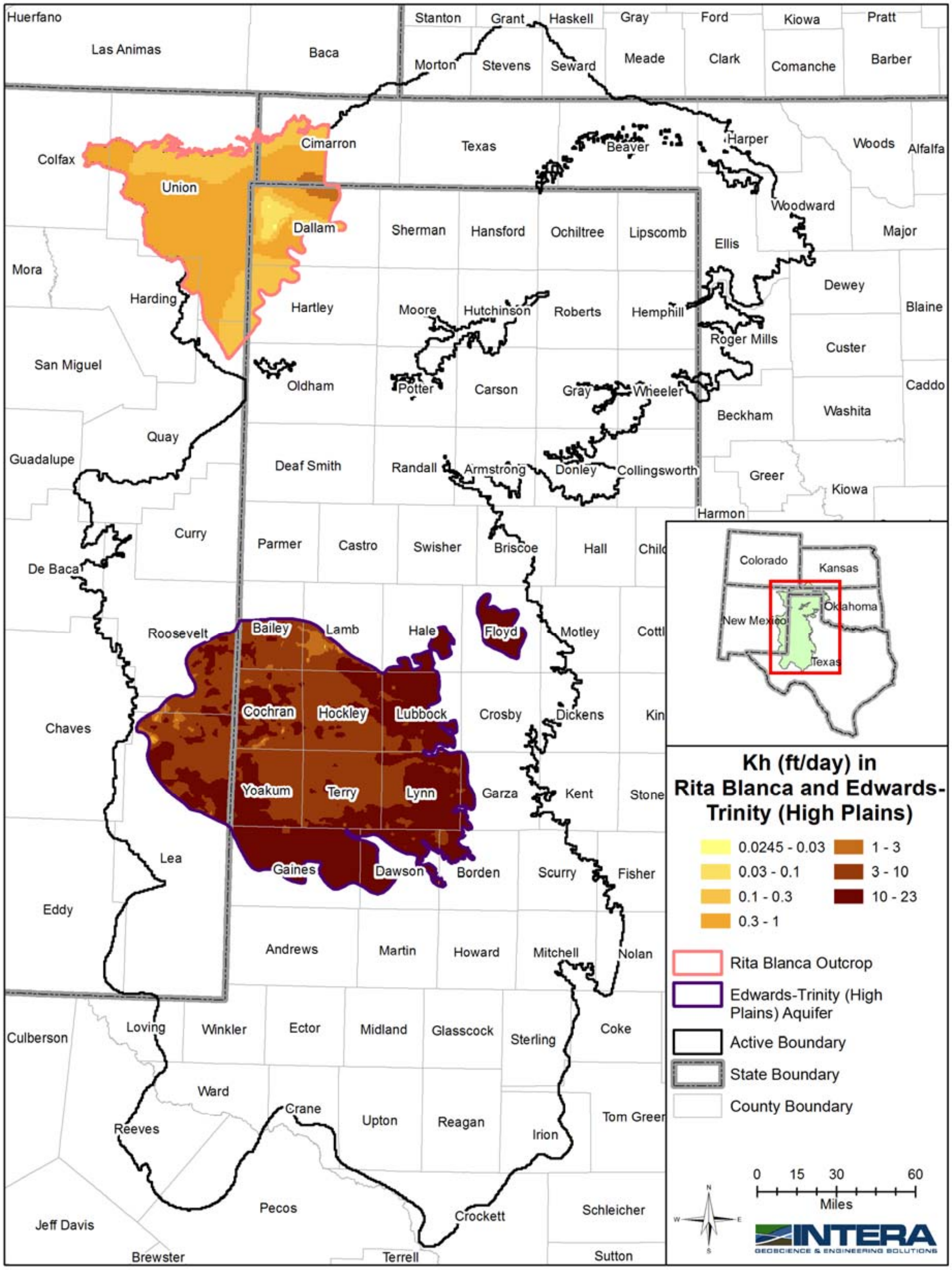


Figure 3.1.2 Calibrated horizontal hydraulic conductivity in feet per day in the Rita Blanca and Edwards-Trinity (High Plains) aquifers.

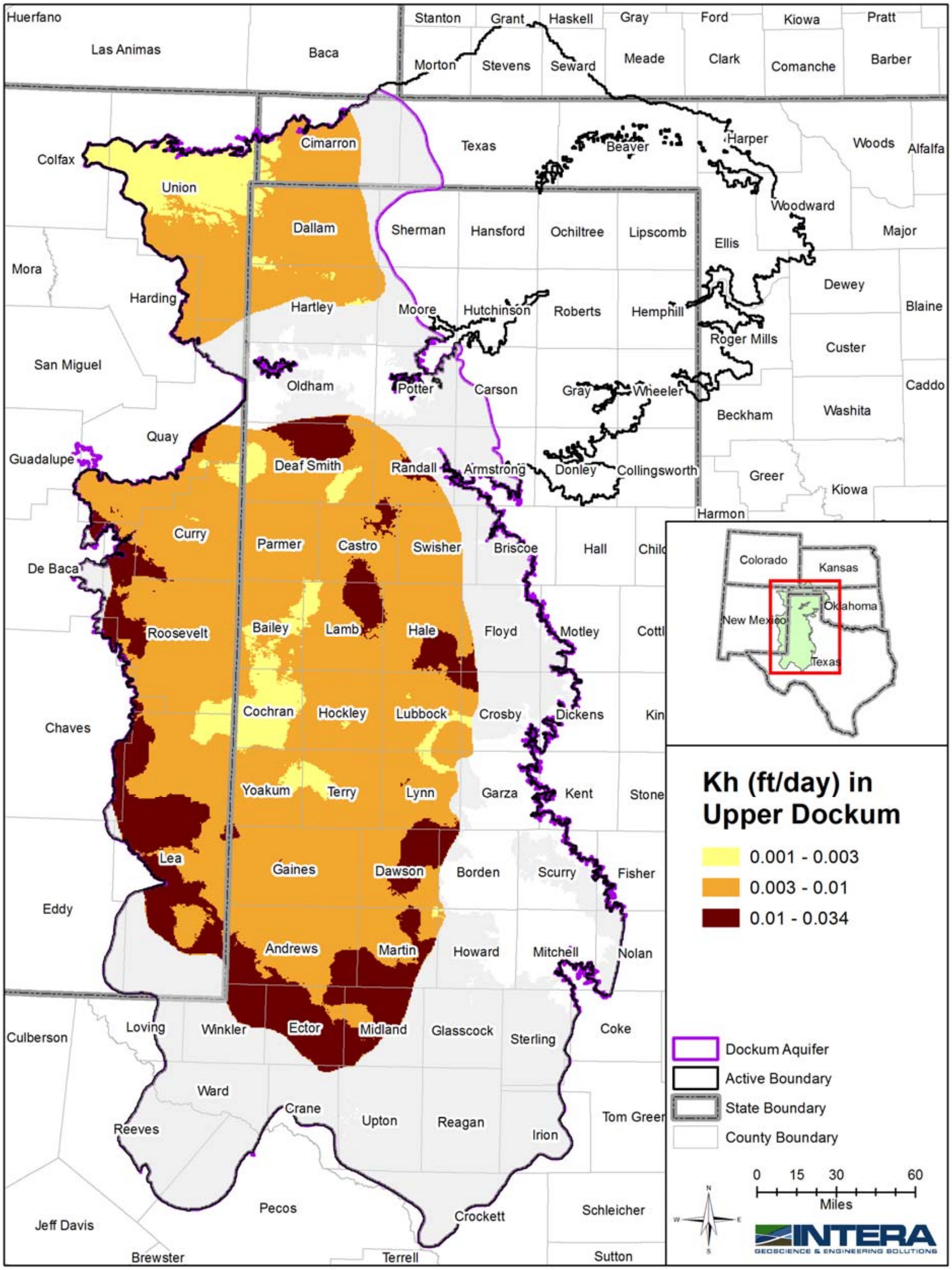


Figure 3.1.3 **Calibrated horizontal hydraulic conductivity in feet per day in the upper Dockum Aquifer.**

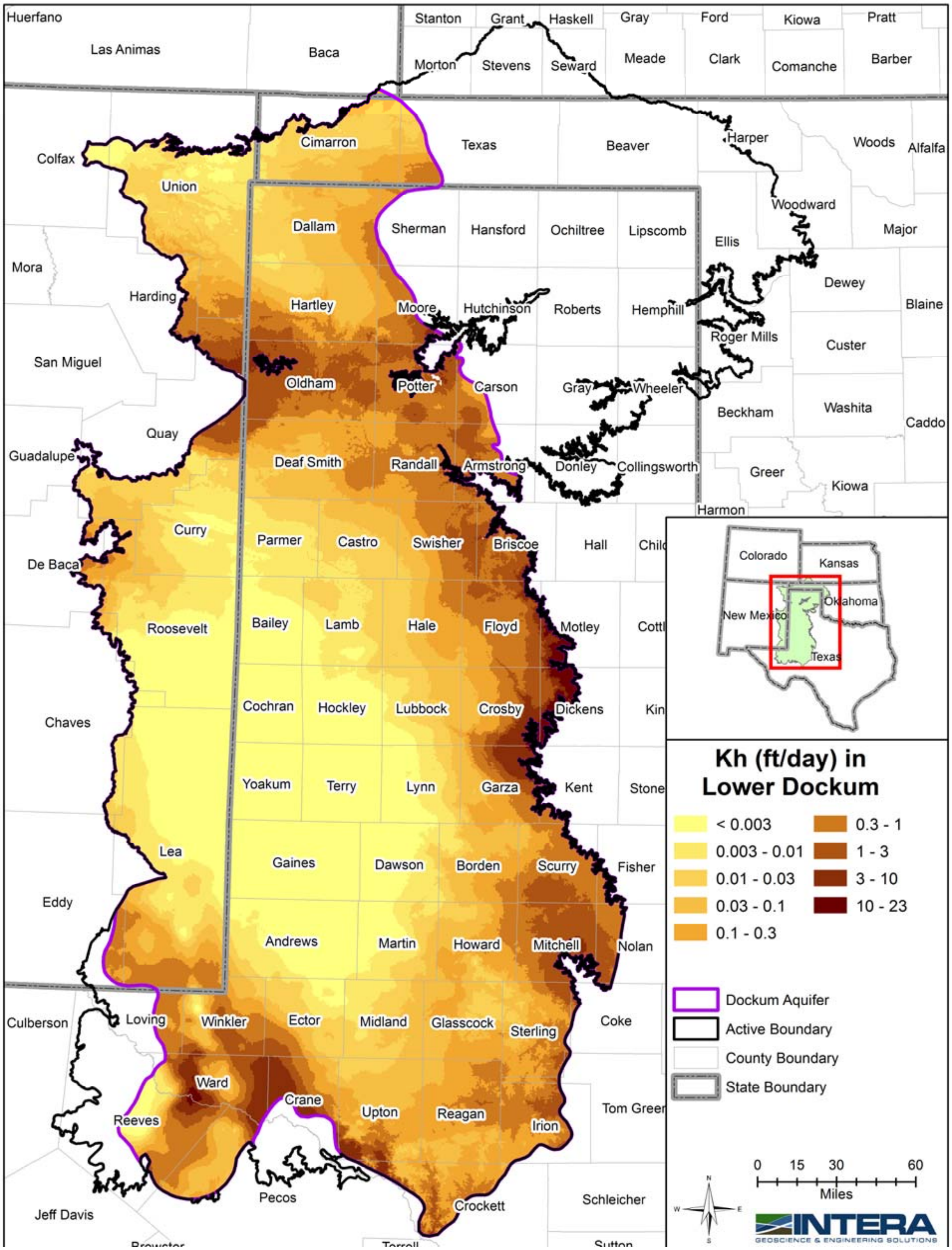


Figure 3.1.4 Calibrated horizontal hydraulic conductivity in feet per day in the lower Dockum Aquifer.

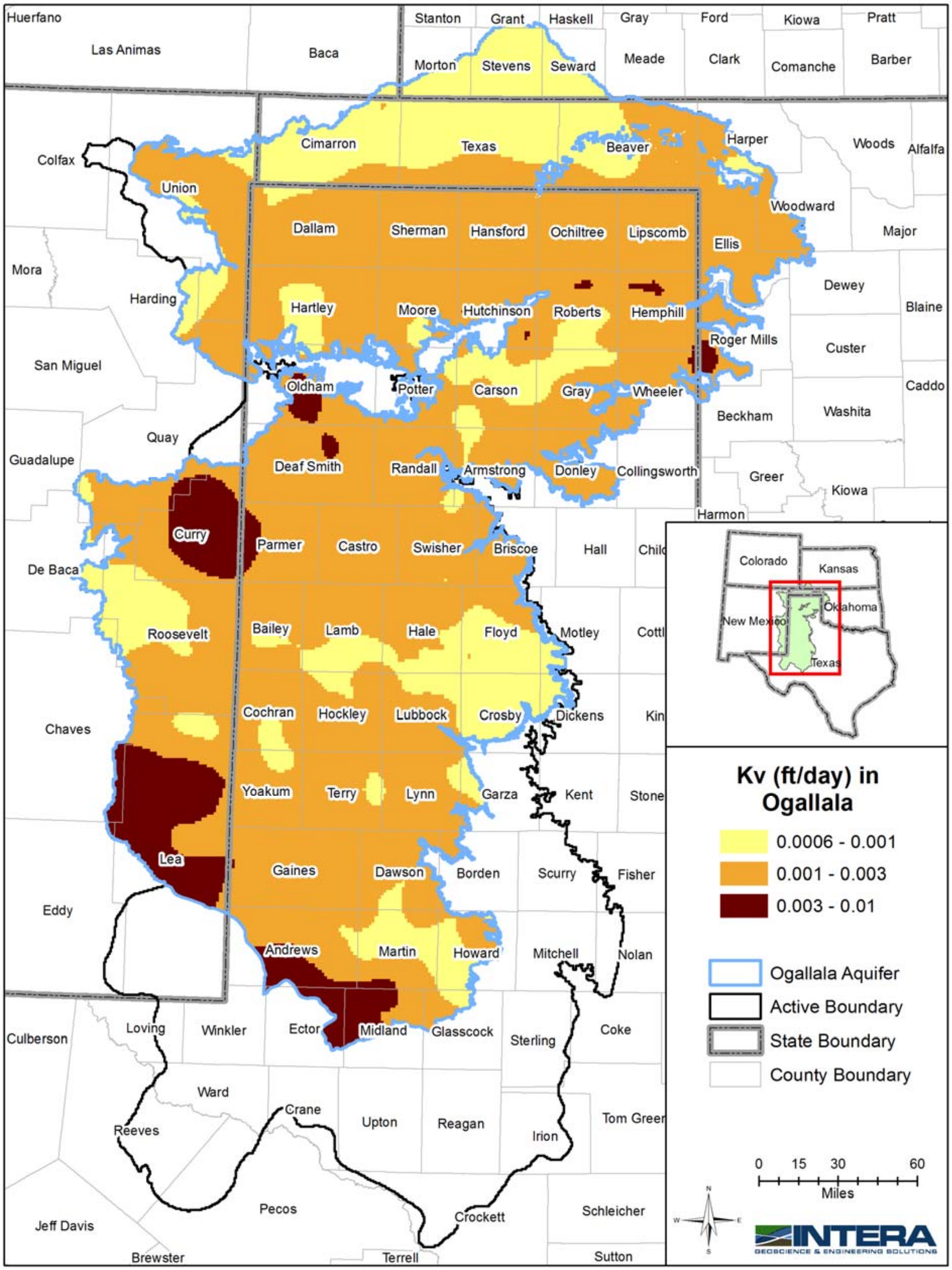


Figure 3.1.5 Calibrated vertical hydraulic conductivity in feet per day in the Ogallala Aquifer.

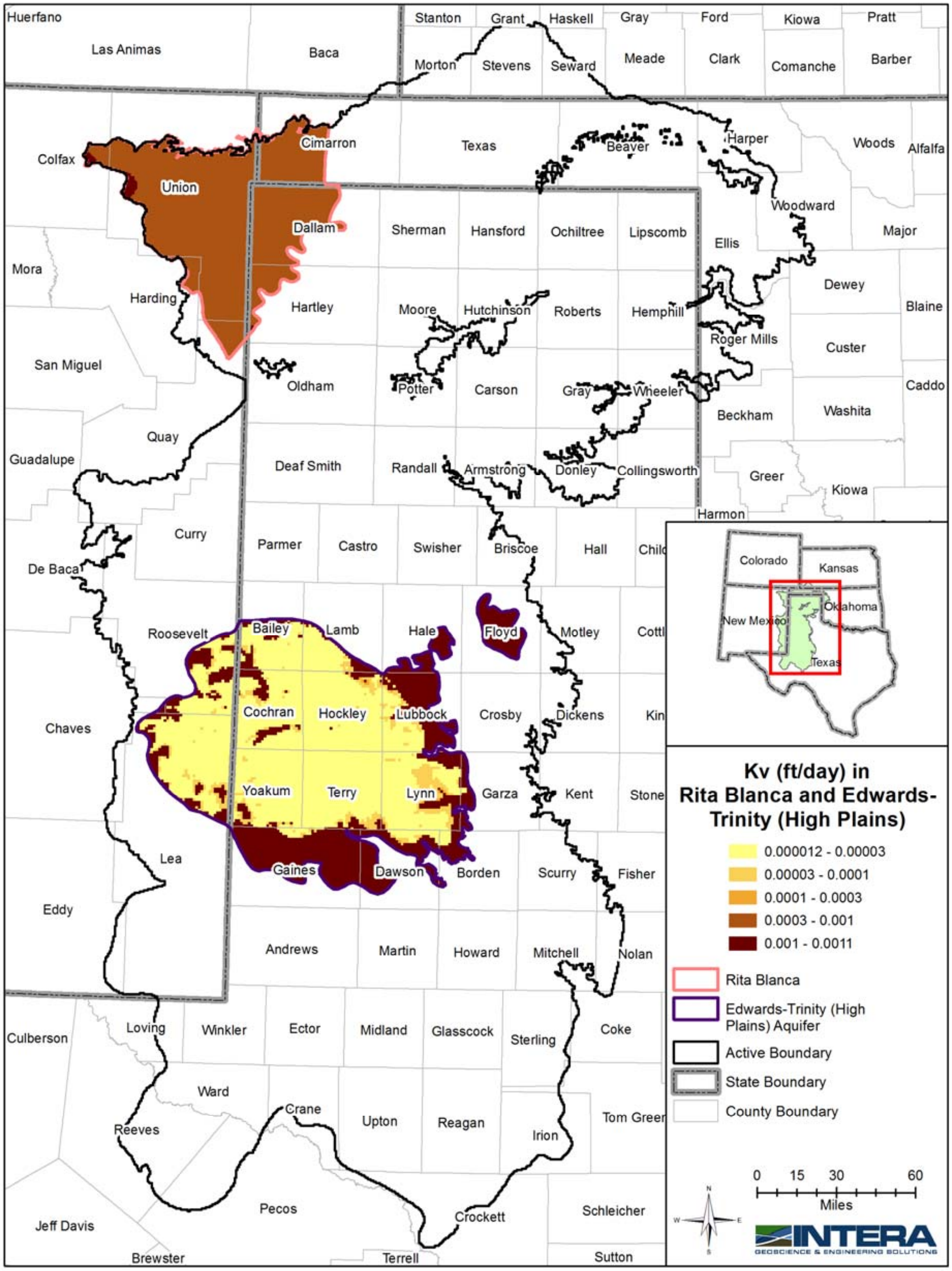


Figure 3.1.6 Calibrated vertical hydraulic conductivity in feet per day in the Rita Blanca and Edwards-Trinity (High Plains) aquifers.

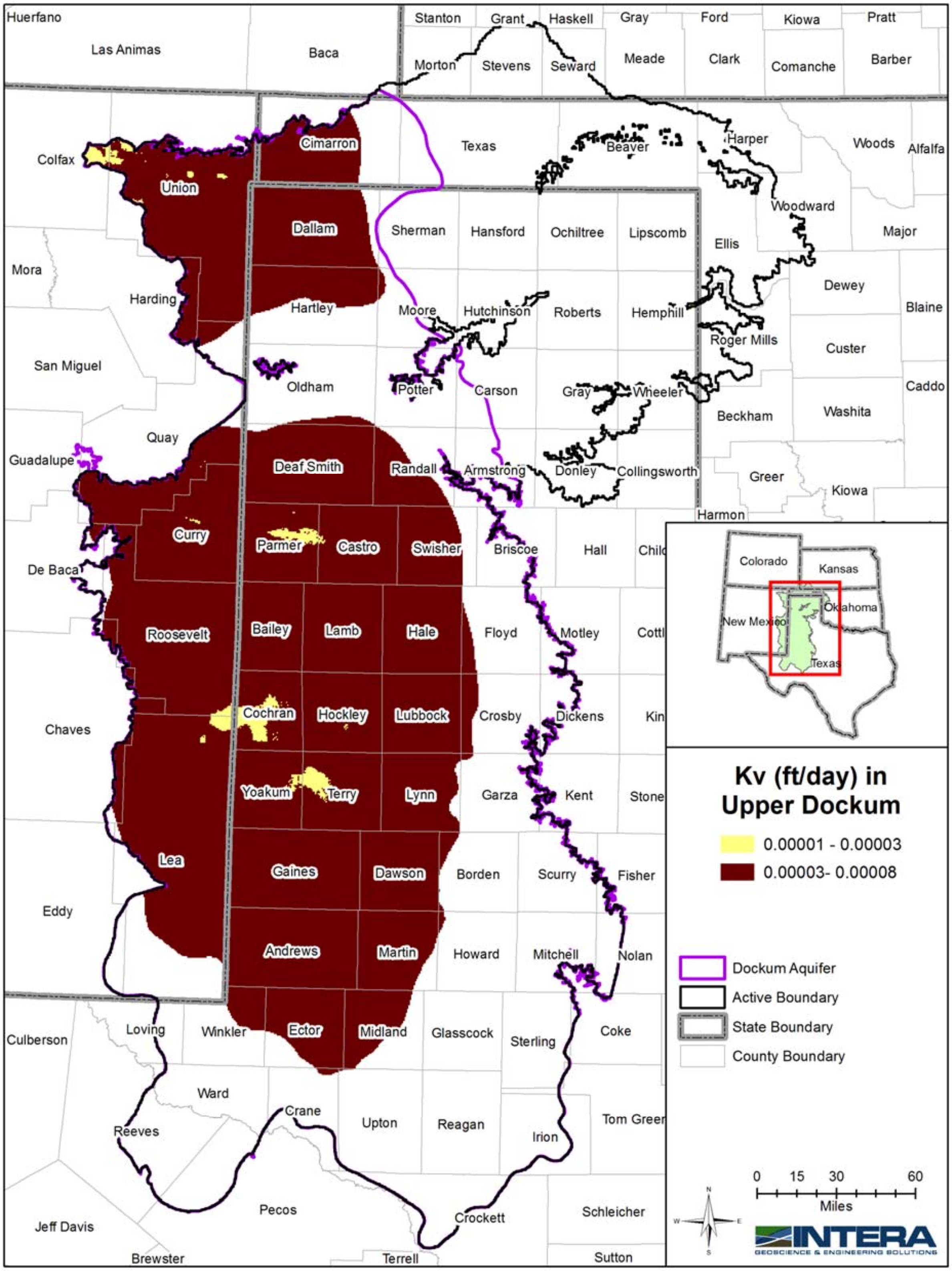


Figure 3.1.7 **Calibrated vertical hydraulic conductivity in feet per day in the upper Dockum Aquifer.**

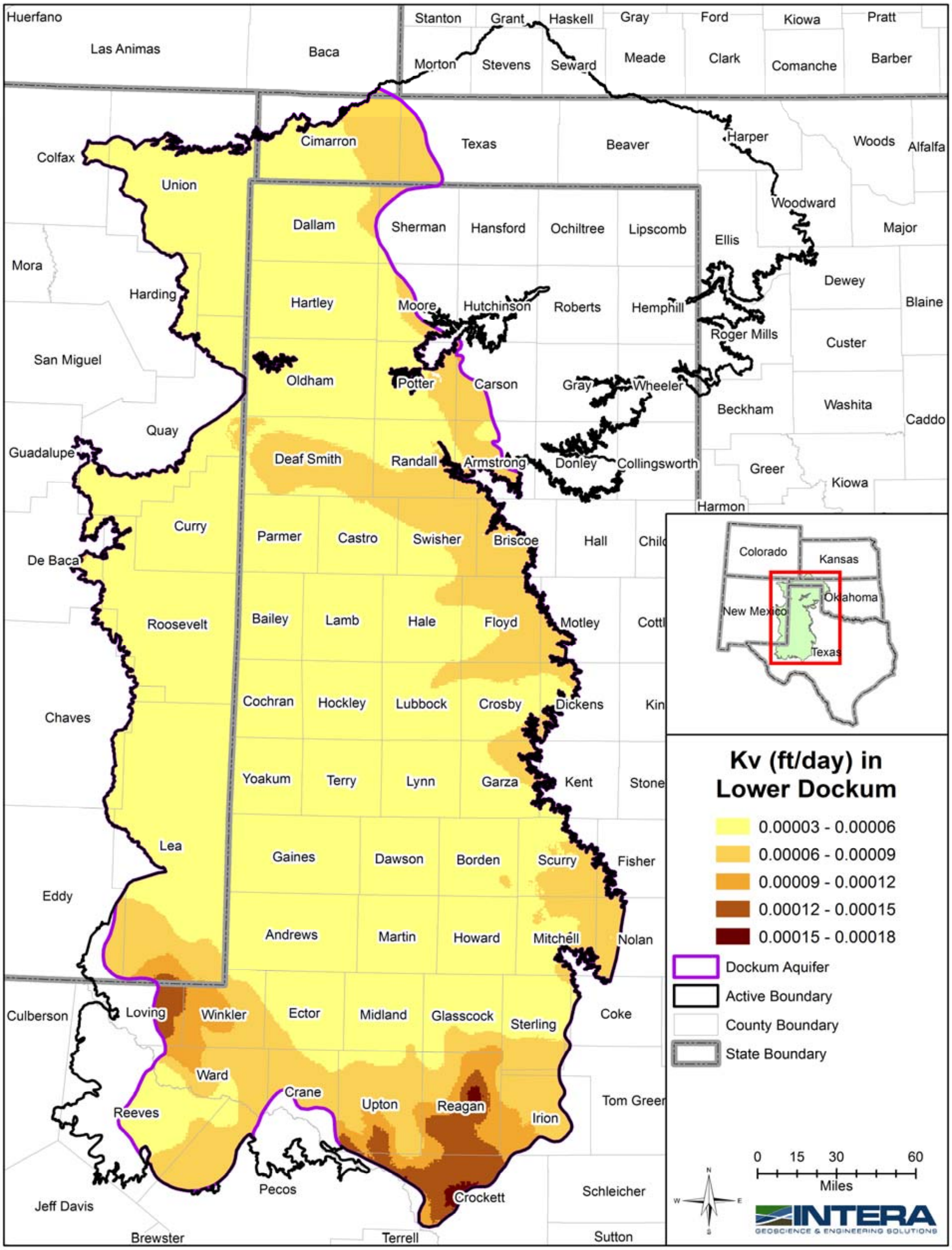


Figure 3.1.8 **Calibrated vertical hydraulic conductivity in feet per day in the lower Dockum Aquifer.**

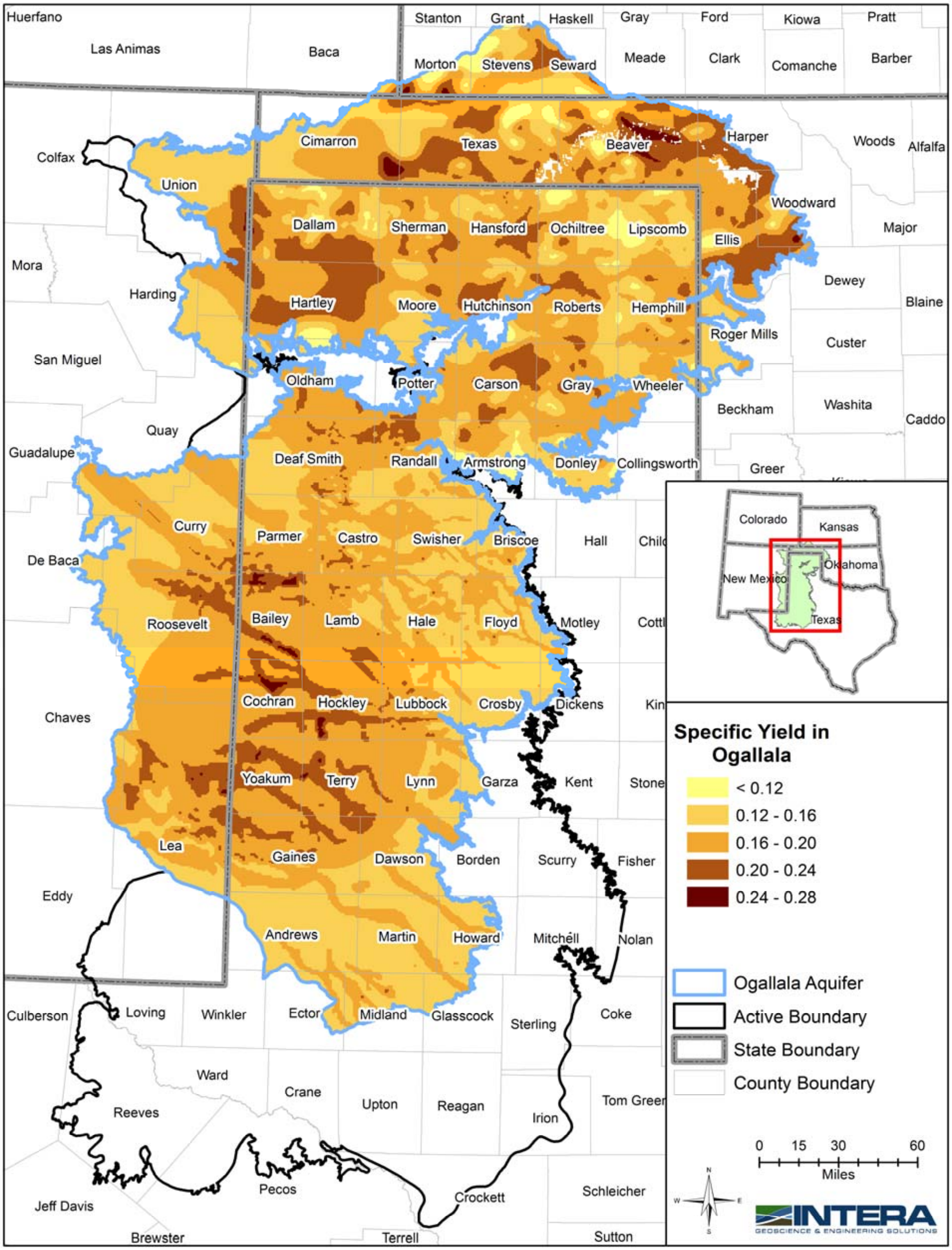


Figure 3.1.9 **Calibrated specific yield in the Ogallala Aquifer.**

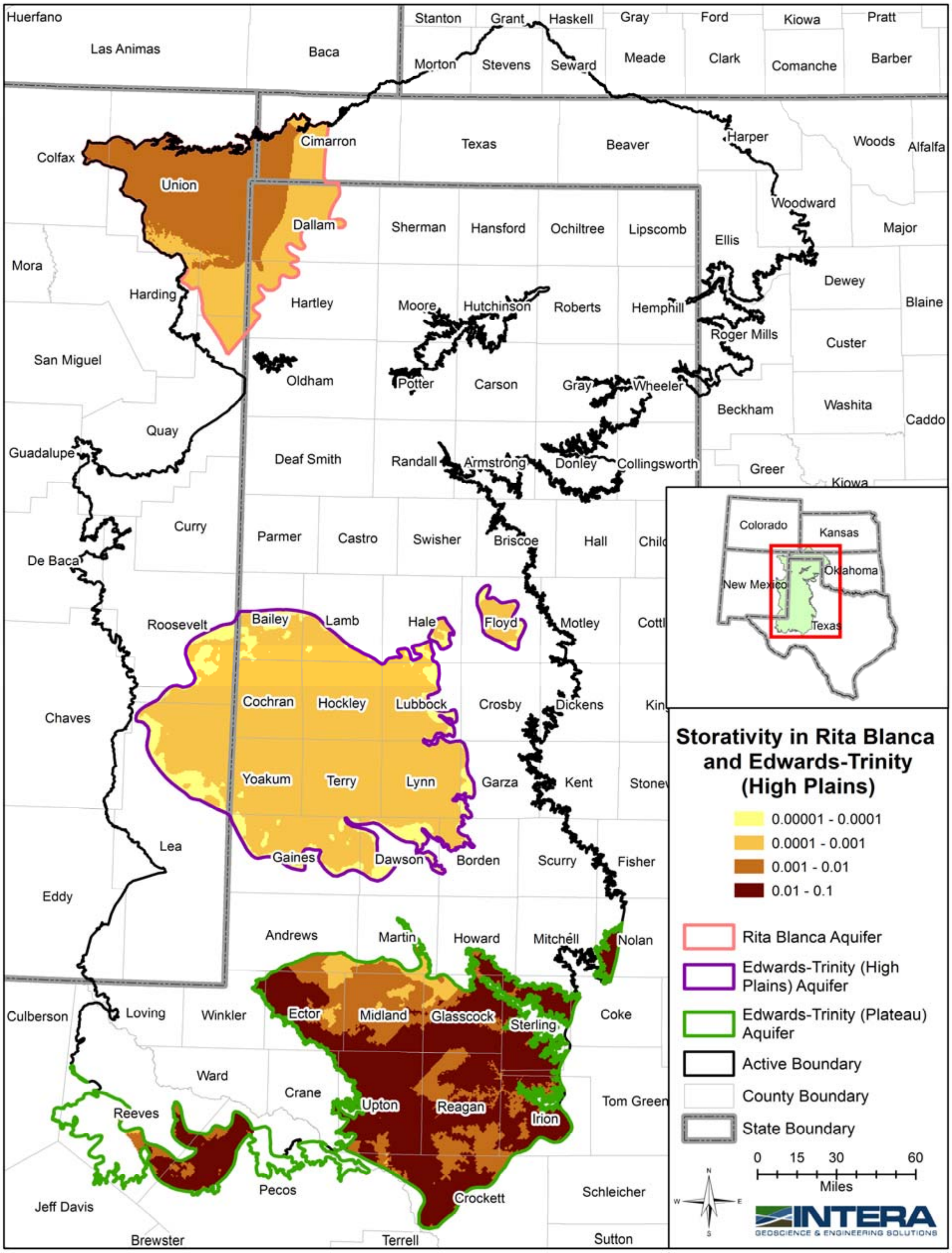


Figure 3.1.10 Calibrated storativity in the Rita Blanca and Edwards-Trinity (High Plains) aquifers.

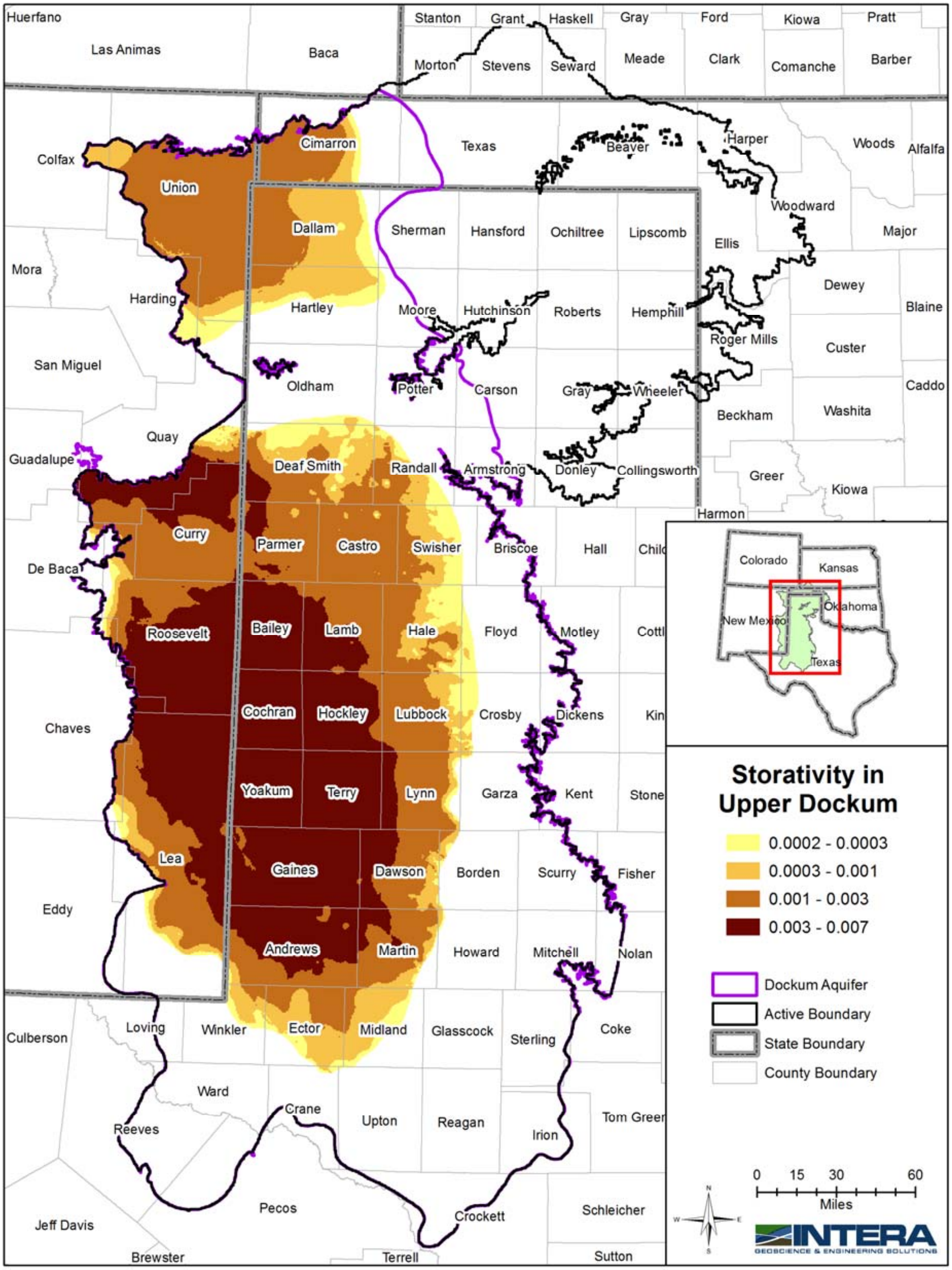


Figure 3.1.11 Calibrated storativity in the upper Dockum Aquifer.

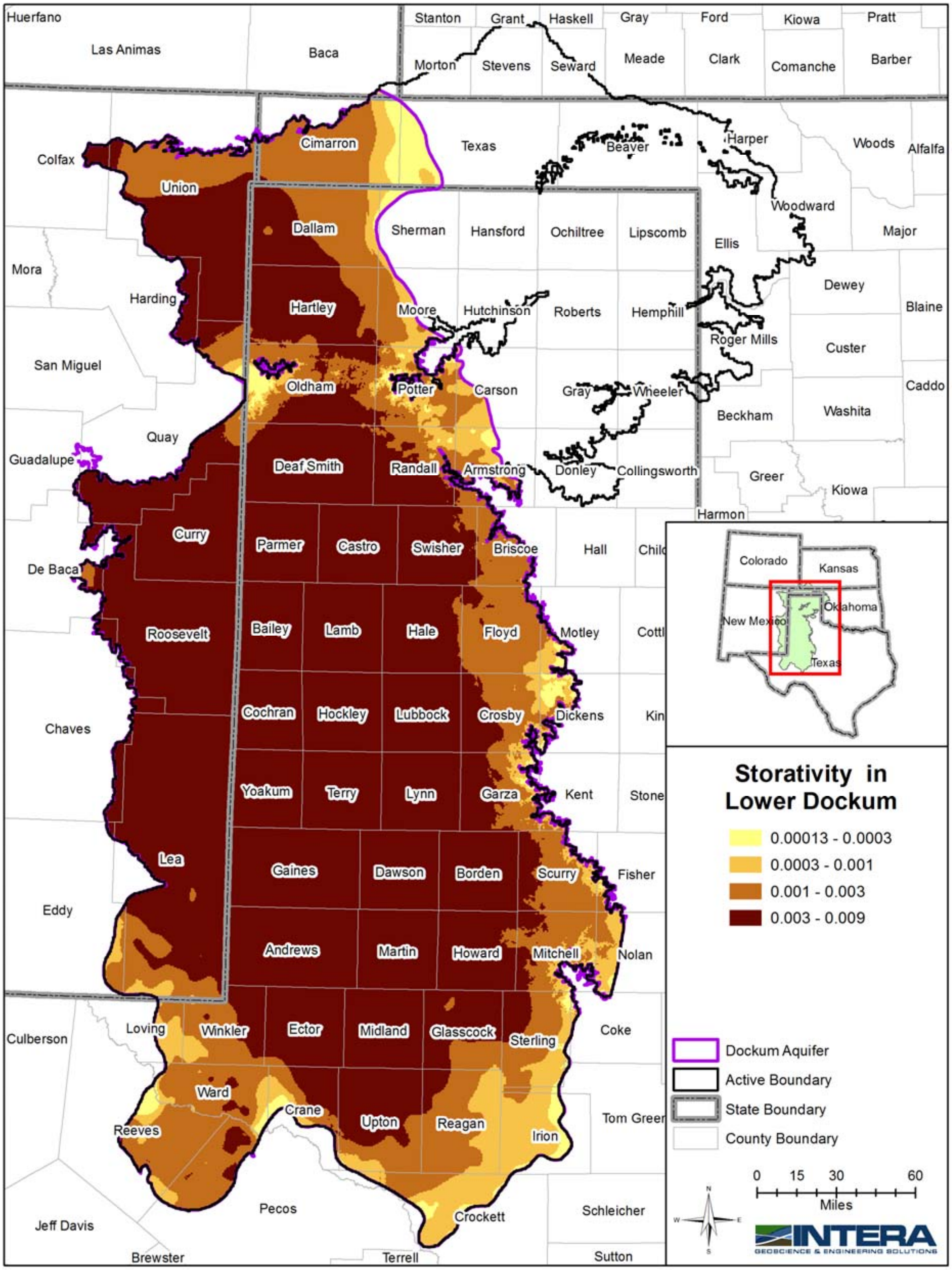


Figure 3.1.12 Calibrated storativity in the lower Dockum Aquifer.

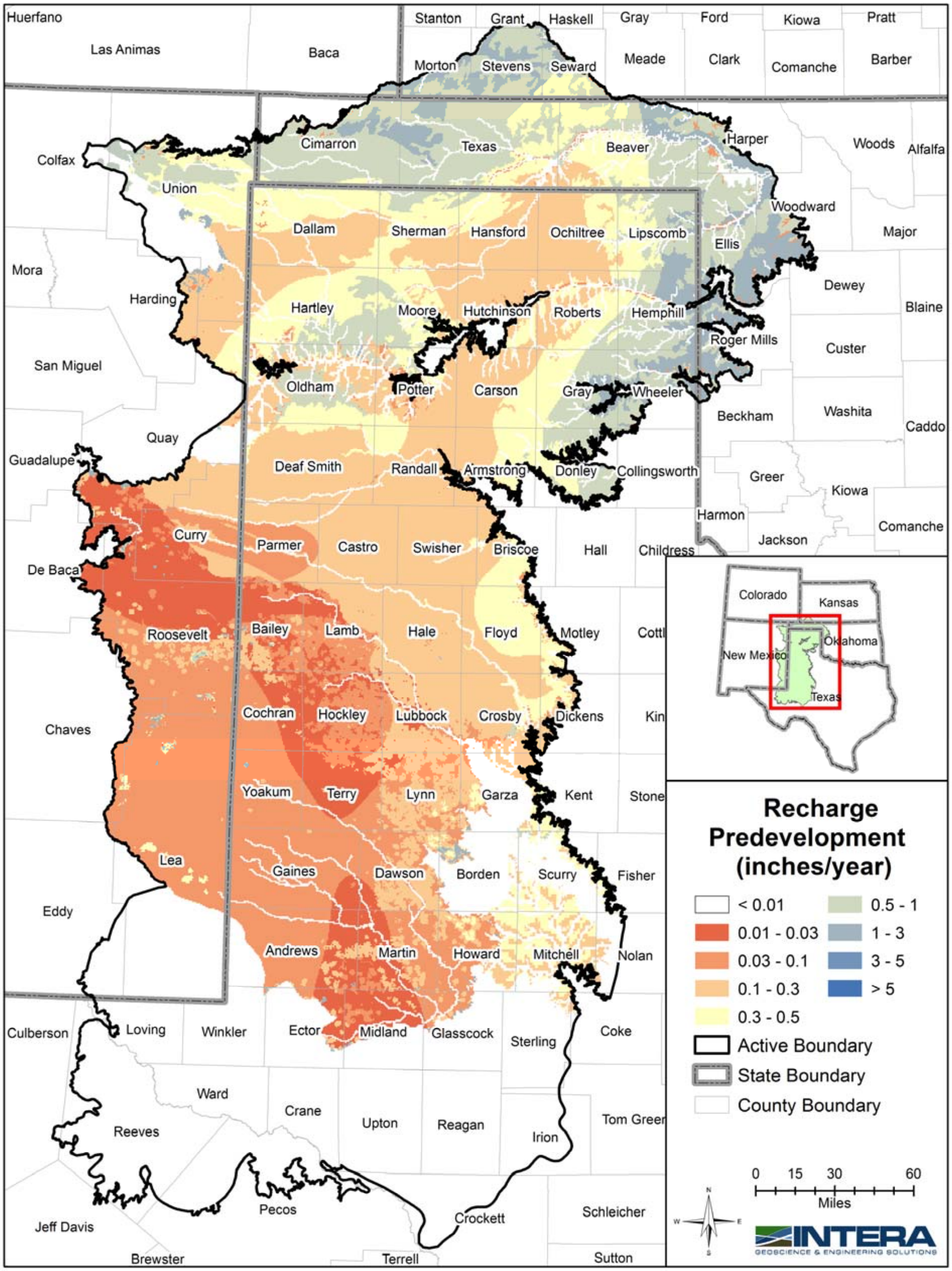


Figure 3.1.13 Calibrated predevelopment (steady-state stress period) recharge distribution.

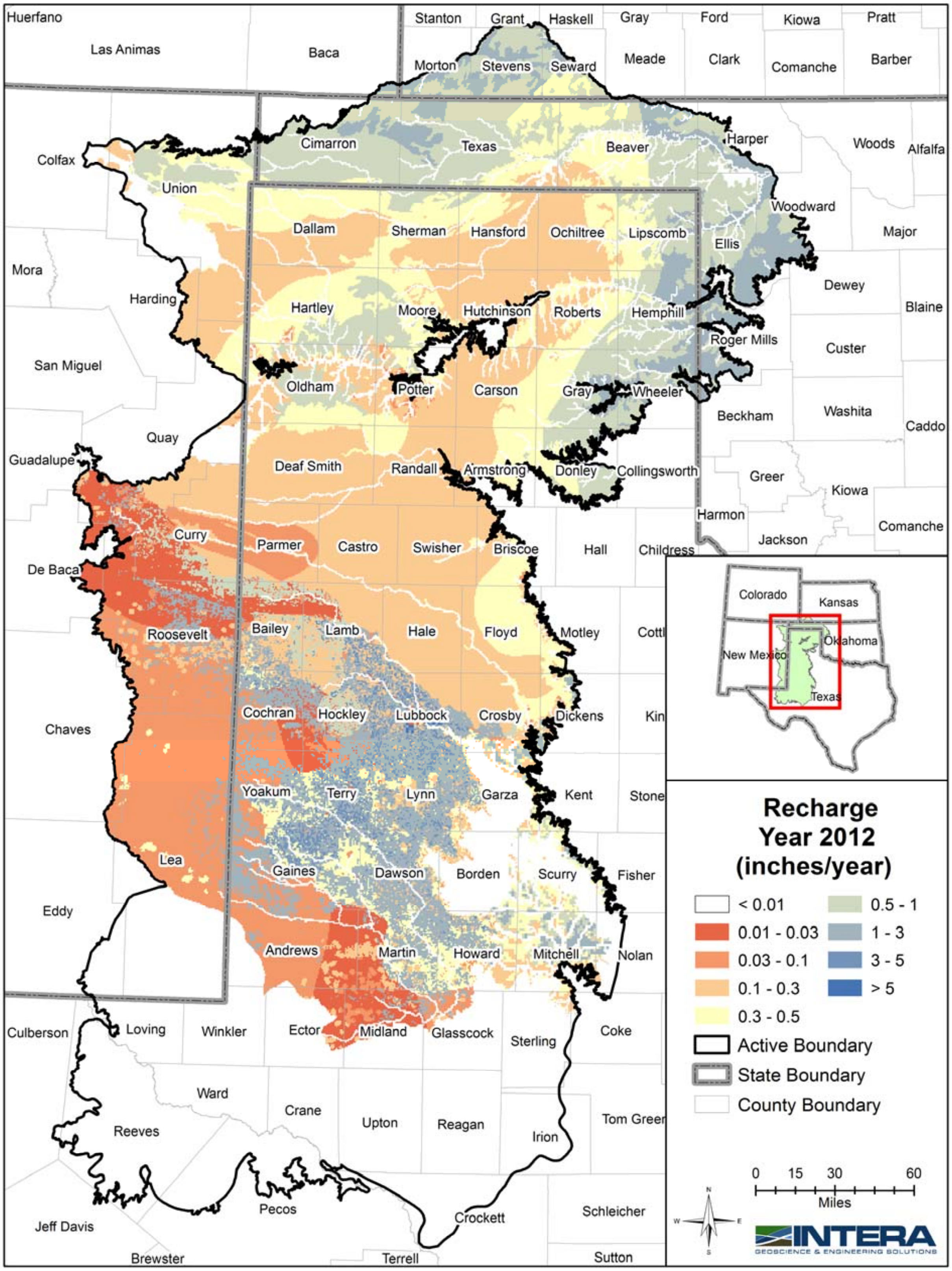


Figure 3.1.14 **Calibrated transient recharge distribution in year 2012 (stress period 84).**

This page intentionally left blank.

3.2 Model Simulated Versus Measured Heads

This section describes the results of the model calibration to observed heads, both spatially and temporally. The calibration will be discussed first in terms of summary statistics and crossplots, followed by a discussion of trends in head residuals, both distribution about the mean and spatial distribution. This will be followed by a presentation of simulated head surfaces, simulated drawdown, and change in saturated thickness, where appropriate.

3.2.1 Summary Statistics and Crossplots

Table 3.2.1 shows the head calibration statistics by aquifer for the steady-state stress period (representing predevelopment), and two transient time ranges, 1930 to1979, and 1980 to 2012. The two transient periods differ in length (50 years versus 33 years), but have similar magnitudes of samples, with the latter period having more as the result of sampling density increasing with time for the study area. The summary statistics can be considered along with Figures 3.2.1 through 3.2.6, which show crossplots for each aquifer for the steady-state (Figures 3.2.1 through 3.2.3) and the last 33 years (1980 to 2012).

The Ogallala Aquifer has a small positive mean error in steady-state, indicating that the model simulates slightly low on average compared to estimated water levels. This bias is not strongly indicated in the crossplot in Figure 3.2.1, although there are points consistently below the line from 4,000 to 5,000 feet above mean sea level. The mean absolute error is less than 30 feet, which is a result comparable to previous Ogallala Aquifer groundwater availability models. The relative error (mean absolute error divided by the range) is less than 1 percent, due to the large range compared to mean absolute error. As noted in Section 2, while standard practice is to calibrate to a relative error of less than 10 percent, the large range for all of the aquifers in this model led to setting more absolute goals for the mean absolute error. Given the calibration of the previous groundwater availability models, the goals were approximately 30 feet mean absolute error for the Ogallala Aquifer, and approximately 50 feet for the minor aquifers.

The Rita Blanca and Edwards-Trinity (High Plains) aquifers both had negative mean errors, indicating that simulated heads were somewhat higher on average than measured heads. However, these mean errors are within acceptable range, especially considering the uncertainty in, and general lack of, steady-state targets for these aquifers. The mean absolute error for the

Rita Blanca Aquifer was higher than the initial goal of 50 feet, but with the small number of samples this was still considered an acceptable calibration for steady-state. The crossplot shown in Figure 3.2.2 shows the slight bias in simulated heads, with more points falling above the line than below. The overall scatter around the line however, is consistent with an acceptable calibration.

The upper Dockum Aquifer also had a mean error indicating that simulated heads were higher than estimated for predevelopment. However, given the general lack of samples, and uncertainty in the predevelopment estimates, the mean error is acceptable. The lower Dockum Aquifer has a small positive mean error. Both the upper and lower Dockum aquifers had an acceptable mean absolute error near 50 feet. The Dockum Aquifer calibration exhibits the broadest scatter (Figure 3.2.3) around the 1:1 line, but still shows a good distribution around that line. Overall, the steady-state calibration for all aquifers is acceptable, based on the summary statistics and crossplots.

The magnitude of mean error for the Ogallala Aquifer decreases through time, and the mean error for the last 30 years is very small, at less than 2 feet. The mean absolute error is less than 30 feet for both time periods, again indicating an acceptable calibration. The crossplot shown in Figure 3.2.4 shows good clustering around the 1:1 line, with only a handful of points outside the main cluster. Even at very high elevations, the points are close to the line, although a slight positive bias (model simulating too low) can be seen at around the 5,000 feet above mean sea level elevation.

The negative mean error for the Rita Blanca Aquifer becomes less negative in the transient period, but still simulates heads approximately 20 feet higher on average than observed heads. The negative mean error in the Edwards-Trinity (High Plains) Aquifer becomes more negative in the early transient period, but gets less negative in the late transient period, indicating that less bias occurs later in the simulation. The mean absolute error for both the Rita Blanca and Edwards-Trinity (High Plains) aquifers stay within an acceptable range for both early and late transient periods. The crossplot shown in Figure 3.2.5 shows more scatter around the 1:1 line for the Rita Blanca Aquifer at higher elevations, but still has a good distribution around the line.

The mean error for the upper Dockum Aquifer becomes less negative in transient, indicating that simulated heads are decreasing somewhat relative to observed heads. The lower Dockum

Aquifer mean error goes from small positive to small negative from steady-state to transient. The mean absolute error for both the upper and lower Dockum aquifers stays within an acceptable range throughout the transient period. Figure 3.2.6 shows that, as with steady-state, the Dockum Aquifer calibration exhibits the most scatter around the 1:1 line. There are a handful of points where the simulated head is well above the 1:1 line, that is, where simulated heads are much higher than observed. A review of these points indicates that they represent single measurements of head, typically when the well was drilled. Because of the low productivity of the Dockum Aquifer in some areas, if the water level was not allowed sufficient time to recover after drilling, the measurements will typically be biased low. Because of the small number of points exhibiting this characteristics, they did not affect calibration, and were left as part of the target dataset.

3.2.2 Residual Distributions

Figures 3.2.7 through 3.2.9 show histograms of the head residuals for the late transient calibration period, 1980 to 2012. Perfectly normally distributed histograms will exhibit the classic symmetric bell shape centered on zero. Residual datasets with a nonzero mean error will be shifted away from zero by approximately the magnitude of the mean error. The head residual histograms behave as expected, showing good symmetry in most cases, and are shifted from zero the amount of the mean error. The Ogallala Aquifer residuals in Figure 3.2.7 have very little mean error, and thus the histogram centers near zero. In Figure 3.2.8, the Rita Blanca Aquifer residual histogram exhibits a shift of approximately 25 feet, and the Edwards-Trinity (High Plains) Aquifer histogram exhibits a shift of less than 20 feet, and both are relatively symmetric about the mean. The upper and lower Dockum Aquifer histograms shown in Figures 3.2.9 and 3.2.10, respectively, show similar characteristics, with good symmetry and a slight shift. In general, all of the histograms show residual distributions that are acceptable for a calibrated model.

Figures 3.2.10 through 3.2.13 show spatial plots of residuals for the steady-state calibration period. As noted previously, negative residuals indicate that the model is simulating high compared to estimated steady-state water levels, while positive residuals indicate that the model is simulating low in comparison. Figure 3.2.10a shows the residuals in the Ogallala Aquifer in the northern portion of the study area. In general, most residuals are within 50 feet of zero, with a scattering of both positive and negative residuals in some places. Figure 3.2.10b shows the residuals in the Ogallala Aquifer for the southern portion of the study area. Again, most of the residuals are small. There is some slight negative bias in New Mexico to the southwest, which is generally consistent with the difficulty that was encountered during calibration in keeping the Ogallala Aquifer layer saturated at the high elevations to the west.

Figure 3.2.11 shows the residuals for the Rita Blanca and Edwards-Trinity (High Plains) aquifers. The majority of residuals are within the 50 foot range, with the Rita Blanca Aquifer having more positive residuals (simulating low) at the higher elevations to the west and more negative residuals (simulating high) moving downdip to the east. This trend in residuals is typical when modeling a strongly dipping aquifer with a single layer, because the intra-aquifer vertical resistance to flow cannot be captured in a single layer. The Edwards-Trinity (High Plains) Aquifer has more negative residuals, which is expected given the mean error of less than -30 feet. As discussed previously, the slight negative residual bias in the Edwards-Trinity (High Plains) Aquifer steady-state calibration was partially due to the difficulty in keeping the Ogallala Aquifer saturated to the west. If heads were allowed to drop significantly in the Edwards-Trinity (High Plains) Aquifer, more dry cells occurred in the Ogallala Aquifer, even when varying properties (that is, reducing the horizontal and vertical hydraulic conductivity) to the limits of their acceptable range. In the end, the slight negative bias was accepted in the Edwards-Trinity (High Plains) Aquifer, as it was not outside the range for a typical regional model calibration. Figure 3.2.12 shows the steady-state residuals for the upper and lower Dockum aquifers combined. The majority of residuals are in the 50 foot range, with a mixture of positive and negative residuals in most areas.

Figures 3.2.13 through 3.2.15 show spatial plots of residuals for the transient calibration period from 1980 to 2012. The northern portion of the Ogallala Aquifer, shown in Figure 3.2.13a, shows the vast majority of residuals falling the 50 foot range, with a mix of positive and negative residuals in some areas. Special attention was required in Dallam County to improve negative residuals that occurred after the initial calibration. As discussed in Section 2.4, additional pilot points were added in this area to allow finer adjustment of recharge and horizontal hydraulic conductivity. The end result still has some large residuals in Dallam County, but a mix of both positive and negative residuals exists, rather than most of the residuals being negative.

Figure 3.2.13b shows the residuals for the Ogallala Aquifer in the southern portion of the study area. The only areas where some bias appears are in New Mexico, where more positive residuals than negative residuals exists. This trend is the same as has been previously discussed, where simulated heads are difficult to sustain at the higher elevations in the Ogallala Aquifer. The majority of the residuals in these areas are within the 50-foot range, and the calibration is considered acceptable.

Figure 3.2.14 shows the residuals for the Rita Blanca and Edwards-Trinity (High Plains) aquifers. The residuals are well distributed for the Rita Blanca Aquifer, and the negative bias has been reduced in the Edwards-Trinity (High Plains) Aquifer residuals, with some positive residuals appearing. Figure 3.2.15 shows the residuals for the Dockum Aquifer. In most areas the residuals are distributed both positively and negatively, although there is a spot in New Mexico where a cluster of positive residuals exists. This area is near the upper Dockum Aquifer outcrop, but increased recharge in the upper Dockum Aquifer resulted in increased flooding in the outcrop, with little effect on the residuals. The large negative residuals that mostly occur deep in the confined section of the Dockum Aquifer are from the same targets discussed in Section 3.2.1, where a driller measurement of a single water level shortly after drilling may be underestimated. Overall, the transient residual plots show an acceptable level of residual distribution for the calibrated model.

3.2.3 Simulated Water Levels

In this section the model simulated water levels, drawdown from steady-state, and saturated thickness are presented. Figures 3.2.16 through 3.2.19 show the simulated heads in each of the modeled aquifers for the steady-state stress period. The overall trend in heads for all aquifers in the High Plains Aquifer System is one of west to east gradient, generally following regional topographic trends. Figure 3.2.20 shows the saturated thickness in the Ogallala Aquifer for the steady-state stress period. Saturated thickness is generally larger in the northern part of the study area than in the south, although saturated thickness over 300 feet occurs in the large paleochannel running primarily through Parmer, Castro, Lamb, and Hale counties.

Figures 3.2.21 through 3.2.24 show the simulated heads in each of the aquifers for 1950, 1980, and 2010 for the transient simulation. The general east-west trend is still evident in all cases. The Ogallala Aquifer head contours by 2010 (Figure 3.2.21c) begin to show the impacts of some of the water level declines that have occurred during the historical period. The minor aquifers mostly show localized effects, with the Rita Blanca Aquifer (Figure 3.2.22c) showing a few areas of bent or closed contours in Dallam and Union counties and the lower Dockum Aquifer (Figure 3.2.24c) showing evidence of drawdown in several locations.

Figures 3.2.25 through 3.2.28 show simulated drawdown from the steady-state stress period representing predevelopment, to year 2010. Figure 3.2.25 shows drawdown in the Ogallala Aquifer, the most widespread of which occurs in the paleochannel in the southern portion of the study area where the greatest initial saturated thickness (south of the Canadian River) existed prior to development. In the northern portion of the study area, over 100 feet of drawdown has occurred in a small region contained by Moore and Sherman counties. Figure 3.2.26 shows that some localized drawdown has occurred in the Rita Blanca Aquifer, and the Edwards-Trinity (High Plains) Aquifer shows one area of drawdown in northern Gaines County that exceeds the drawdown in the overlying Ogallala Aquifer. The other areas of drawdown in the Edwards-Trinity (High Plains) Aquifer are attributable to, or at least correlated with, drawdown in the overlying Ogallala Aquifer. The drawdown in the upper Dockum Aquifer (Figure 3.2.27) directly correlates with the drawdown in the overlying Ogallala Aquifer. Because the storativity and horizontal conductivity in the upper Dockum Aquifer are low, only a small rate of cross-formational flux needs to occur in order to create large drawdowns. The rate of flux between aquifers is discussed in more detail in Sections 3.3 and 3.4. The lower Dockum Aquifer (Figure 3.3.28) shows areas of localized drawdown, with the largest in spatial extent occurring in conjunction with drawdown in the overlying Ogallala Aquifer. The drawdown along the eastern boundary of the Dockum Aquifer corresponds with the area where the Ogallala Aquifer and Santa Rosa sandstone (in the Dockum Aquifer) are in direct contact.

Figures 3.2.29 and 3.2.30 show the simulated saturated thickness in the Ogallala Aquifer in years 1980 and 2010. The areas where the most significant drawdown has occurred still have significant saturated thickness, since initial saturated thickness is a good indicator for where wells are most productive and therefore where the greatest amount of production has occurred [see Section 5 of Deeds and others (2015)].

Figures 3.2.31 through 3.2.49 show selected simulated versus observed water level hydrographs. These hydrographs are meant to demonstrate some of the basic trends in water levels through time, and how the simulated water levels follow these trends. Appendix B contains over 2,500 more hydrographs, sorted by county name.

Figure 3.2.31 shows hydrographs for wells completed in the Ogallala Aquifer in the northern part of the study area. General trends are downward both in observed and simulated water levels, with the exception of a hydrograph in Lipscomb County, which is relatively flat. Similarly, Figure 3.2.32 shows downward trends of varying slopes. Two hydrographs in Dallam County show a relatively well-matched simulated water level in later time (well 234803), and another (well 236601) where an initial offset separates the observed and simulated curves by about 100 feet. Hydrographs further east (Figure 3.2.33), such as in Hemphill and Roberts counties, show relatively flat trends, which are well-represented in the simulated heads. Roberts County has not had much development outside of the Canadian River Municipal Water Authority well fields. Figure 3.2.34 shows mixed trends, even within a single county, with a reasonable simulated match in most of the cases. In Figure 3.2.35 the well locations are further south, and exhibit water levels dominantly trending downward, with the exception of a hydrograph in Cochran County. These trends are generally followed in the simulated water levels as well. Figure 3.2.36 shows more wells from the southern portion of the study area. The well in Dawson County shows that the model is able to duplicate the sometimes rising water levels that occur in several of the southern counties. Figure 3.2.37, which contains hydrographs in the southern portion of the study area, shows a similar hydrograph in Lynn County that shows historical fluctuation, including a short period of recovery in the late 1980s and early 1990s that is matched somewhat by the model.

Figure 3.2.38 shows hydrographs from the Rita Blanca Aquifer in Dallam and Union counties. The trends are mostly downward both in the measured and simulated water levels. Figure 3.2.39 shows hydrographs from the Edwards-Trinity (High Plains) Aquifer. Most of the trends are either flat or have both upward and downward trends in the same time series. The simulated trends are mostly flat, and do not follow the variations exactly. Figure 3.2.40 show similar trends for the Edwards-Trinity (High Plains) Aquifer. The simulated heads follow the trends well in some cases (Gaines County) but are offset in other cases.

Figure 3.2.41 shows hydrographs from the upper Dockum Aquifer. Trends are mixed, with some downward trends (Deaf Smith County) but more flat trends. The simulated water levels match the trends relatively well in most of the cases. Figure 3.2.42 shows hydrographs from the lower Dockum Aquifer in the northern portion of the study area. Most of the trends are flat, with the exception of a well in Hartley County that shows a downward trend that is only partially matched by the simulated water level. Figure 3.2.43 shows additional lower Dockum Aquifer hydrographs from the northern and central portions of the study area. In these wells, trends are again mixed, with the simulated trends typically better matching the flatter observed trends. Figure 3.2.44 shows hydrographs from the lower Dockum Aquifer in near the southeast outcrop area. Two of the hydrographs in Martin and Dawson counties show downward trends in the observed data that are not matched by the simulated water levels, due to either missing or mislocated pumping in the model. As discussed in Section 3.1.6, the location of pumping within a county was guided by the drawdown trends, but the objective was not to fit every hydrograph, but rather match the majority of county trends where possible.

3.2.4 Dry and Flooded Cells

MODFLOW-NWT does not allow cells to go dry, but does allow head to drop below cell bottom (and then restricts hydraulic conductivity so the cell becomes minimally active), which will be called “dry” for the purposes of this discussion. Cells where head is above the top of the cell are typically called “flooded” cells. Due to the high topographic relief, especially in the western portion of the model, dry cells were monitored closely during model construction and calibration. Adding the minor aquifers to the bottom of the Ogallala Aquifer increased the potential for dry cell issues in areas with the potential for high vertical gradients.

Large variation in local topography also increases the chances of flooded cells. A small amount of flooding, within the mean absolute error of the model, is considered normal, but a model should not have large areas with heads consistently far above land surface. For the most part, the boundary conditions representing springs, rivers, and draws controlled flooding.

The calibrated model was assessed for dry cells and flooding in the model outcrops. This included the active outcrops for the Ogallala Aquifer (the whole active area), the Rita Blanca Aquifer, and the upper and lower Dockum aquifers. The cells with head boundaries representing portions of the Edwards-Trinity (Plateau) and Pecos Valley aquifers were not considered. Of the 242,200 outcrop cells, 961 cells were dry in steady-state, and 395 were flooded (Figure 3.2.45). The tolerance for flooding was set at 40 feet, the approximate mean absolute error among the various aquifers. The maximum flood value for the steady-state heads was 60 feet above tolerance. At the end of the simulation in 2012, 1965 cells were dry and 400 cells were flooded, with a maximum flood height above tolerance of 60 feet (Figure 3.2.46). In all, the total flooded and dry cells represented less than 1 percent of the outcrop cells.

Table 3.2.1 Calibration statistics for steady-state, 1930 to 1980, and 1980 to 2012.

Year Range	Aquifer	Mean Error (feet)	Mean Absolute Error (feet)	Range	Mean Absolute Error/Range	Number
Predevelopment	Ogallala	15.3	27.3	2,752	0.010	436
	Rita Blanca	-30.3	61.7	3,014	0.020	87
	Edwards-Trinity (High Plains)	-35.3	42.9	1,415	0.030	257
	Upper Dockum	-39.0	47.4	2,119	0.022	84
	Lower Dockum	10.3	52.0	3,050	0.017	233
1930-1979	Ogallala	-3.8	25.2	3,091	0.008	78,063
	Rita Blanca	-20.3	32.9	746	0.044	301
	Edwards-Trinity (High Plains)	-45.1	49.0	1,430	0.034	1,113
	Upper Dockum	-27.9	30.9	1,912	0.016	326
	Lower Dockum	-14.3	45.1	3,145	0.014	3,220
1980-2012	Ogallala	1.5	28.4	3,529	0.008	91,805
	Rita Blanca	-24.0	42.6	2,841	0.015	1,078
	Edwards-Trinity (High Plains)	-19.4	29.7	1,327	0.022	1,945
	Upper Dockum	-27.4	33.2	2,125	0.016	671
	Lower Dockum	-15.6	53.3	3,465	0.015	4,744

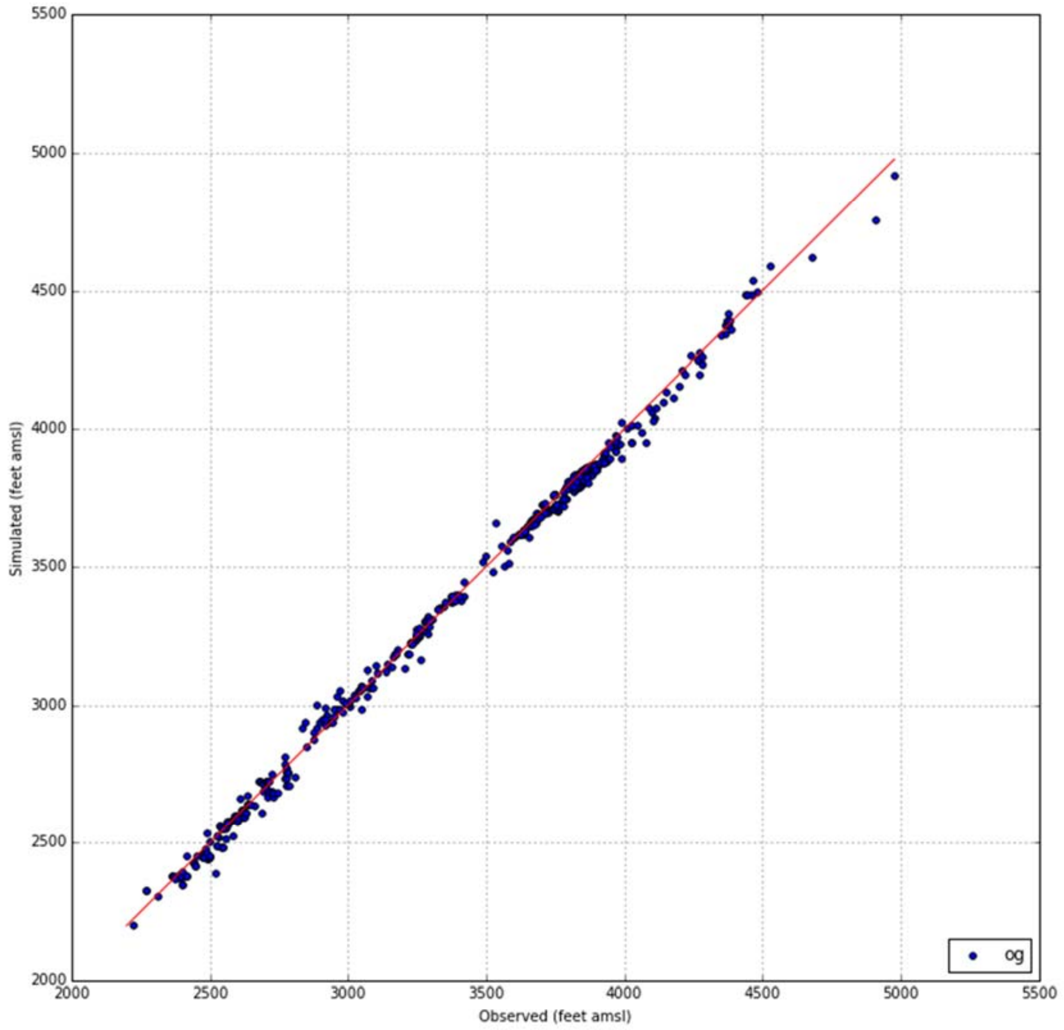


Figure 3.2.1 **Scatter plot of simulated versus observed hydraulic head in the Ogallala Aquifer in feet above mean sea level for the steady-state stress period. (Abbreviation key: og = Ogallala Aquifer)**

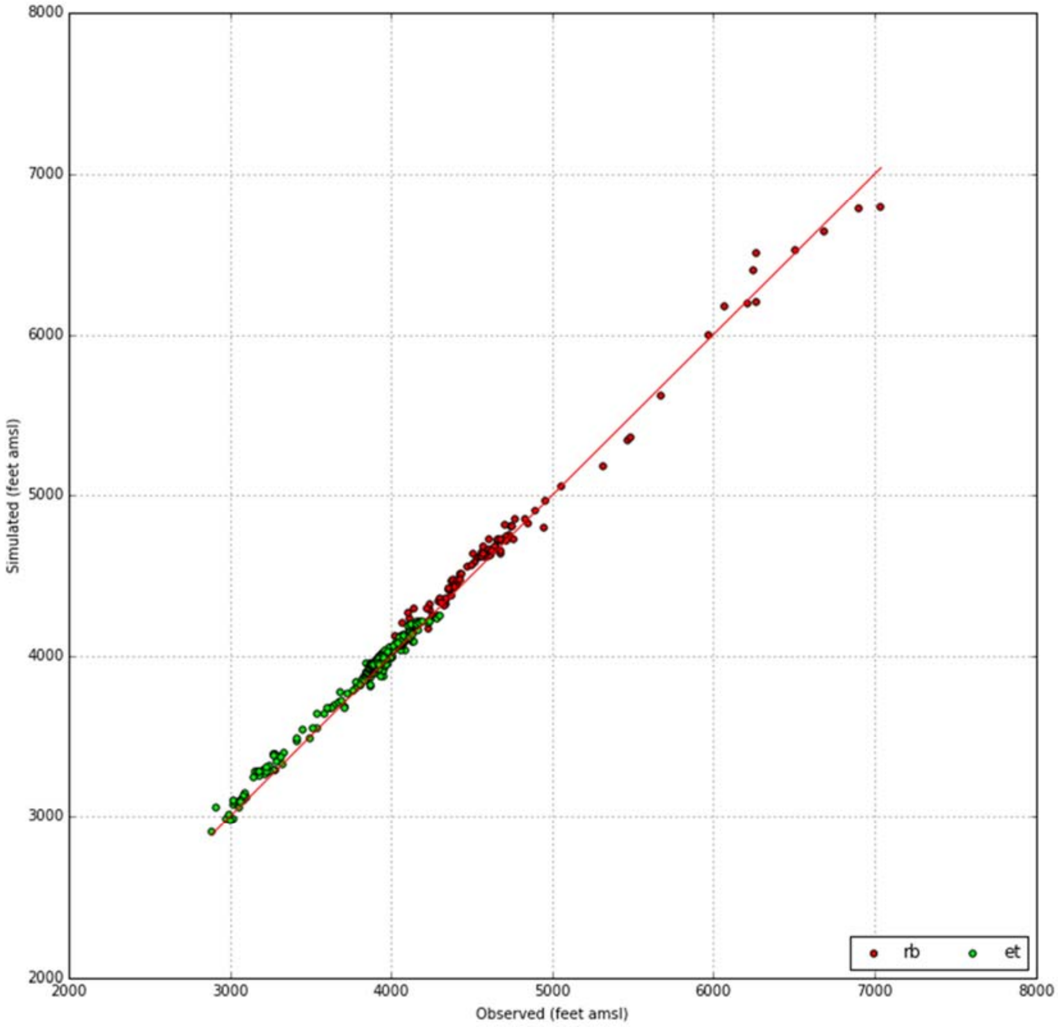


Figure 3.2.2 Scatter plot of simulated versus observed hydraulic head in the Rita Blanca and Edwards-Trinity (High Plains) aquifers in feet above mean sea level for the steady-state stress period. (Abbreviation key: rb = Rita Blanca Aquifer, et = Edwards-Trinity (High Plains) Aquifer)

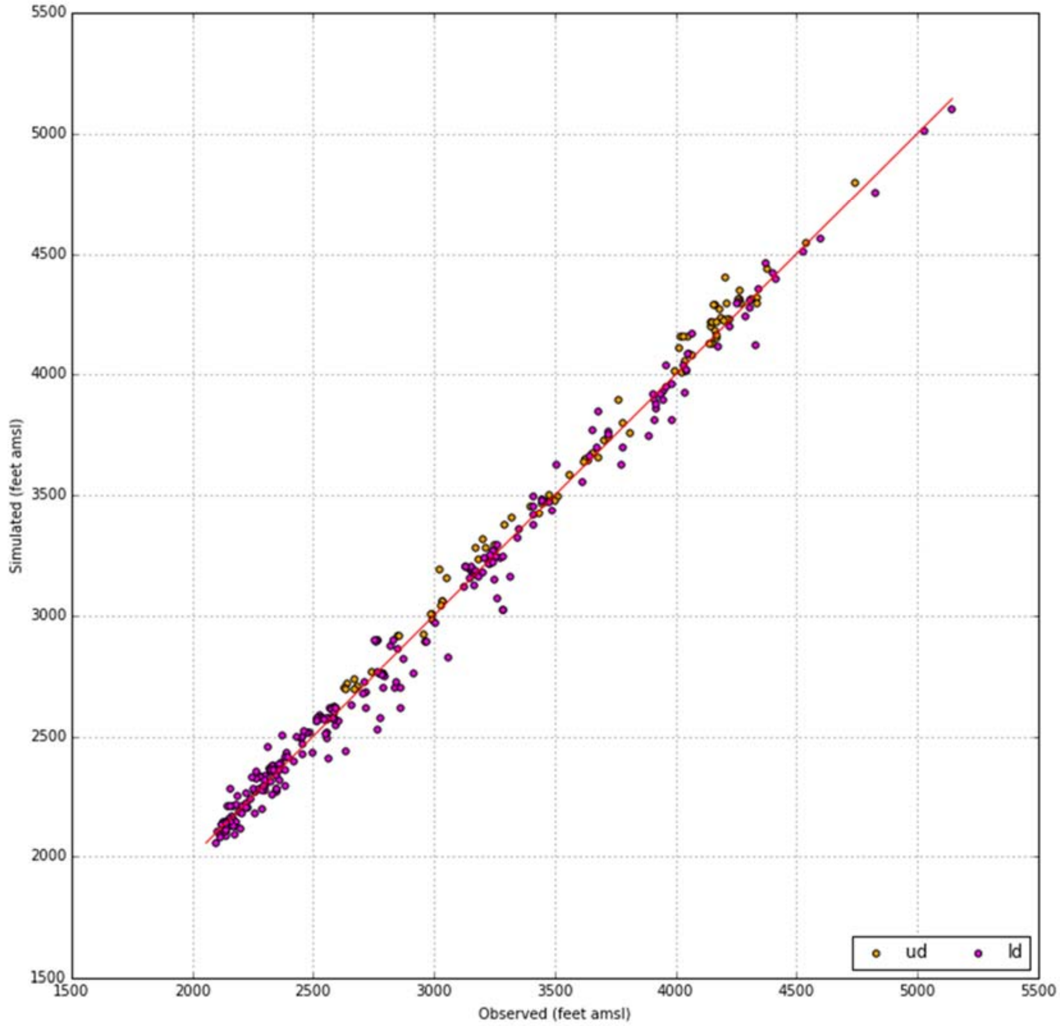


Figure 3.2.3 **Scatter plot of simulated versus observed hydraulic head in the Dockum Aquifer in feet above mean sea level for the steady-state stress period. (Abbreviation key: ud = upper Dockum Aquifer, ld = lower Dockum Aquifer)**

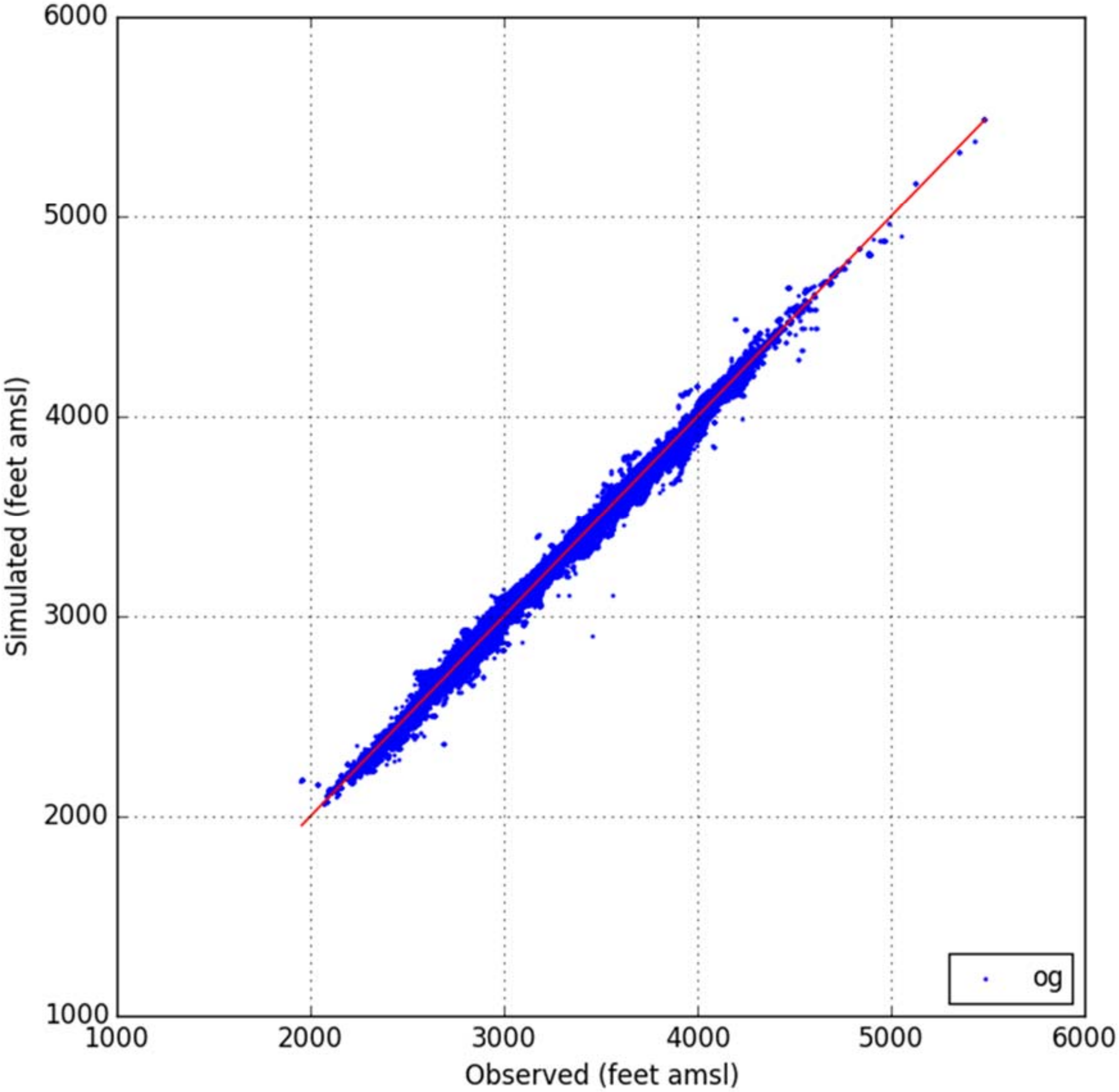


Figure 3.2.4 **Scatter plot of simulated versus observed hydraulic head in the Ogallala Aquifer in feet above mean sea level for years 1980 to 2012. (Abbreviation key: og = Ogallala Aquifer)**

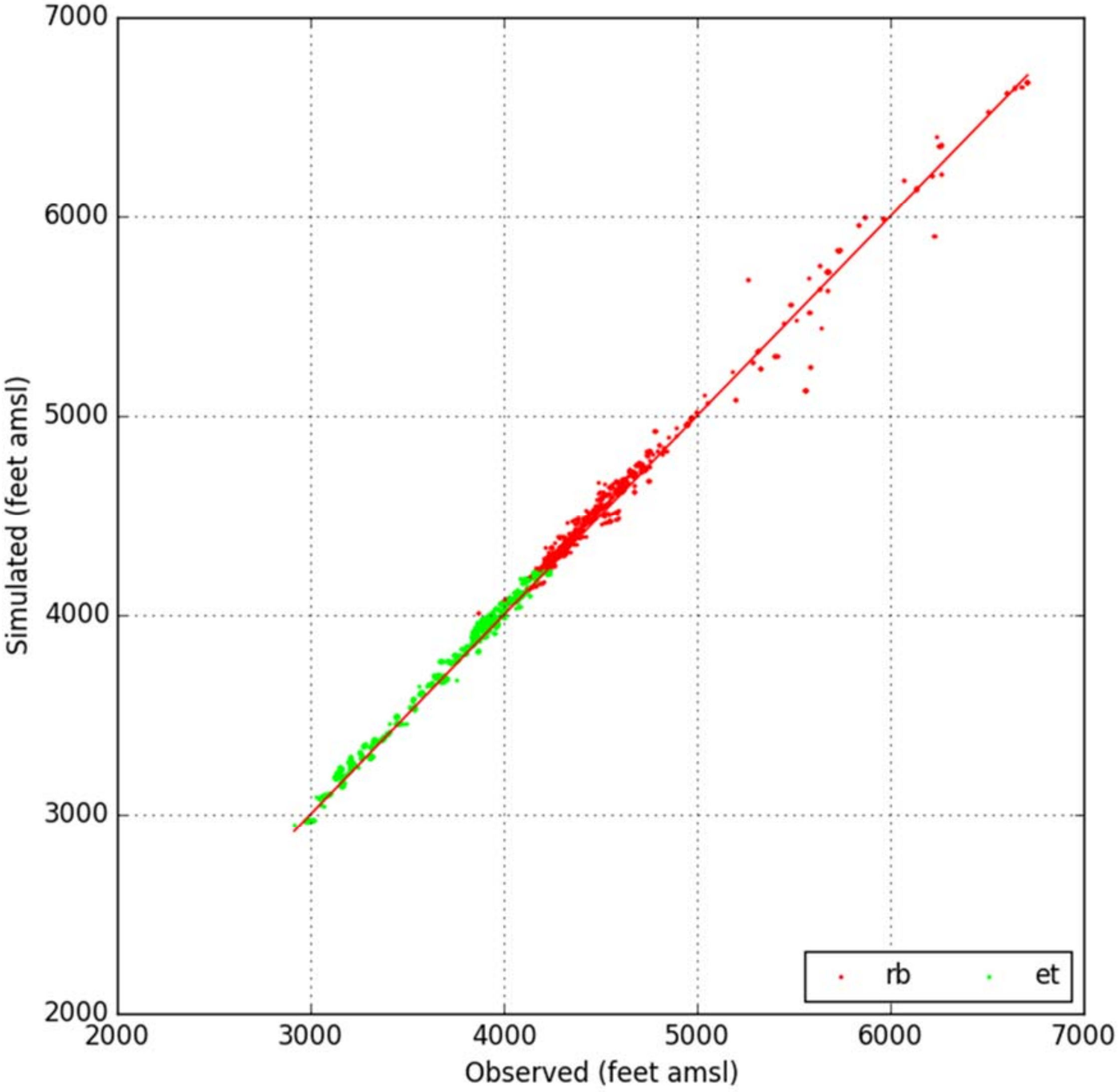


Figure 3.2.5 Scatter plot of simulated versus observed hydraulic head in the Rita Blanca and Edwards-Trinity (High Plains) aquifers for years 1981 to 2012. (Abbreviation key: rb = Rita Blanca Aquifer, et = Edwards-Trinity (High Plains) Aquifer)

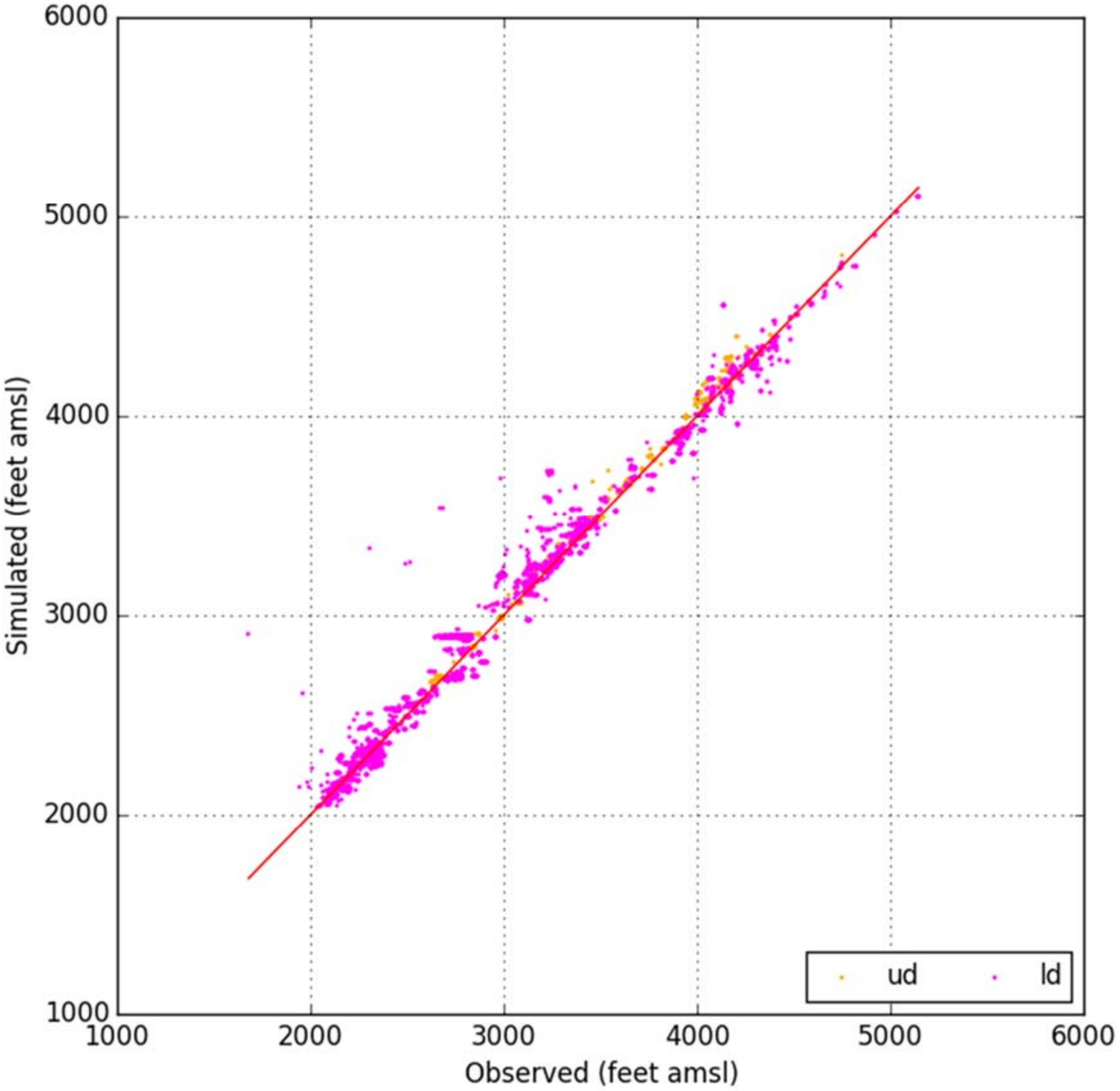


Figure 3.2.6 **Scatter plot of simulated versus observed hydraulic head in the Dockum Aquifer in feet above mean sea level for years 1981 to 2012. (Abbreviation key: ud = upper Dockum Aquifer, ld = lower Dockum Aquifer)**

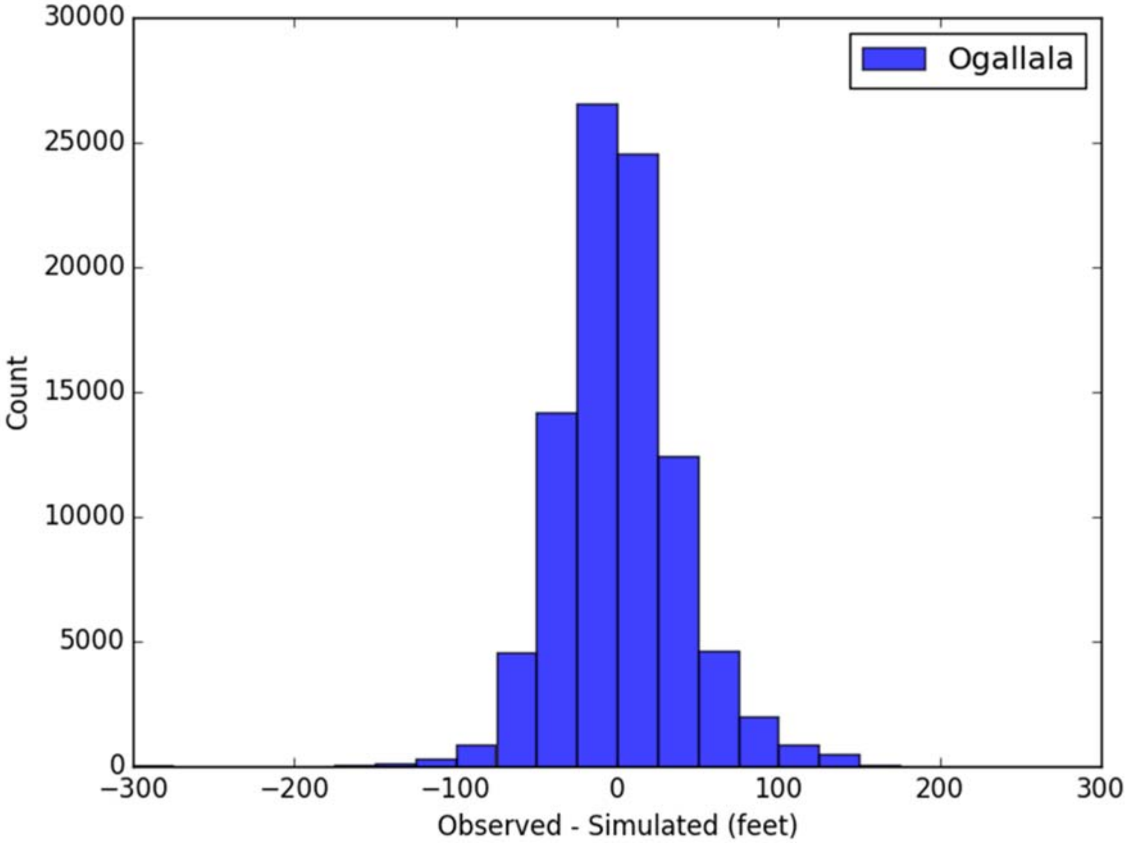


Figure 3.2.7 **Histogram of hydraulic head residuals in the Ogallala Aquifer for years 1980 to 2012.**

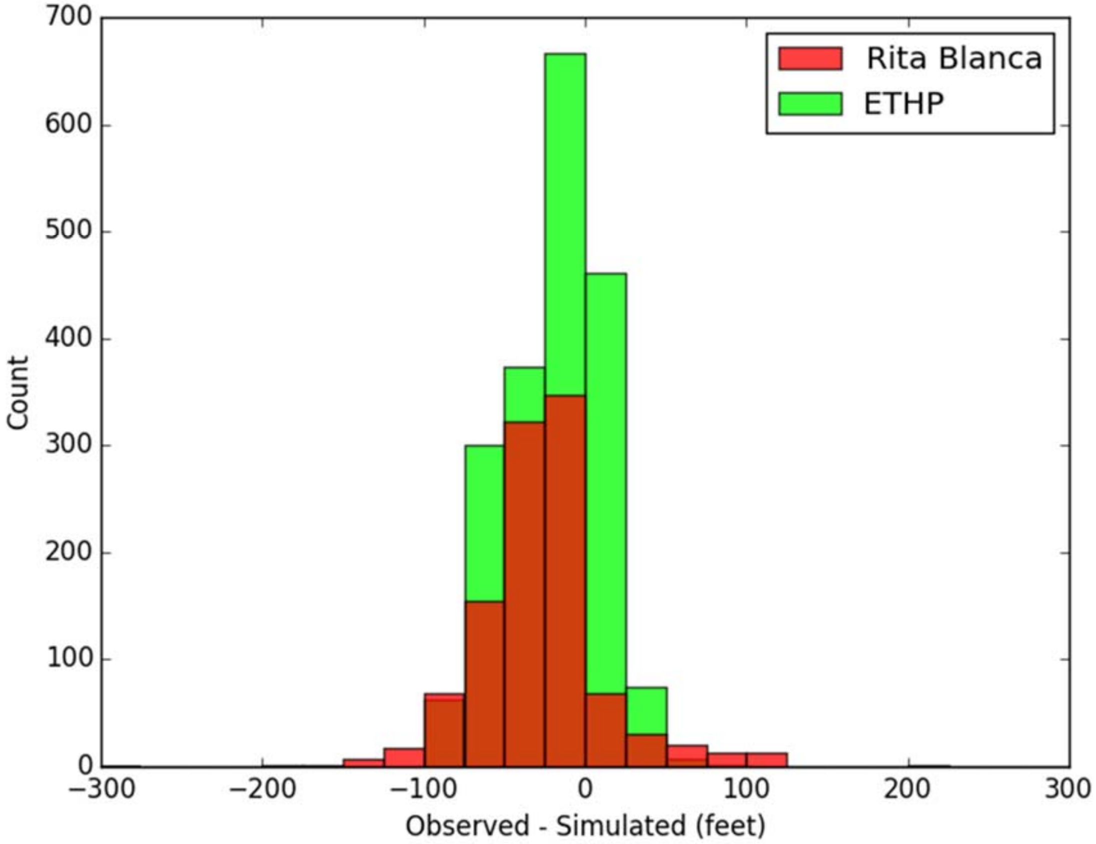


Figure 3.2.8 **Histogram of hydraulic head residuals in feet in the Rita Blanca and Edwards-Trinity (High Plains) aquifers for years 1980 to 2012. (Abbreviation key: ETHP = Edwards-Trinity (High Plains) Aquifer)**

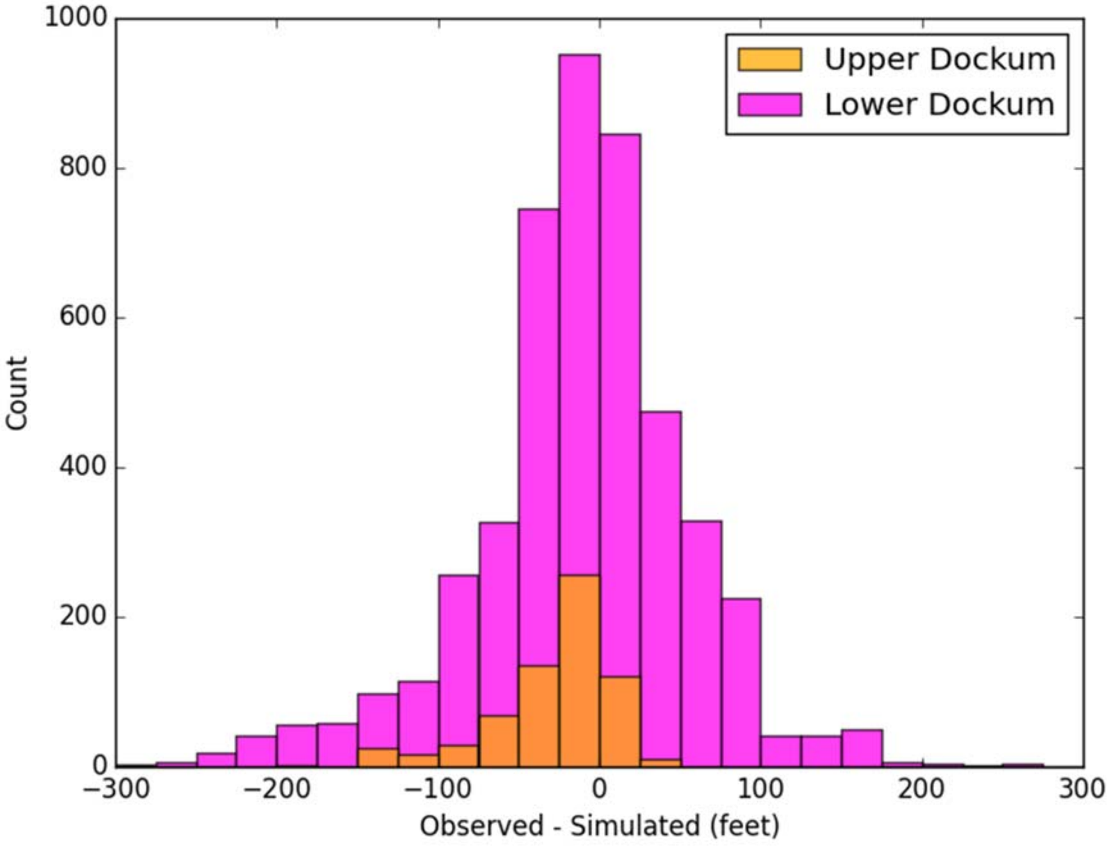


Figure 3.2.9 **Histogram of hydraulic head residuals in feet in the upper and lower Dockum Aquifer for years 1980 to 2012.**

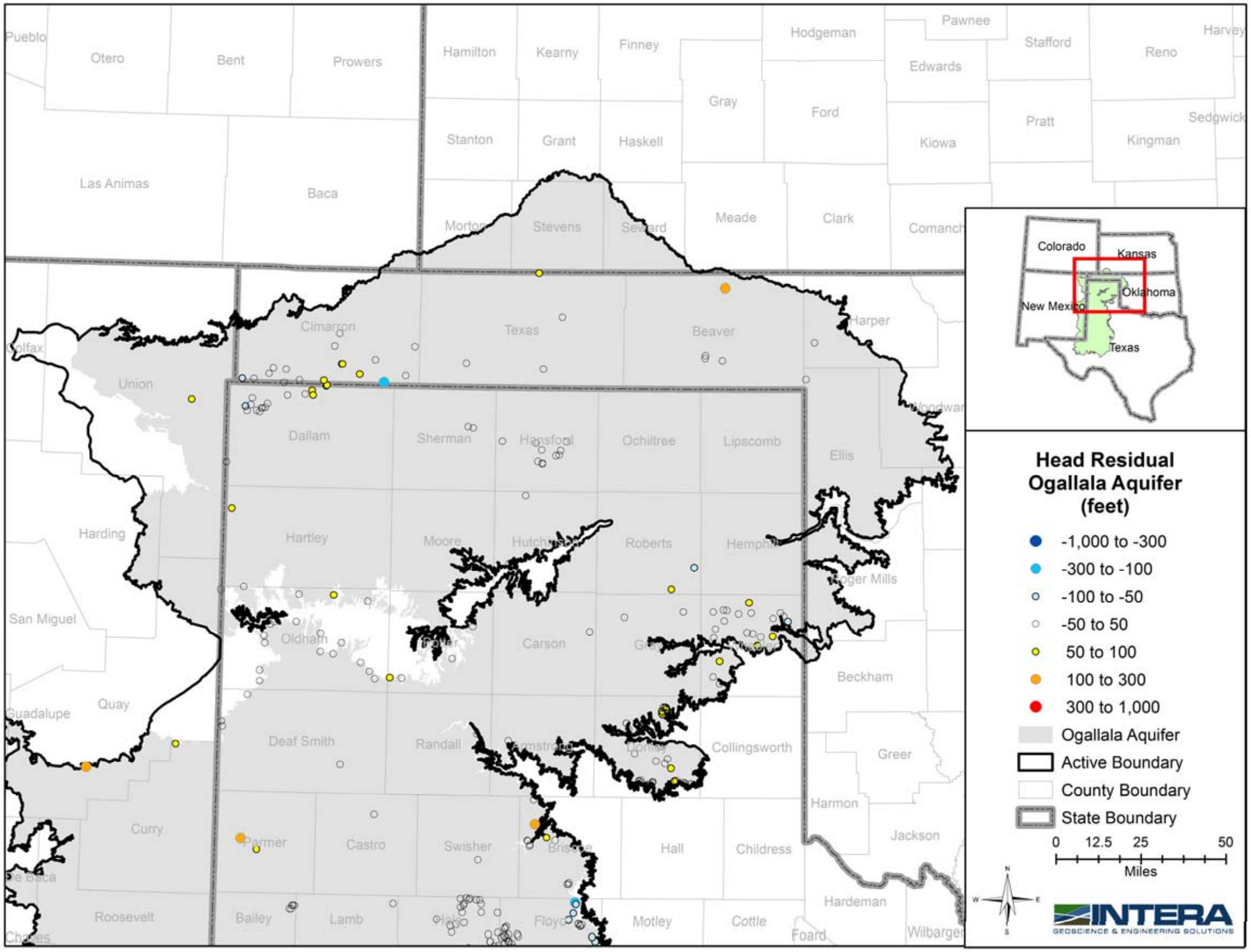


Figure 3.2.10a **Spatial distribution of head residuals in feet in the Ogallala Aquifer for the pre-development (steady-state) stress period in the northern portion of the study area.**

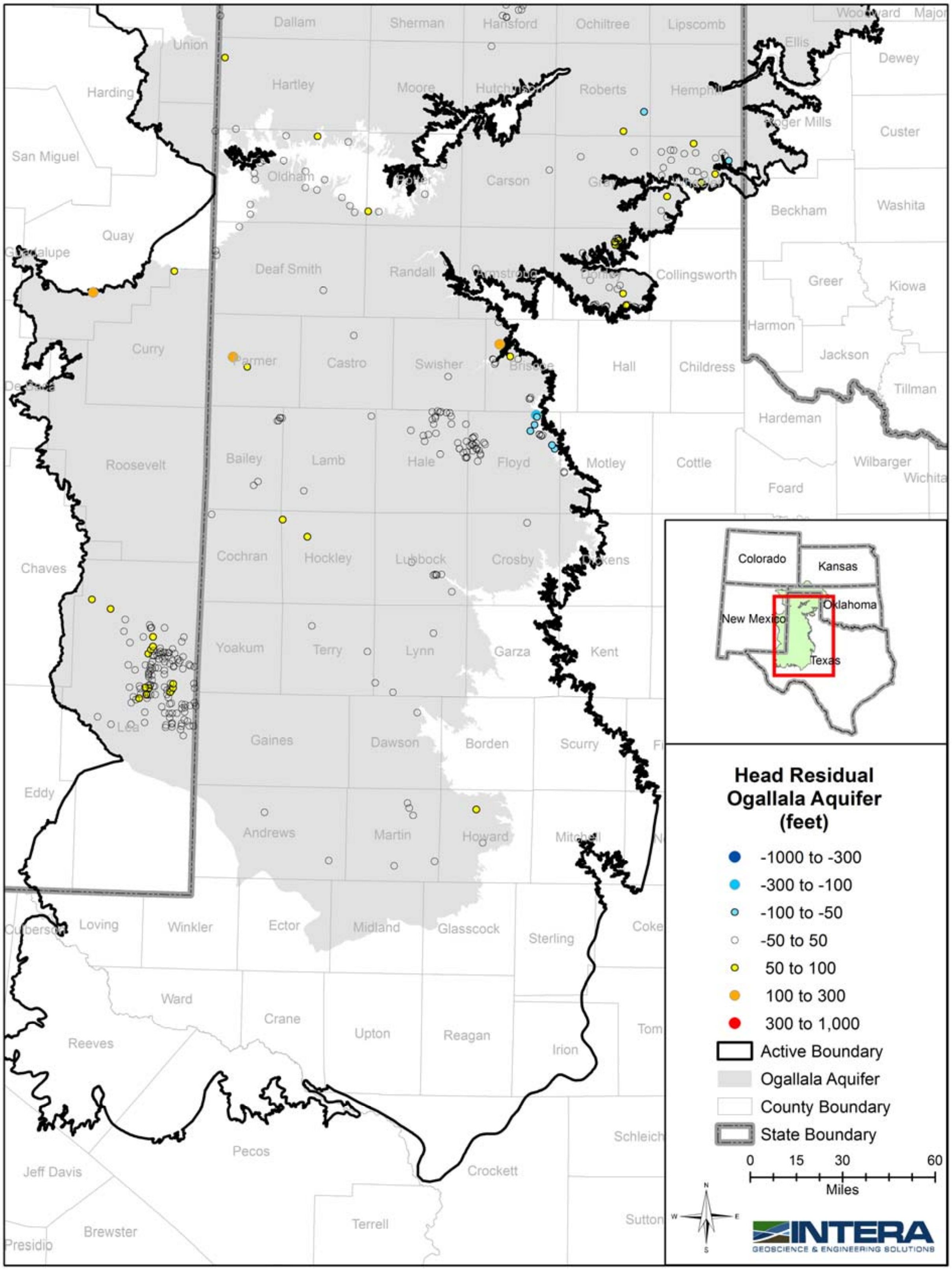


Figure 3.2.10b Spatial distribution of head residuals in feet in the Ogallala Aquifer for the pre-development (steady-state) stress period in the southern portion of the study area.

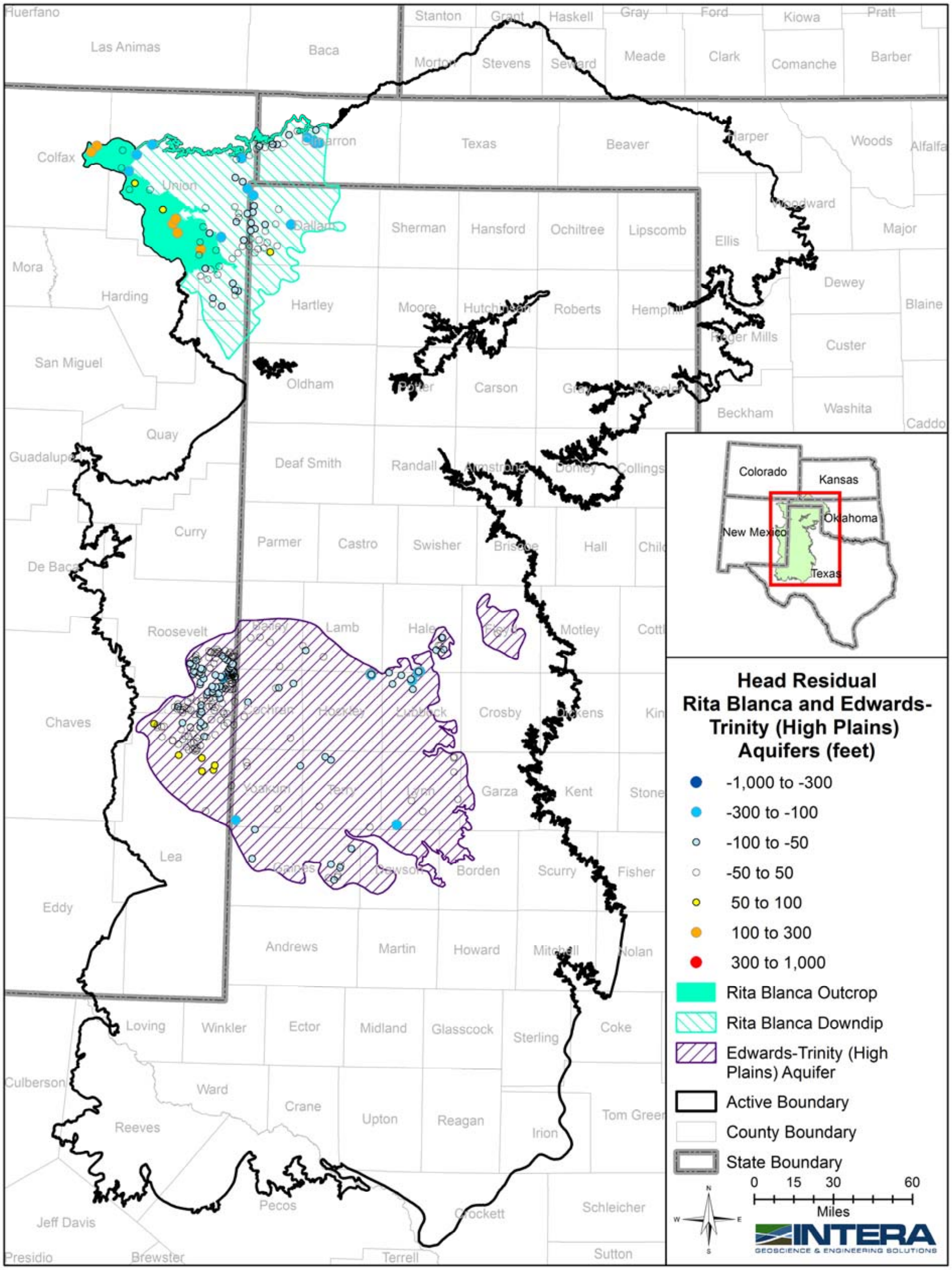


Figure 3.2.11 Spatial distribution of head residuals in feet in the Rita Blanca and Edwards-Trinity (High Plains) aquifers for the pre-development (steady-state) stress period.

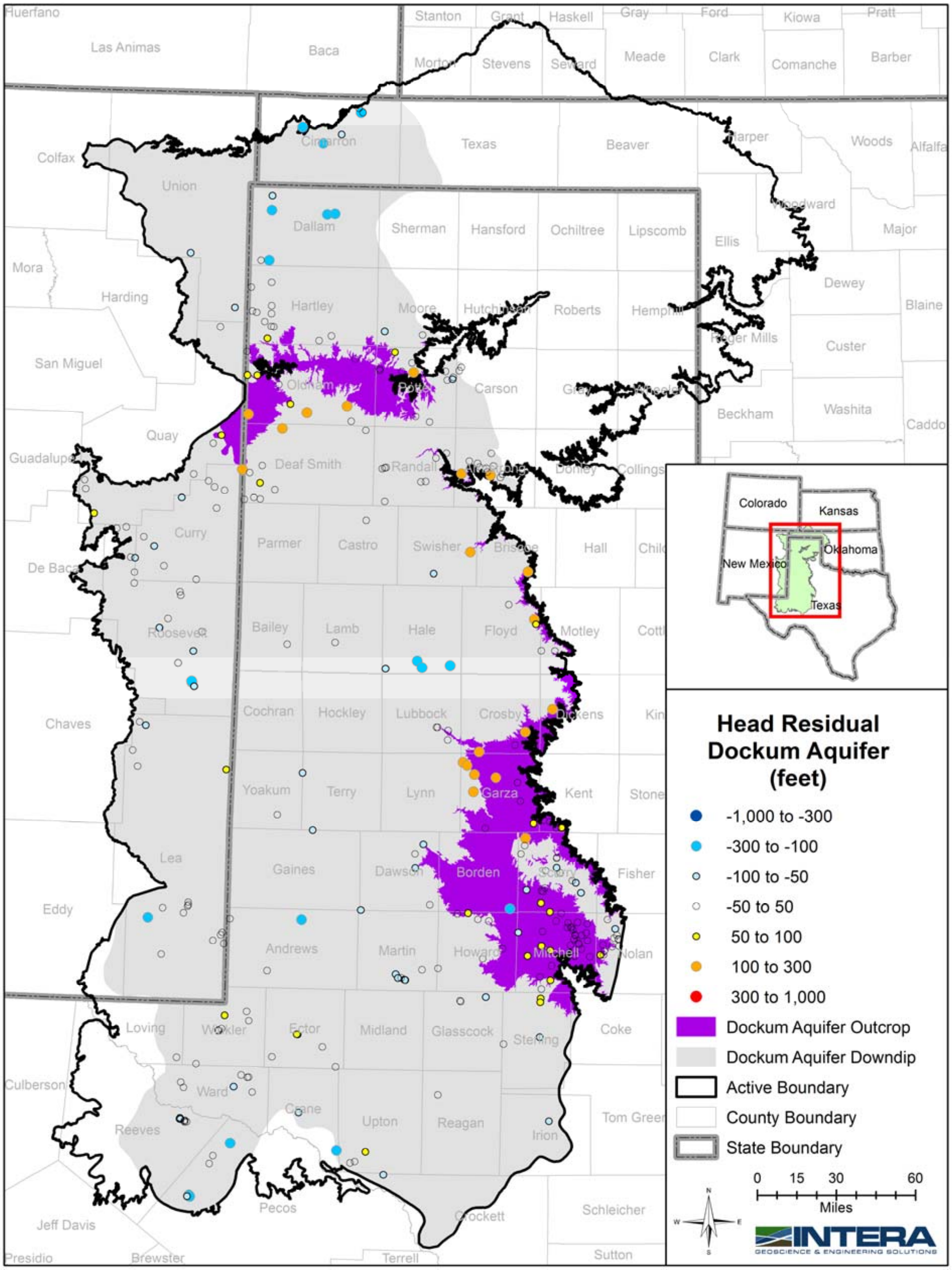


Figure 3.2.12 Spatial distribution of head residuals in feet in the Dockum Aquifer in the pre-development (steady-state) stress period

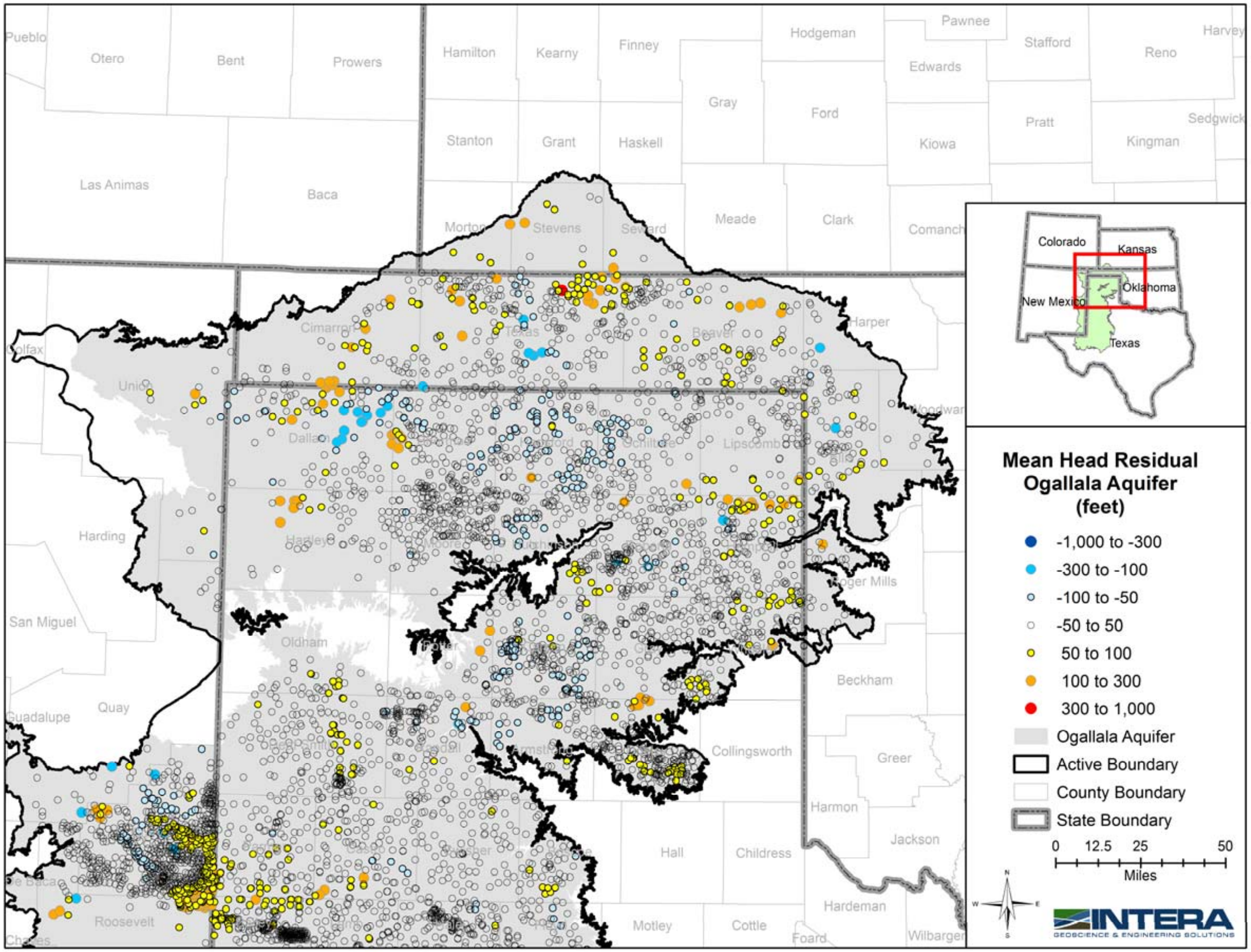


Figure 3.2.13a Spatial distribution of average head residuals in feet in the Ogallala Aquifer for years 1980 to 2012 in the northern portion of the study area.

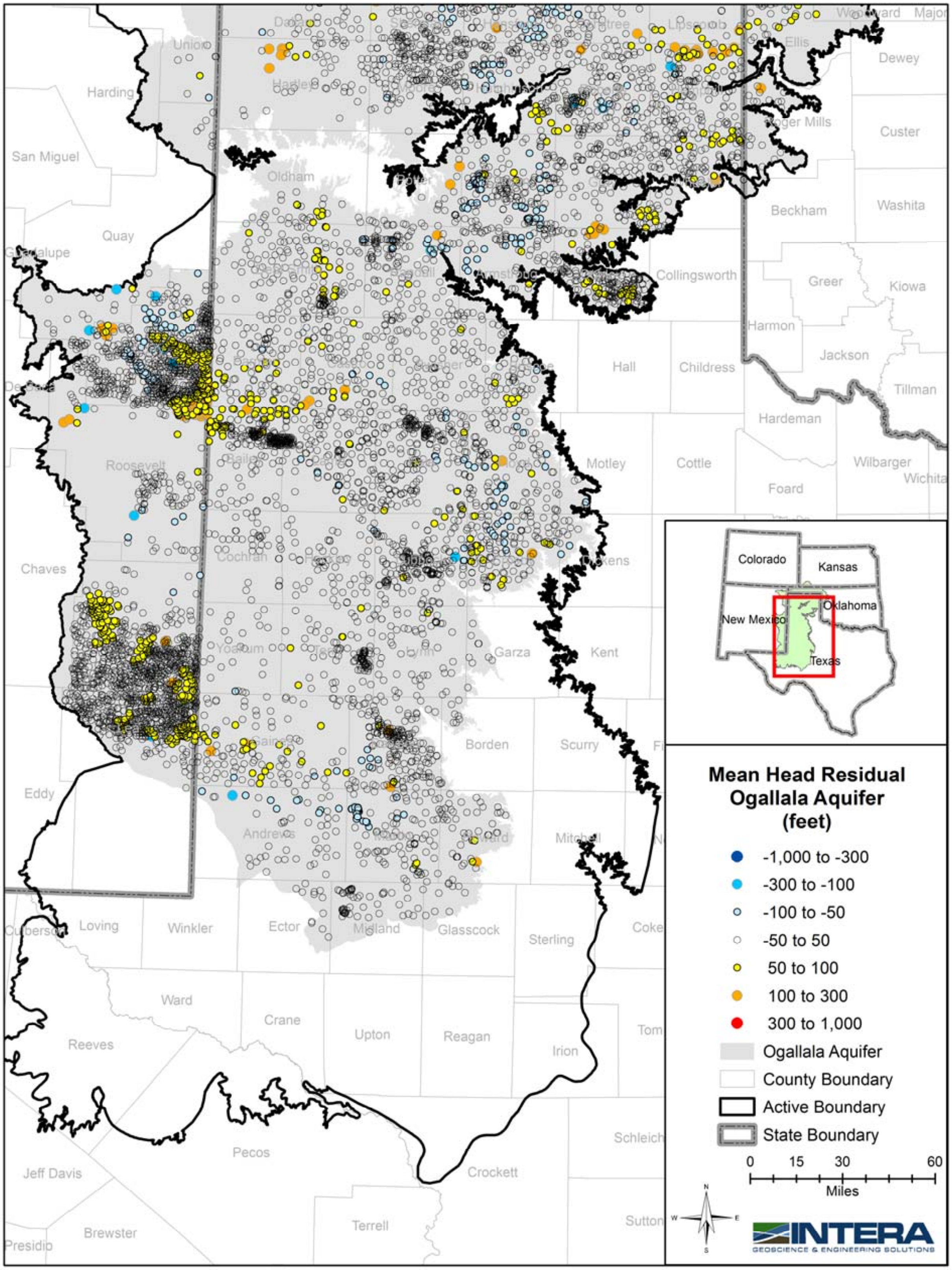


Figure 3.2.13b **Spatial distribution of average head residuals in feet in the Ogallala Aquifer for years 1980 to 2012 in the southern portion of the study area.**

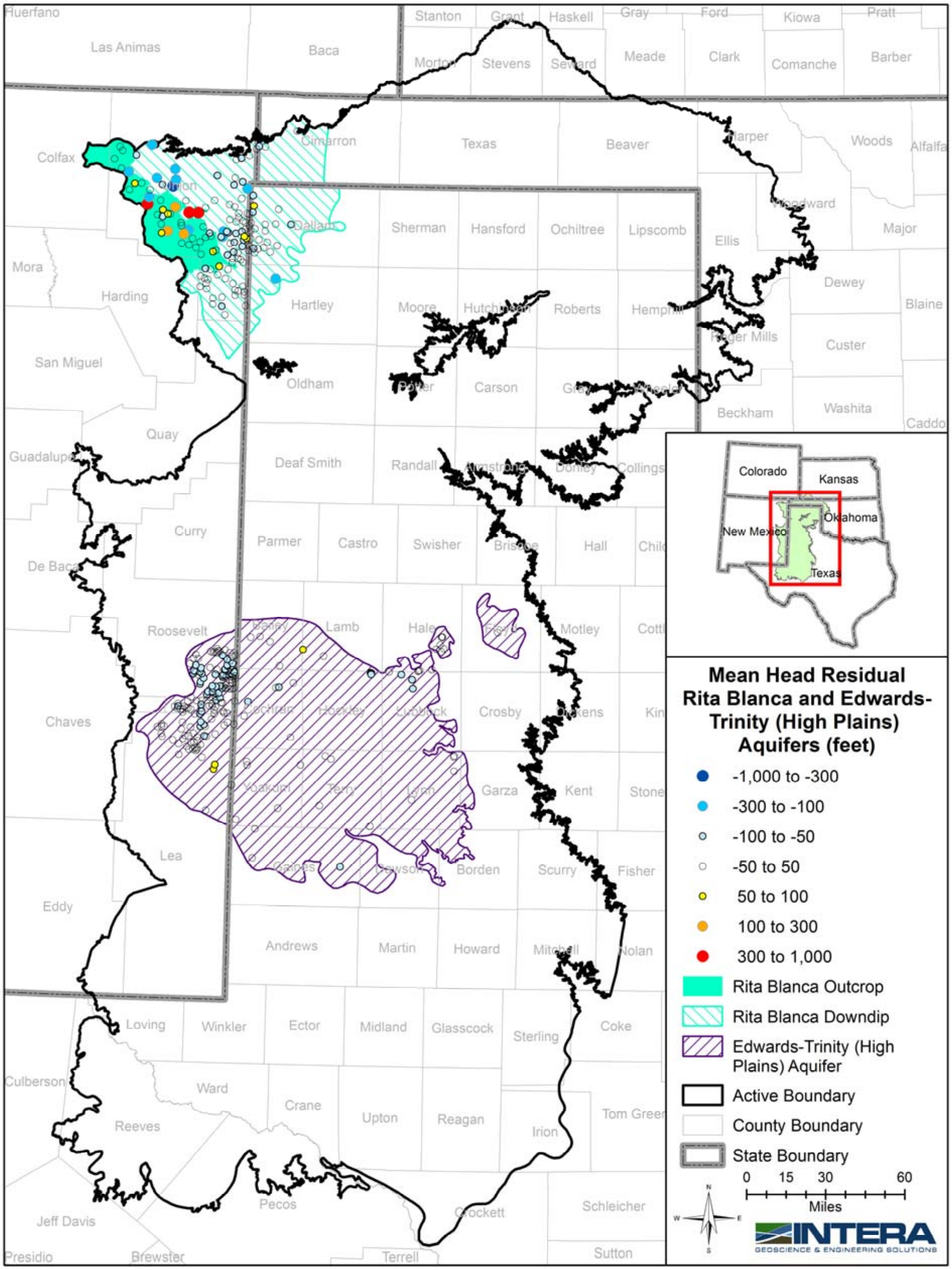


Figure 3.2.14 **Spatial distribution of average head residuals in feet in the Rita Blanca and Edwards-Trinity (High Plains) aquifers for years 1980 to 2012.**

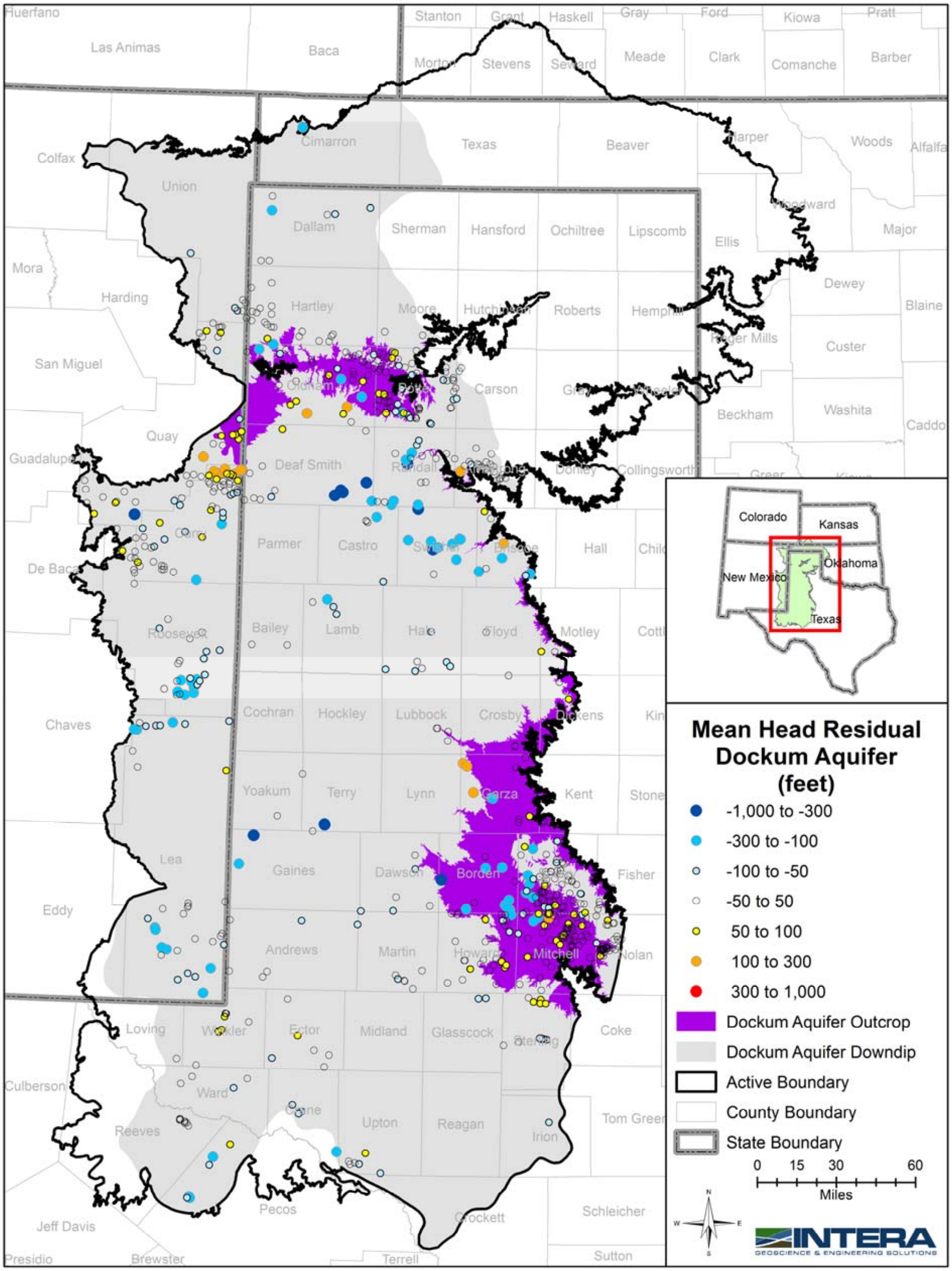


Figure 3.2.15 **Spatial distribution of average head residuals in feet in the Dockum Aquifer for years 1980 to 2012.**

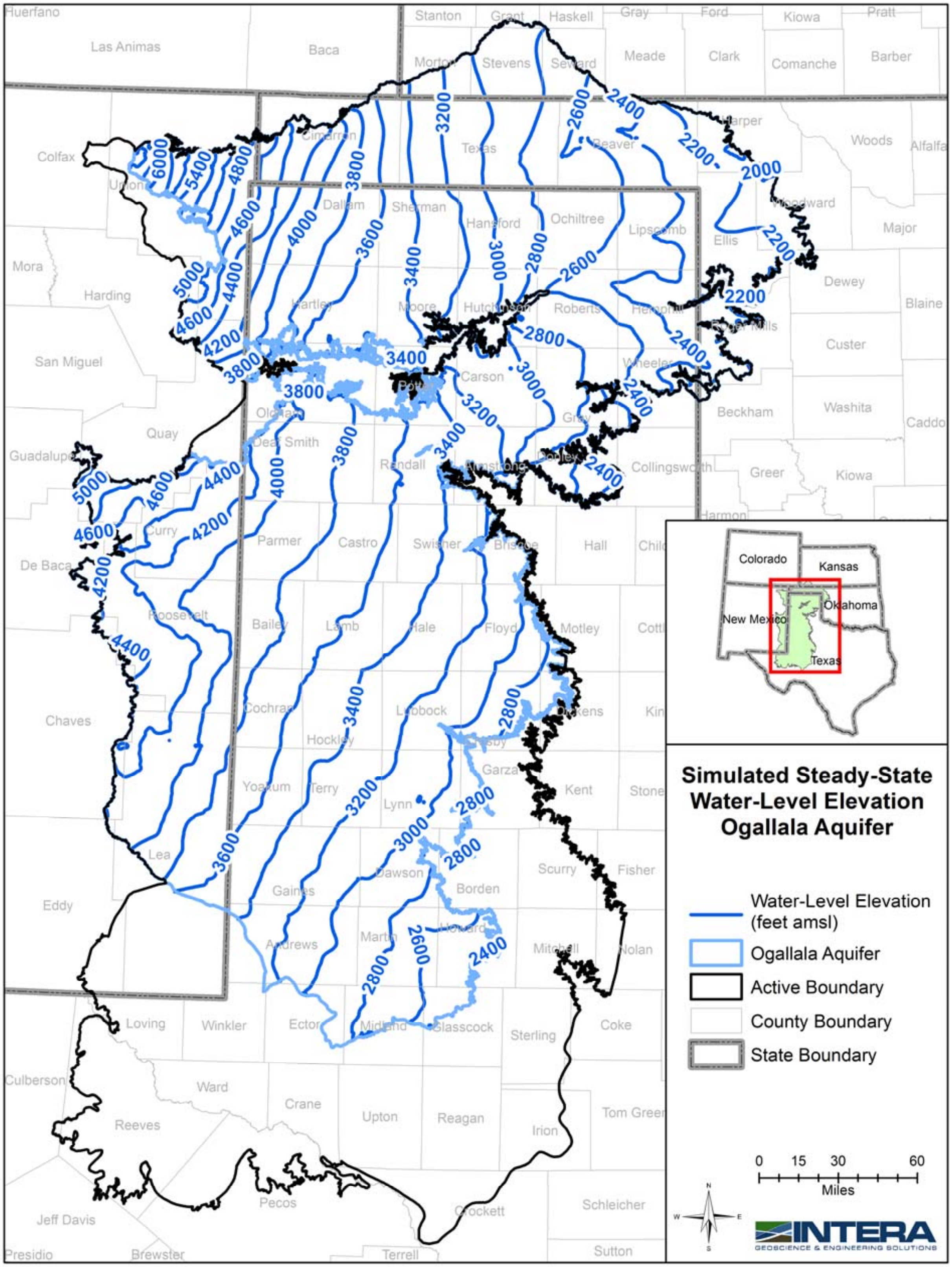


Figure 3.2.16 Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Ogallala Aquifer for the pre-development (steady-state) stress period.

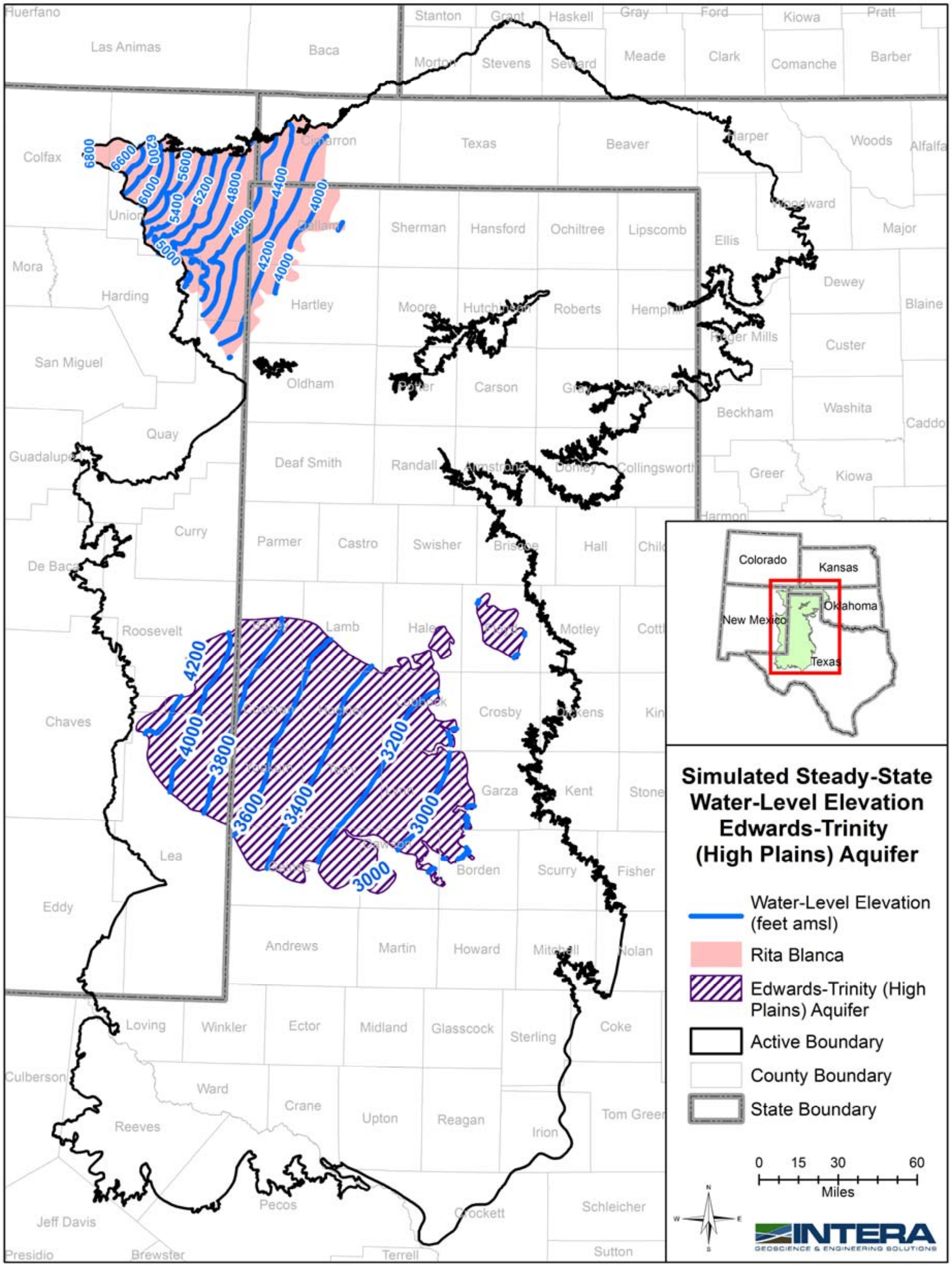


Figure 3.2.17 Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Rita Blanca and Edwards-Trinity (High Plains) aquifers for the pre-development (steady-state) stress period.

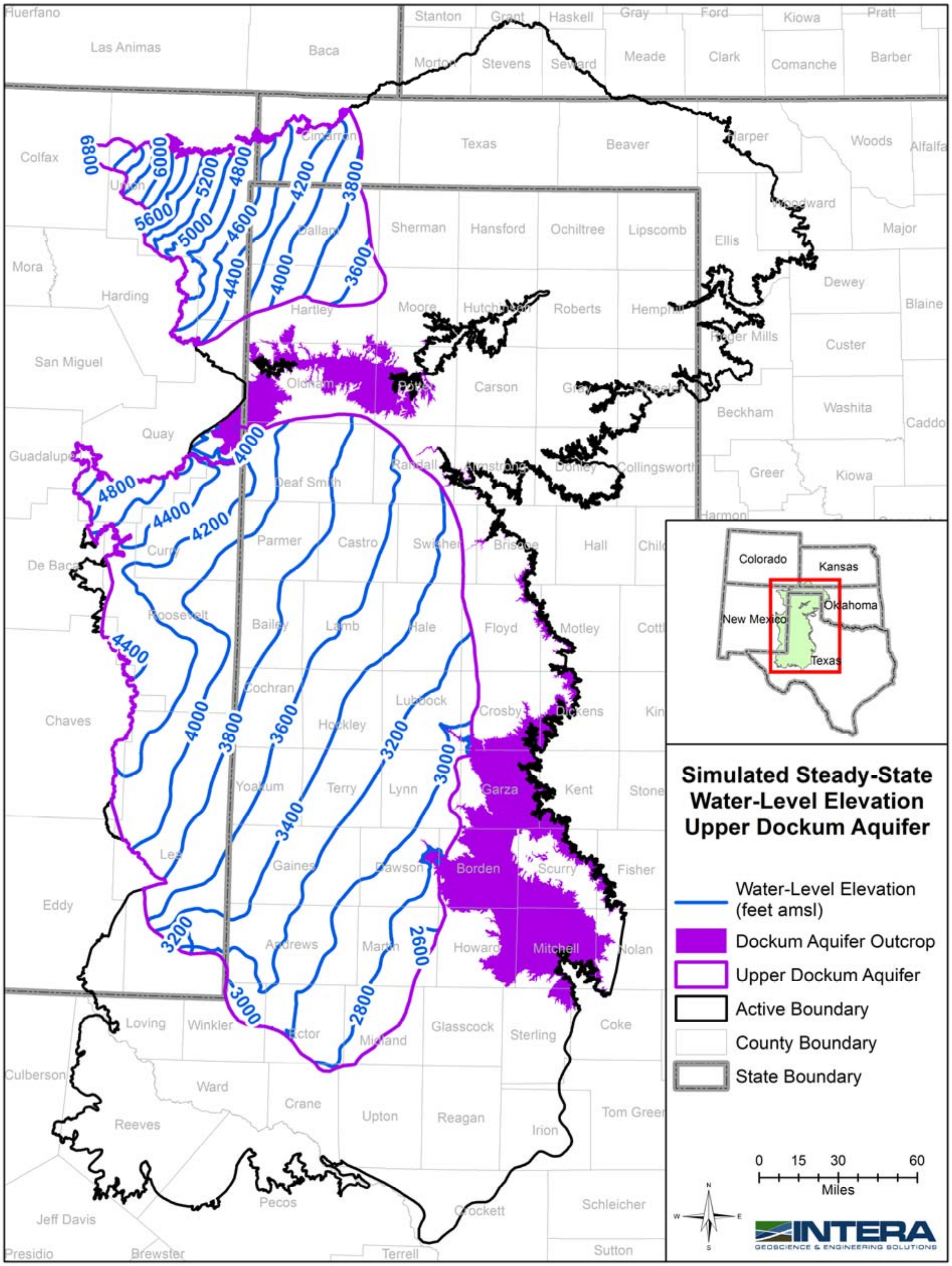


Figure 3.2.18 **Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the upper Dockum Aquifer for the pre-development (steady-state) stress period.**

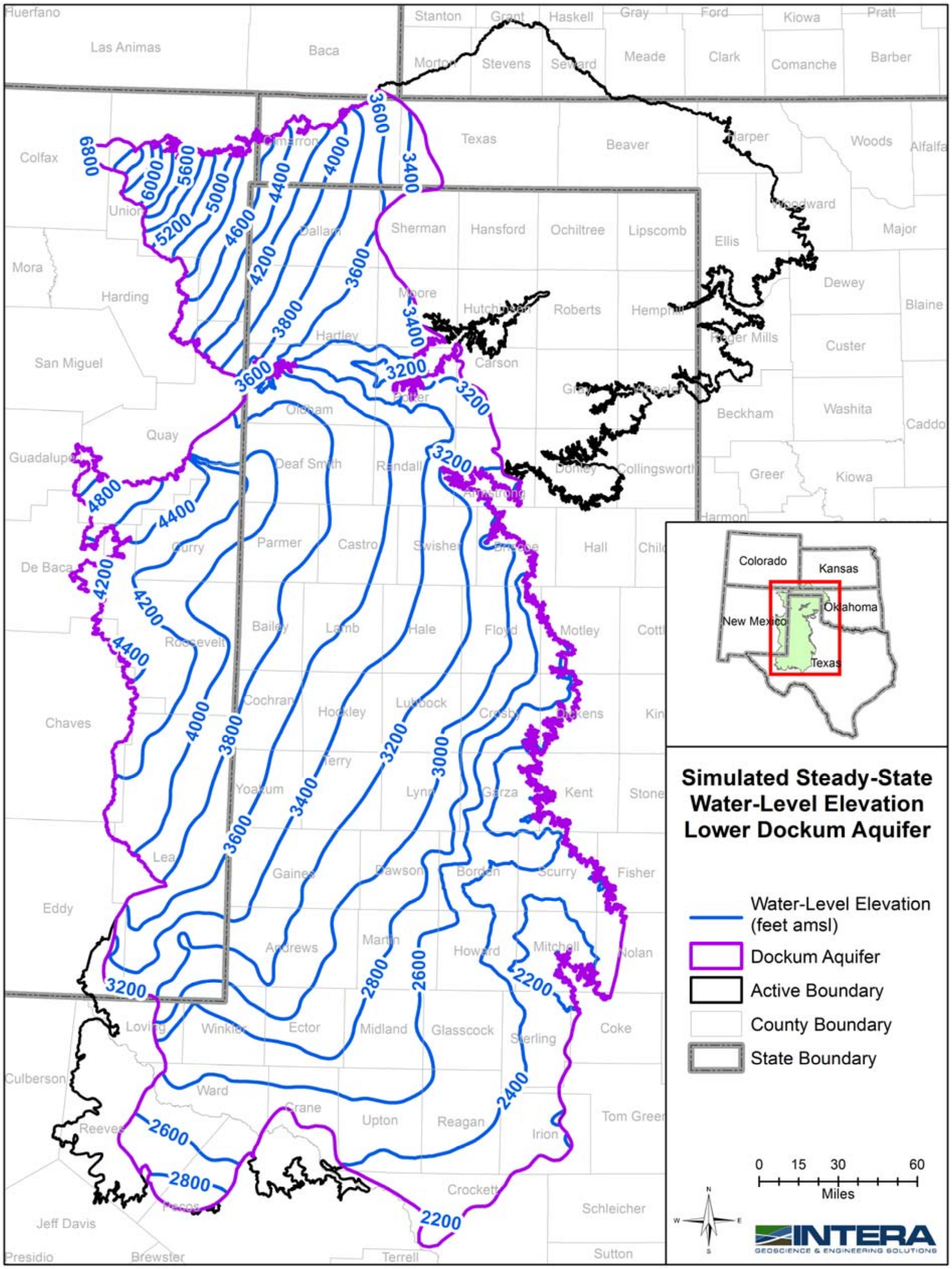


Figure 3.2.19 Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the lower Dockum Aquifer for the pre-development (steady-state) stress period.

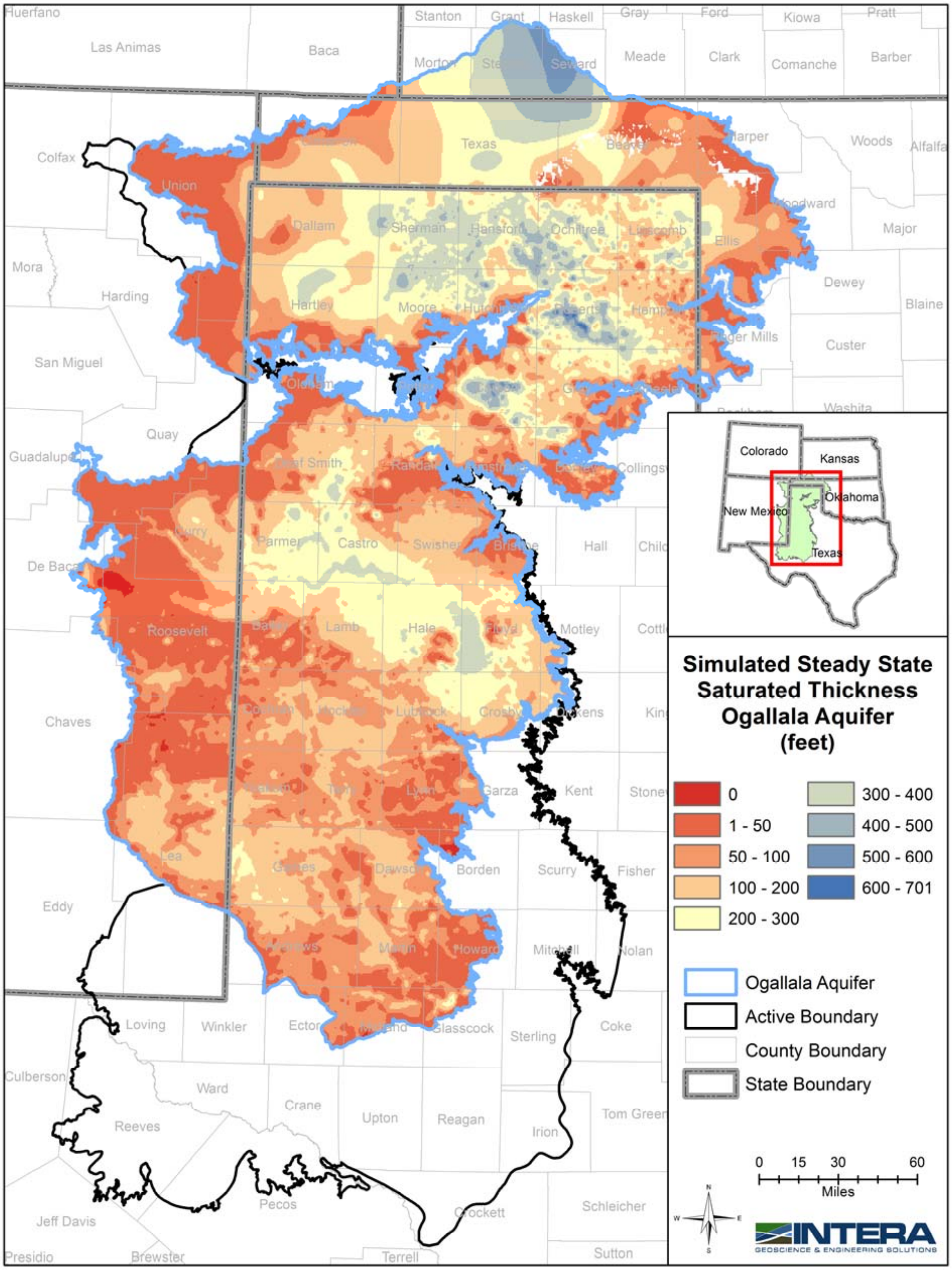


Figure 3.2.20 Simulated saturated thickness in feet above mean sea level in the Ogallala Aquifer in the pre-development (steady-state) stress period.

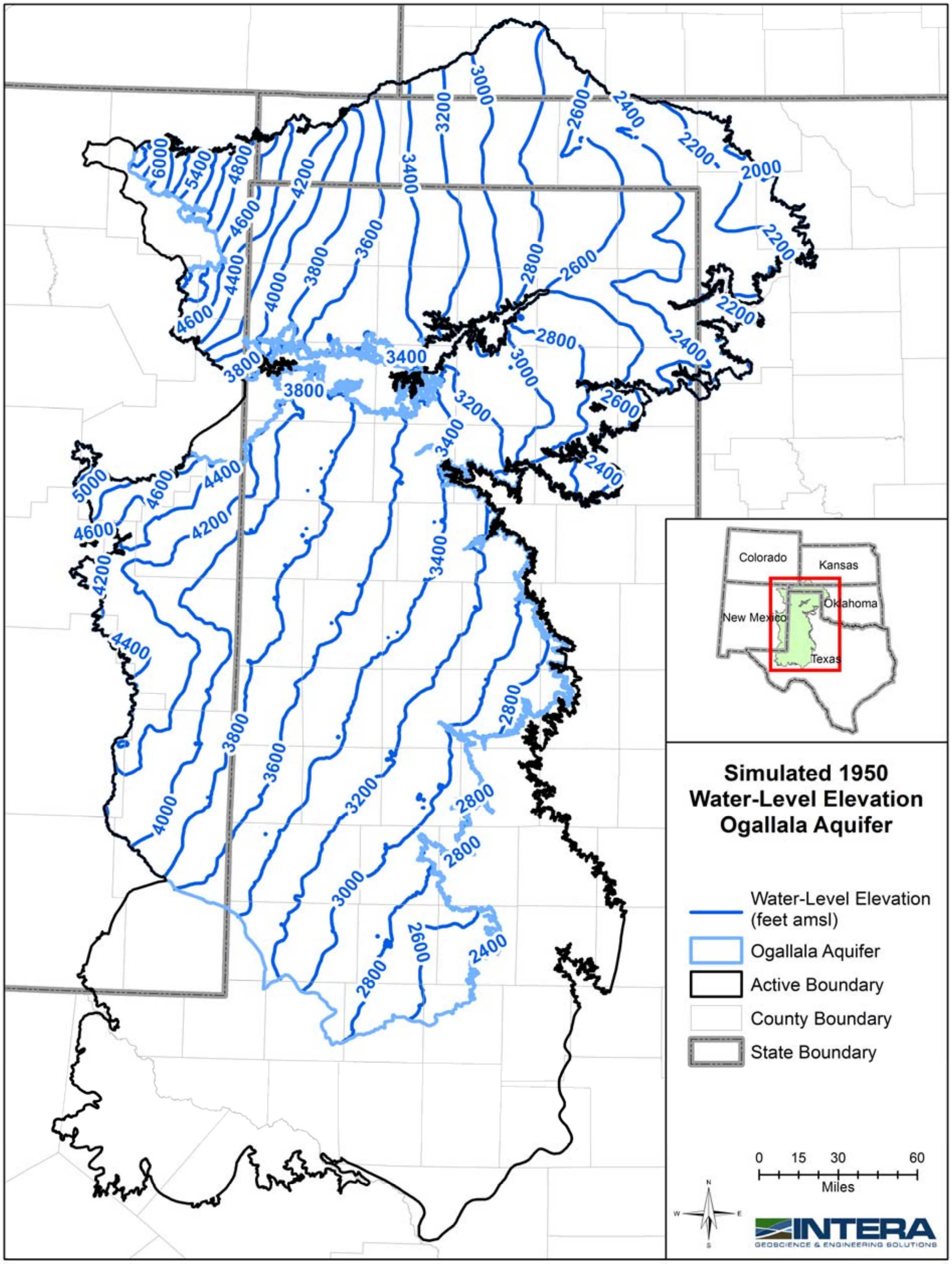


Figure 3.2.21a Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Ogallala Aquifer in 1950 (stress period 22).

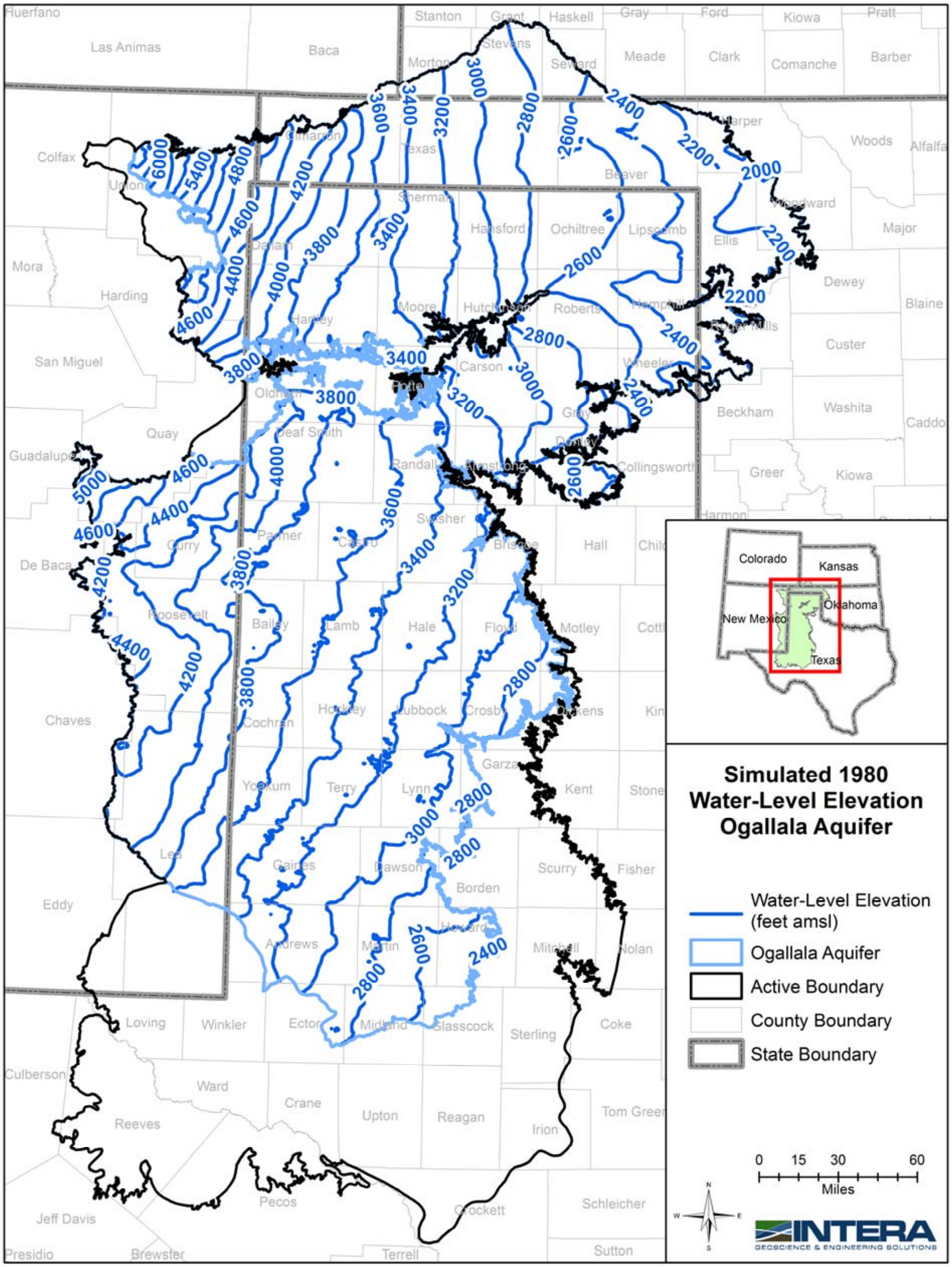


Figure 3.2.21b Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Ogallala Aquifer in 1980 (stress period 52).

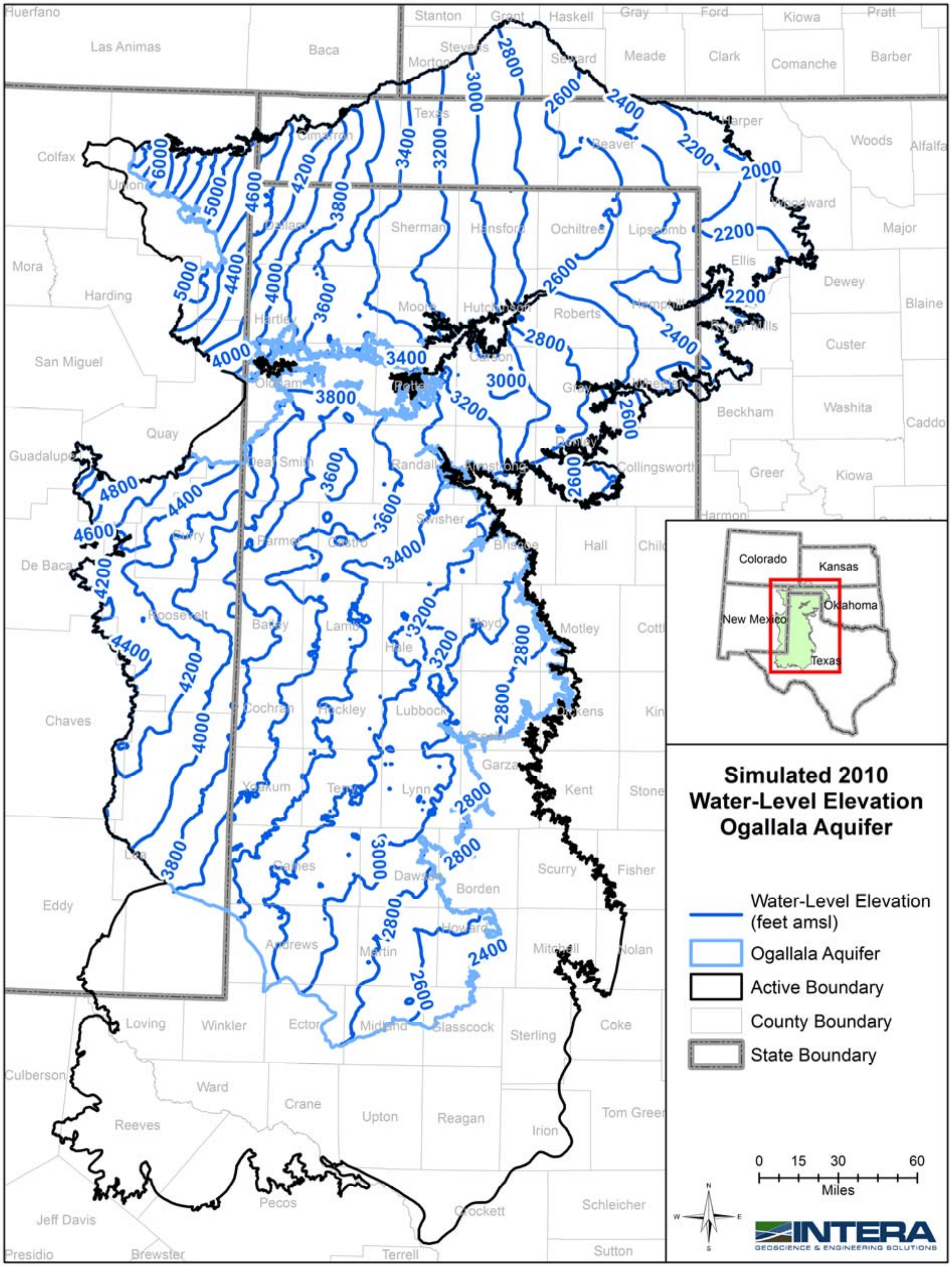


Figure 3.2.21c Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Ogallala Aquifer in 2010 (stress period 82).

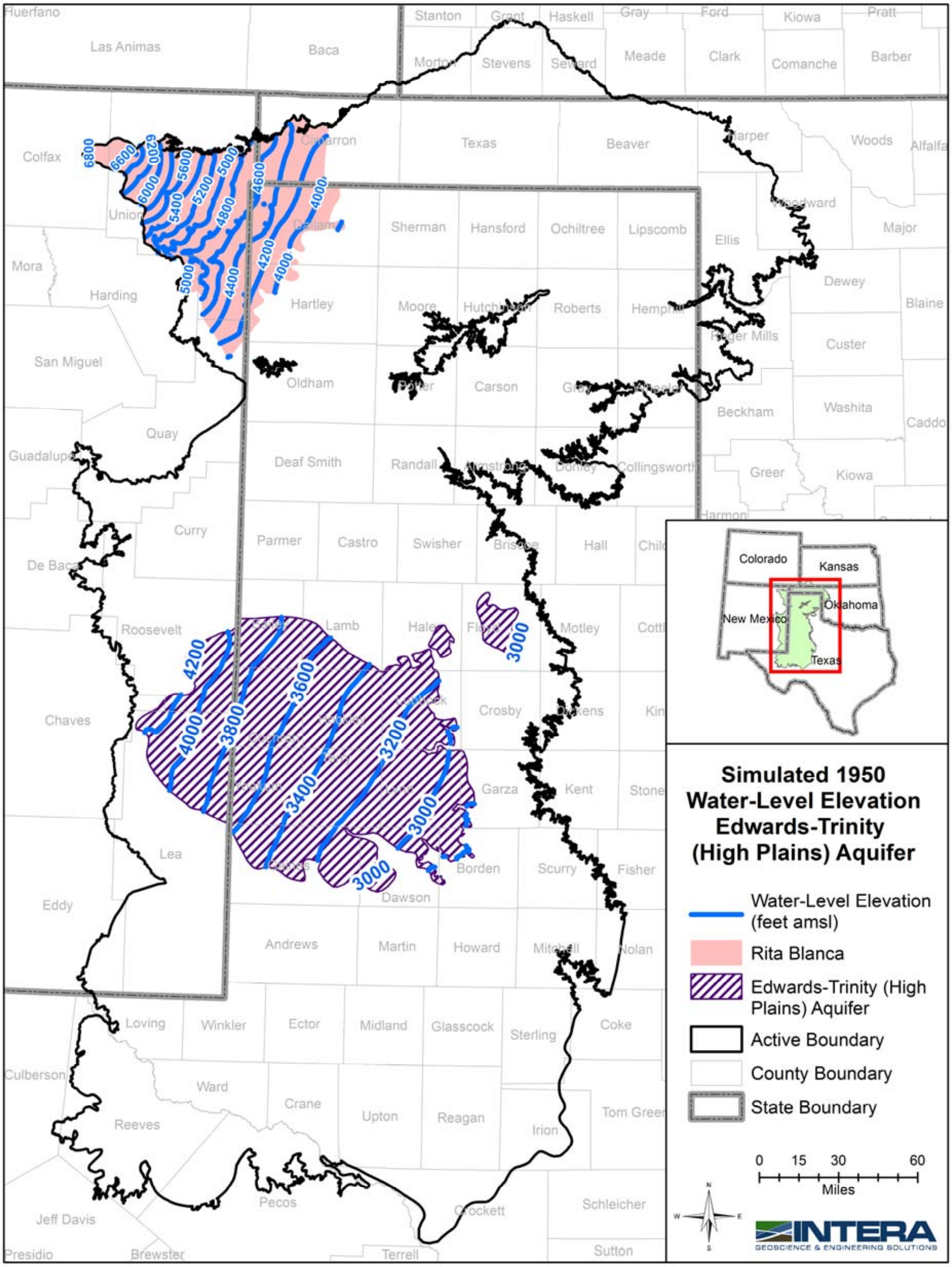


Figure 3.2.22a Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Rita Blanca and Edwards-Trinity (High Plains) aquifers in 1950 (stress period 22).

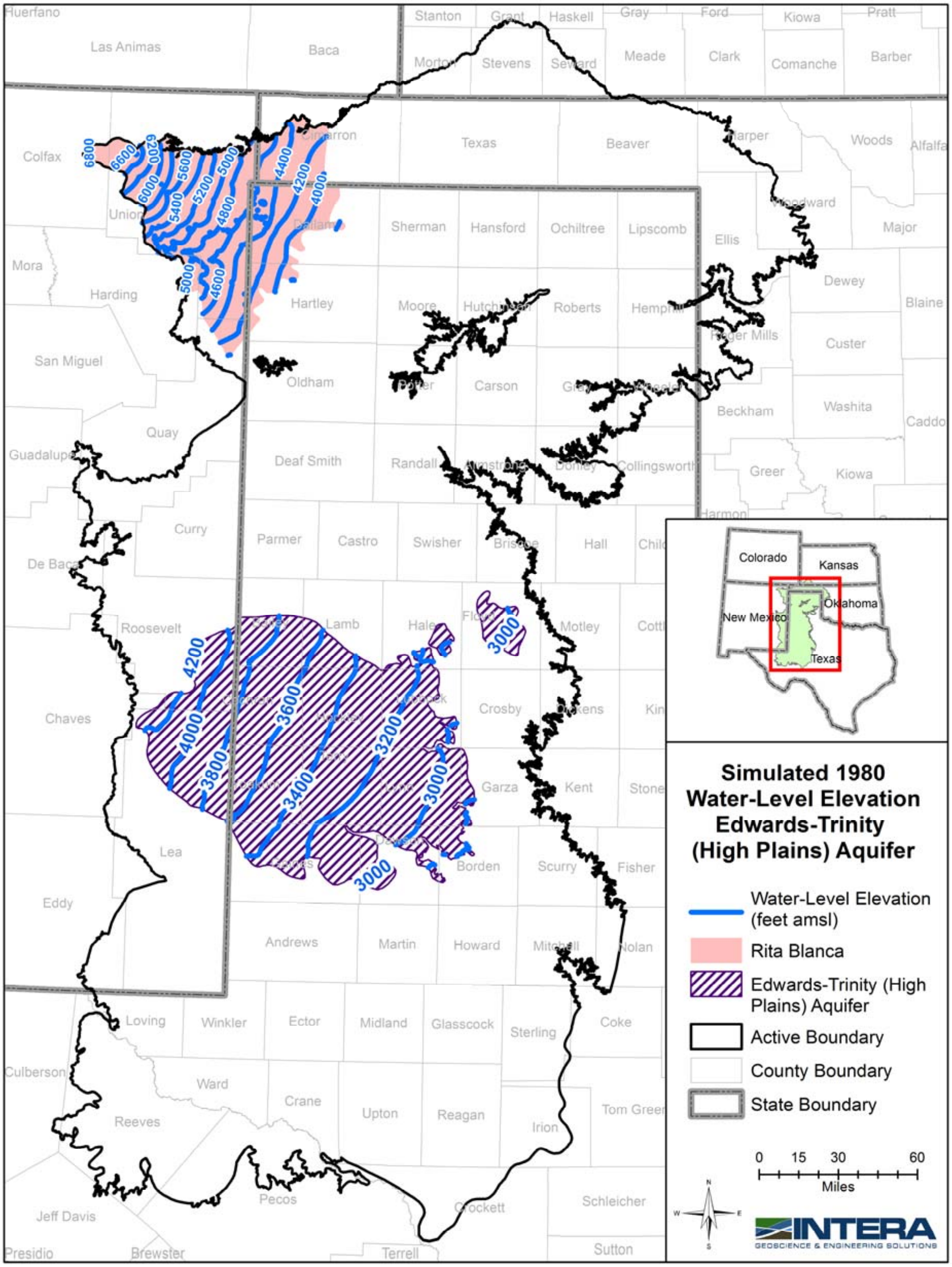


Figure 3.2.22b **Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Rita Blanca and Edwards-Trinity (High Plains) aquifers in 1980 (stress period 52).**

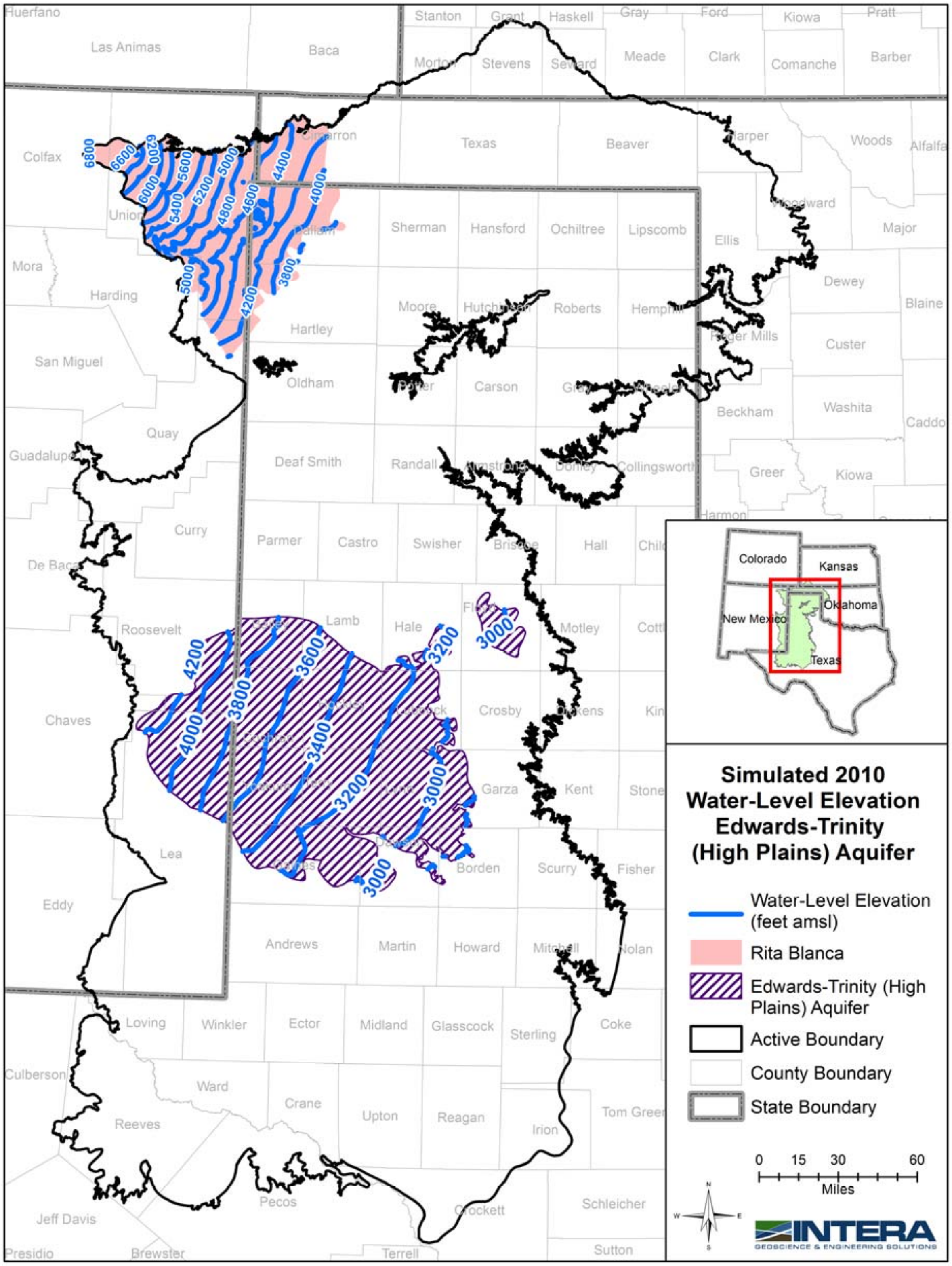


Figure 3.2.22c Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the Rita Blanca and Edwards-Trinity (High Plains) aquifers in 2010 (stress period 82).

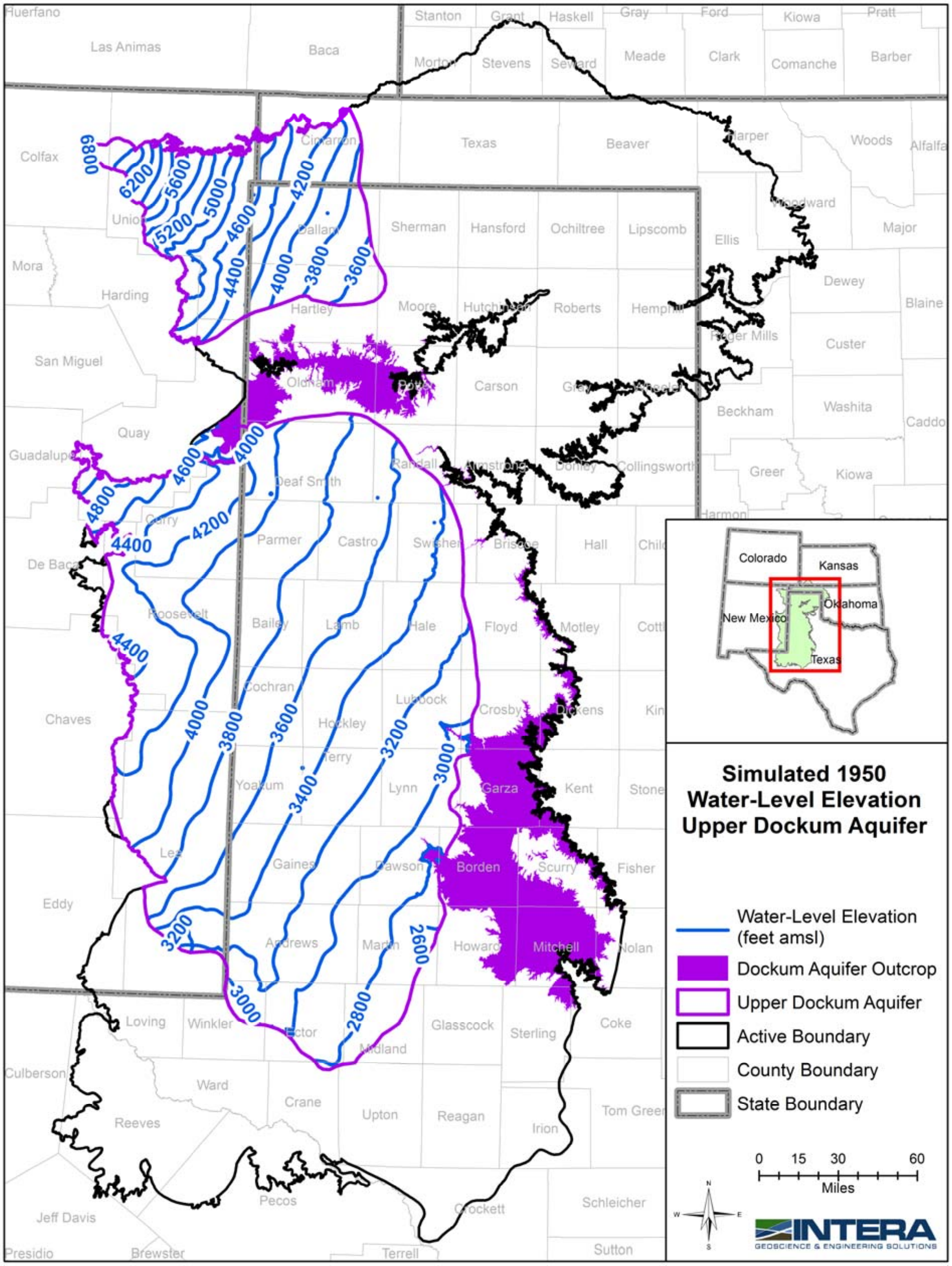


Figure 3.2.23a Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the upper Dockum Aquifer in 1950 (stress period 22).

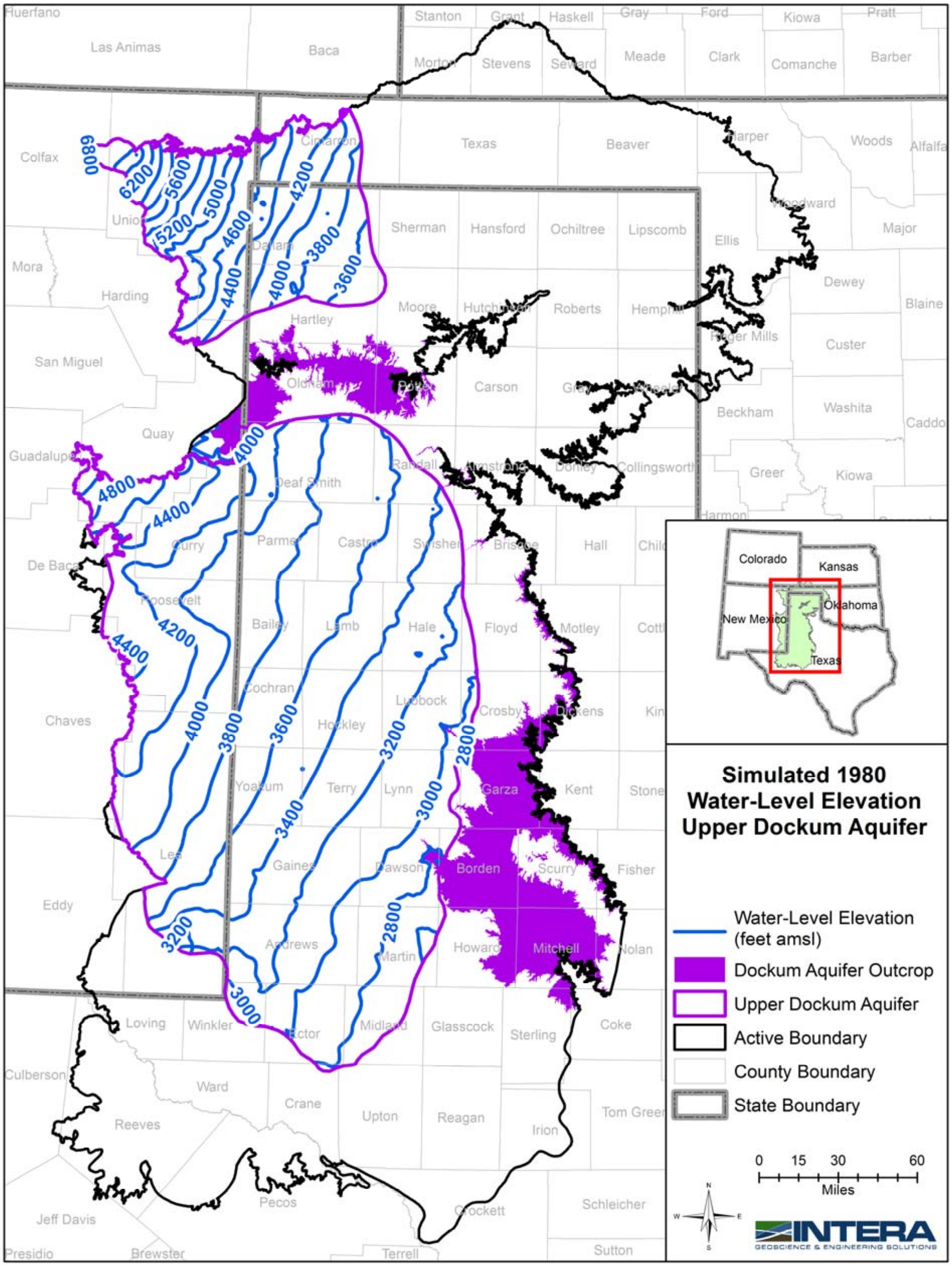


Figure 3.2.23b **Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the upper Dockum Aquifer in 1980 (stress period 52).**

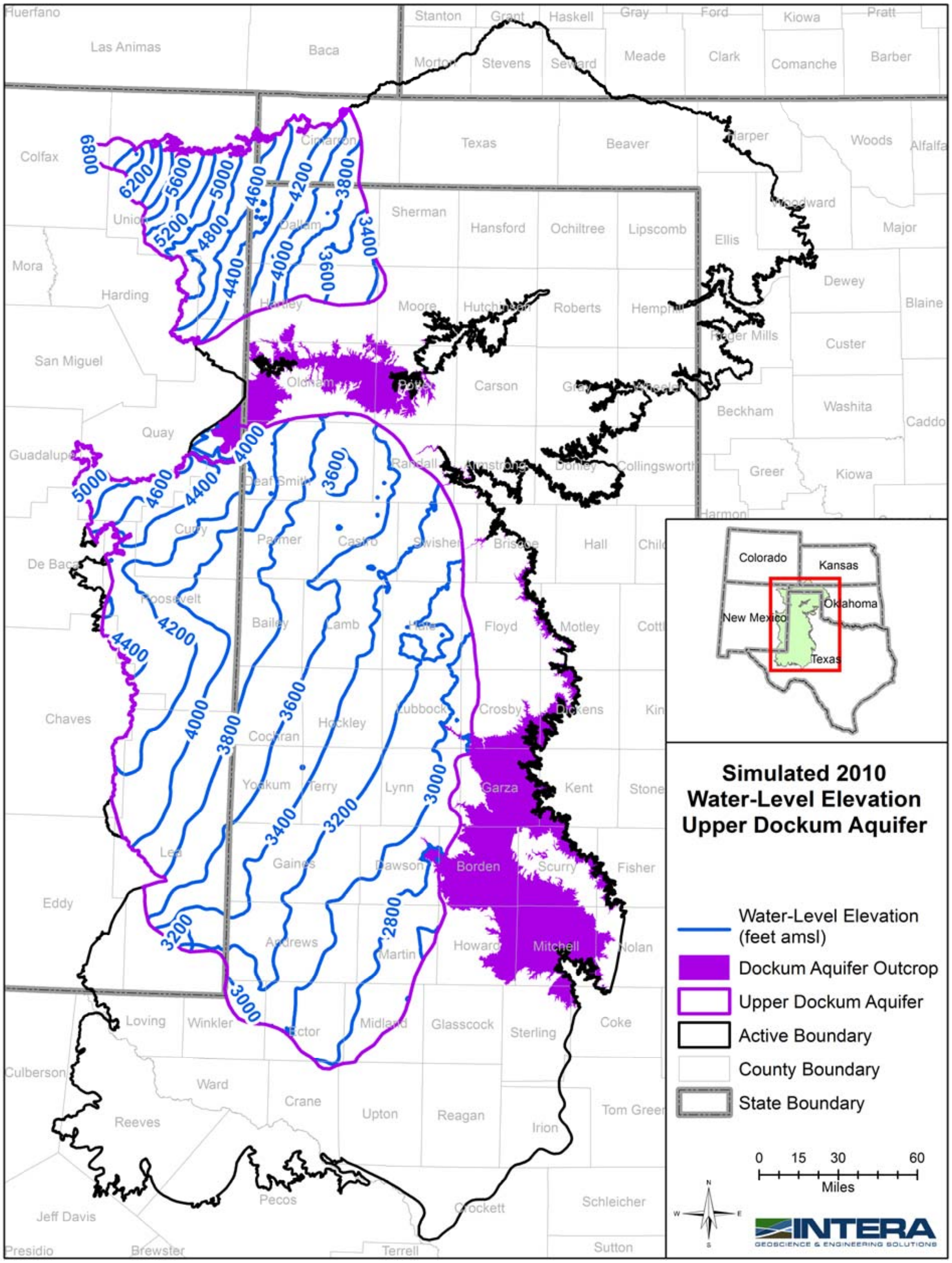


Figure 3.2.23c **Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the upper Dockum Aquifer in 2010 (stress period 82).**

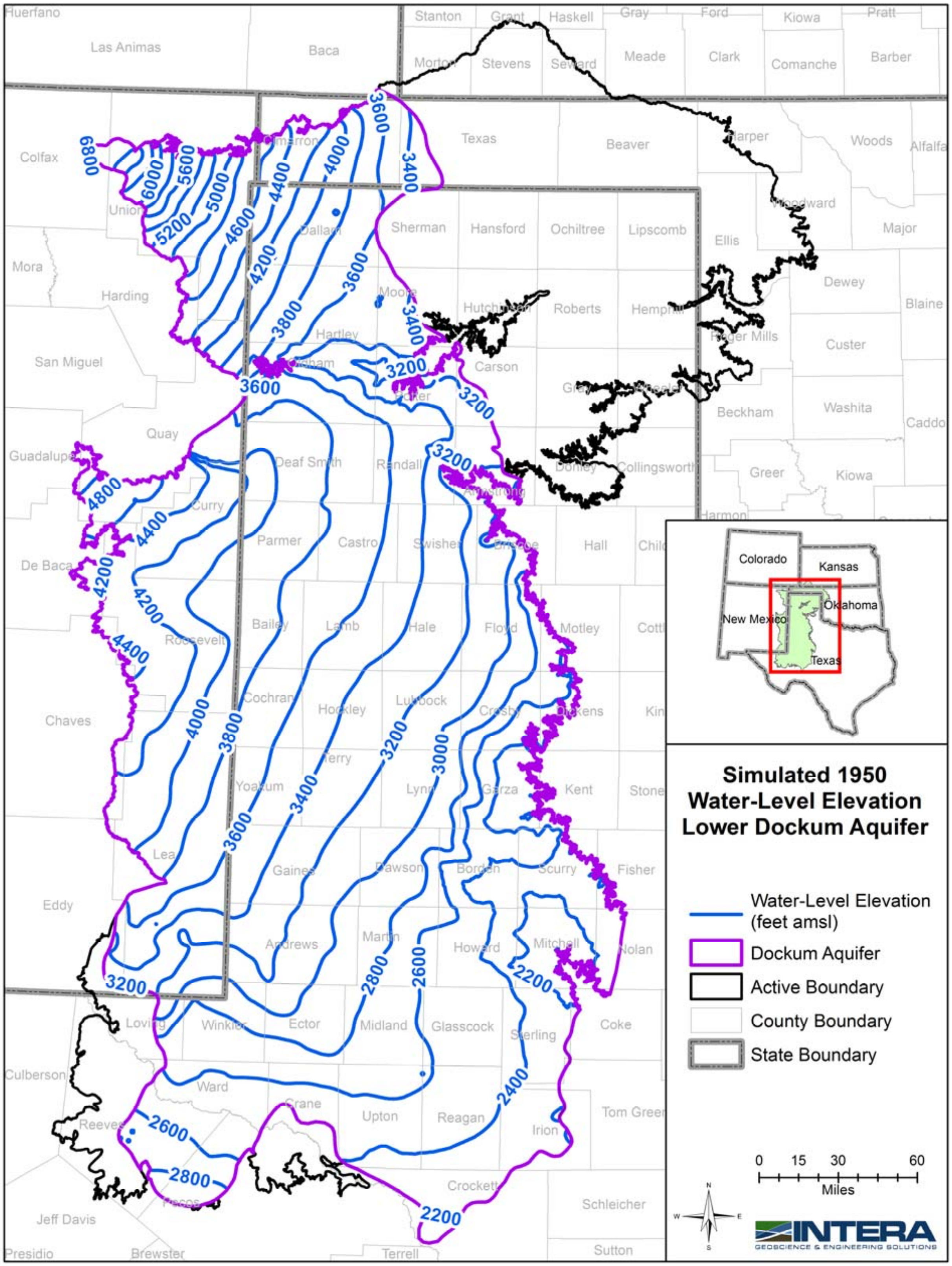


Figure 3.2.24a **Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the lower Dockum Aquifer in 1950 (stress period 22).**

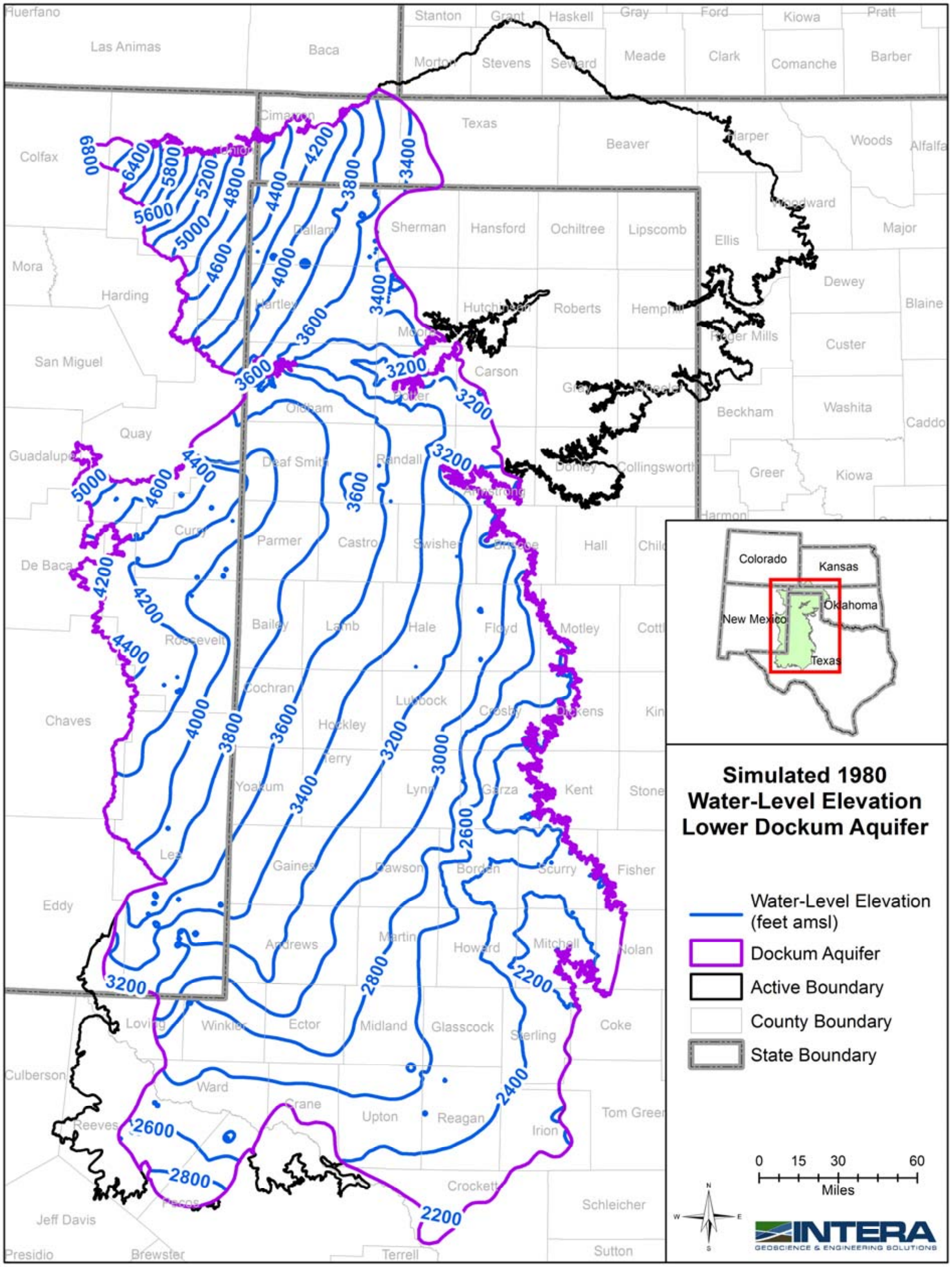


Figure 3.2.24b Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the lower Dockum Aquifer in 1980 (stress period 52).

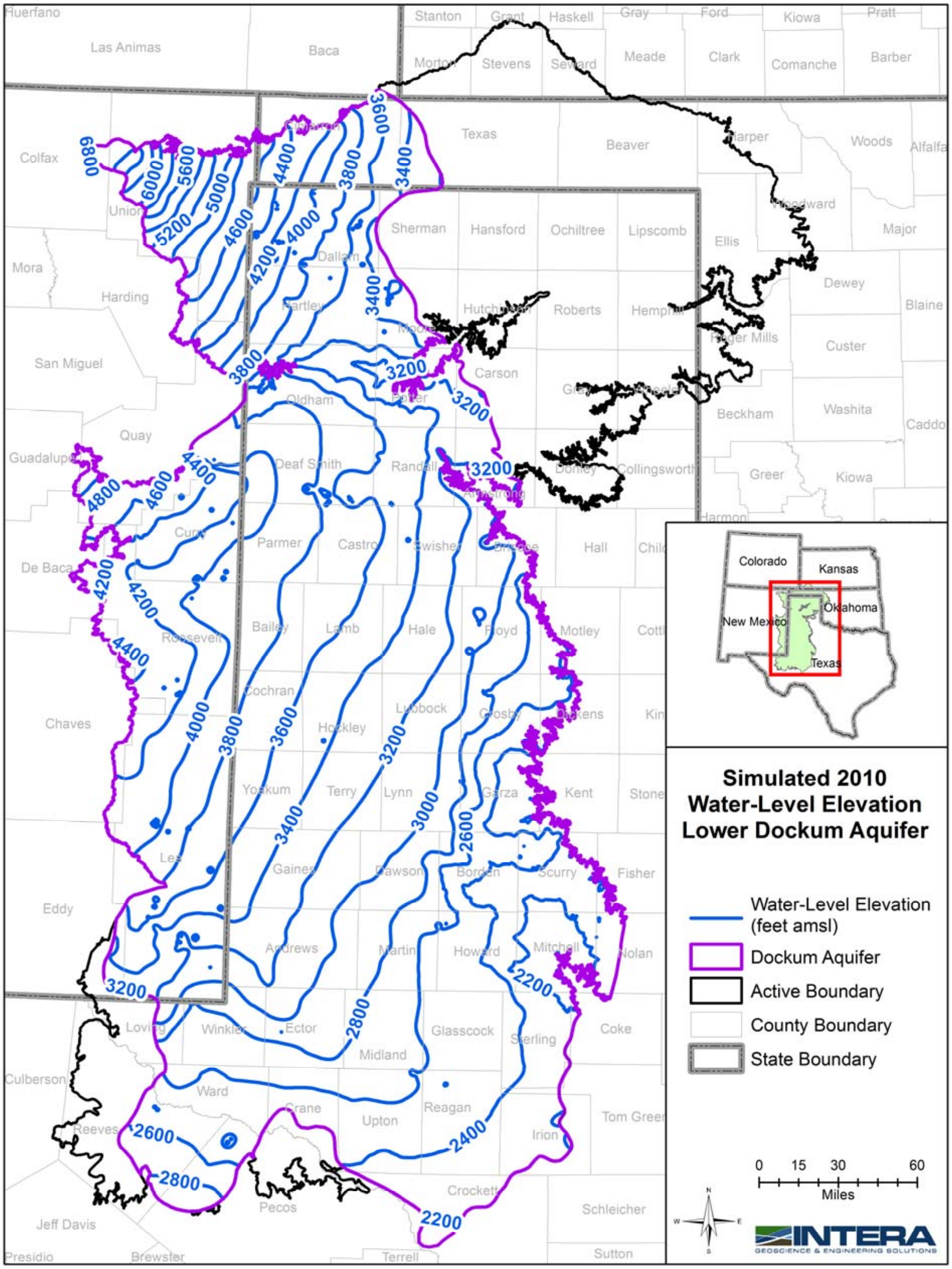


Figure 3.2.24c Simulated water-level elevations (hydraulic heads) in feet above mean sea level in the lower Dockum Aquifer in 2010 (stress period 82).

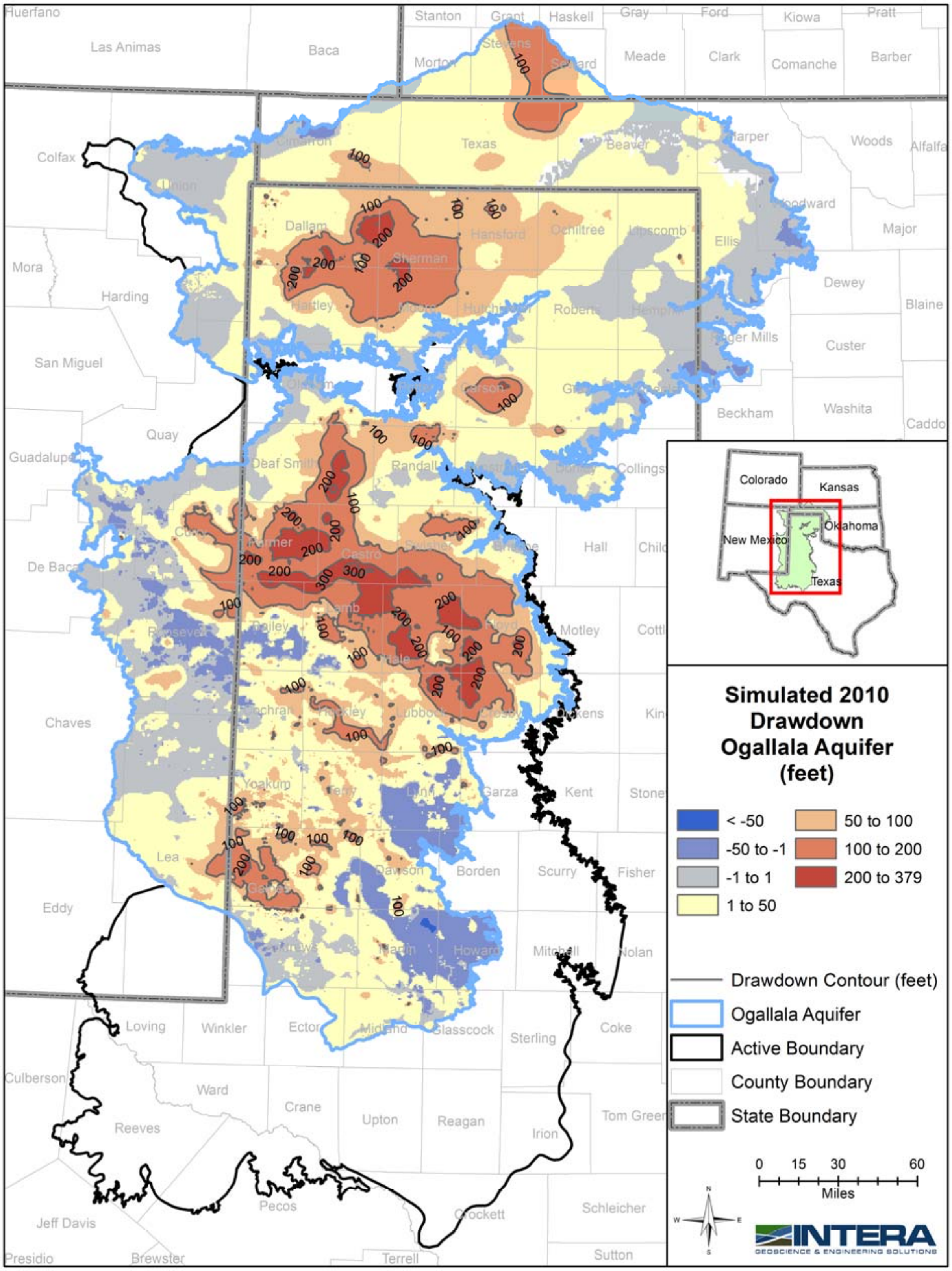


Figure 3.2.25 Simulated drawdown in feet in the Ogallala Aquifer from the pre-development (steady-state) stress period to 2010 (stress period 82).

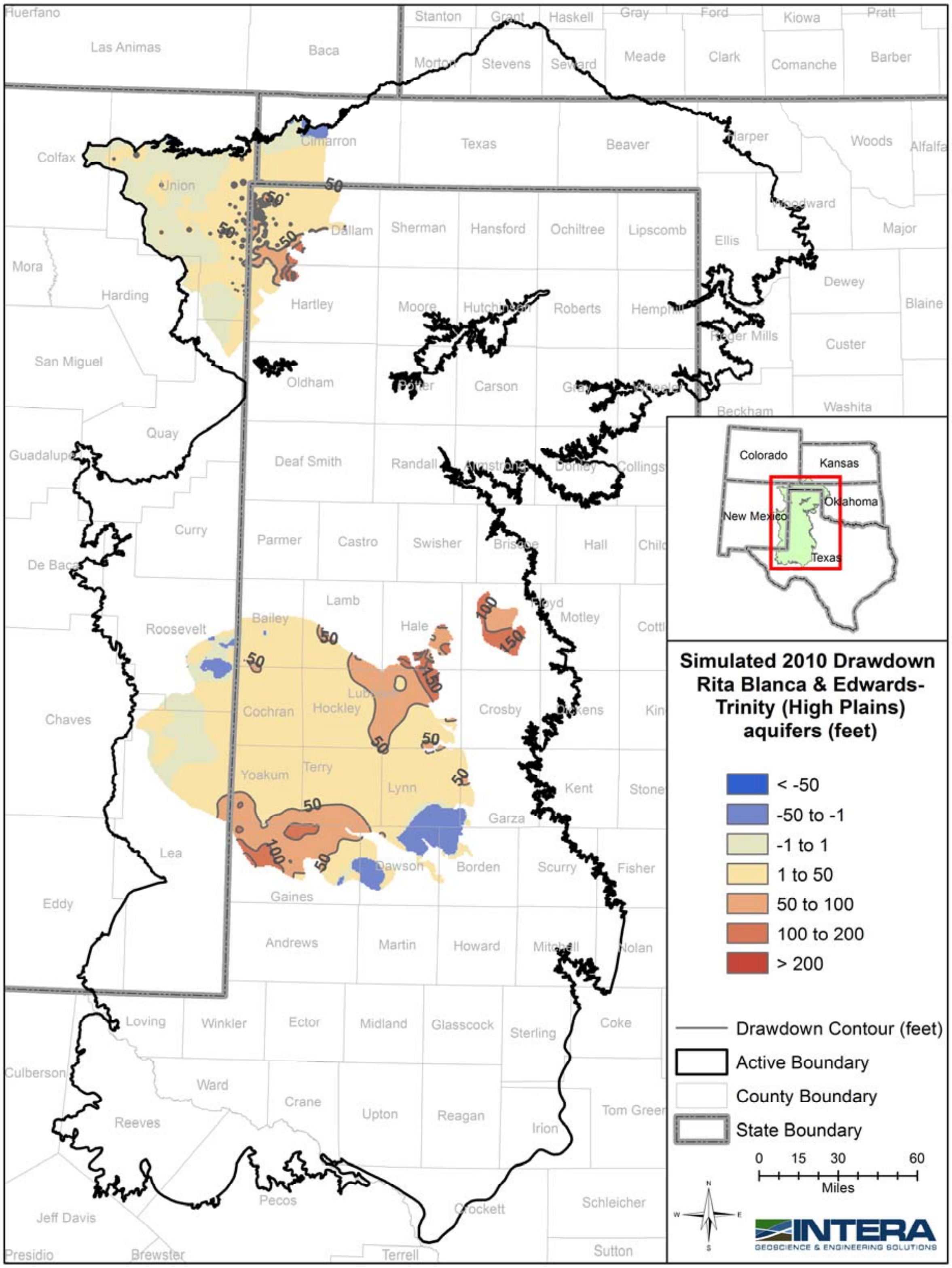


Figure 3.2.26 Simulated drawdown in feet in the Rita Blanca and Edwards-Trinity (High Plains) aquifers from the pre-development (steady-state) stress period to 2010 (stress period 82).

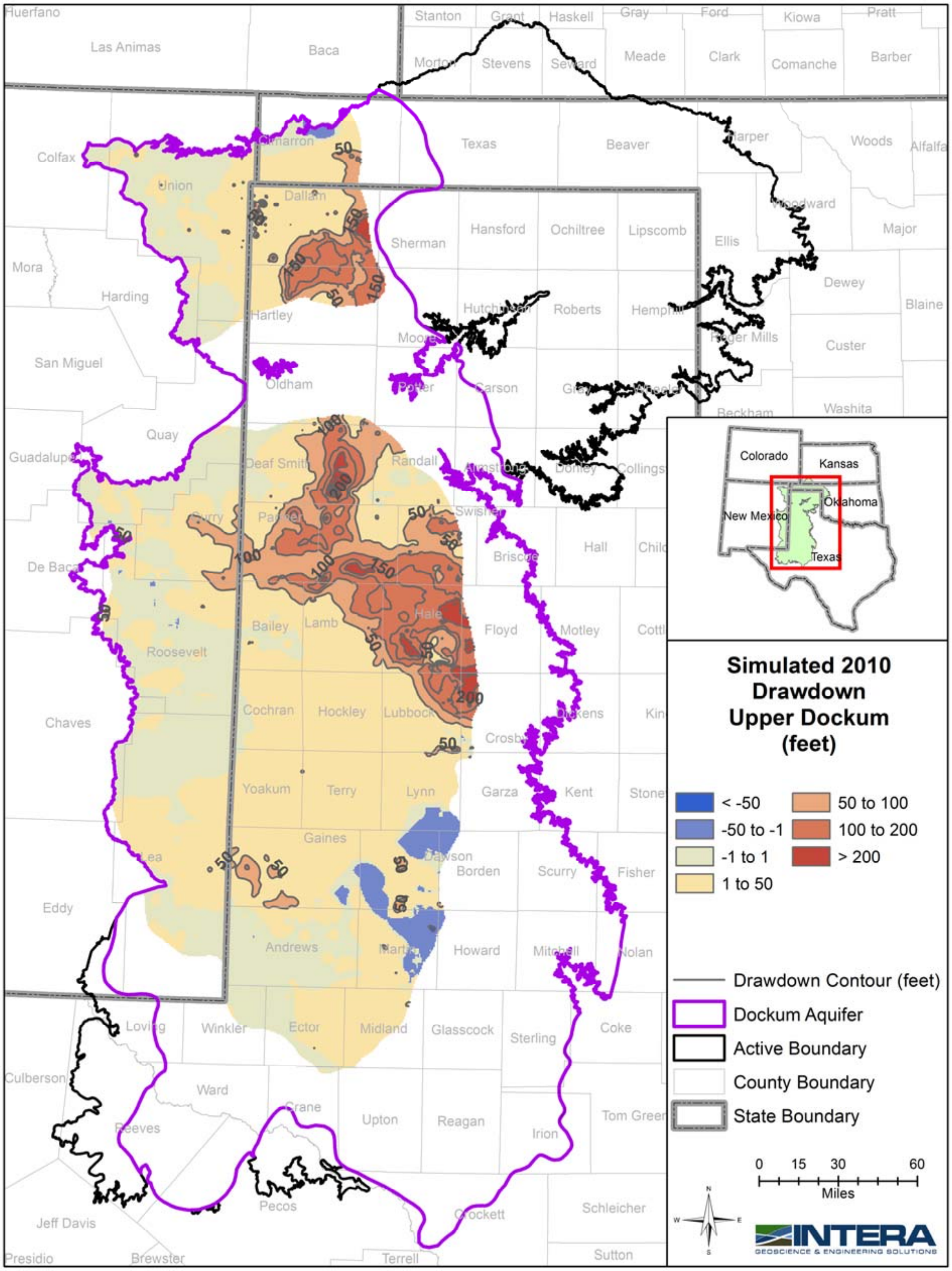


Figure 3.2.27 **Simulated drawdown in feet in the upper Dockum Aquifer from the pre-development (steady-state) stress period to 2010 (stress period 82).**

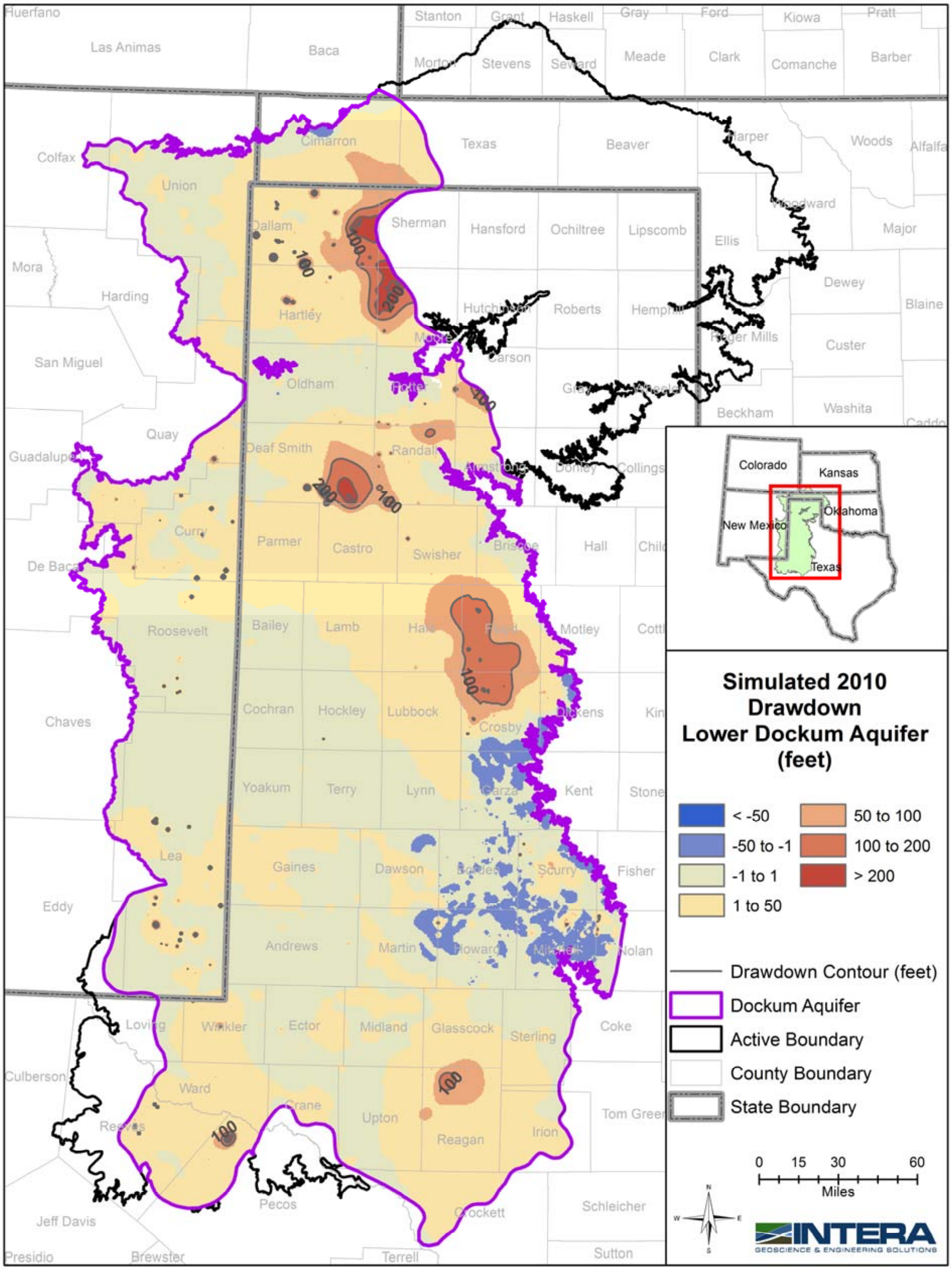


Figure 3.2.28 Simulated drawdown in feet in the lower Dockum Aquifer from the pre-development (steady-state) stress period to 2010 (stress period 82).

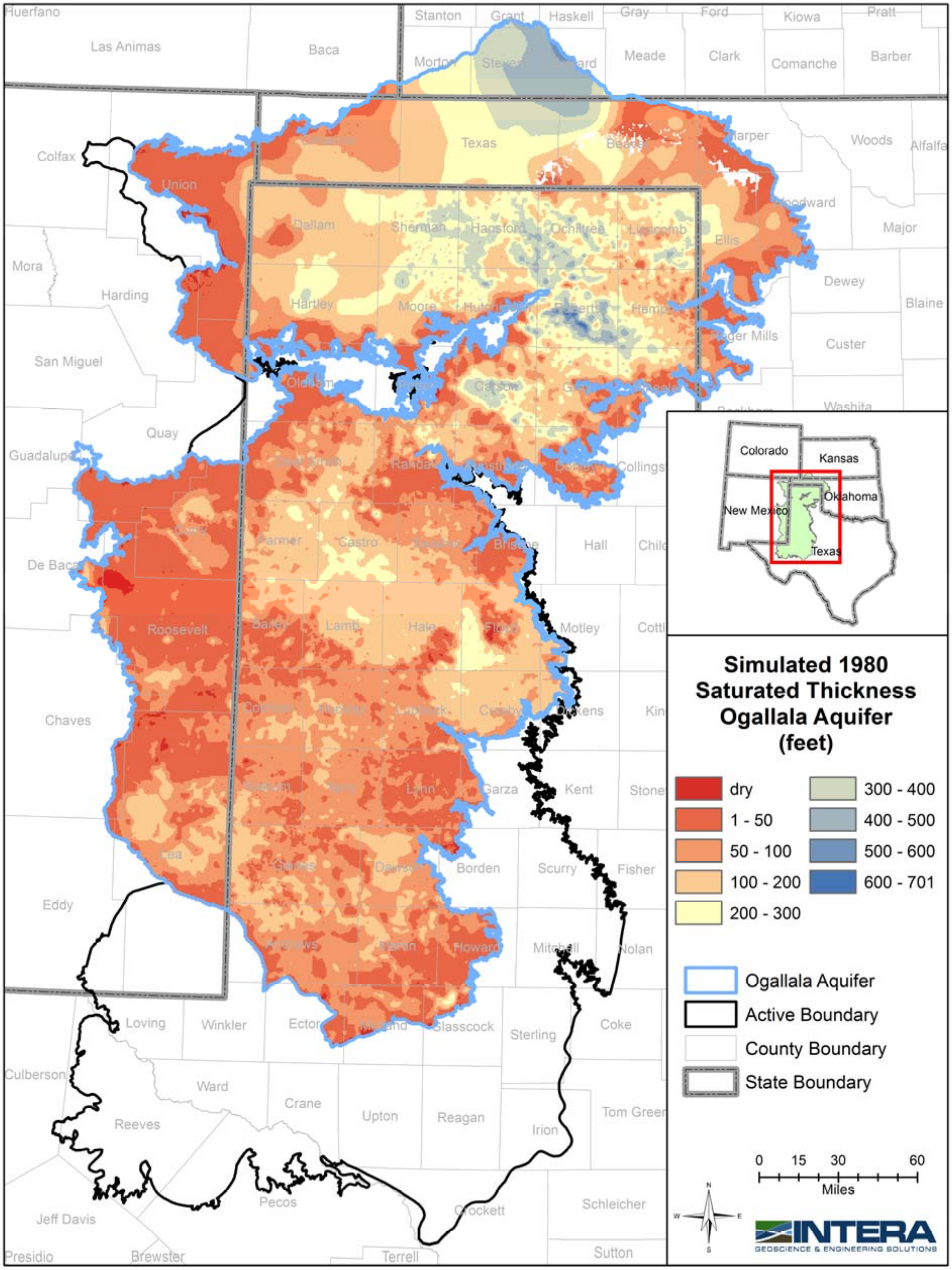


Figure 3.2.29 Simulated saturated thickness in feet in the Ogallala Aquifer in 1980 (stress period 52).

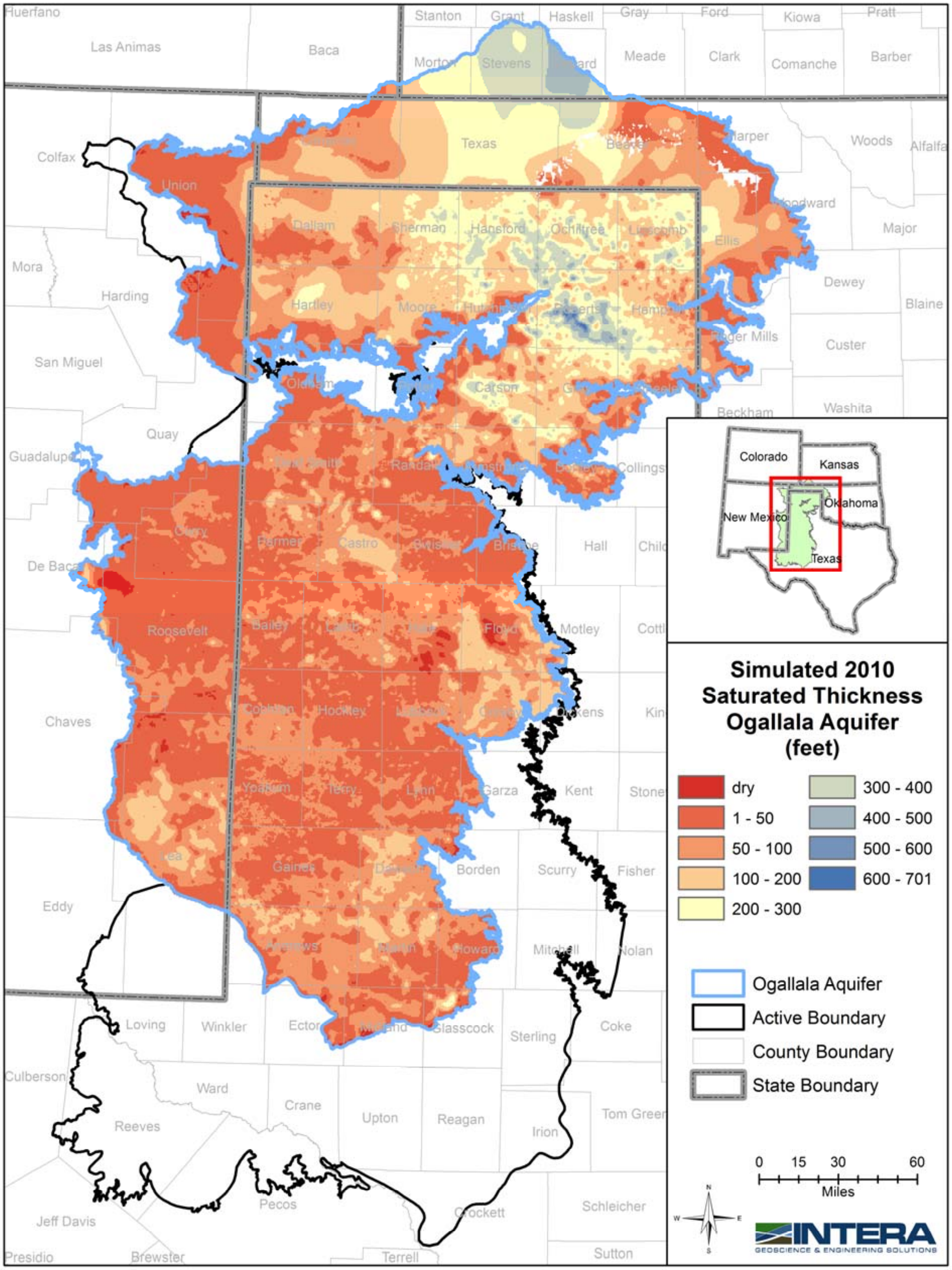


Figure 3.2.30 Simulated saturated thickness in feet in the Ogallala Aquifer in 2010 (stress period 82).

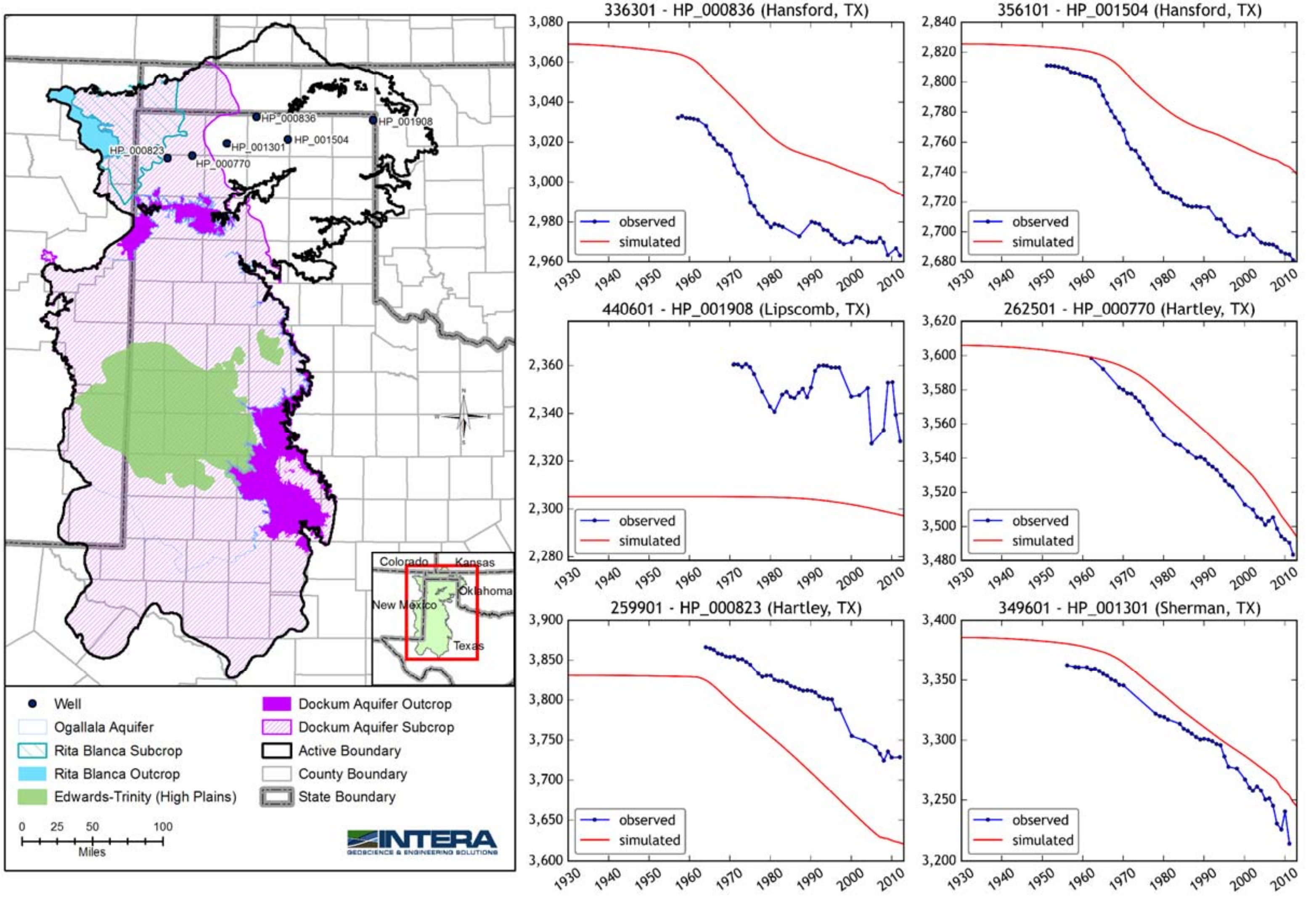


Figure 3.2.31 **Select hydrographs (group 1) for wells completed in the Ogallala Aquifer in the northern part of the study area.**

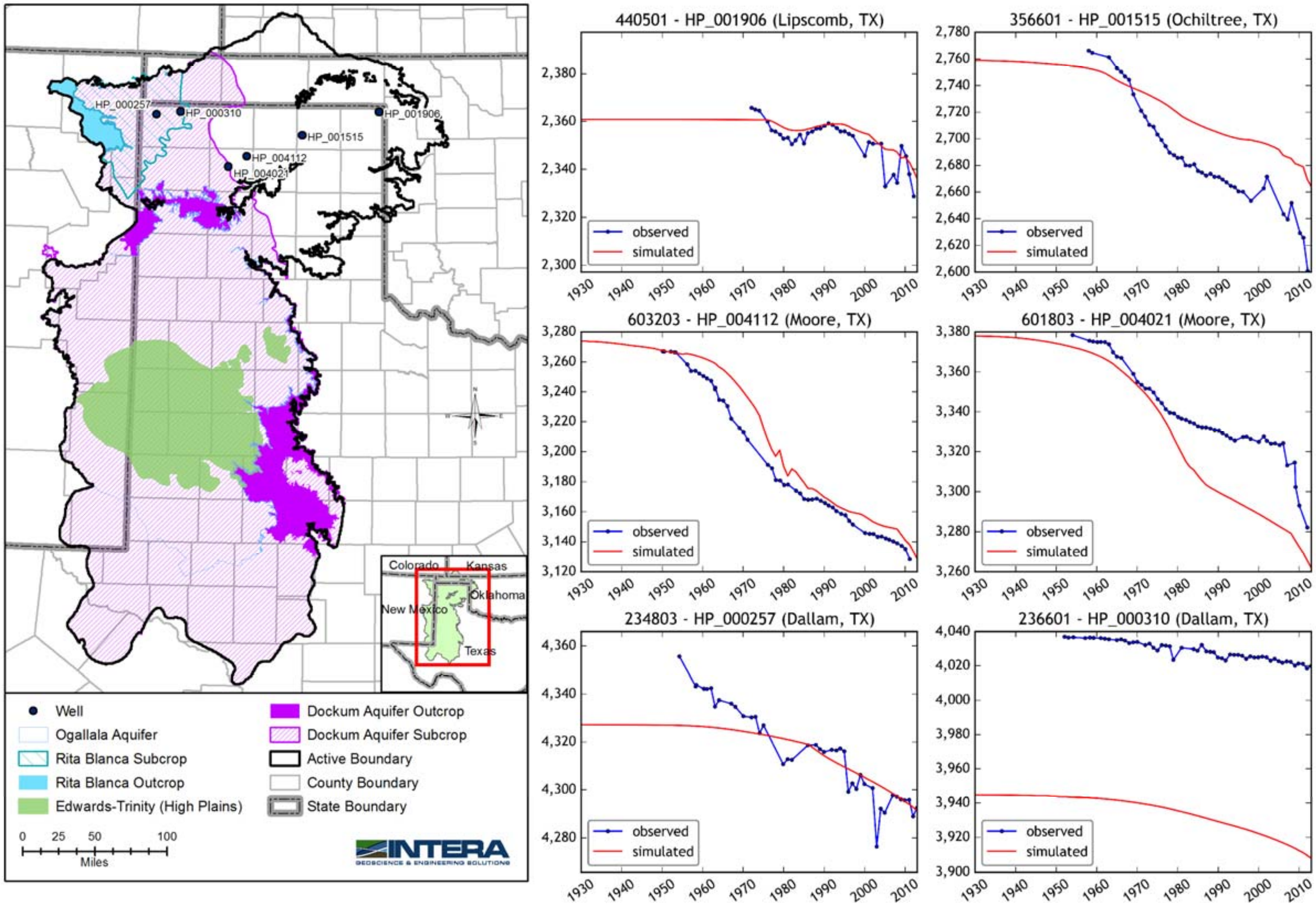


Figure 3.2.32 Select hydrographs (group 2) for wells completed in the Ogallala Aquifer in the northern part of the study area.

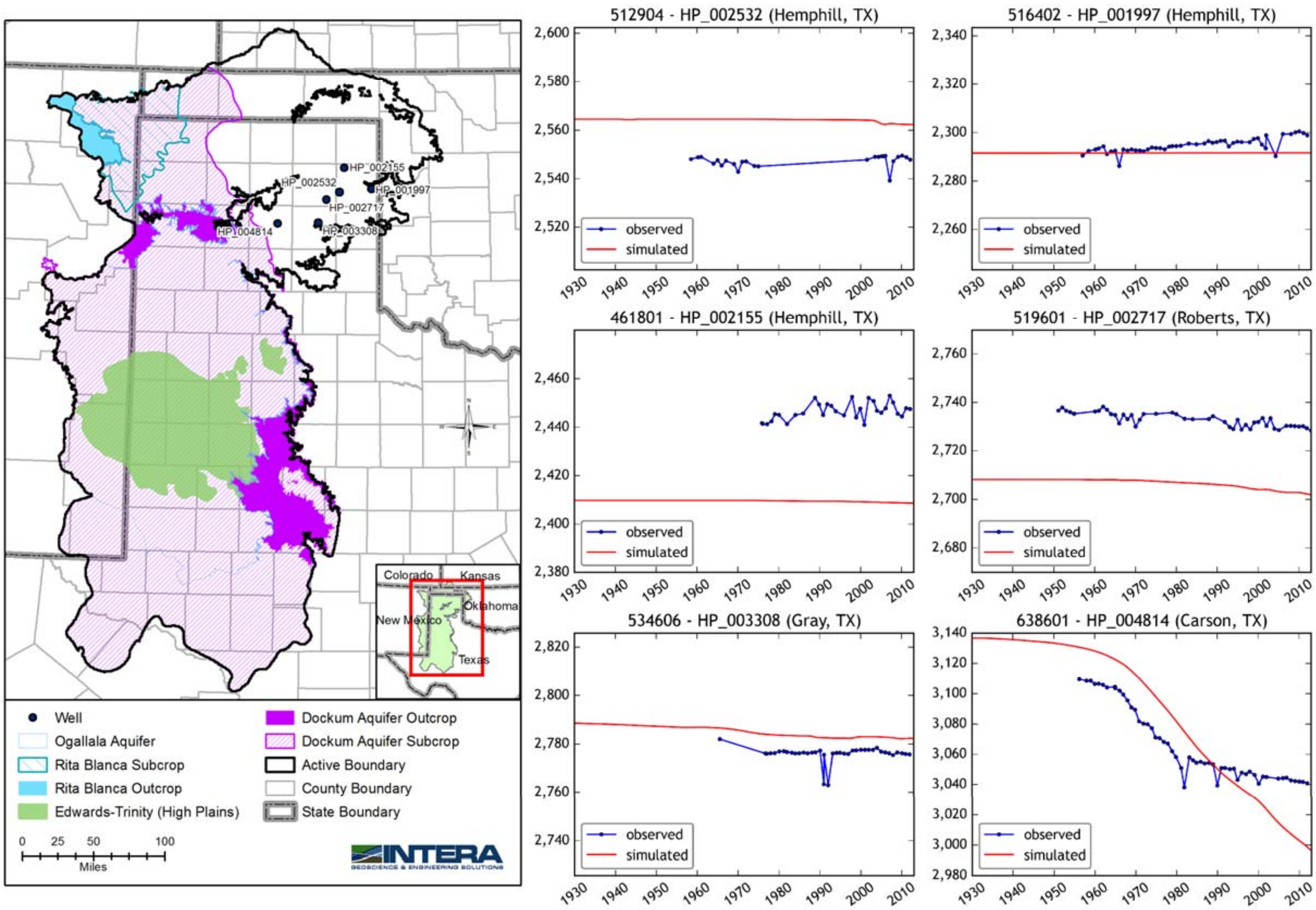


Figure 3.2.33 Select hydrographs (group 3) for wells completed in the Ogallala Aquifer in the northern part of the study area.

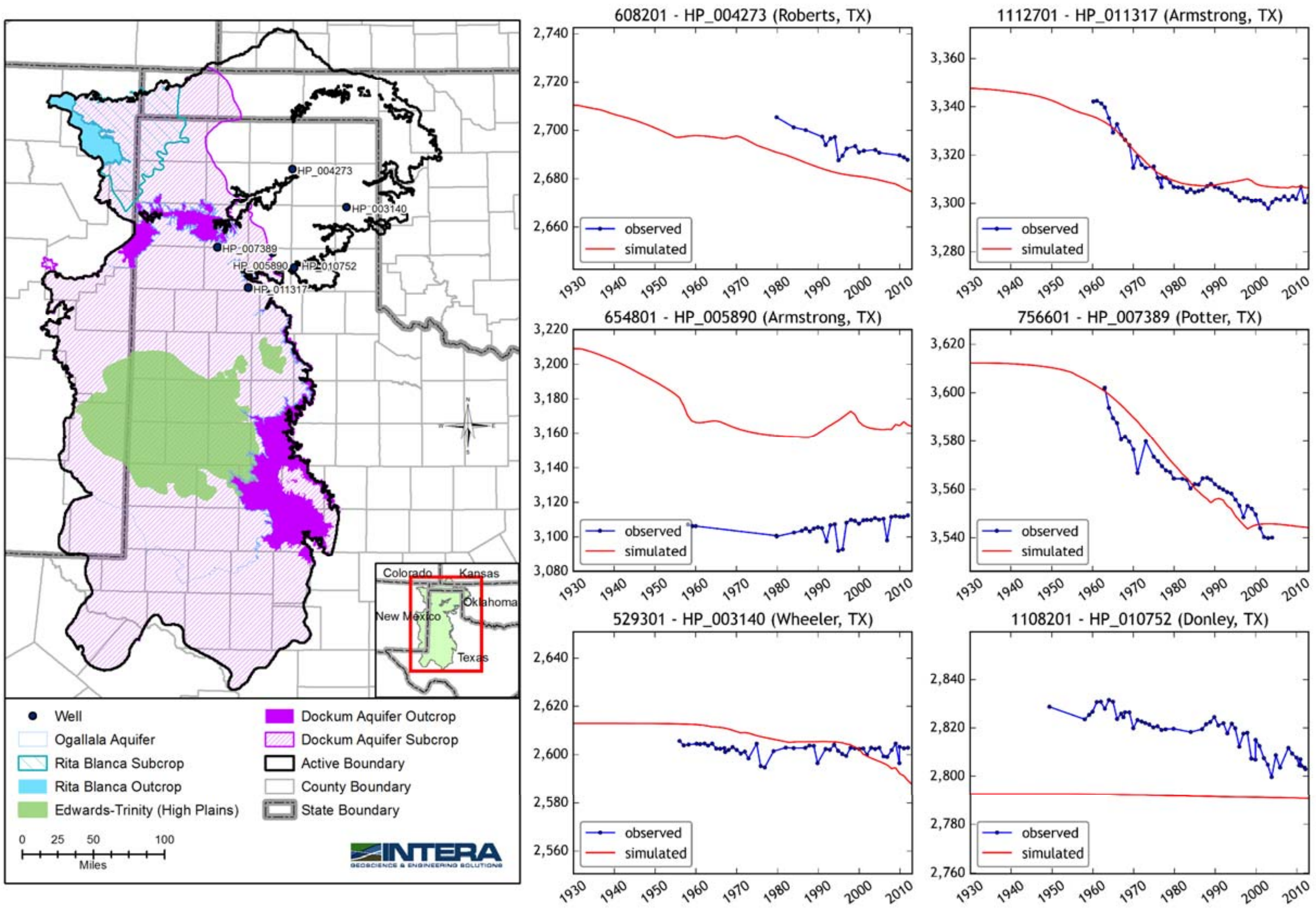


Figure 3.2.34 **Select hydrographs for wells completed in the Ogallala Aquifer in the north and central parts of the study area.**

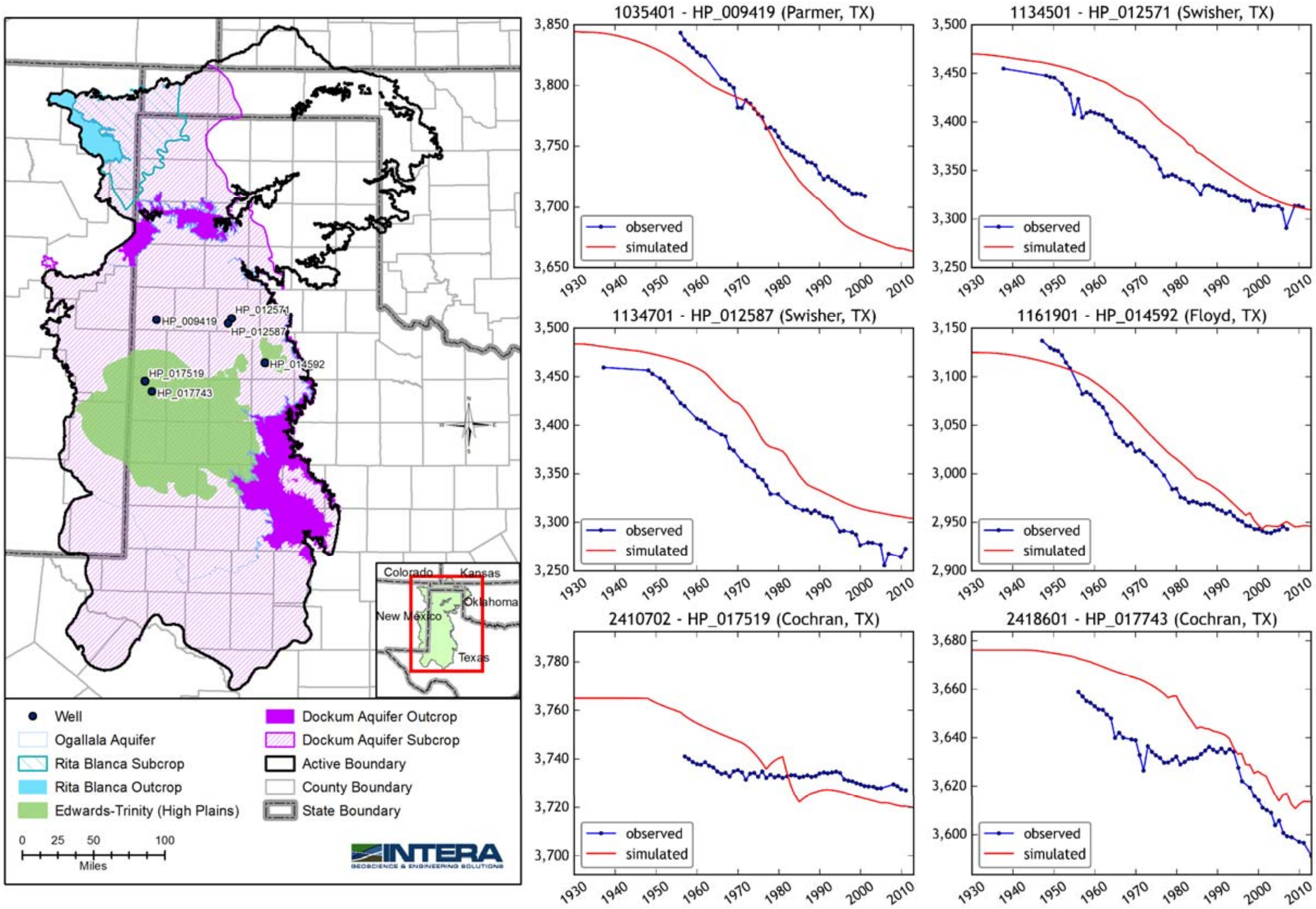


Figure 3.2.35 **Select hydrographs for wells completed in the Ogallala Aquifer in the central part of the study area.**

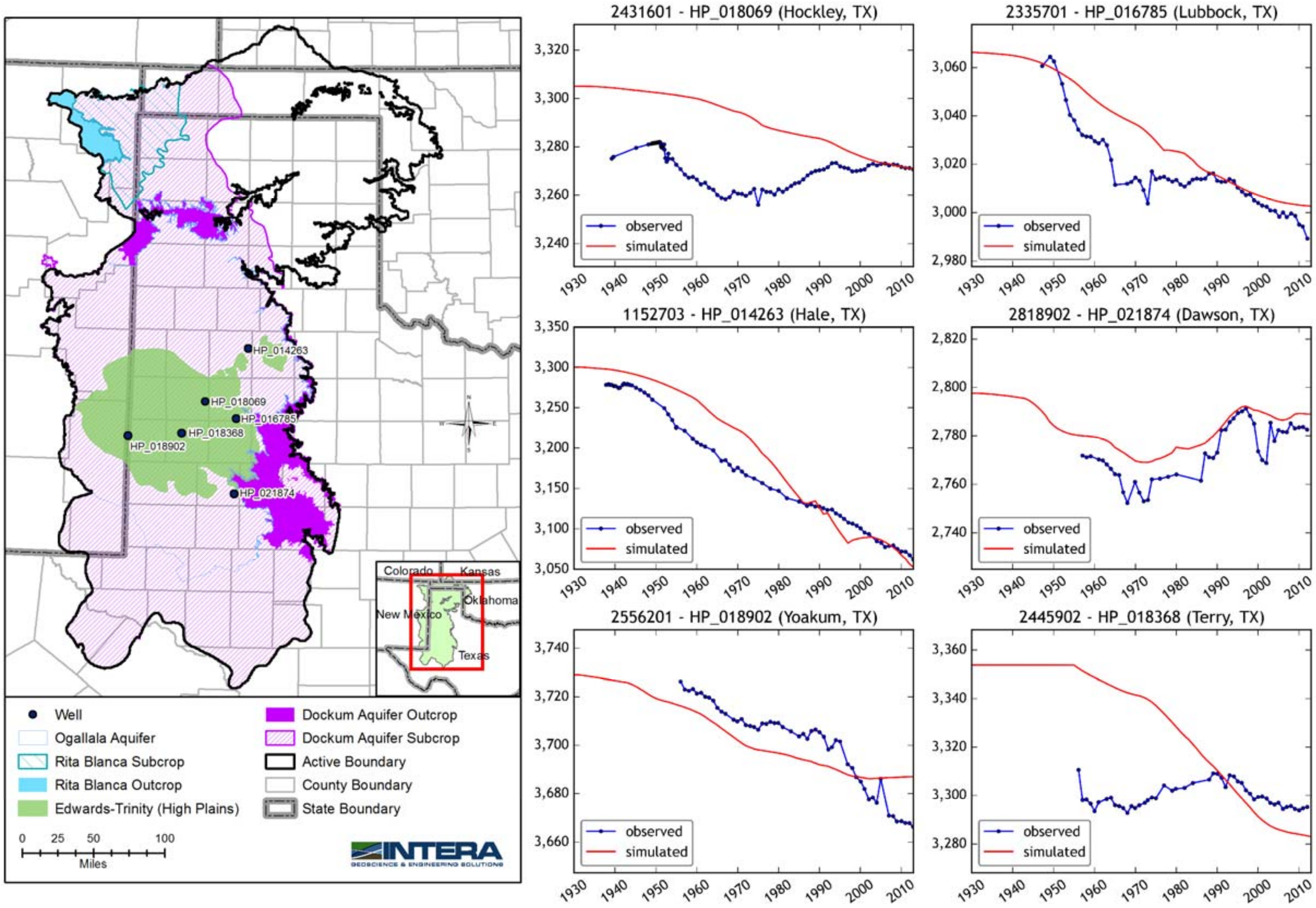


Figure 3.2.36 Select hydrographs (group 1) for wells completed in the Ogallala Aquifer in the south-central part of the study area.

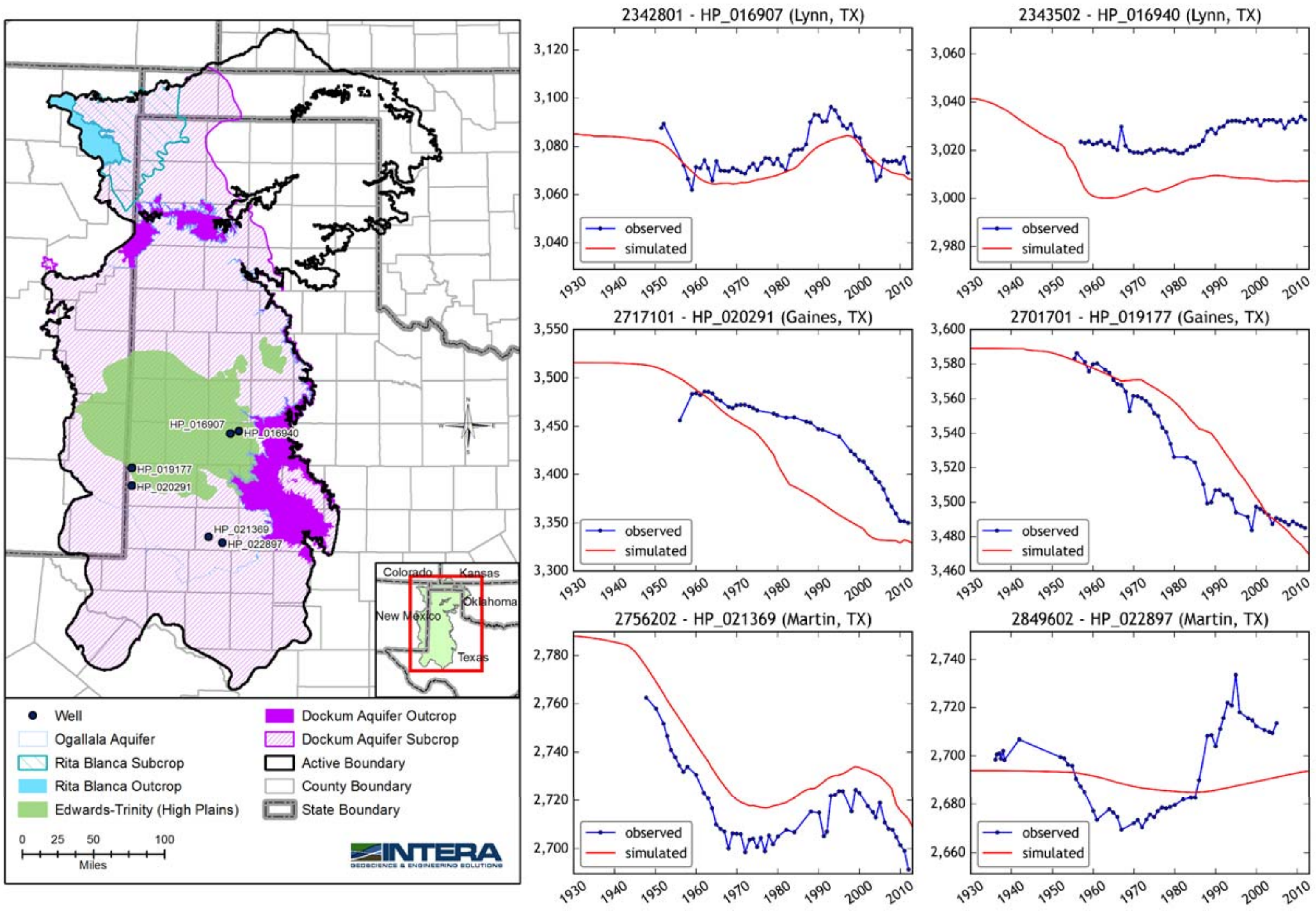


Figure 3.2.37 Select hydrographs (group 2) for wells completed in the Ogallala Aquifer in the south-central part of the study area.

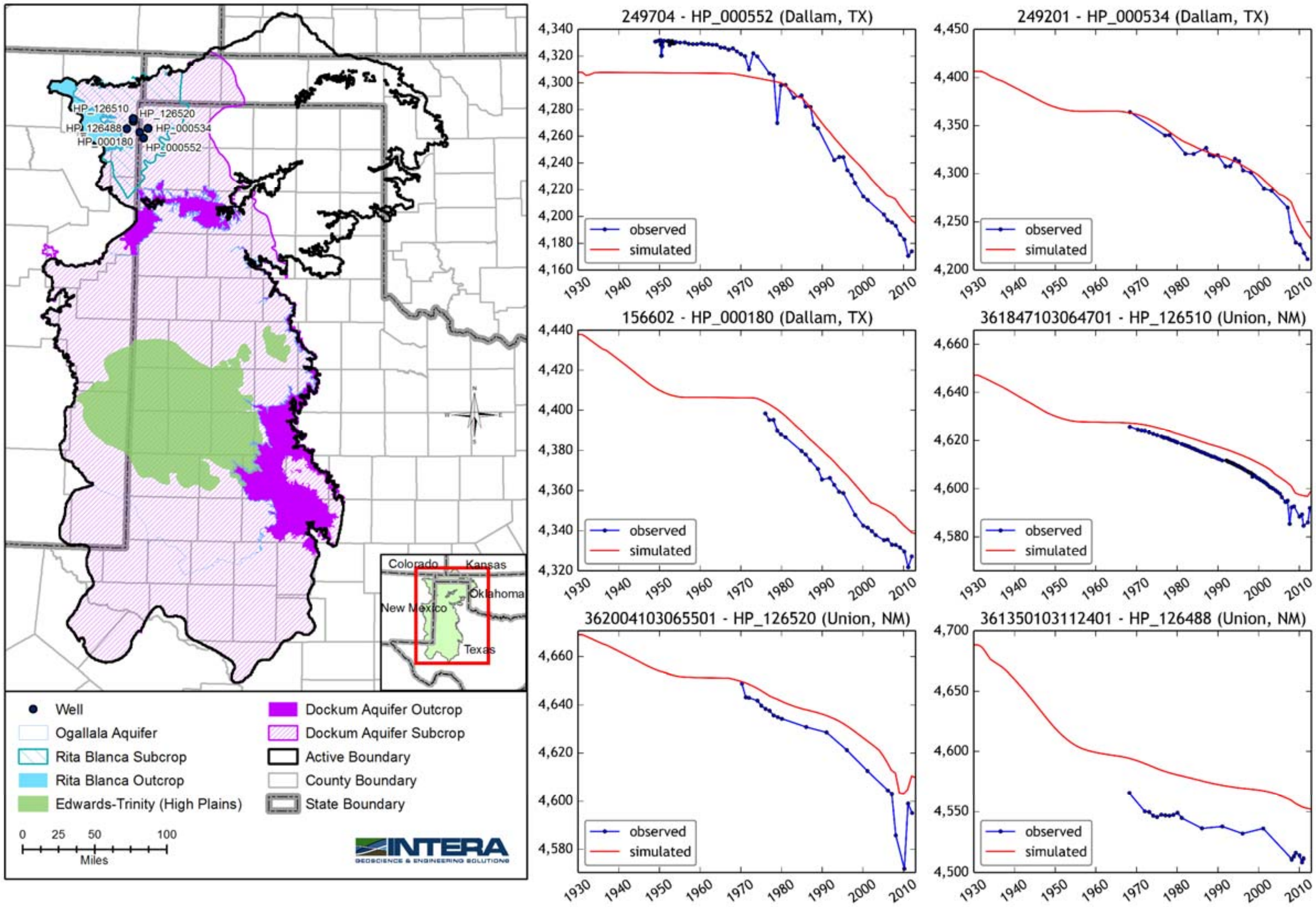


Figure 3.2.38 **Select hydrographs for wells completed in the Rita Blanca Aquifer.**

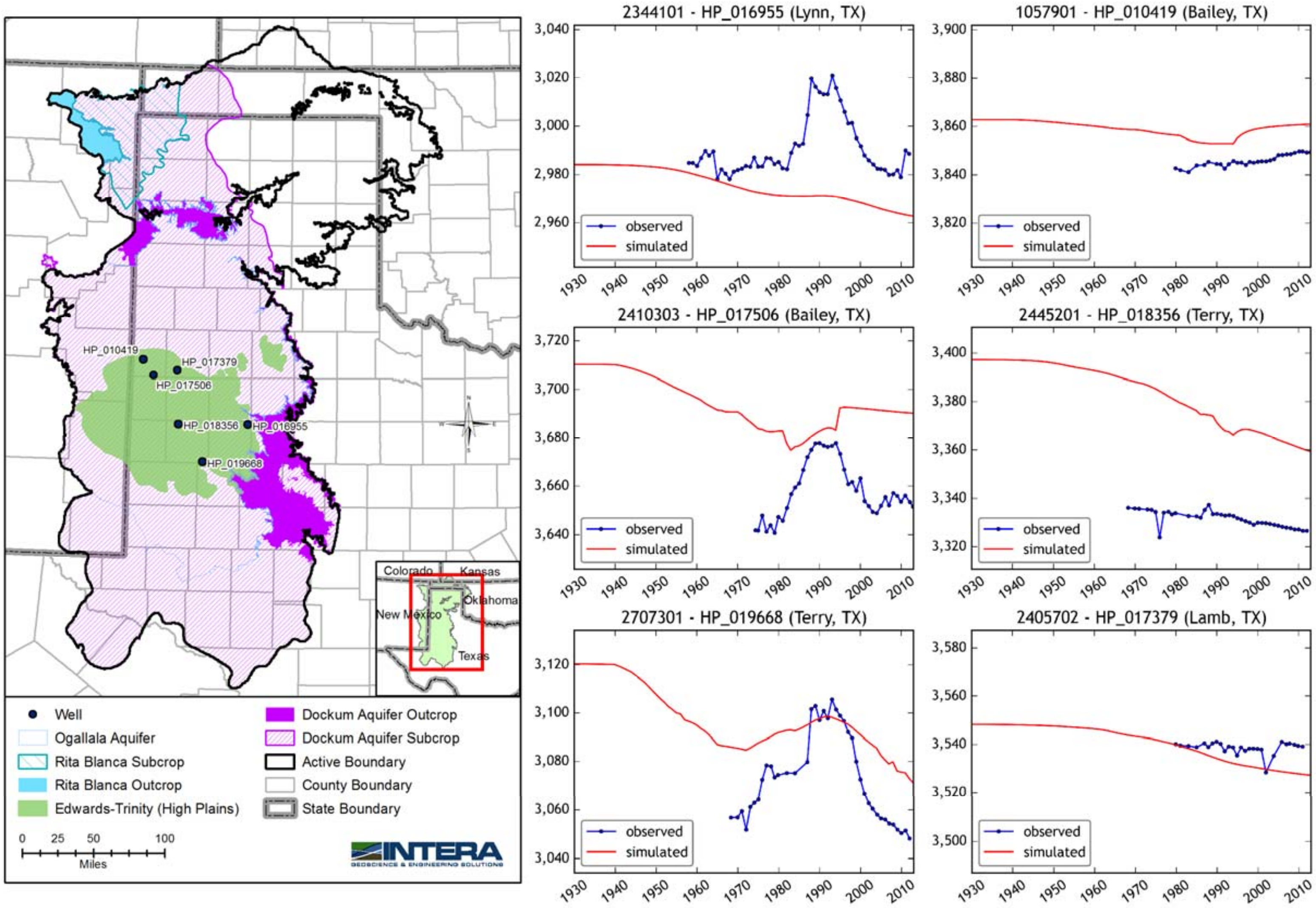


Figure 3.2.39 Select hydrographs (group 1) for wells completed in the Edwards-Trinity (High Plains) Aquifer.

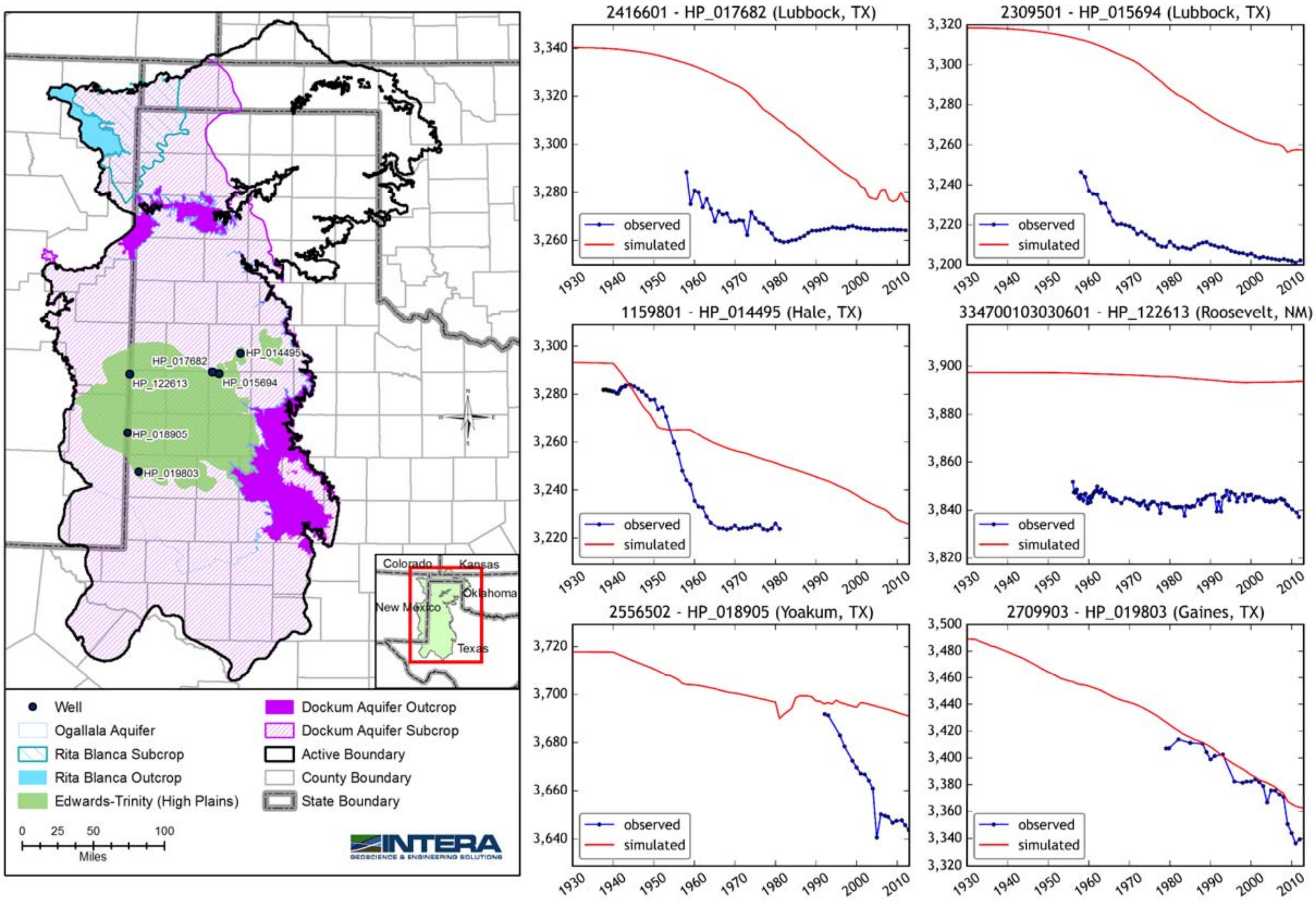


Figure 3.2.40 **Select hydrographs (group 2) for wells completed in the Edwards-Trinity (High Plains) Aquifer.**

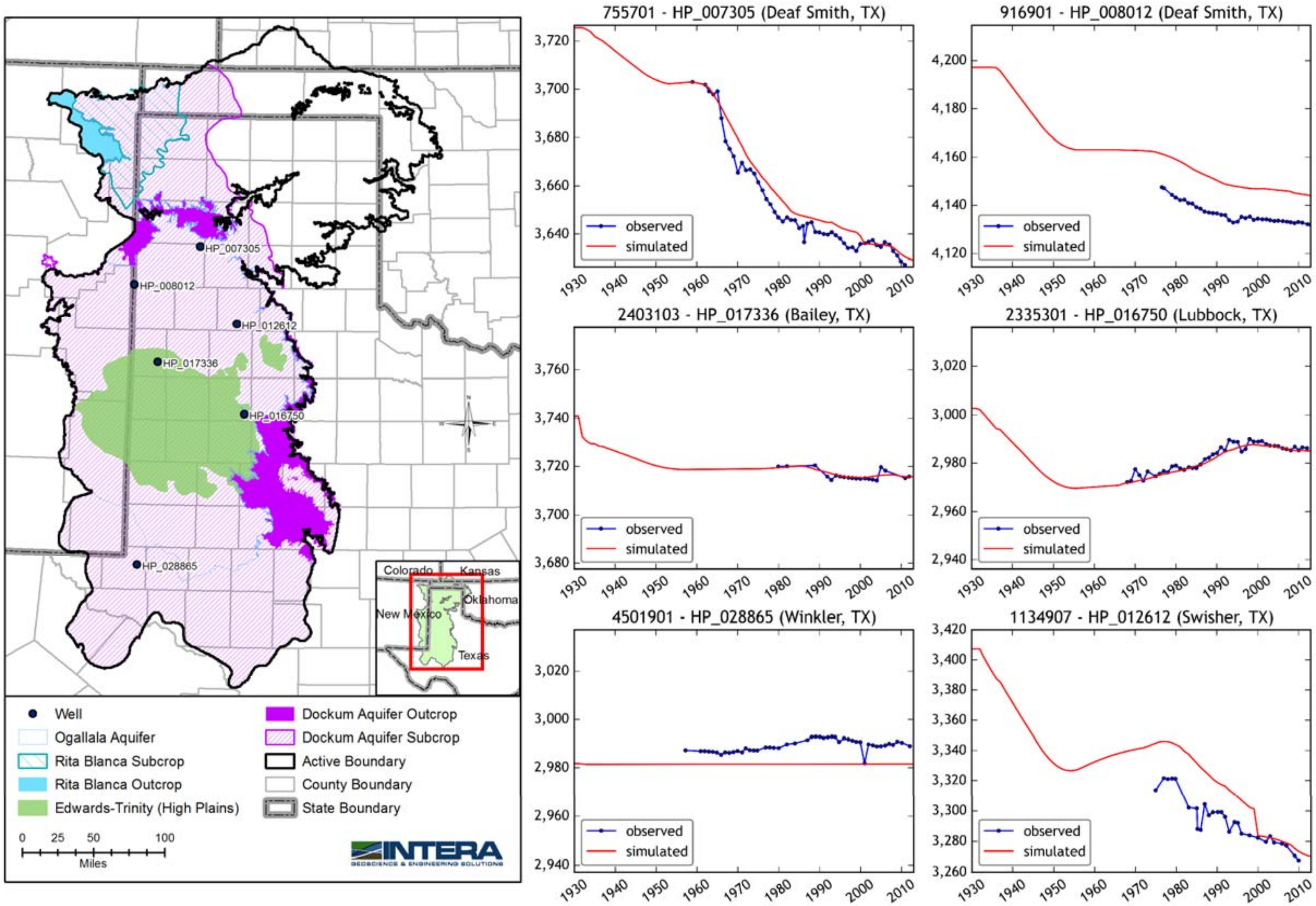


Figure 3.2.41 Select hydrographs for wells completed in the upper Dockum Aquifer.

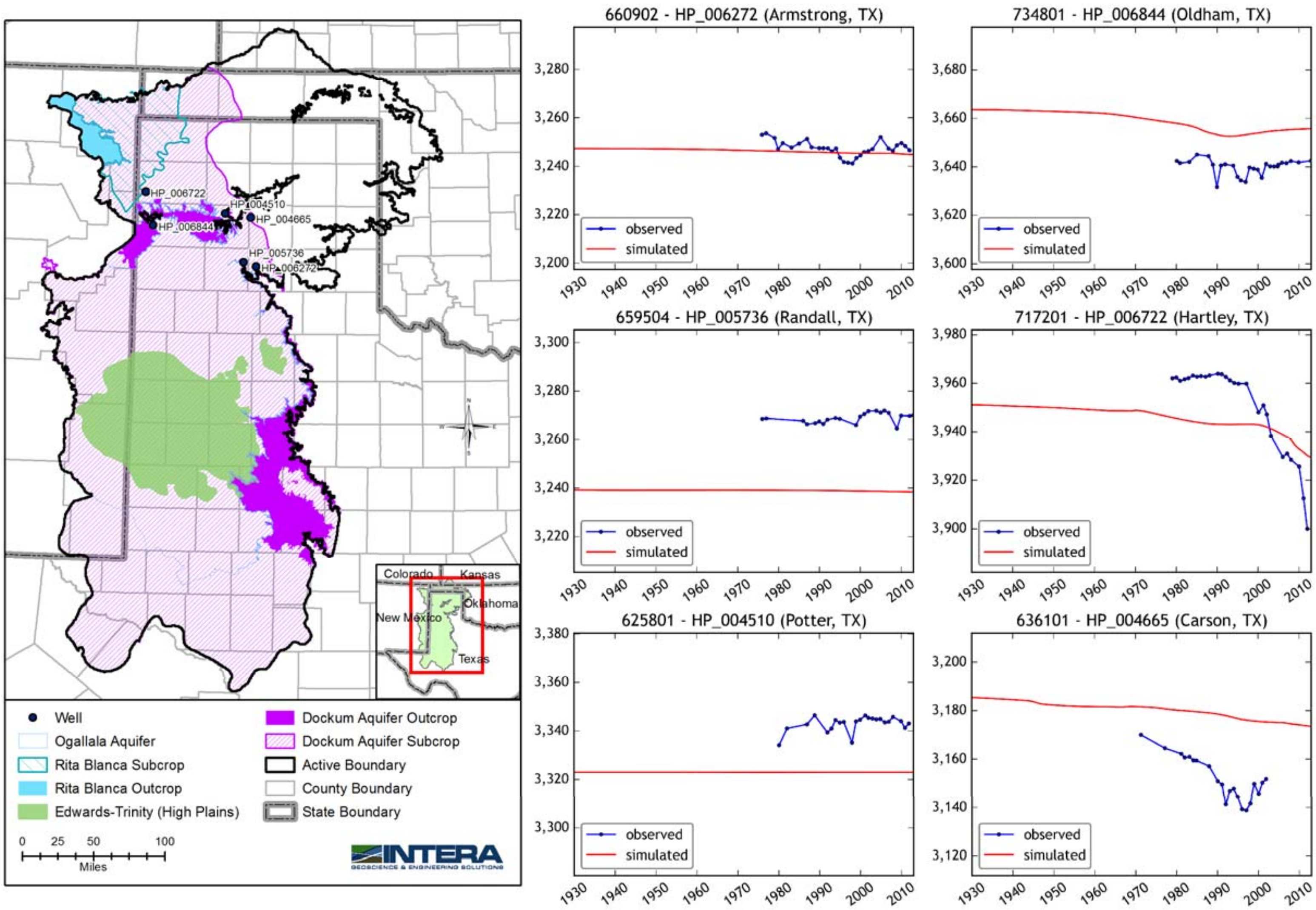


Figure 3.2.42 **Select hydrographs for wells completed in the lower Dockum Aquifer in the northern part of the study area.**

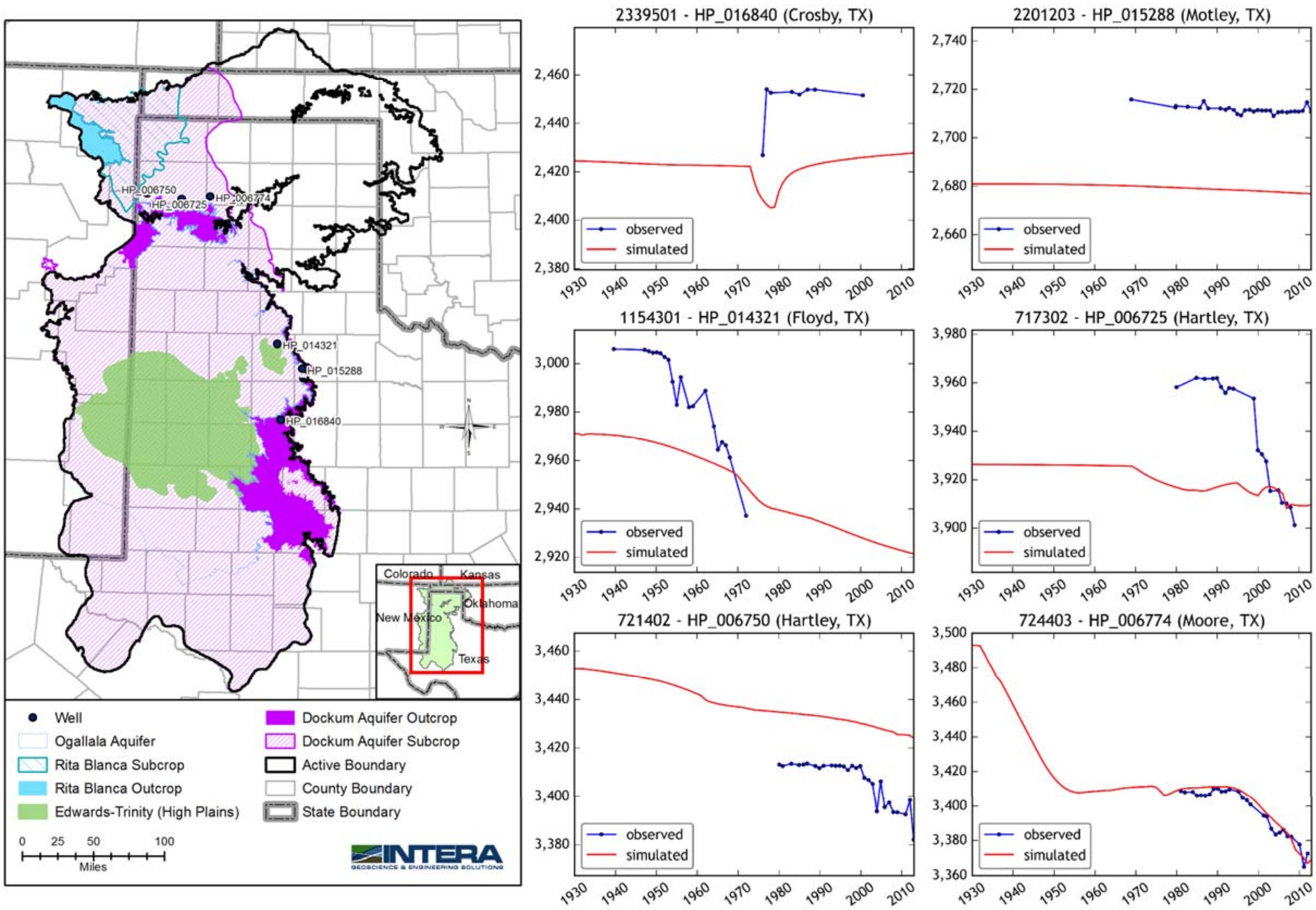


Figure 3.2.43 **Select hydrographs for wells completed in the lower Dockum Aquifer in the northern and central portions of the study area.**

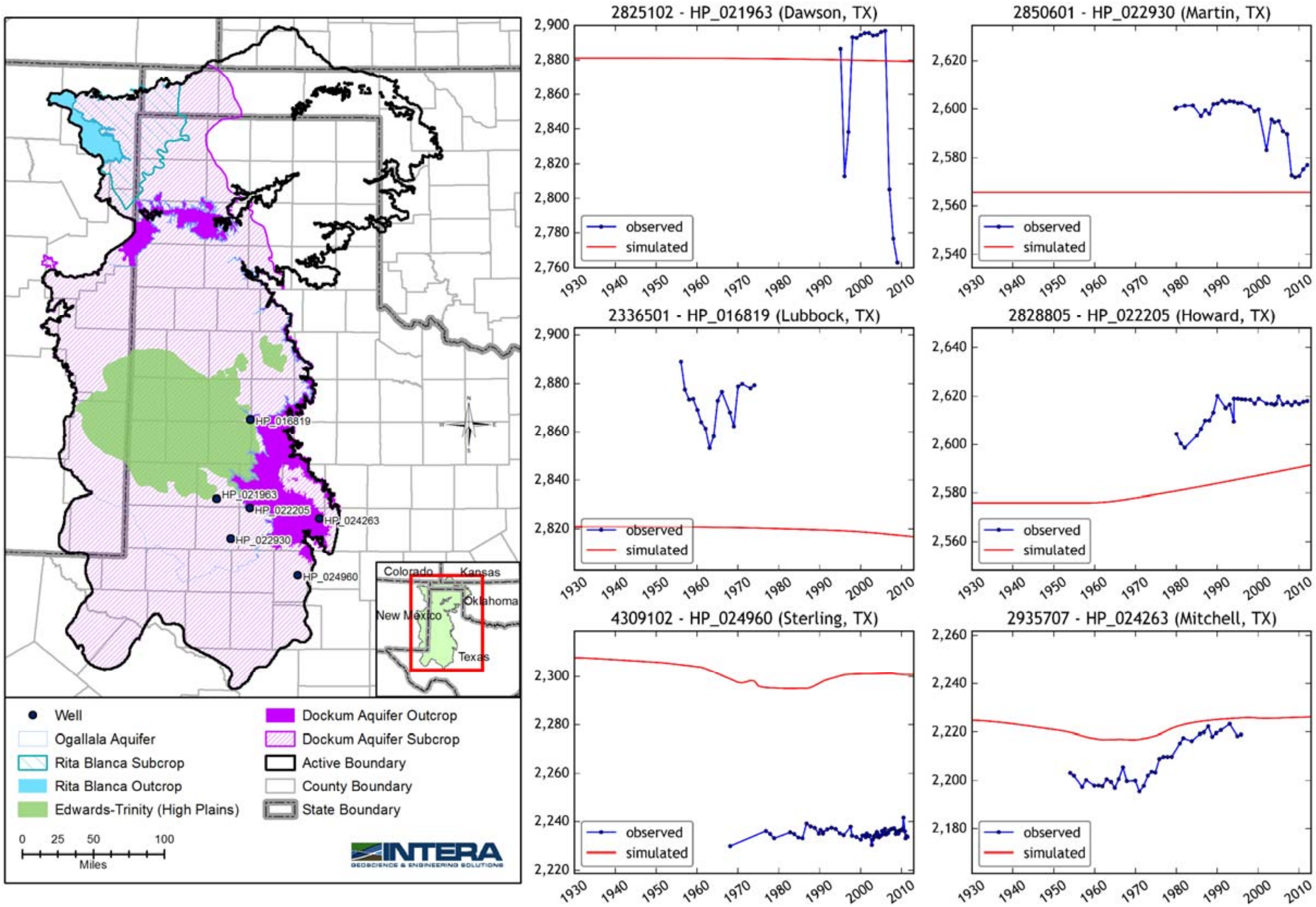


Figure 3.2.44 Select hydrographs for wells completed in the lower Dockum Aquifer in the southern portion of the study area.

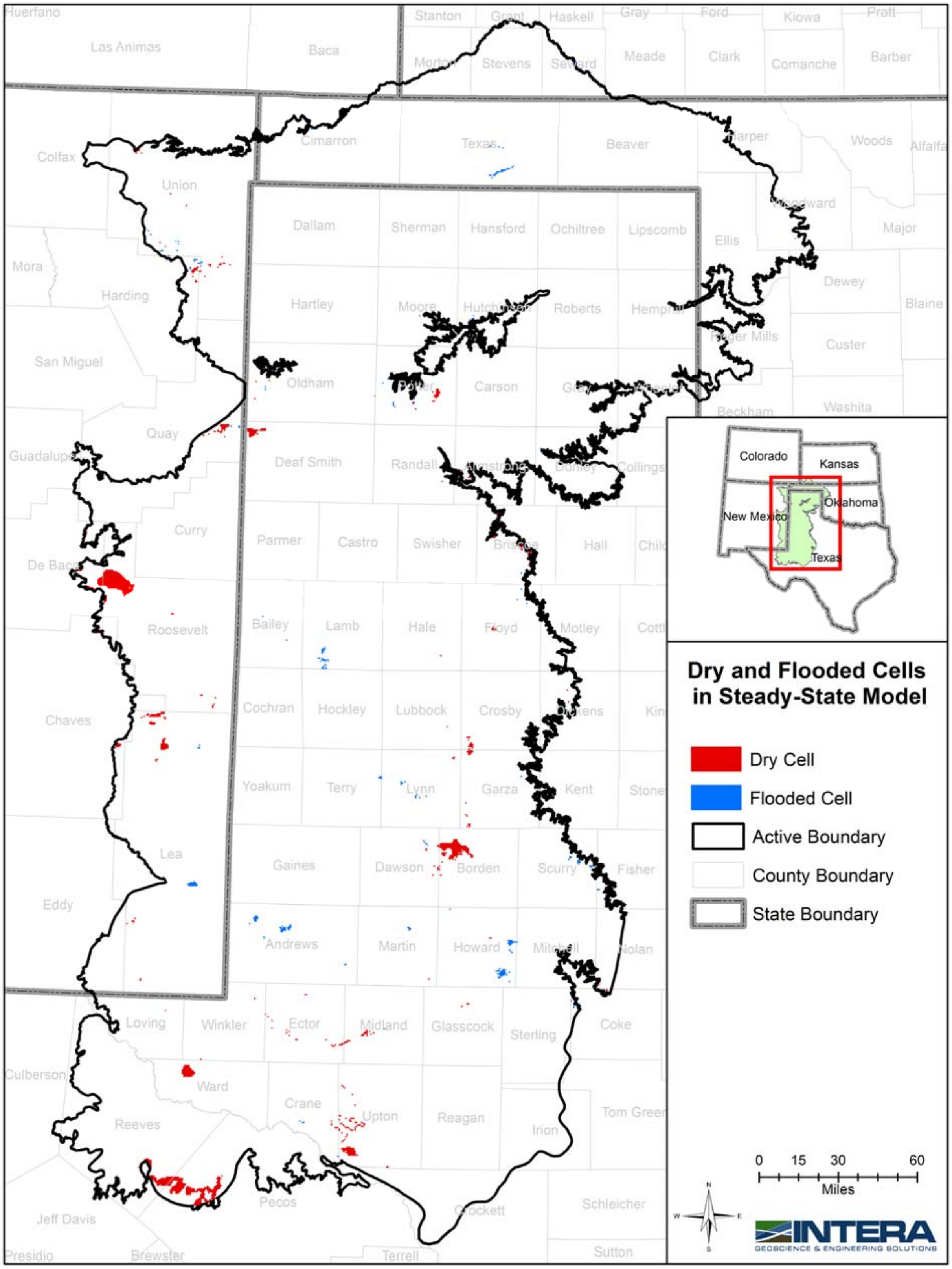


Figure 3.2.45 **Dry and flooded cells in the steady-state model.**

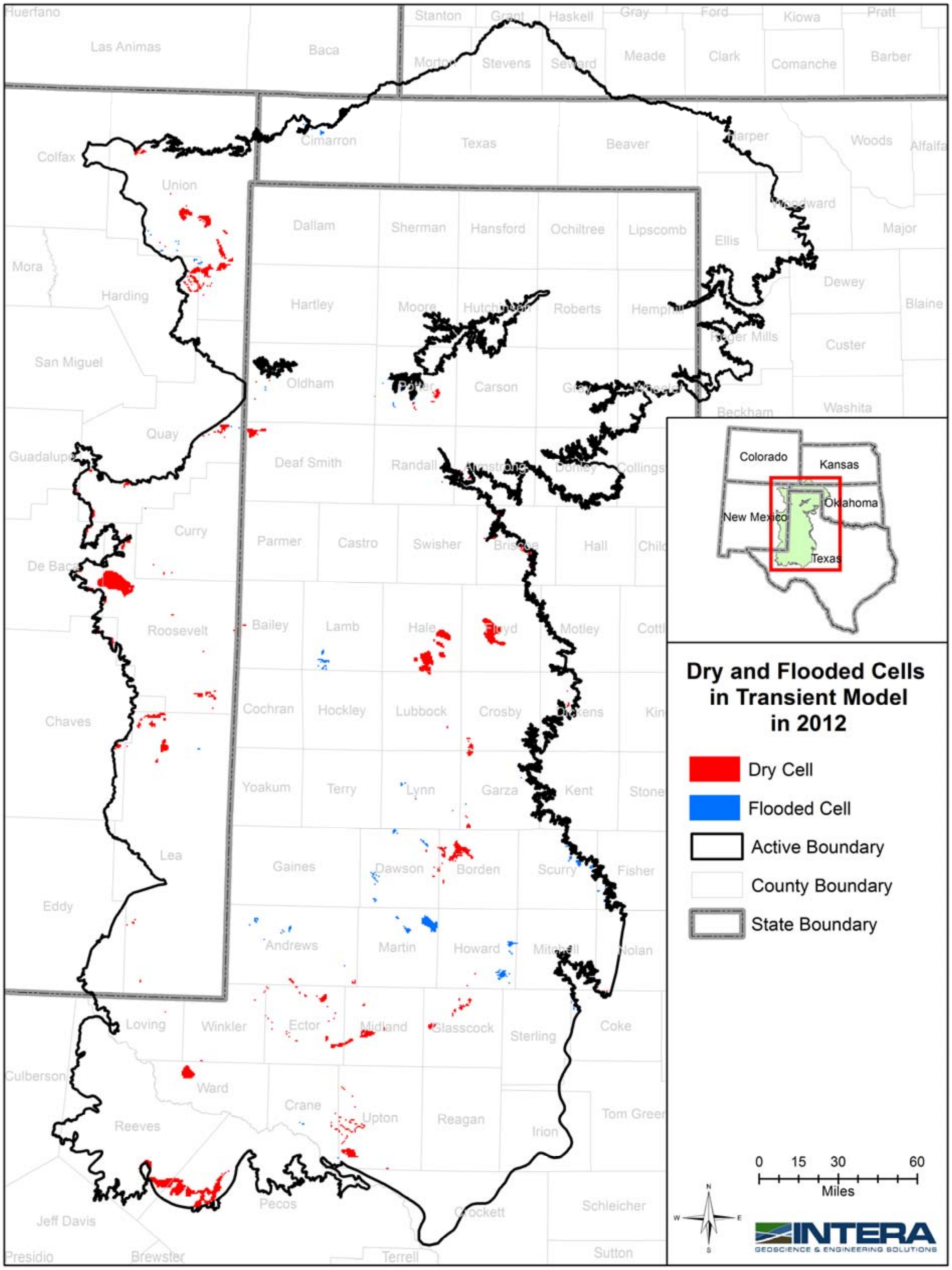


Figure 3.2.46 Dry and flooded cells in the transient model in 2012.

3.3 Model Simulated Fluxes

In this section, the model simulated fluxes are discussed, including recharge/discharge from the rivers, discharge to springs, and cross-formational flows between the aquifers. The results discussed in this section cover components of the overall water budget, which is further discussed in Section 3.4.

3.3.1 Rivers and Springs

As discussed in Section 3.1, the available river gain/loss and springflow estimates, which are synoptic (1 or 2 days of measurements over the entire historical period) were not considered to be quantitative targets for calibration. However, the simulated fluxes were monitored during calibration and compared to ranges established by the observed estimates and previous modeling studies.

Figure 3.3.1 shows the spatial distribution of simulated flux in and out of rivers in the model for the predevelopment stress period. In the northern region (Figure 3.3.1a), the tributaries are typically slightly losing, while the larger, main channels are gaining. The rate of gain tends to increase from west to east, following the distribution of recharge (and precipitation). In steady-state, the rivers are a larger source of discharge than recharge. The southern region (Figure 3.3.1b) shows a similar pattern, with tributaries typically losing in the higher, western elevations, and the larger channels gaining in the lower, eastern region. Rivers comprise the largest discharge component in steady-state.

Figure 3.3.2 shows the spatial distribution of simulated flux in and out of the rivers in the model for the last year of the simulation, 2012. In the northern region (Figure 3.3.2a), there is a clear decrease in the number of gaining reaches due to the decrease in water levels. A similar trend is seen in Figure 3.3.2b which shows the southern region. Comparison to Figure 3.2.25 shows that wherever drawdown has occurred since steady-state, discharge to rivers has decreased. Where drawdown has not occurred, such as in Martin and Howard counties, the discharge in 2012 is similar to that in steady-state. This overall decline in discharge to rivers is evident in the transient water budget, discussed in Section 3.4.2.

Figure 3.3.3 shows the simulated flux at spring locations for the steady-state stress period. In the northern portion of the study area (Figure 3.3.3a), most of the springs occur along the eastern escarpment, while in the southern portion of the study area (Figure 3.3.3b), many large springs also occur in more central areas where the water table is shallow, such as in Lubbock and Lynn counties. Figure 3.3.4 shows the simulated flux at spring locations in 2012. Spring flows have decreased slightly along the escarpment in the north (Figure 3.3.4a), but have decreased more dramatically in the southern area (Figure 3.3.4b) where historical declines in the water table are more pronounced.

3.3.2 Cross-Formational Flow

One of the opportunities created by modeling all of the aquifers in the High Plains Aquifer System in a single model is the ability to analyze cross-formational flow under predevelopment and post-development conditions. Figure 3.3.5 shows the simulated flux through the bottom of the Ogallala Aquifer in predevelopment. The figure uses the MODFLOW sign convention of "positive down", so downward flux through the bottom is expressed as a positive number. In the northeast portion of the model where Ogallala Aquifer overlies Permian, the no-flow boundary prevents any flux through the bottom of the layer. Flux rates tend to be less than 0.1 inches per year, with isolated areas that exceed that rate. The higher rates occur along the escarpment, where water moves down into the shallow Dockum Aquifer from the Ogallala Aquifer and then discharges in the outcrop. In addition, higher rates both downward and upward occur where the Edward-Trinity (High Plains) Aquifer does not contain shale (Figure 3.1.6 shows the impact of shale on the estimated vertical conductivity). The Ogallala and Edwards-Trinity (High Plains) aquifers are well-connected vertically in those non-shale areas, typically where the latter is thinning along the edges. A pattern of alternating upward and downward flow is evident between the Ogallala Aquifer and Edwards-Trinity (High Plains) Aquifer in Gaines and Dawson counties to the south and Lubbock County to the northeast. The Edwards-Trinity (High Plains) Aquifer is thinning in these areas, so connection is good with the Ogallala Aquifer. In addition, stream channels are cutting through the exposed Ogallala Aquifer, so in areas where groundwater is discharging to these streams, the head in the Ogallala Aquifer is at its lowest, and vertical flow tends to be upward from the Edwards-Trinity (High Plains) Aquifer. In the interstream areas, vertical flow tends to be downward to the Edwards-Trinity (High Plains) Aquifer as is more common in the thicker parts of the aquifer.

Figure 3.3.6 shows the simulated flux through the top of the Rita Blanca Aquifer and Edwards-Trinity (High Plains) Aquifer, which is identical to the flux through the bottom of the Ogallala Aquifer where overlap occurs. No cross-formational flux can occur in the Rita Blanca Aquifer outcrop, since it represents the top of the model in that area. Higher rates occur where the Rita Blanca Aquifer transitions from outcrop to subcrop, where vertical gradients are significant, and discharge can occur in rivers and draws crossing the outcrop. Figure 3.3.7 shows simulated flux through the top of the upper Dockum Aquifer in steady-state. Because of low vertical conductivity, most of the fluxes are less than 0.1 inches per year. No clear imprint of the Edwards-Trinity (High Plains) Aquifer is seen in the flux pattern, indicating that the Edwards-Trinity (High Plains) Aquifer interacts far more with the overlying Ogallala Aquifer than the underlying upper Dockum Aquifer. More mixed (upward/downward) flux occurs in the west, where topography is highest, and more consistently downward flux occurs in the east, where the lower Dockum Aquifer outcrop provides a topographically lower elevation discharge boundary.

Figure 3.3.8 shows the simulated flux through the top of the lower Dockum Aquifer in steady-state. Rates are higher in the lower Dockum Aquifer than in the upper Dockum Aquifer, since the lower Dockum Aquifer is more transmissive, both horizontally and vertically. Higher rates of downward flux are evident along the eastern boundary, near the escarpment, where water moves down from the Ogallala Aquifer and discharges in springs and seeps in the outcrop and along the escarpment. Downward flux from the Ogallala Aquifer to the lower Dockum Aquifer also occurs on the edges of where outcrop transitions to subcrop, especially in the northern outcrop near the Canadian River. Low rates of both downward and upward flux occur where the lower Dockum Aquifer is overlain by Pecos Valley Aquifer or the Edwards-Trinity (Plateau) Aquifer.

Figure 3.3.9 shows the simulated flux through the bottom of the Ogallala Aquifer for year 2012. Again, the convention is positive downward, so flux from the Ogallala Aquifer to an underlying unit is positive and the reverse is negative. The most visible change between steady-state and year 2012 is the dominance of flux upward into the Ogallala Aquifer in 2012 in areas where significant drawdown has occurred. In many cases the upward flux is small, less than 0.1 inches per year, especially where the Ogallala Aquifer overlies the upper Dockum Aquifer. The alternating pattern of upward and downward flux between the Ogallala Aquifer and the Edwards-

Trinity (High Plains) Aquifer is still evident in 2012, indicating that the head gradients between the two aquifers in Gaines, Dawson, and Lubbock counties, still have the same general spatial variation.

Figure 3.3.10 shows the simulated flux through the top of Rita Blanca and Edwards-Trinity (High Plains) aquifers for year 2012. On the southern edge of the Edwards-Trinity (High Plains) Aquifer, where some drawdown has occurred, downward flux from the Ogallala Aquifer has increased. This effect has occurred in the Rita Blanca Aquifer, as well, where some of the localized drawdown has induced downward flow from the Ogallala Aquifer.

Figure 3.3.11 shows the simulated flux through the top of the upper Dockum Aquifer for year 2012. As noted in Section 3.2, because little pumping exists in the upper Dockum Aquifer, most of the drawdown in the upper Dockum Aquifer from steady-state has occurred due to influence from the overlying Ogallala Aquifer or underlying lower Dockum Aquifer. The influence of drawdown in the Ogallala Aquifer can be seen in the dominance of upward flux in the center of the area. The flux rates are small, typically less than 0.1 inches per year. Figure 3.3.12 shows the simulated flux through the top of the lower Dockum Aquifer for year 2012. The flux from the Ogallala Aquifer to the lower Dockum Aquifer along the eastern boundary is still present, but has decreased in rate. Where the Rita Blanca Aquifer overlies the lower Dockum Aquifer, upward flow from the lower Dockum Aquifer to the Rita Blanca Aquifer has increased due to drawdown in the Rita Blanca Aquifer. Finally, in the southeast where the Edwards-Trinity (Plateau) Aquifer overlies the lower Dockum Aquifer, there is evidence of increased upward flow from the lower Dockum Aquifer due to drawdown in the Edwards-Trinity (Plateau) Aquifer.

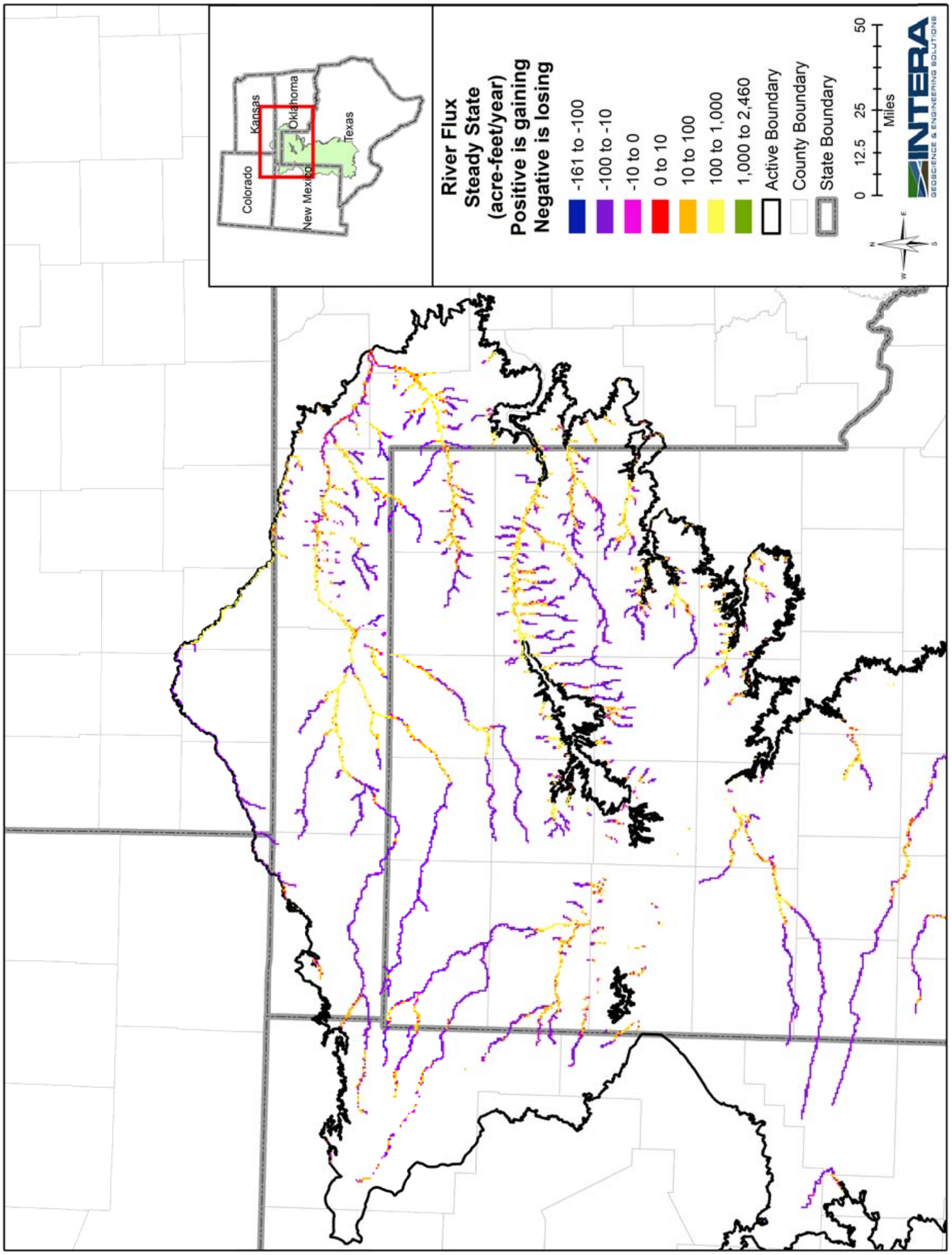


Figure 3.3.1a Spatial distribution of flux in and out of rivers in acre-feet per year in the pre-development (steady-state) stress period in the northern portion of the study area.

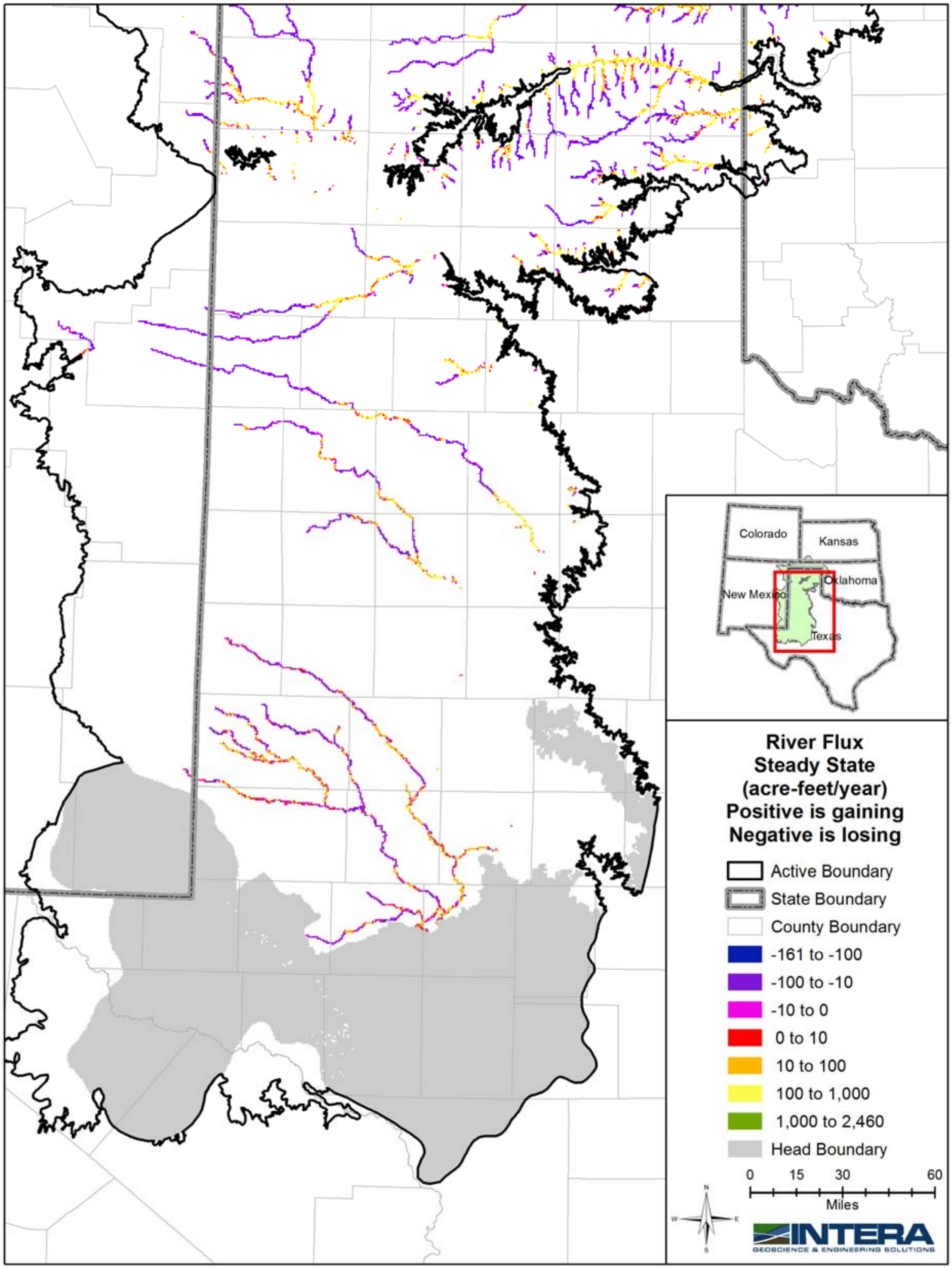


Figure 3.3.1b Spatial distribution of flux in and out of rivers in acre-feet per year in the pre-development (steady-state) stress period in the southern portion of the study area.

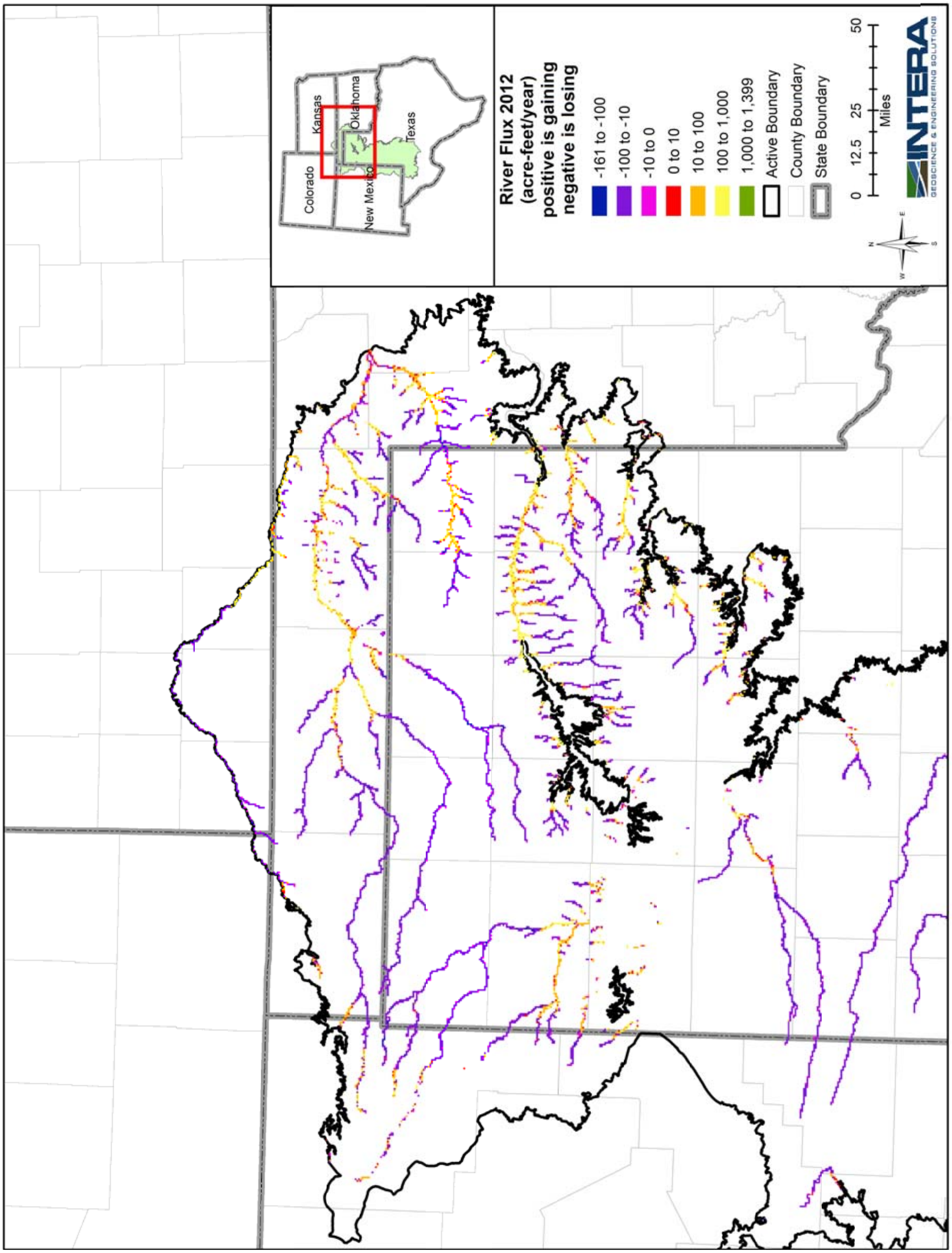


Figure 3.3.2a Spatial distribution of flux in and out of rivers in acre-feet per year in 2012 (stress period 84) in the northern portion of the study area.

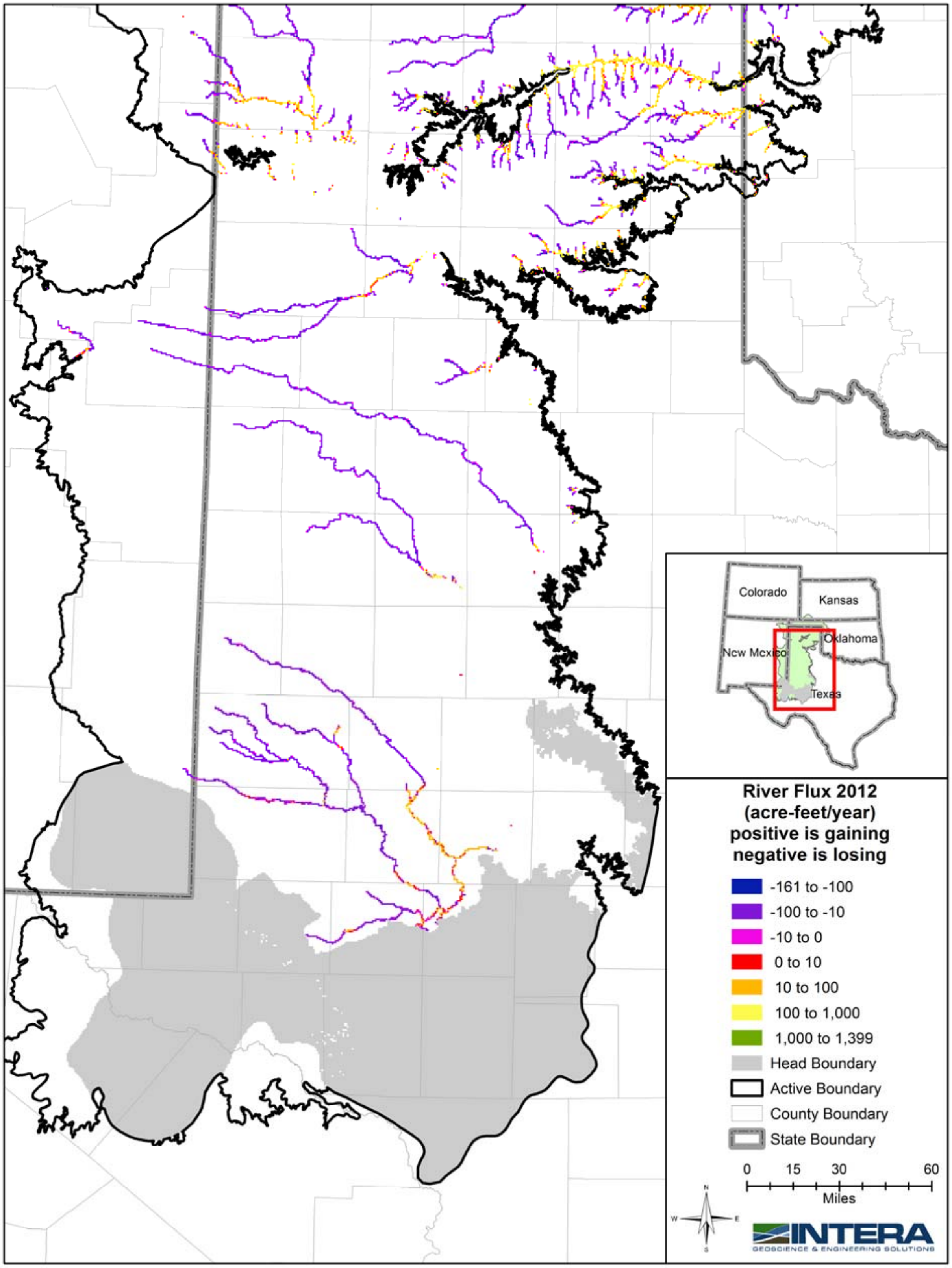


Figure 3.3.2b Spatial distribution of flux in and out of rivers in acre-feet per year in 2012 (stress period 84) in the southern portion of the study area.

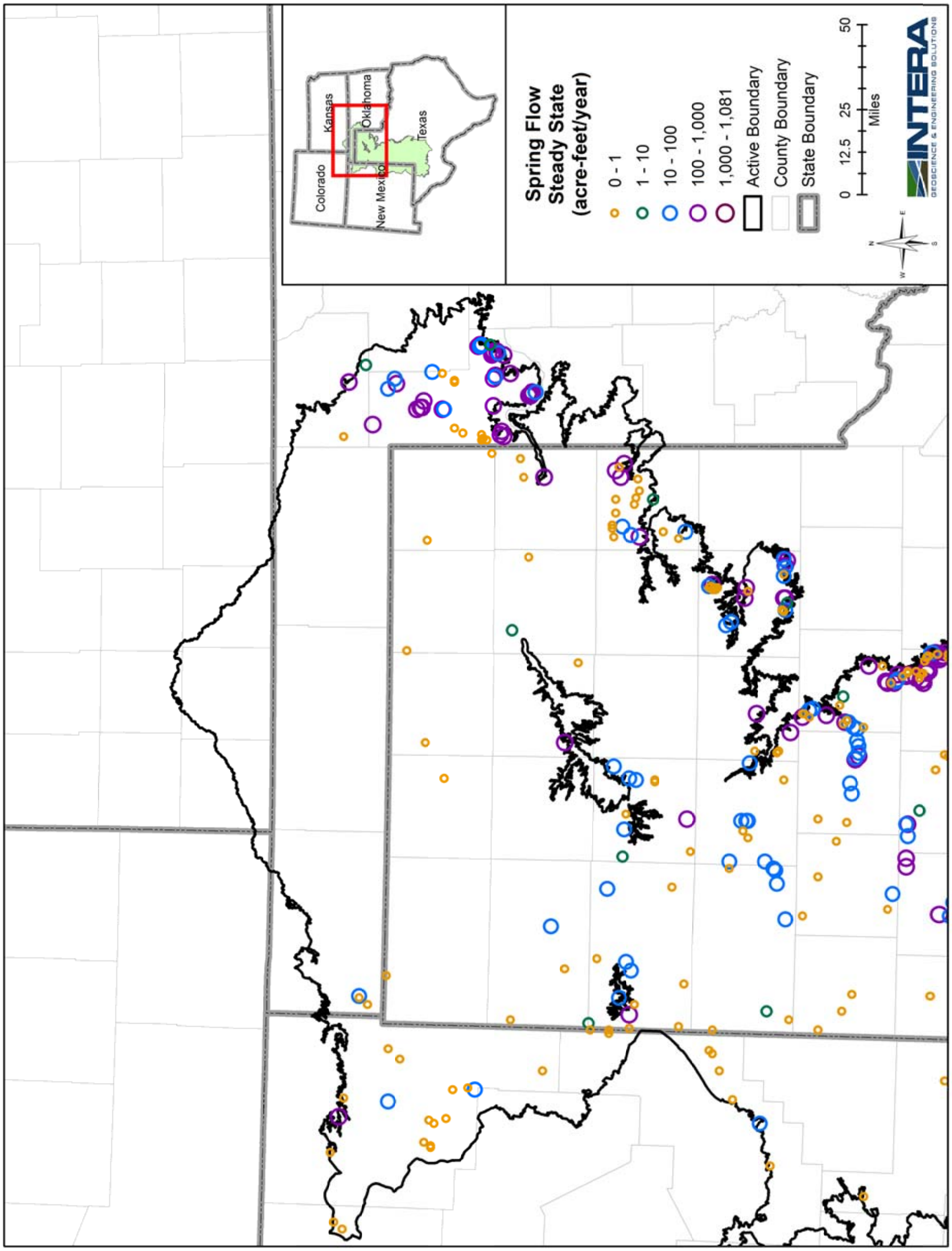


Figure 3.3.3a Spatial distribution of flux out of springs in acre-feet per year in the pre-development (steady-state) stress period in the northern portion of the study area.

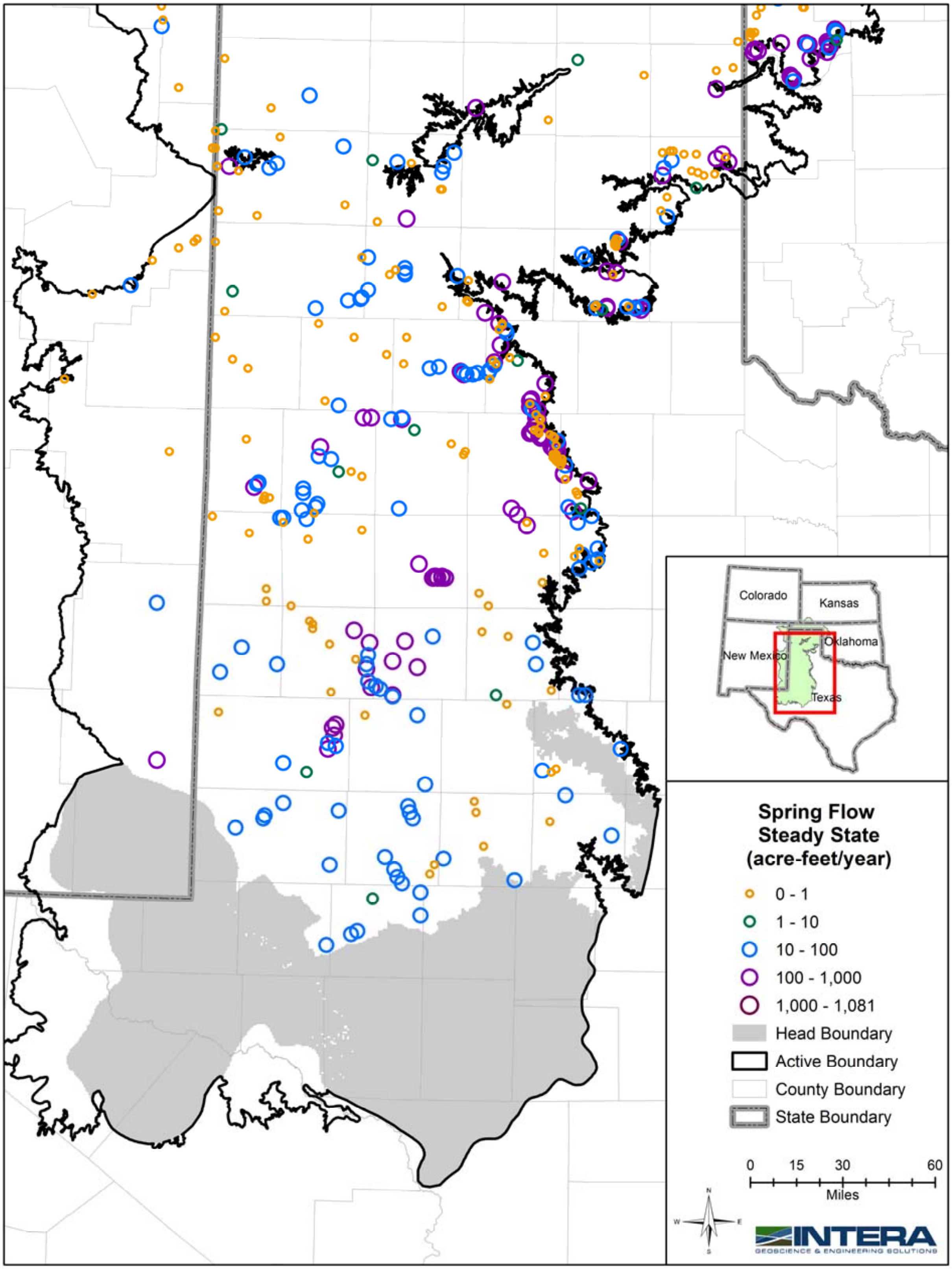


Figure 3.3.3b Spatial distribution of flux out of springs in acre-feet per year in the pre-development (steady-state) stress period in the southern portion of the study area.

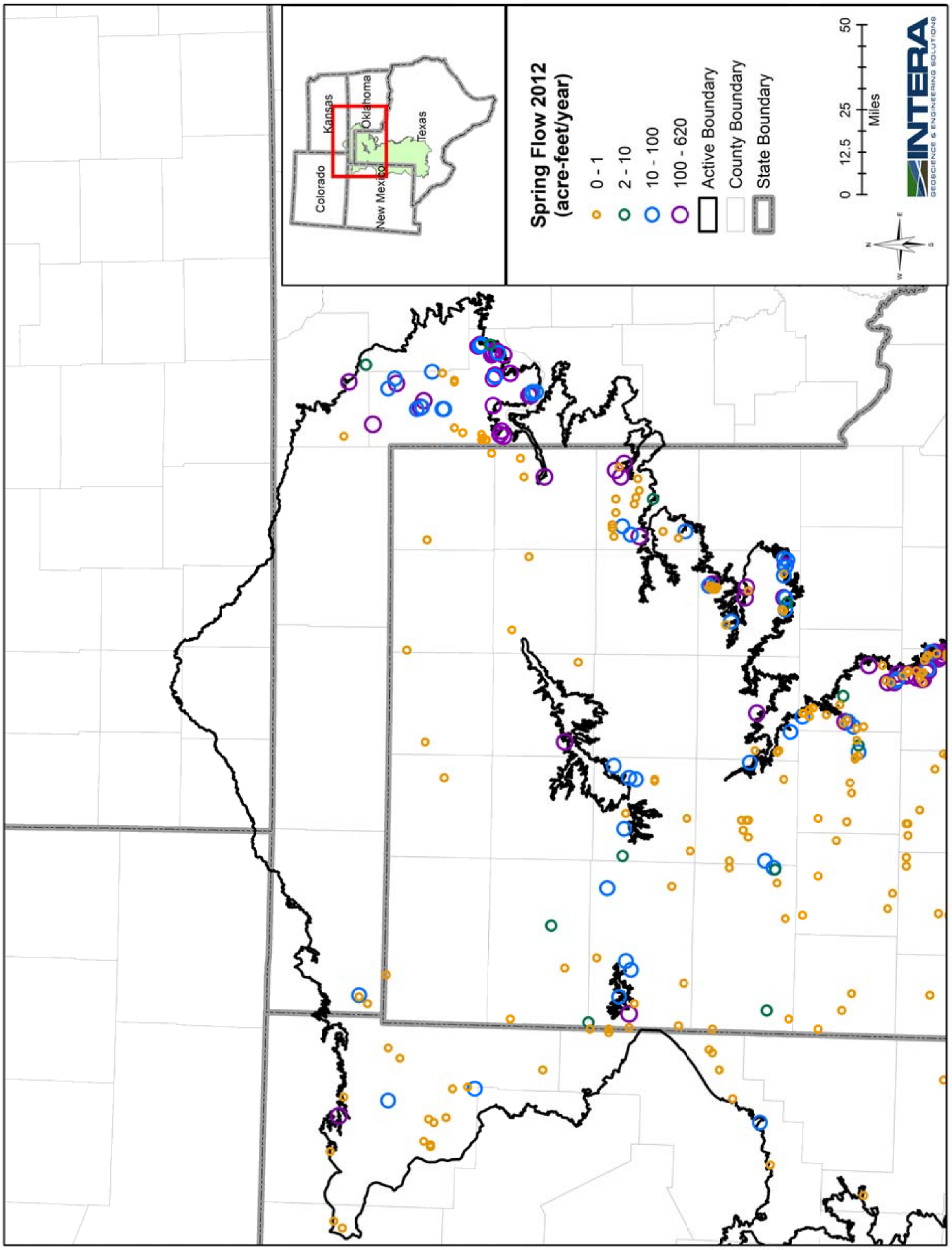


Figure 3.3.4a Spatial distribution of flux out of springs in acre-feet per year in 2012 (stress period 84) in the northern portion of the study area.

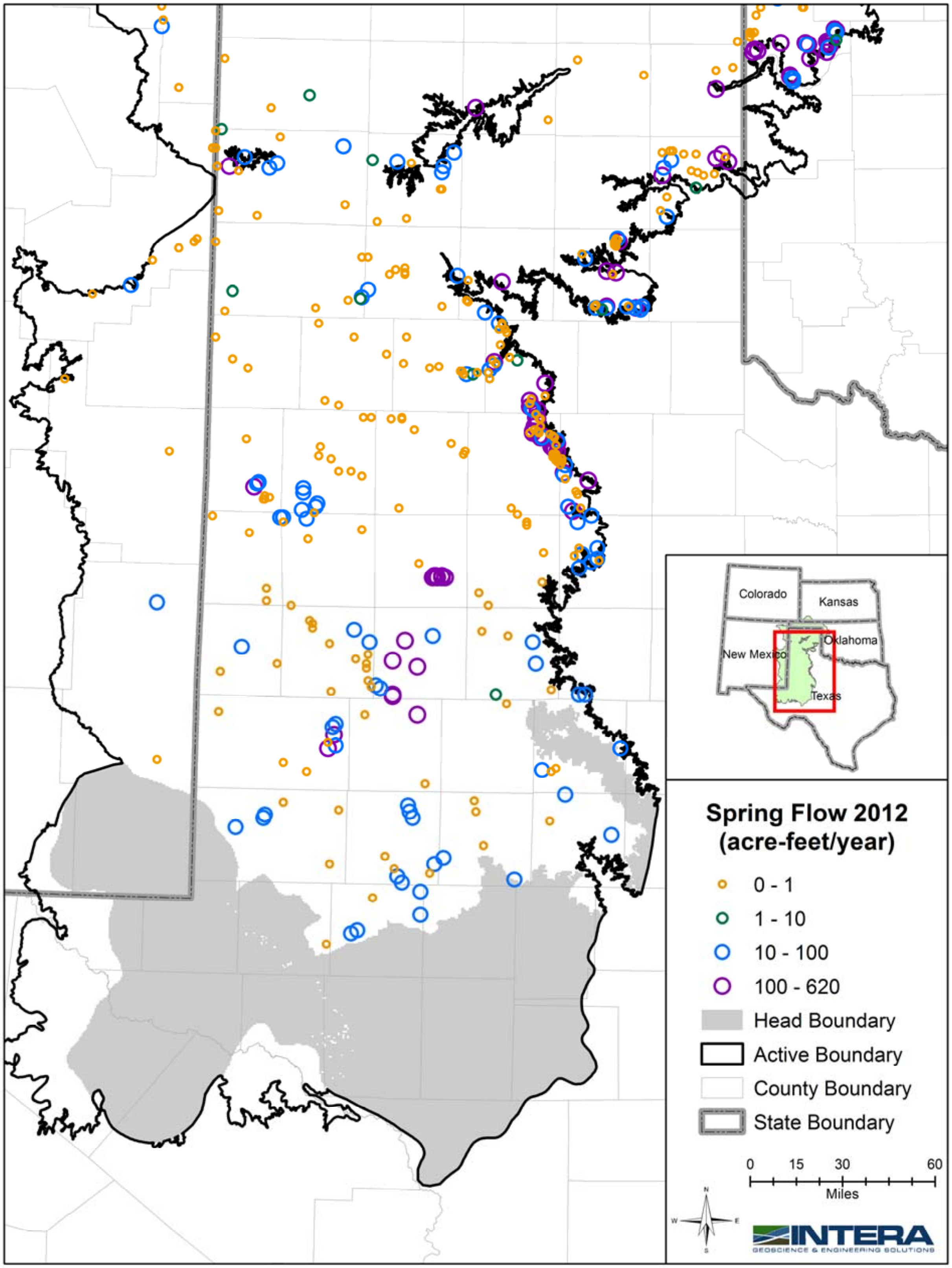


Figure 3.3.4b Spatial distribution of flux out of springs in acre-feet per year in 2012 (stress period 84) in the southern portion of the study area.

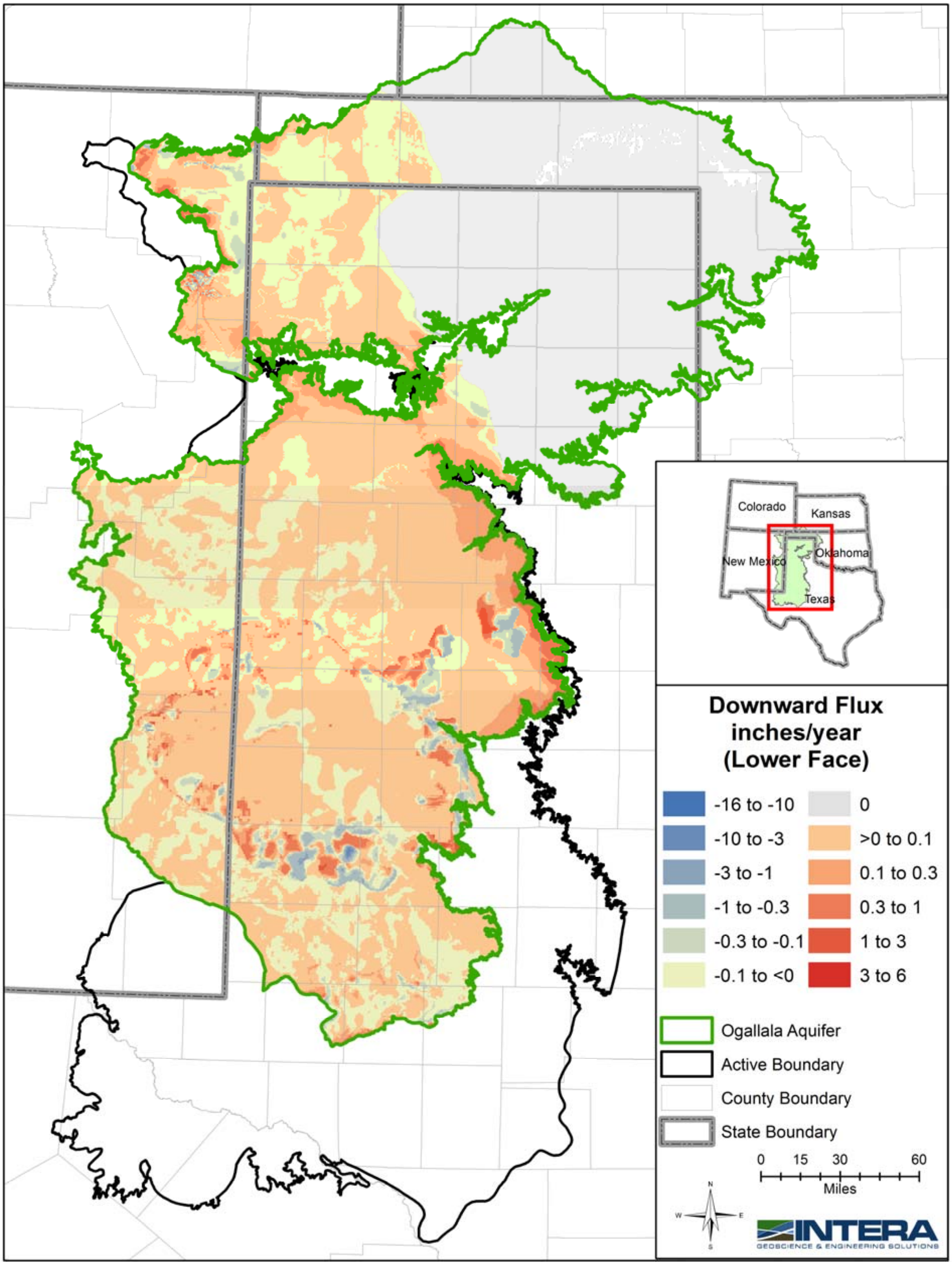


Figure 3.3.5 **Spatial distribution of flux across the bottom of the Ogallala Aquifer in the pre-development (steady-state) stress period.**

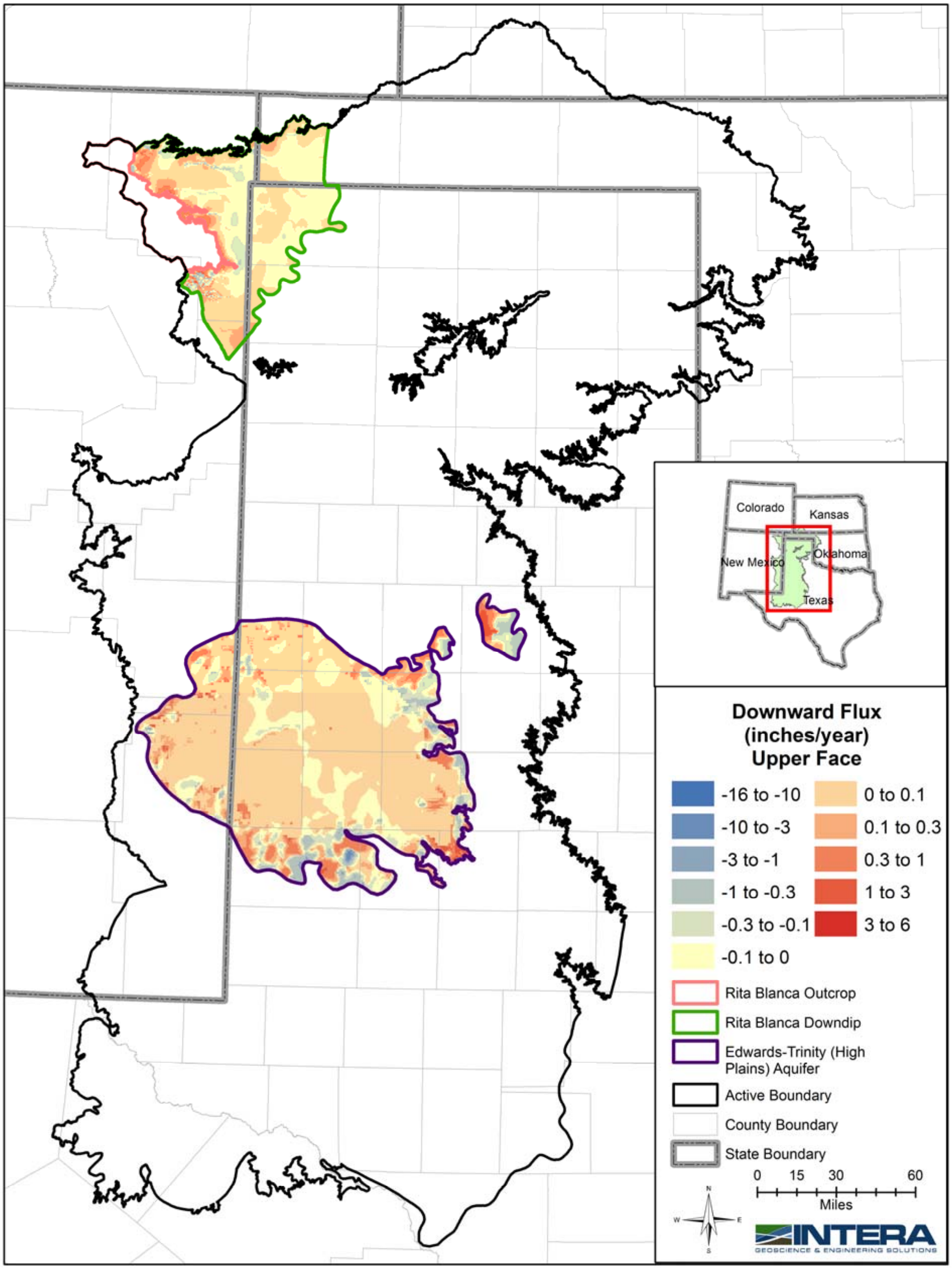


Figure 3.3.6 **Spatial distribution of flux across the top of the Rita Blanca and Edwards-Trinity (High Plains) aquifers in the pre-development (steady-state) stress period.**

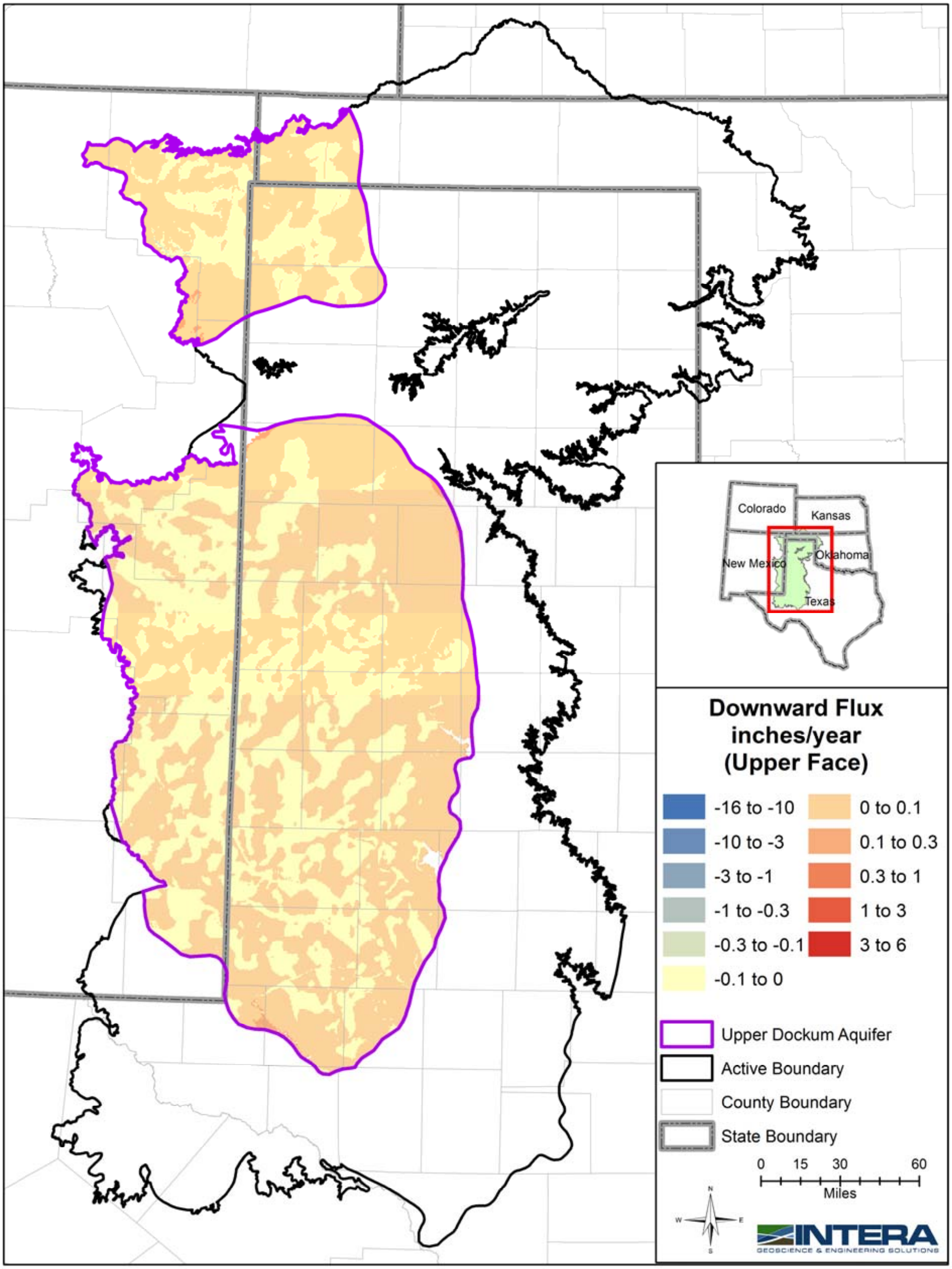


Figure 3.3.7 Spatial distribution of flux across the top of the upper Dockum Aquifer in the pre-development (steady-state) stress period.

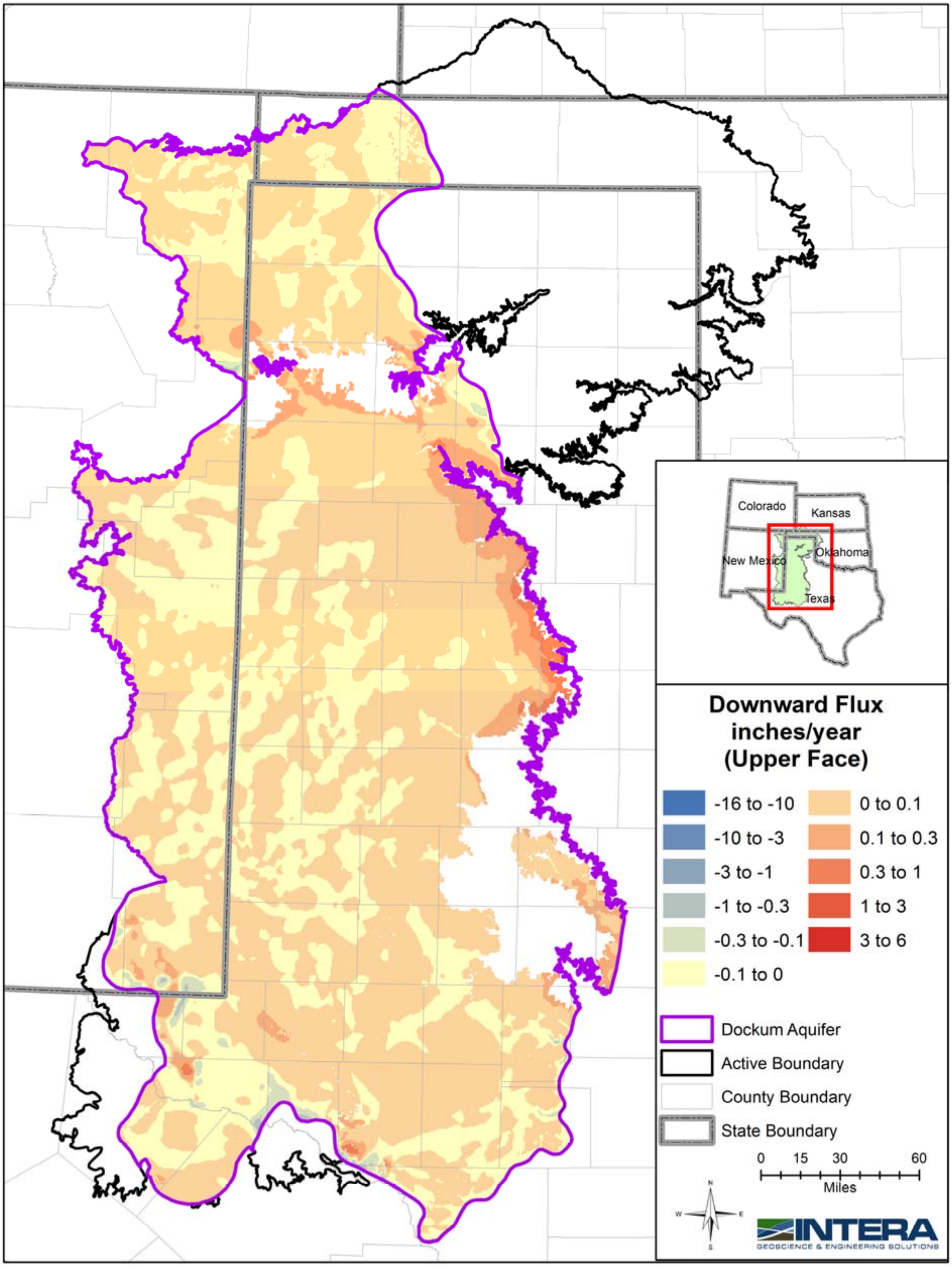


Figure 3.3.8 **Spatial distribution of flux across the top of the lower Dockum Aquifer in the pre-development (steady-state) stress period.**

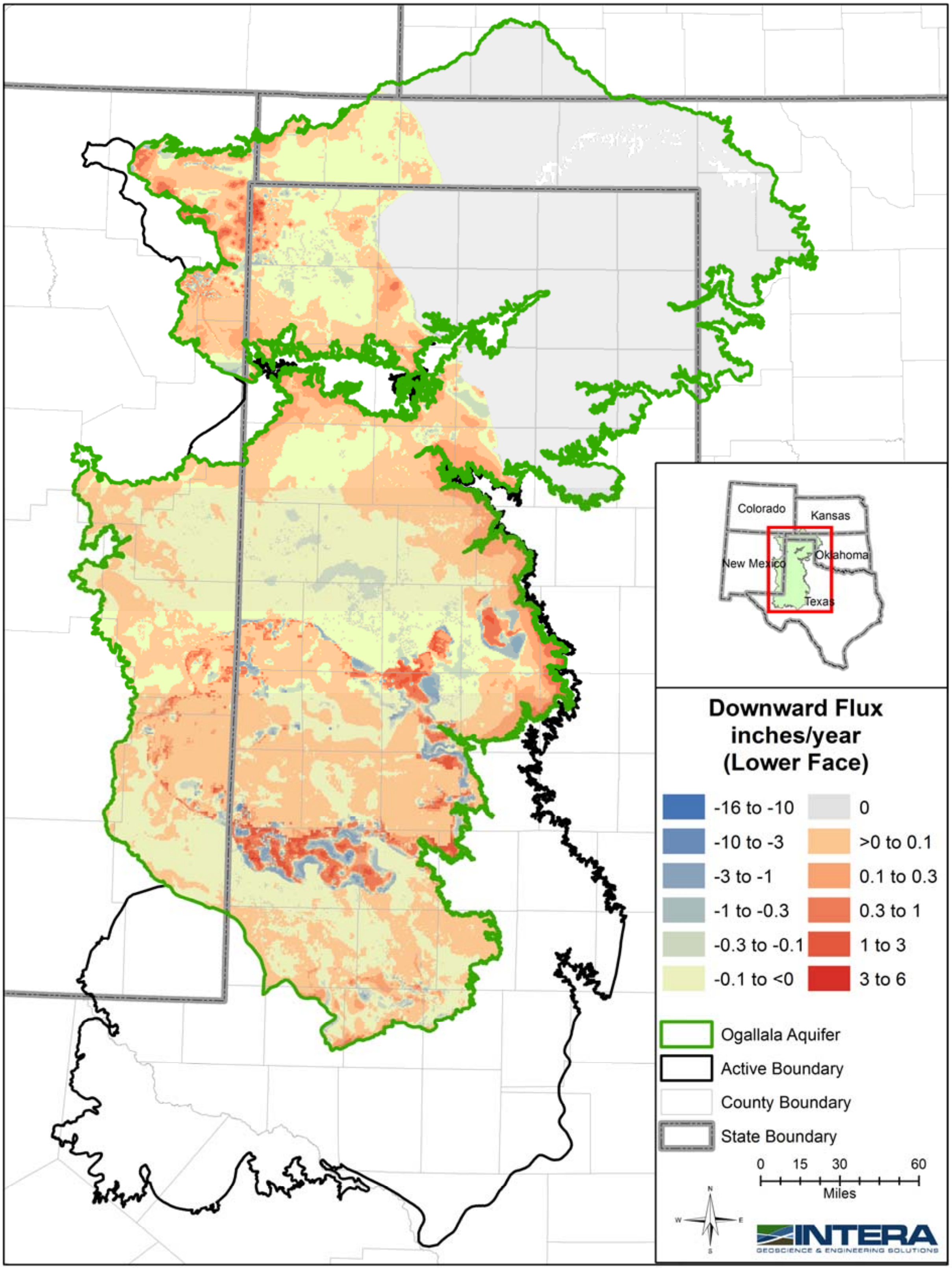


Figure 3.3.9 **Spatial distribution of flux across the bottom of the Ogallala Aquifer in 2012 (stress period 84).**

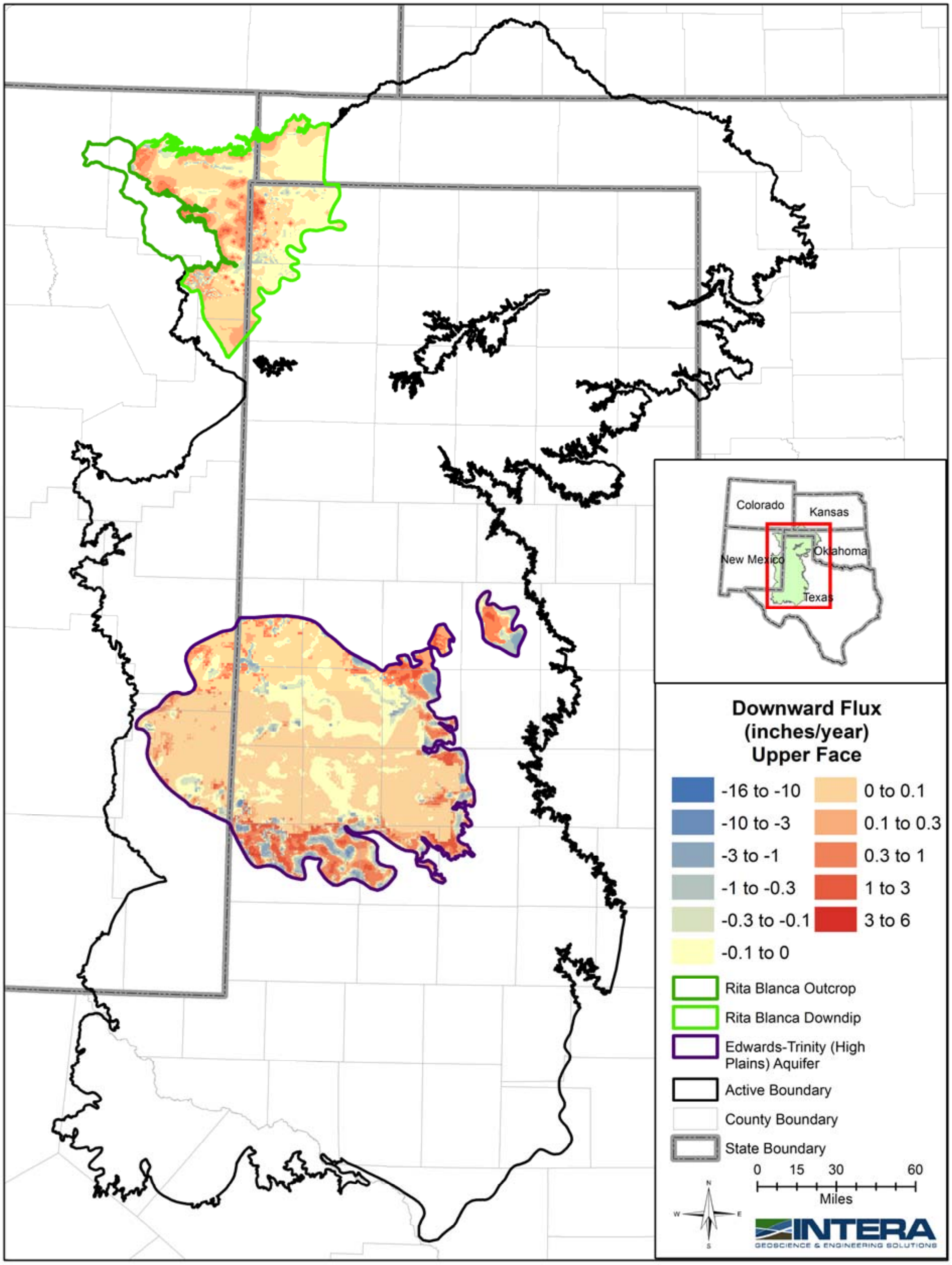


Figure 3.3.10 Spatial distribution of flux across the top of the Rita Blanca and Edwards-Trinity (High Plains) aquifers in 2012 (stress period 84).

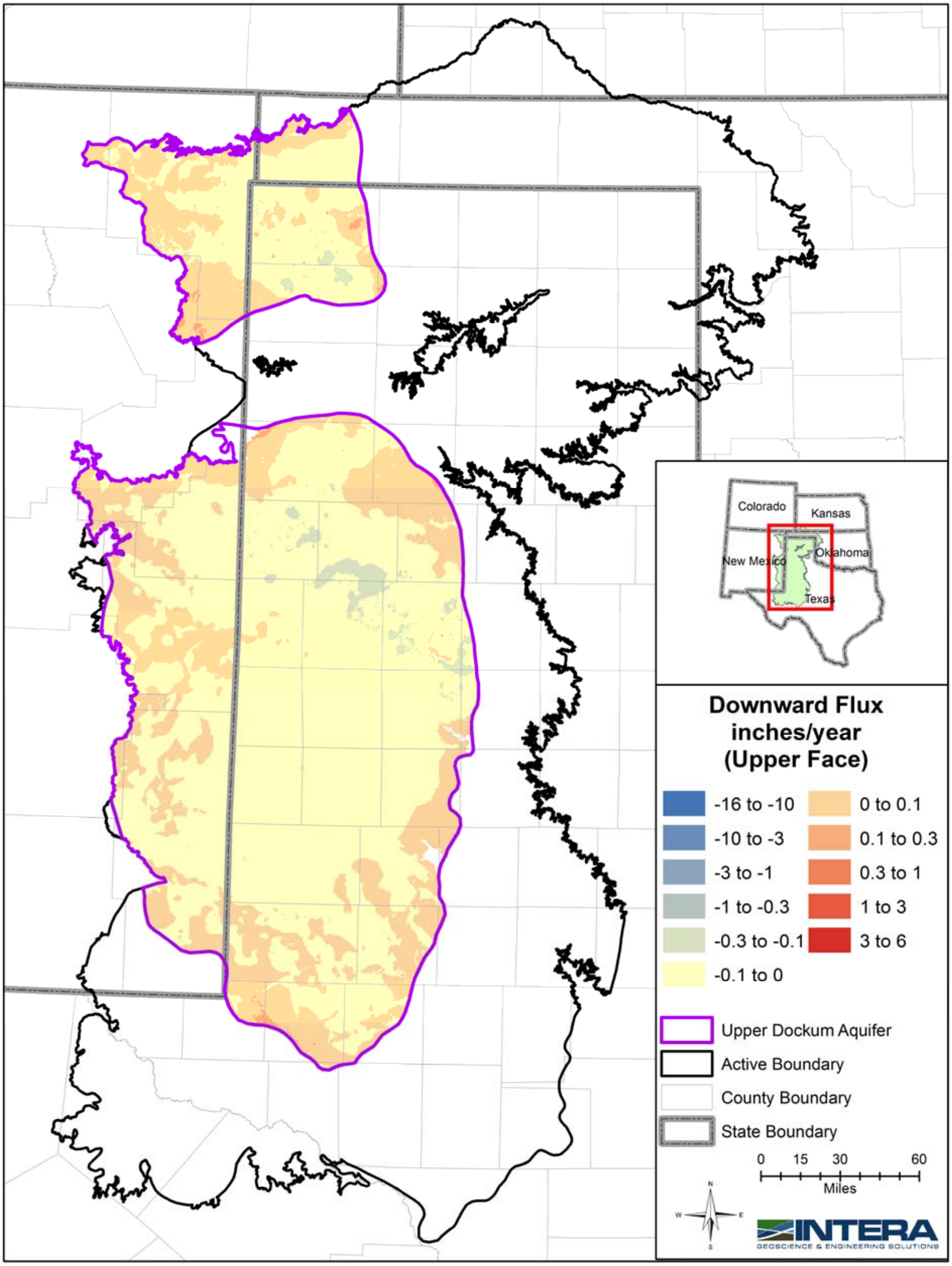


Figure 3.3.11 Spatial distribution of flux across the top of the upper Dockum Aquifer in 2012 (stress period 84).

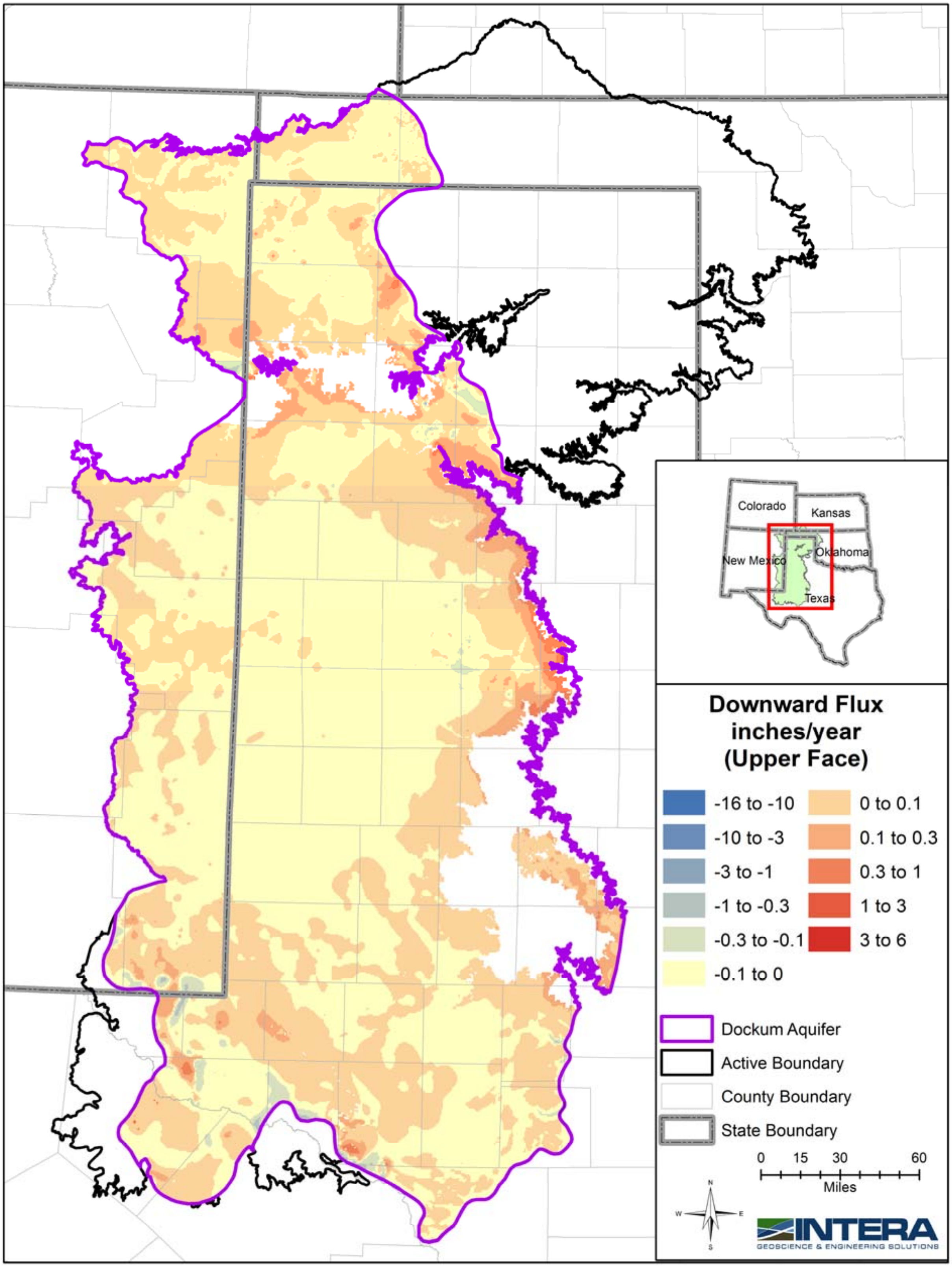


Figure 3.3.12 Spatial distribution of flux across the top of the lower Dockum Aquifer in 2012 (stress period 84).

3.4 Model Simulated Water Budgets

In this section, the simulated water budgets are discussed both for the steady-state and transient stress periods. The water budgets are one of the more important aspects of the High Plains Aquifer System groundwater availability model, since the model provides an opportunity to analyze flow between the aquifers that was not possible before. Previous models had simulated only one aquifer at a time (or in the case of the Southern Ogallala Aquifer groundwater availability model (Blandford and others, 2008), the southern Ogallala Aquifer and Edwards-Trinity (High Plains) Aquifer. In this section the water budget is discussed with respect to the overall aquifers. Appendix A contains the water budget summarized by county and groundwater conservation district, for all counties and groundwater conservation districts in the study area.

3.4.1 Steady-State Water Budget

One aspect of the water budget involves checking that unacceptable errors do not occur in the net balance. The calibrated model had an overall budget error of 0.00 percent for any stress period. As discussed in Section 2, one of the advantages of MODFLOW-NWT over previous MODFLOW versions, is the ability to constrain convergence based on cell flux, as well as head. This constraint helps to ensure that local mass balance errors do no occur undetected while the global balance appears acceptable.

Table 3.4.1 summarizes the water budget for the steady-state model in acre-feet per year. The water budget contains components of flow to and from other aquifers. Because the Ogallala Aquifer is the most productive in the system, flow to and from the Ogallala Aquifer is tracked separately, while interaction with other aquifers is combined into a single term, to help simplify the analysis. The cross-formational flow terms are shown to help understand the interactions among the aquifers. Note that the cross-formational flow into the Ogallala Aquifer from other aquifers (44,330 acre-feet per year) is the same number as the sum of cross-formational flow out from other aquifers to the Ogallala Aquifer (bottom row of the table, -44,330 acre-feet per year). Similarly, the sum of the cross-formational flow into other aquifers from the Ogallala Aquifer (last row of the IN table, 86,240 acre-feet per year) is identical in magnitude to the cross-formational flow (other) in the first row of the OUT table (-86,240 acre-feet per year). These are the types of comparisons that help to ensure that the budget components are being correctly accounted. The cross-formational flow (other aquifers) sum, for both input and output, does not include the Ogallala Aquifer, so that the sum in the IN table can be compared exactly to the sum in the OUT table. Table 3.4.2 contains the model-wide water budget components for each aquifer as a percentage of total inflow and outflow. We will refer to some of the percentages in this table when discussing the per-aquifer water budgets next.

Figures 3.4.1 through 3.4.5 show bar charts of the steady-state water budgets for each aquifer. The discussion begins with the Ogallala Aquifer (Figure 3.4.1), which receives over 96 percent of the 903,000 acre-feet per year of areal recharge in the system. Recharge comprises 68 percent of the total inflow to the model in steady-state. The second large contributor to inflow to the Ogallala Aquifer is rivers, with more than 246,000 acre-feet per year inflow. A relatively small component of inflow to the Ogallala Aquifer comes from other aquifers, at about 44,000 acre-feet per year. A little less than half of the inflow discharges to the rivers, while the remaining discharge is about half groundwater evapotranspiration and half drain flow, which includes flow to draws, springs, and seeps along the escarpments. As with inflow, a relatively small component of the discharge goes to other aquifers, at about 86,000 acre-feet per year.

Figure 3.4.2 shows the steady-state water balance for the Rita Blanca Aquifer. All inflows to the Rita Blanca Aquifer total about 13,400 acre-feet per year. For the Rita Blanca Aquifer, the largest recharge mechanism is cross-formational flow from the Ogallala Aquifer, followed by areal recharge on the outcrop. The largest discharge components are cross-formational flow to the Ogallala Aquifer and discharge to rivers in the outcrop. Because the outcrop discharge components are roughly equal to the outcrop recharge components, little water is moving from the outcrop to the downdip section of the aquifer. The confined section is dominantly interacting through vertical flow with the Ogallala and Dockum aquifers.

Figure 3.4.3 shows the steady-state water balance for the Edwards-Trinity (High Plains) Aquifer. Because the Edwards-Trinity (High Plains) Aquifer is confined, all of the water budget consists of cross-formational flow (34,300 acre-feet per year), of which 99 percent is with the Ogallala Aquifer.

Figure 3.4.4 shows the steady-state water balance for the upper Dockum Aquifer. The upper Dockum Aquifer is also mostly confined, with a small outcrop that contributes minimally in terms of recharge and discharge. About 13,600 acre-feet per year passes into the upper Dockum Aquifer. This value compares favorably to the existing Dockum Aquifer groundwater availability model (Ewing and others, 2008) which estimated 17,000 acre-feet per year of inflow. The largest inflow component is from the Ogallala Aquifer, while the most discharge occurs to other aquifers, predominantly downward to the lower Dockum Aquifer.

Figure 3.4.5 shows the steady-state water balance for the lower Dockum Aquifer. Inflows to the lower Dockum Aquifer account for 4.6 percent of the total inflows to the model. Total input to the lower Dockum Aquifer is about 116,000 acre-feet per year. This compares favorably (the values happen to be identical when rounded to the nearest 1,000) to the existing Dockum Aquifer groundwater availability model (Ewing and others, 2008) which also estimated 116,000 acre-feet per year input to the lower Dockum Aquifer. The existing Dockum Aquifer groundwater availability model has less input from recharge and rivers, and more input from cross-formational flow, but the total input came out the same as for the High Plains Aquifer System groundwater availability model. The primary discharge component is the rivers in the outcrop. Recall that the Dockum Aquifer outcrops are in regional lows, so the outcrops are areas of regional discharge, as well as areas where recharge occurs and discharges locally.

3.4.2 Transient Water Budget

Tables 3.4.3 and 3.4.4 show a summary of the transient water budget for years 1980 and 2012, respectively. As noted at the beginning of the section, Appendix A contains the water budget summarized by county and groundwater conservation district, for all counties and groundwater conservation districts in the study area for several years of the historical period. In this subsection, time series plots will be used as the basis for the discussion of the transient water balance for each of the aquifers in the system.

Figure 3.4.6a shows the water budget for the Ogallala Aquifer in the transient model. Pumping dominates outflow from the aquifer, and water from storage dominates inflow, which means that water is coming out of storage to balance the groundwater production, and water levels are declining in some portion of the area. Figure 3.4.6b shows the same plot with a zoomed y-axis, to allow focus outside of storage and pumping. One notable trend is the steady increase in recharge through time, which results from the “breakthrough” of agriculturally-enhanced recharge at various decades in the southern portion of the study area. Recharge increases from about 870,000 acre-feet per year to nearly 1.5 million acre-feet per year by the end of the transient period. Discharge to rivers decreases from over 500,000 acre-feet per year to less than

300,000 acre-feet per year. Flow to drains and evapotranspiration also is reduced somewhat over time as water levels decline. A slight increase can be seen in both flow to and from other zones, as both the Ogallala Aquifer and underlying aquifers experience the increased vertical gradients that result from drawdown.

Figure 3.4.7 shows the water budget for the Rita Blanca Aquifer in the transient model. As with the Ogallala Aquifer budget, the impact on storage can be seen to mirror the increase in production. However, a second part of the response, besides increasing water coming from storage, is the increase in water coming in from the Ogallala Aquifer, as vertical gradients increase due to drawdown in the Rita Blanca Aquifer.

Figure 3.4.8 shows the water budget for the Edwards-Trinity (High Plains) Aquifer in the transient model. The effect of production on storage is muted, although the long term increasing trend is the same. The oscillation of production is mirrored more closely by a change in the inflow from the Ogallala Aquifer. However, the bulk of the inflow from the Ogallala Aquifer returns as outflow to the Ogallala Aquifer.

Figure 3.4.9 shows the water budget for the upper Dockum Aquifer in the transient model. An increasing, but still small, amount of flow goes to the Ogallala Aquifer as drawdown increases in the Ogallala Aquifer through time. This is consistent with the imprint of Ogallala Aquifer drawdown seen in some portions of the underlying upper Dockum Aquifer. The flow going to and from other zones increases slightly through time.

Figure 3.4.10 shows the water budget for the lower Dockum Aquifer in the transient model. The mirror trends of storage and production are clearly seen, with production becoming the largest outflow component by the end of the transient period. Discharge to rivers is fairly steady through time, while recharge increases due to agriculturally enhanced percolation in some areas. The increase in recharge creates a slight rise in water levels in some portions of the aquifer, which is displayed in the slight negative increase in storage.

Table 3.4.1 Steady-state water budget.

IN

Aquifer	Recharge	Rivers		GHB[1]	Cross-formational (Ogallala)	Cross-formational (Other)	Layer Total	Model[3] Total
Ogallala	866,085	246,092				44,330	1,156,507	1,112,177
Rita Blanca	3,141	495			9,355	452	13,443	3,636
Edwards-Trinity (High Plains)	0	0			34,251	167	34,418	0
Upper Dockum	301	62			8,109	5,201	13,673	363
Lower Dockum	33,422	25,368			30,421	26,715	115,926	58,789
Edwards-Trinity (Plateau)[2]				43,849	3,220	5,674	52,744	43,849
Pecos Valley[2]				55,117	885	11,478	67,480	55,117
Sum	902,949	272,017		98,967	86,240	49,687[4]		1,273,932

OUT

Aquifer	ET[5]		Drains					
Ogallala	-280,914	-528,193	-261,201			-86,240	-1,156,548	-1,070,307
Rita Blanca	-679	-3,930	-1,175		-5,262	-2,397	-13,443	-5,784
Edwards-Trinity (High Plains)	0	0	0		-32,357	-2,061	-34,418	0
Upper Dockum	-25	-108	-39		-1,125	-12,377	-13,673	-171
Lower Dockum	-15,876	-69,042	-17,113		-2,721	-11,174	-115,926	-102,031
Edwards-Trinity (Plateau)[2]				-38,017	-2,830	-11,896	-52,744	-38,017
Pecos Valley[2]				-57,663	-35	-9,782	-67,480	-57,663
Sum	-297,493	-601,272	-279,528	-95,680	-44,330	-49,687[4]		-1,273,973

[1] GHB denotes general head boundary implemented using River package.

[2] Not part of the High Plains Aquifer System and treated as head boundaries.

[3] Model total does not include cross-formational flow, since cross-formational flow is internal to the overall model.

[4] Sum does not include Ogallala, to allow comparison of sums between IN and OUT.

[5] ET denotes evapotranspiration.

Table 3.4.2 Steady-state water budget components expressed as a percentage of total inflow and outflow.

Aquifer	**Recharge**	**Rivers**		**GHB[1]**	**Model Total**
Ogallala	68.0%	19.3%			87.3%
Rita Blanca	0.2%	0.0%			0.3%
Edwards-Trinity (High Plains)	0.0%	0.0%			0.0%
Upper Dockum	0.0%	0.0%			0.0%
Lower Dockum	2.6%	2.0%			4.6%
Edwards-Trinity (Plateau)[2]				3.4%	3.4%
Pecos Valley[2]				4.3%	4.3%
Sum	70.9%	21.4%		7.8%	100.0%
Aquifer	**ET[3]**		**Drains**		
Ogallala	-22.1%	-41.5%	-20.5%		-84.0%
Rita Blanca	-0.1%	-0.3%	-0.1%		-0.5%
Edwards-Trinity (High Plains)	0.0%	0.0%	0.0%		0.0%
Upper Dockum	0.0%	0.0%	0.0%		0.0%
Lower Dockum	-1.2%	-5.4%	-1.3%		-8.0%
Edwards-Trinity (Plateau)[2]				-3.0%	-3.0%
Pecos Valley[2]				-4.5%	-4.5%
Sum	-23.4%	-47.2%	-21.9%	-7.5%	-100.0%

[1] GHB denotes general head boundary implemented using River package.

[2] Not part of the High Plains Aquifer System and treated as head boundaries.

[3] ET denotes evapotranspiration.

Table 3.4.3 Transient Water Budget for 1980.

IN											
Aquifer	**Recharge**	**Rivers**		**GHB[1]**		**Storage**	**Reservoirs**	**Cross-formational (Ogallala)**	**Cross-formational (Other)**	**Layer Total**	**Model[3] Total**
Ogallala	1,062,294	312,041				6,182,166	1,496		71,315	7,629,313	7,557,997
Rita Blanca	3,101	543				7,137	0	14,087	1,188	26,055	10,780
Edwards-Trinity (High Plains)	0	0				11,062	0	56,922	3,211	71,195	11,062
Upper Dockum	301	63				16,576	0	5,691	10,074	32,705	16,940
Lower Dockum	58,730	24,540				53,735	1,486	30,804	25,515	194,811	138,491
Edwards-Trinity (Plateau)[2]				30,257		68,292	0	2,779	6,339	107,666	98,549
Pecos Valley[2]				50,221		35,200	0	460	12,294	98,174	85,421
Sum	1,124,426	337,186		80,478		6,374,169	2,982	110,742	58,621[4]		7,919,241
OUT											
Aquifer	**ET[5]**		**Drains**		**Pumping**						
Ogallala	-204,241	-370,508	-214,496		-6,526,538	-202,699	-42		-110,742	-7,629,267	-7,518,524
Rita Blanca	-648	-3,768	-1,117		-13,559	-18	0	-4,699	-2,245	-26,055	-19,111
Edwards-Trinity (High Plains)	0	0	0		-26,765	-523	0	-42,503	-1,405	-71,195	-27,288
Upper Dockum	-24	-106	-39		-96	-202	0	-17,556	-14,684	-32,707	-466
Lower Dockum	-16,857	-69,880	-17,535		-48,085	-22,348	-52	-3,326	-16,732	-194,815	-174,757
Edwards-Trinity (Plateau)[2]				-91,001		-670	0	-3,173	-12,822	-107,667	-91,672
Pecos Valley[2]				-86,277		-1,106	0	-59	-10,734	-98,175	-87,383
Sum	-221,771	-444,262	-233,187	-177,278	-6,615,043	-227,565	-94	-71,315	-58,621[4]		-7,919,201

[1] GHB denotes general head boundary implemented using River package.
[2] Not part of the High Plains Aquifer System and treated as head boundaries.
[3] Model total does not include cross-formational flow, since cross-formational flow is internal to the overall model.
[4] Sum does not include Ogallala, to allow comparison of sums between IN and OUT.
[5] ET denotes evapotranspiration.

Table 3.4.4 Transient Water Budget for 2012.

<table>
<tr><th colspan="12">IN</th></tr>
<tr><th>Aquifer</th><th>Recharge</th><th>Rivers</th><th></th><th>GHB[1]</th><th></th><th>Storage</th><th>Reservoirs</th><th>Cross-formational (Ogallala)</th><th>Cross-formational (Other)</th><th>Layer Total</th><th>Model[3] Total</th></tr>
<tr><td>Ogallala</td><td>1,467,708</td><td>339,445</td><td></td><td></td><td></td><td>5,285,644</td><td>1,997</td><td></td><td>94,534</td><td>7,189,328</td><td>7,094,794</td></tr>
<tr><td>Rita Blanca</td><td>3,101</td><td>583</td><td></td><td></td><td></td><td>8,520</td><td>0</td><td>16,757</td><td>1,935</td><td>30,895</td><td>12,204</td></tr>
<tr><td>Edwards-Trinity (High Plains)</td><td>0</td><td>0</td><td></td><td></td><td></td><td>19,038</td><td>0</td><td>59,881</td><td>4,879</td><td>83,798</td><td>19,038</td></tr>
<tr><td>Upper Dockum</td><td>303</td><td>69</td><td></td><td></td><td></td><td>19,051</td><td>0</td><td>5,511</td><td>17,499</td><td>42,433</td><td>19,423</td></tr>
<tr><td>Lower Dockum</td><td>63,001</td><td>24,241</td><td></td><td></td><td></td><td>90,013</td><td>1,423</td><td>26,266</td><td>25,541</td><td>230,485</td><td>178,678</td></tr>
<tr><td>Edwards-Trinity (Plateau)[2]</td><td></td><td></td><td></td><td>30,292</td><td></td><td>48,819</td><td>0</td><td>3,104</td><td>6,799</td><td>89,014</td><td>79,111</td></tr>
<tr><td>Pecos Valley[2]</td><td></td><td></td><td></td><td>49,426</td><td></td><td>33,381</td><td>0</td><td>481</td><td>11,989</td><td>95,277</td><td>82,808</td></tr>
<tr><td>Sum</td><td>1,534,112</td><td>364,339</td><td></td><td>79,718</td><td></td><td>5,504,466</td><td>3,420</td><td>112,000</td><td>68,641[4]</td><td></td><td>7,486,056</td></tr>
<tr><th colspan="12">OUT</th></tr>
<tr><th>Aquifer</th><th>ET[5]</th><th></th><th>Drains</th><th></th><th>Pumping</th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>Ogallala</td><td>-169,746</td><td>-292,131</td><td>-188,847</td><td></td><td>-6,235,411</td><td>-190,951</td><td>-219</td><td></td><td>-112,000</td><td>-7,189,304</td><td>-7,077,305</td></tr>
<tr><td>Rita Blanca</td><td>-624</td><td>-3,692</td><td>-1,082</td><td></td><td>-15,978</td><td>-1,739</td><td>0</td><td>-5,522</td><td>-2,260</td><td>-30,897</td><td>-23,115</td></tr>
<tr><td>Edwards-Trinity (High Plains)</td><td>0</td><td>0</td><td>0</td><td></td><td>-24,754</td><td>-674</td><td>0</td><td>-56,977</td><td>-1,393</td><td>-83,798</td><td>-25,428</td></tr>
<tr><td>Upper Dockum</td><td>-23</td><td>-100</td><td>-37</td><td></td><td>-163</td><td>-254</td><td>0</td><td>-24,794</td><td>-17,064</td><td>-42,434</td><td>-577</td></tr>
<tr><td>Lower Dockum</td><td>-18,286</td><td>-72,551</td><td>-19,405</td><td></td><td>-66,939</td><td>-24,551</td><td>-335</td><td>-4,000</td><td>-24,414</td><td>-230,482</td><td>-202,067</td></tr>
<tr><td>Edwards-Trinity (Plateau)[2]</td><td></td><td></td><td></td><td>-72,934</td><td></td><td>-344</td><td>0</td><td>-3,189</td><td>-12,547</td><td>-89,014</td><td>-73,278</td></tr>
<tr><td>Pecos Valley[2]</td><td></td><td></td><td></td><td>-83,208</td><td></td><td>-1,053</td><td>0</td><td>-52</td><td>-10,963</td><td>-95,277</td><td>-84,262</td></tr>
<tr><td>Sum</td><td>-188,678</td><td>-368,474</td><td>-209,370</td><td>-156,143</td><td>-6,343,245</td><td>-219,566</td><td>-554</td><td>-94,534</td><td>-68,641[4]</td><td></td><td>-7,486,032</td></tr>
</table>

[1] GHB denotes general head boundary implemented using River package.
[2] Not part of the High Plains Aquifer System and treated as head boundaries.
[3] Model total does not include cross-formational flow, since cross-formational flow is internal to the overall model.
[4] Sum does not include Ogallala, to allow comparison of sums between IN and OUT.
[5] ET denotes evapotranspiration.

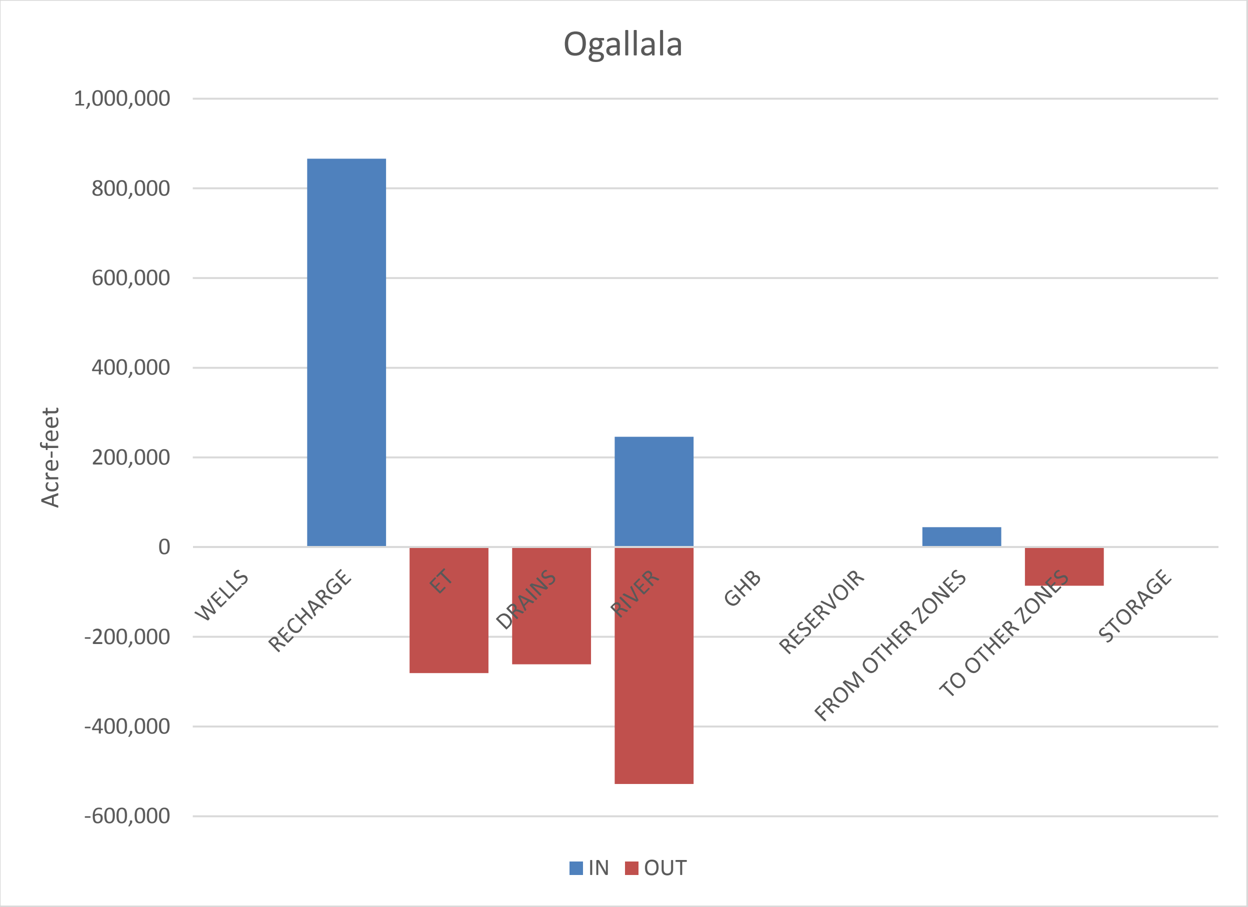


Figure 3.4.1 **Water budget in acre-feet per year in the Ogallala Aquifer for the steady-state model. (Abbreviation key: ET = evapotranspiration, GHB = general head boundary)**

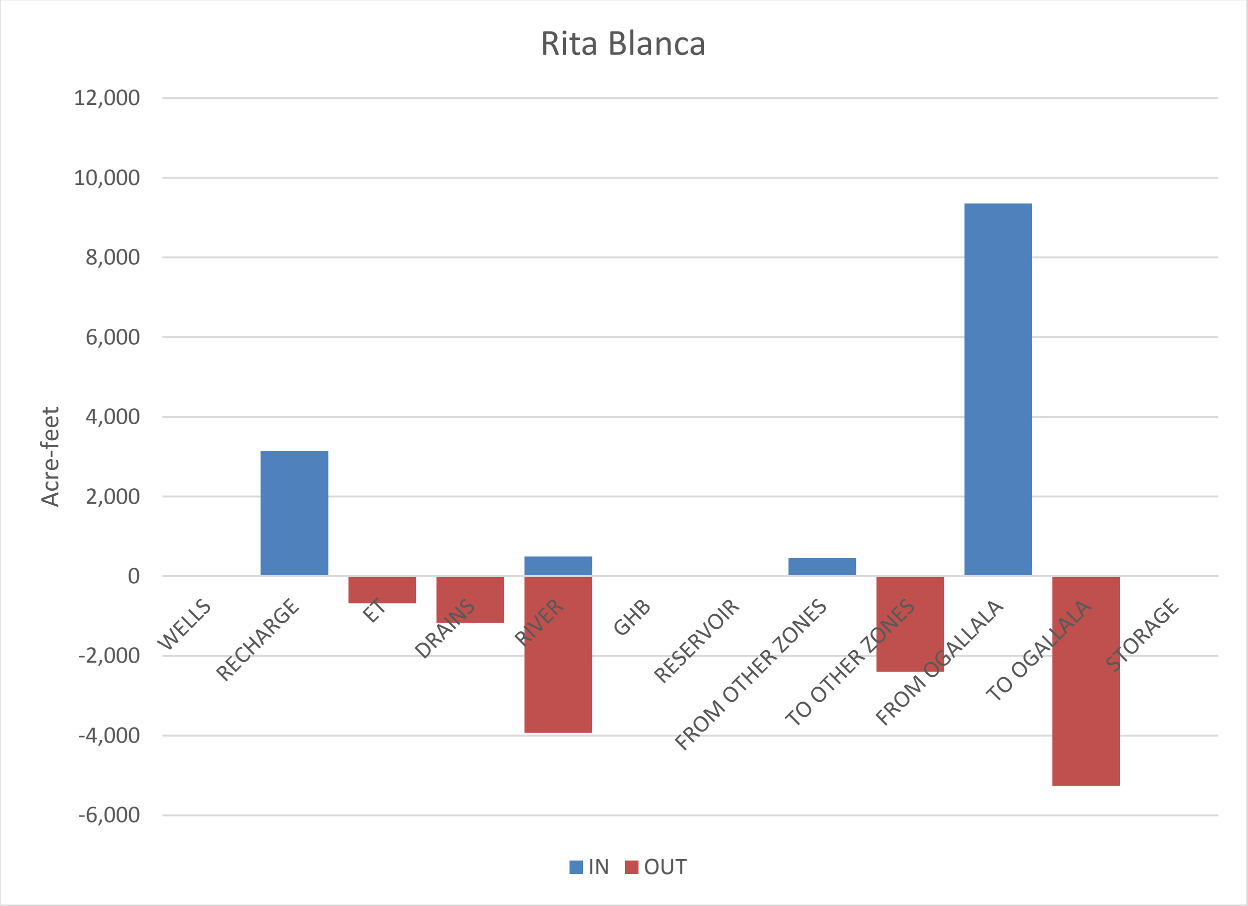


Figure 3.4.2 **Water budget in acre-feet per year in the Rita Blanca Aquifer for the steady-state model. (Abbreviation key: ET = evapotranspiration, GHB = general head boundary)**

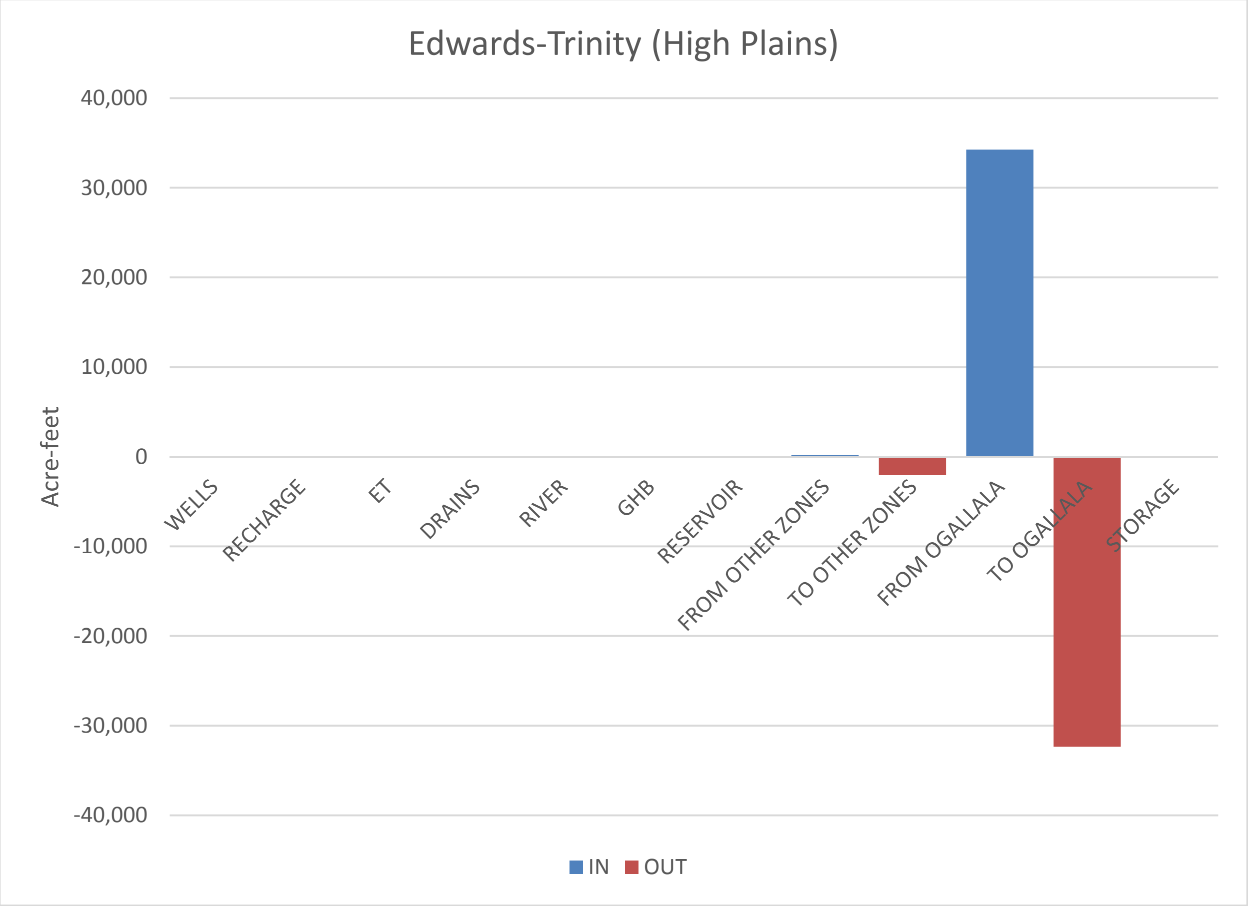


Figure 3.4.3 **Water budget in acre-feet per year in the Edwards-Trinity (High Plains) Aquifer for the steady-state model. (Abbreviation key: ET = evapotranspiration, GHB = general head boundary)**

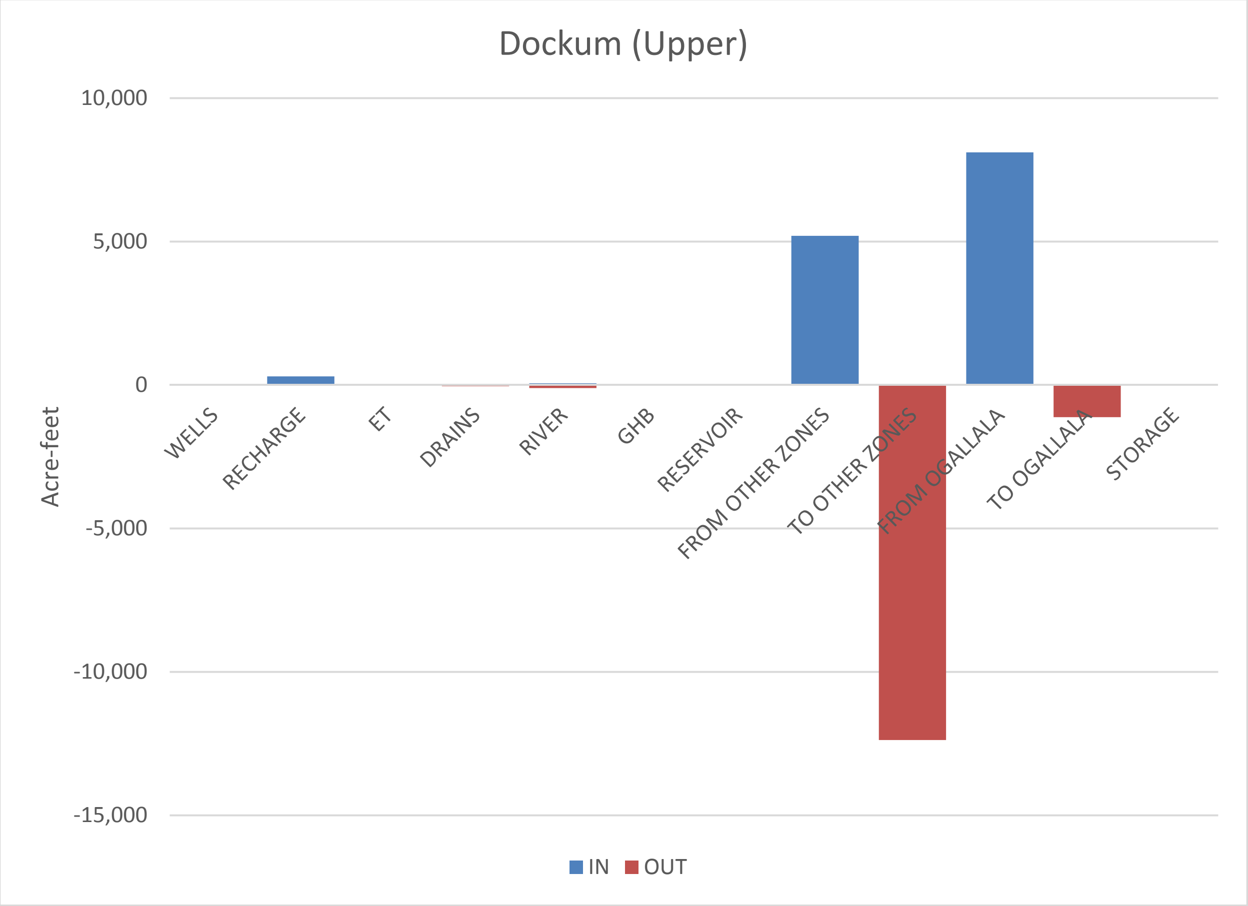


Figure 3.4.4 **Water budget in acre-feet per year in the upper Dockum Aquifer for the steady-state model. (Abbreviation key: ET = evapotranspiration, GHB = general head boundary)**

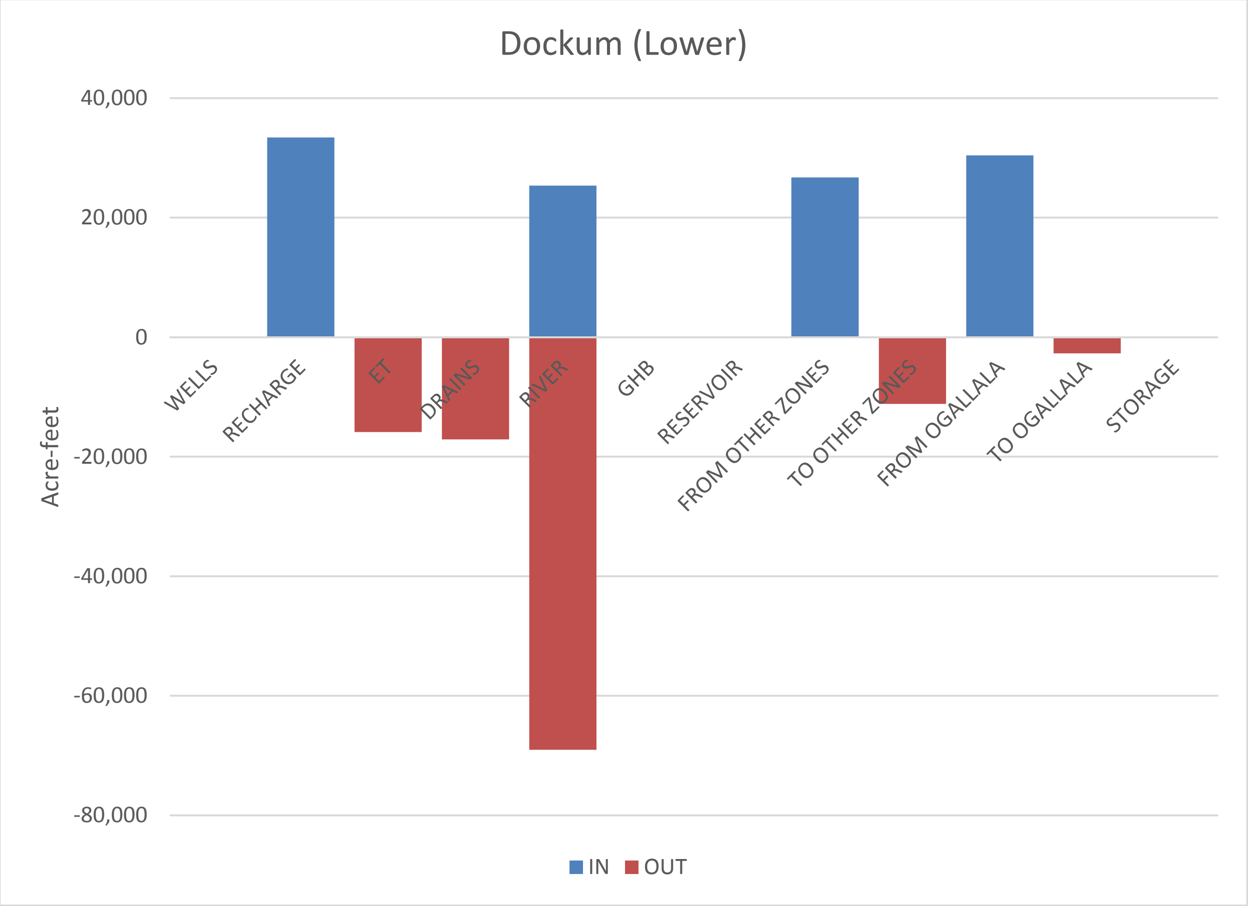


Figure 3.4.5 **Water budget in acre-feet per year in the lower Dockum Aquifer for the steady-state model. (Abbreviation key: ET = evapotranspiration, GHB = general head boundary)**

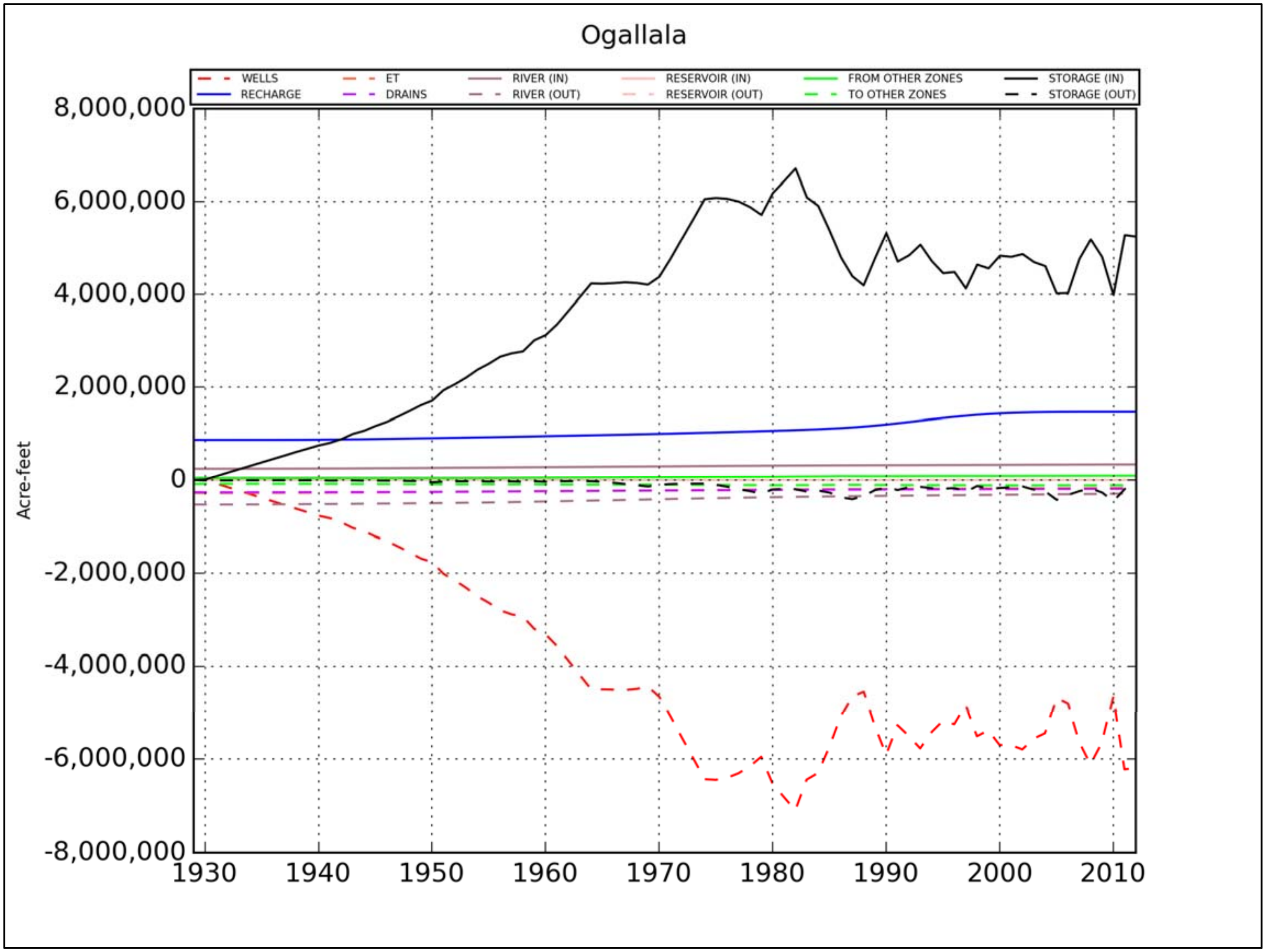


Figure 3.4.6a **Water budget in acre-feet per year in the Ogallala Aquifer for the transient model. (Abbreviation key: ET = evapotranspiration)**

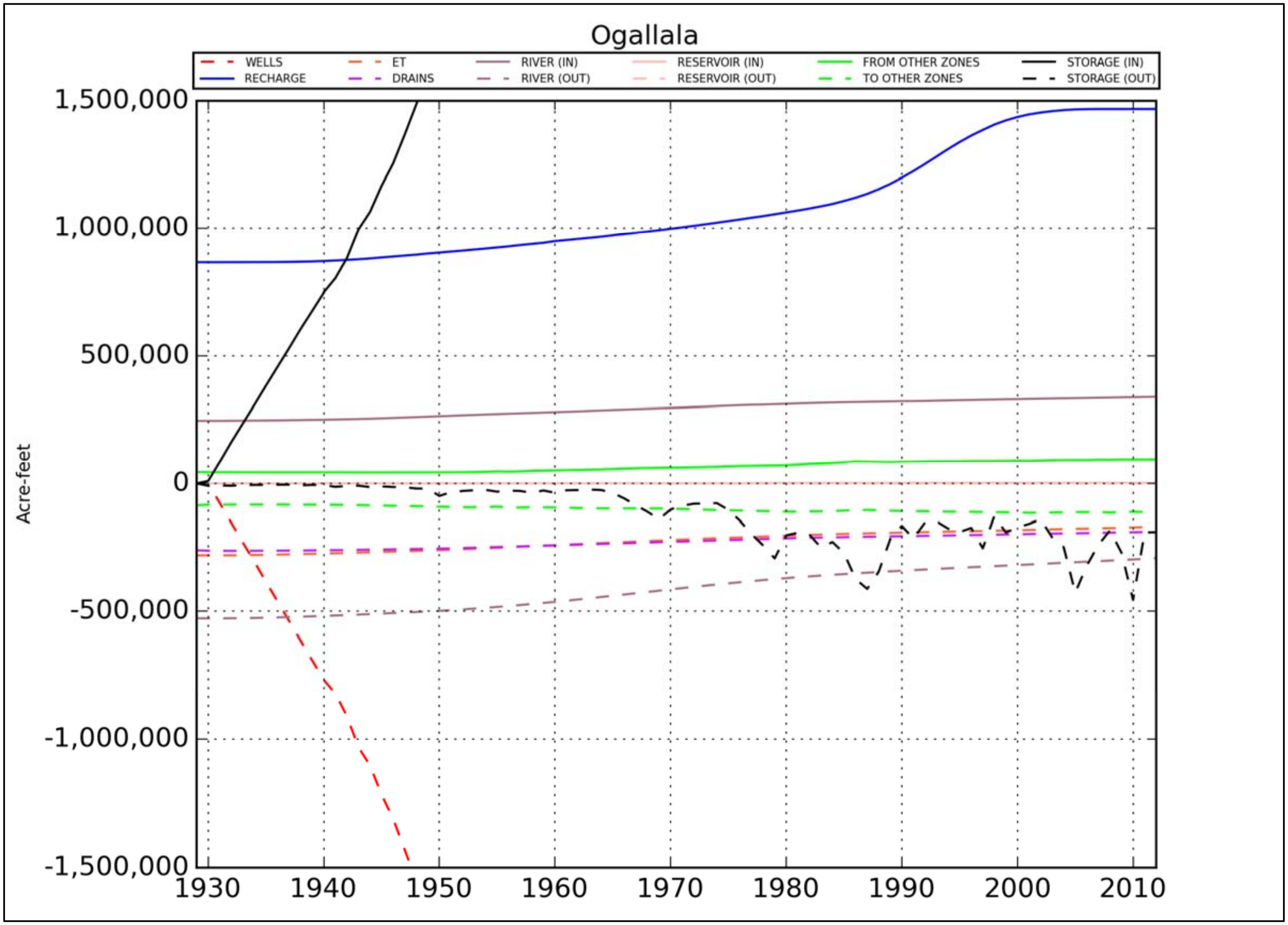


Figure 3.4.6b **Water budget in acre-feet per year in the Ogallala Aquifer for the transient model with zoomed y-axis scale to show smaller components. (Abbreviation key: ET = evapotranspiration)**

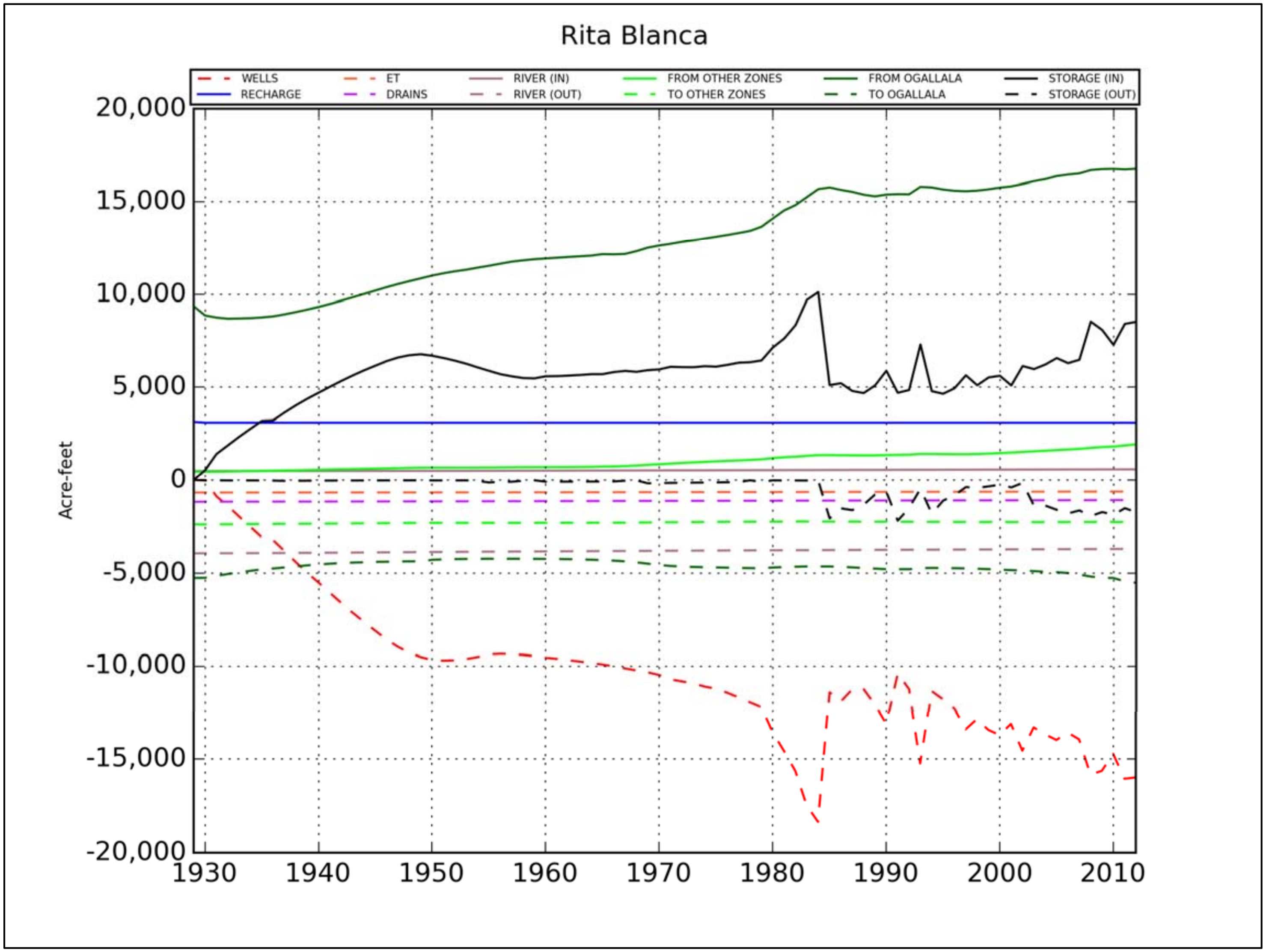


Figure 3.4.7 **Water budget in acre-feet per year in the Rita Blanca Aquifer for the transient model. (Abbreviation key: ET = evapotranspiration)**

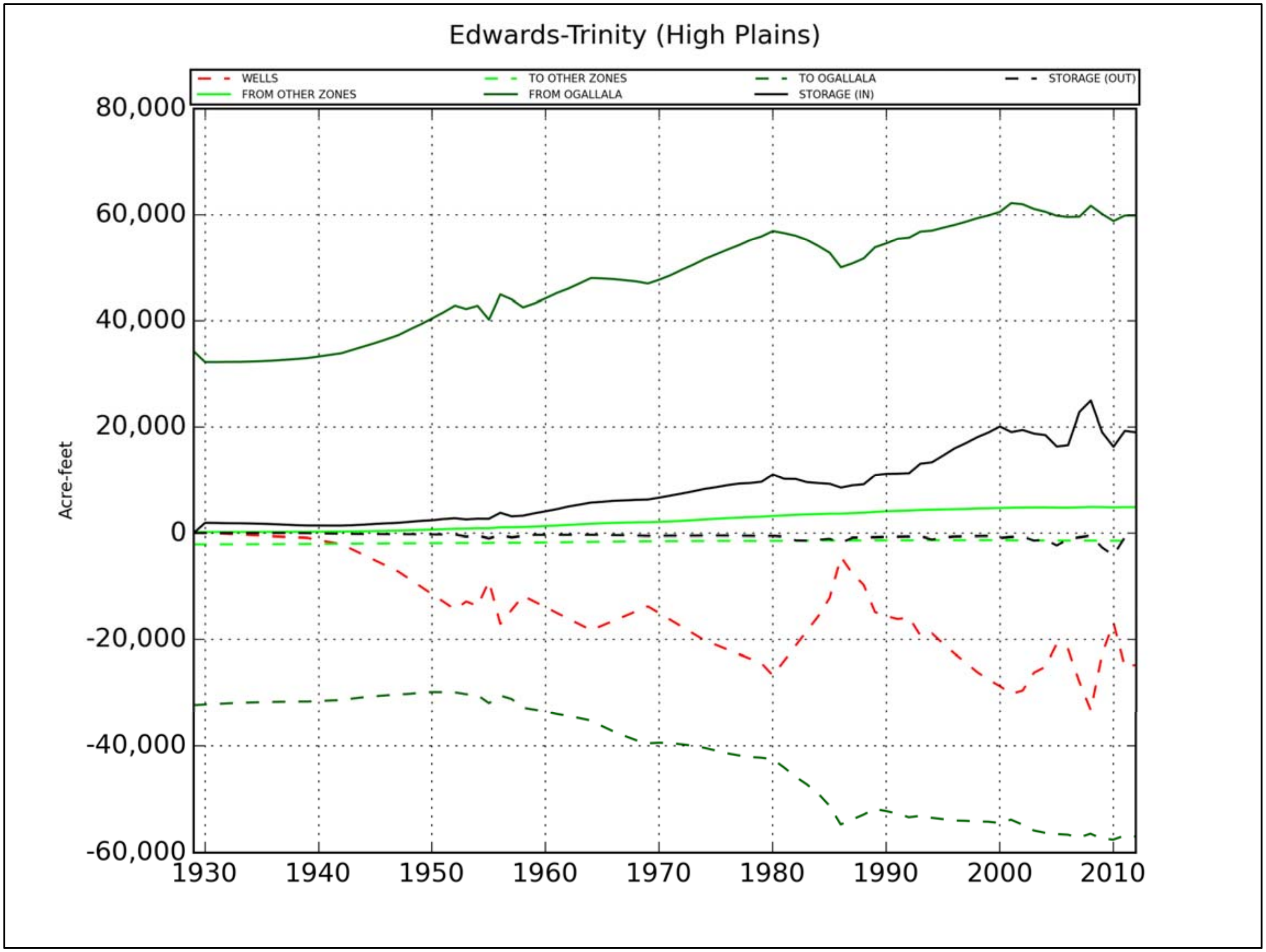


Figure 3.4.8 **Water budget in acre-feet per year in the Edwards-Trinity (High Plains) Aquifer for the transient model. (Abbreviation key: ET = evapotranspiration)**

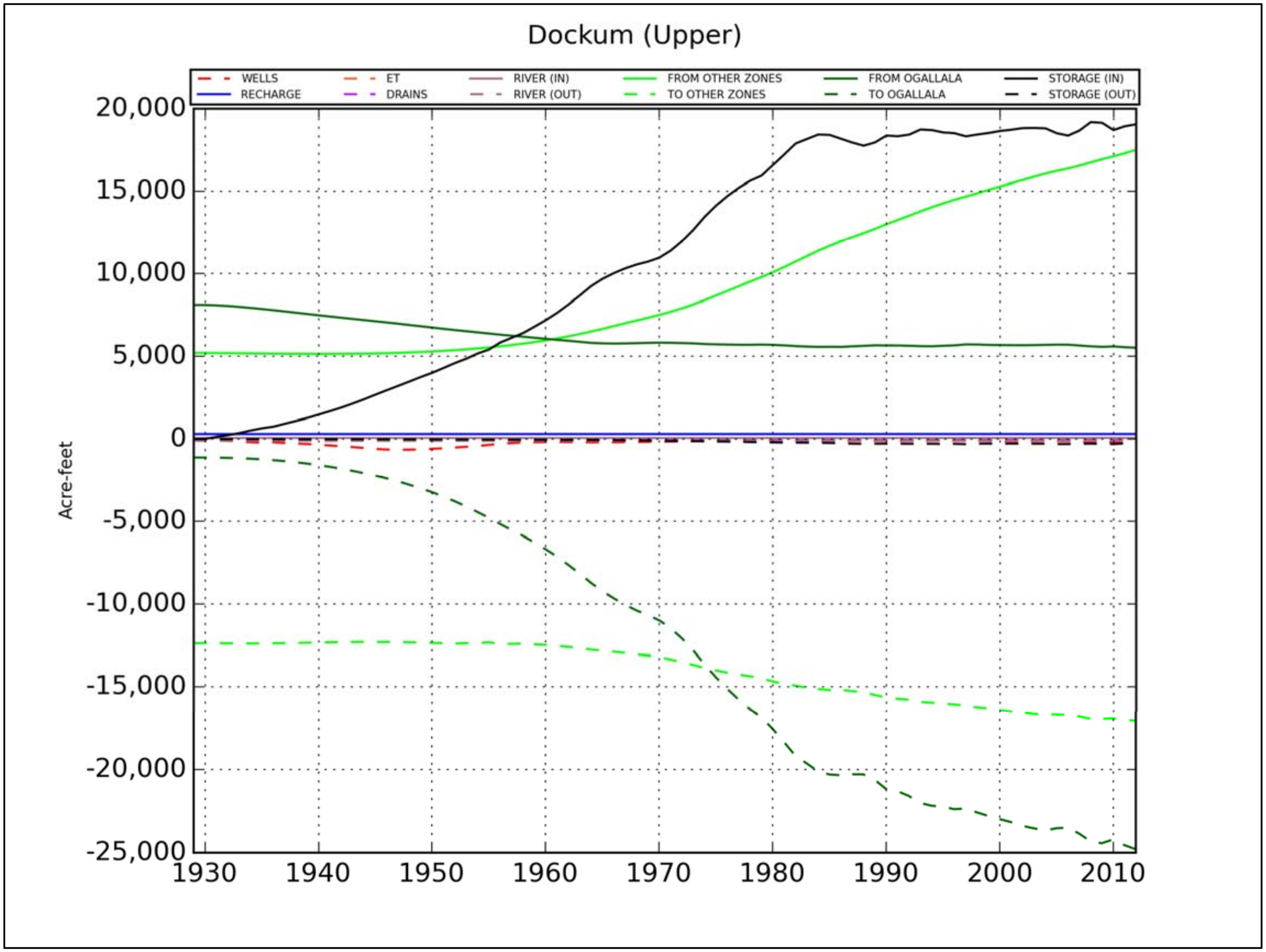


Figure 3.4.9 **Water budget in acre-feet per year in the upper Dockum Aquifer for the transient model. (Abbreviation key: ET = evapotranspiration)**

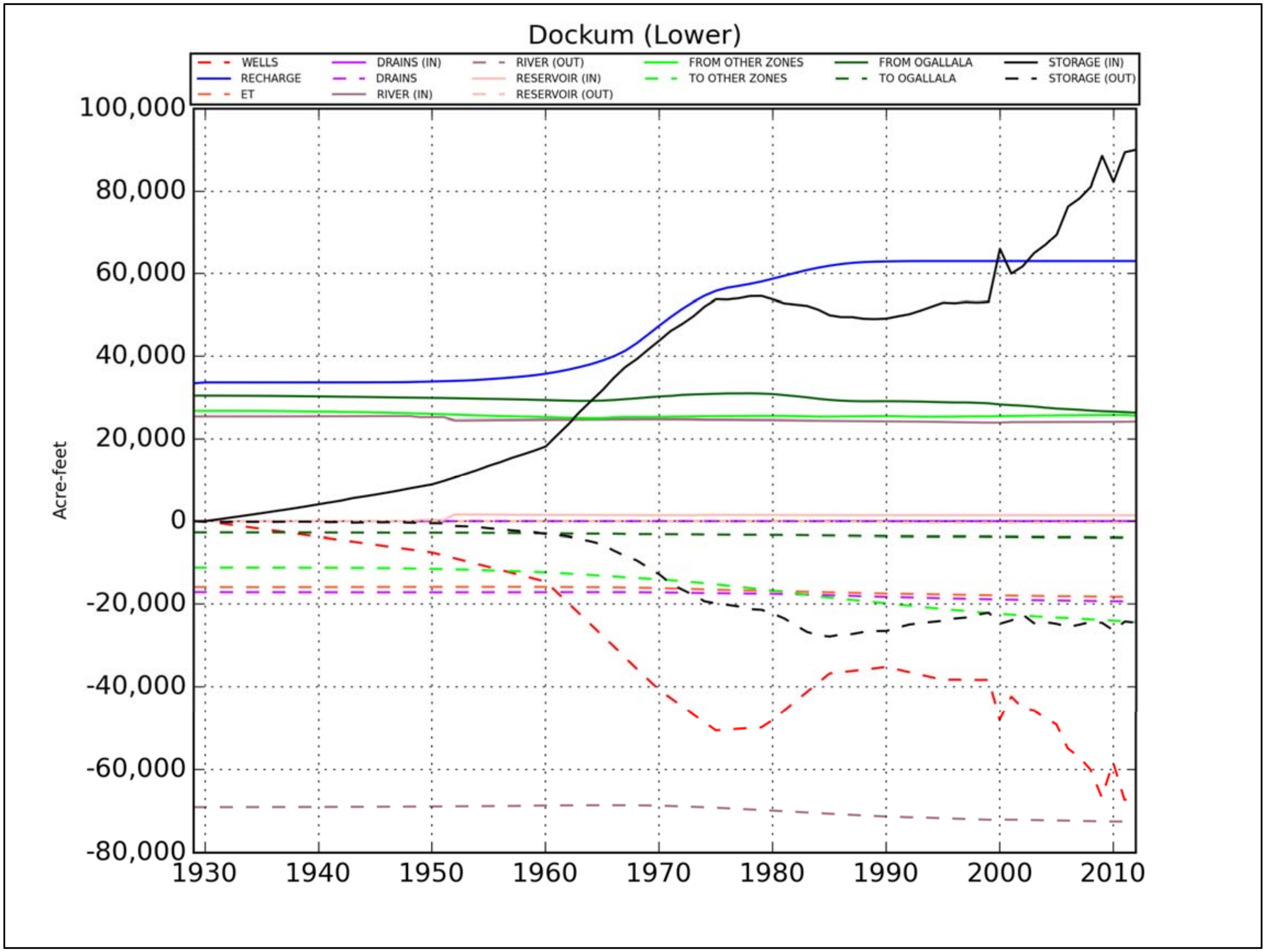


Figure 3.4.10 **Water budget in acre-feet per year in the lower Dockum Aquifer for the transient model. (Abbreviation key: ET = evapotranspiration)**

This page intentionally left blank.

4.0 Sensitivity Analysis

A sensitivity analysis was performed on the calibrated model to determine the impact of changes in calibrated parameters on the predictions of the calibrated model. A sensitivity analysis provides a means of formally describing the impact of varying specific parameters or groups of parameters on model outputs. In this sensitivity analysis, input parameters were systematically increased and decreased from their calibrated values while the change in hydraulic heads and flows was recorded. Informally, this is referred to as a standard "one-off" sensitivity analysis. This means that hydraulic parameters or stresses were adjusted from their calibrated "base case" values one at a time while all other hydraulic parameters remained unperturbed.

Section 4.1 describes the sensitivity analysis procedure. Section 4.2 contains a discussion of the results of the steady-state and transient sensitivity analyses, primarily presented using spider plots. In addition, the sensitivity of transient simulated hydrograph responses to several parameters is shown at the end of the section.

4.1 Sensitivity Analysis Procedure

Four simulations were completed for each parameter sensitivity, where the input parameters were varied either according to:

$$\text{(new parameter)} = \text{(old parameter)} * \text{factor} \tag{4.1.1}$$

or

$$\text{(new parameter)} = \text{(old parameter)} * 10^{\text{(factor - 1)}} \tag{4.1.2}$$

and the factors were 0.5, 0.9, 1.1, and 1.5. Parameters such as recharge were varied linearly using Equation 4.1.1. For parameters such as hydraulic conductivity, which are typically thought of as log-varying, Equation 4.1.2 was used. For the output variable, the mean difference between the calibrated simulated hydraulic head and the sensitivity simulated hydraulic head was calculated as:

$$MD = \frac{1}{n}\sum_{i=1}^{n}\left(h_{sens,i} - h_{cal,i}\right) \tag{4.1.3}$$

where

MD = mean difference

$h_{sens,i}$ = sensitivity simulation hydraulic head at active grid cell i

$h_{cal,i}$ = calibrated simulation hydraulic head at active grid cell i

n = number of active grid cells, or the number of target locations

Equation 4.1.3 was applied separately both model-wide (that is, in all active grid cells) and at target locations only. If the results are different between these two applications, it can be an indication that the targets are poorly distributed. However, if the results did not differ substantially, the second case will not be specifically discussed in this section.

Similarly, the mean difference in flows was calculated for flow boundaries as:

$$MD = \frac{1}{n}\sum_{i=1}^{n}\left(q_{sens,i} - q_{cal,i}\right) \tag{4.1.4}$$

where

MD = mean difference

$q_{sens,i}$ = sensitivity simulation flow at active grid cell i

$q_{cal,i}$ = calibrated simulation flow at active grid cell i

n = number of cells for flow boundary

For the steady-state sensitivity analysis, 41 combinations of input parameters and output metrics were investigated. Whether hydraulic head, flow, or both were considered are noted in parentheses in the list below.

1. Horizontal hydraulic conductivity of the Ogallala Aquifer, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head, flow).
2. Vertical hydraulic conductivity of the Ogallala Aquifer, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head, flow).
3. Recharge in of the Ogallala Aquifer, the Rita Blanca Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head, flow).
4. Conductance of the river boundaries representing rivers (hydraulic head, flow).
5. Conductance of the river boundaries as a proxy for general-head boundaries (hydraulic head, flow).

6. Conductance of the drain boundaries representing ephemeral streams (hydraulic head, flow).
7. Conductance of the drain boundaries representing springs (hydraulic head, flow).
8. Evapotranspiration rate of the evapotranspiration boundaries representing groundwater evapotranspiration (hydraulic head, flow).
9. Extinction depth of the evapotranspiration boundaries representing groundwater evapotranspiration (hydraulic head, flow).

Equation 4.1.1 was used for sensitivities 3, 8, and 9, while Equation 4.1.2 was used for the remaining sensitivities.

In addition to the sensitivities computed for the steady-state model, the transient model adds storage properties, reservoirs, and pumping sensitivities, for a total of 49 combinations of input parameters and output metrics:

1. Horizontal hydraulic conductivity of the Ogallala Aquifer, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head, flow).
2. Vertical hydraulic conductivity of the Ogallala Aquifer, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head, flow).
3. Recharge in of the Ogallala Aquifer, the Rita Blanca Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head, flow).
4. Conductance of the river boundaries representing rivers (hydraulic head, flow).
5. Conductance of the river boundaries as a proxy for general-head boundaries (hydraulic head, flow).
6. Conductance of the drain boundaries representing ephemeral streams (hydraulic head, flow).
7. Conductance of the drain boundaries representing springs (hydraulic head, flow).
8. Evapotranspiration rate of the evapotranspiration boundaries representing groundwater evapotranspiration (hydraulic head, flow).
9. Extinction depth of the evapotranspiration boundaries representing groundwater evapotranspiration (hydraulic head, flow).

10. Conductance of the river boundaries representing reservoirs (hydraulic head, flow)
11. Specific yield of the Ogallala Aquifer (hydraulic head, flow).
12. Specific storage of the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, the upper Dockum Aquifer, and the lower Dockum Aquifer (hydraulic head).
13. Pumping (hydraulic head, flow)

Equation 4.1.1 was used for sensitivities 3, 8, 9, 11, and 13, while equation 4.1.2 was used for the remaining sensitivities.

4.2 Sensitivity Analysis Results

In the discussion of sensitivity analysis results, we consider head or flow as potential output metrics. In some cases, changing a particular parameter does not result in any significant change to heads or flows. We can judge the lower bound of significant change based on the head and flow convergence criteria used in the Model Solver package. The head convergence criteria was 0.01 foot, so any average changes in head that are approximately 0.01 foot or less are considered to be insignificant. Similarly, a typical flow convergence value was about 100 cubic feet per day, or approximately 0.8 acre foot per year (convergence was typically limited by head rather than flow, so we examined the maximum flux residual at head convergence to develop this range). As we discuss the sensitivity analysis results, we will keep these limits in mind, at which perturbations in head or flow are within the range of “noise” of the model.

For some cases, parameters were varied outside the range where the model was stable, so the model did not converge in steady-state. When non-convergence was severe (water balance significantly affected), the heads or flows that resulted were not valid for the purposes of evaluating sensitivity. For those cases, the results are not shown on the plot, so the absence of a particular parameter and factor combination indicates that this severe non-convergence occurred. This result occurred most often in cases where the heads in the Ogallala Aquifer were decreased significantly due to parameter changes, so that dry cells became pronounced in steady-state. One example is Figure 4.2.1, where increasing the horizontal hydraulic conductivity of the Ogallala Aquifer by a factor of 1.5 caused heads to drop 10s of feet, and dry cell issues caused severe non-convergence.

4.2.1 Steady-State Sensitivities

Figure 4.2.1 shows the sensitivity in hydraulic heads to changes in the horizontal hydraulic conductivity of the Ogallala Aquifer for the steady-state model. Decreasing horizontal hydraulic conductivity increases hydraulic heads in the Ogallala Aquifer which then propagate through the model to the other aquifers. Increasing the horizontal hydraulic conductivity of the Ogallala Aquifer has the reverse effect. Figure 4.2.2 shows the sensitivity to changes in the horizontal hydraulic conductivity of the Rita Blanca Aquifer with decreasing horizontal hydraulic conductivity increasing hydraulic heads in the Rita Blanca Aquifer which then propagate to a lesser degree through the model. Little change occurs in the hydraulic heads of the Ogallala Aquifer in response to variation in the horizontal hydraulic conductivity of the Rita Blanca Aquifer because the Rita Blanca Aquifer underlays the Ogallala Aquifer. Likewise, the Edwards-Trinity (High Plains) Aquifer shows little variation in hydraulic heads in response to changes in the horizontal hydraulic conductivity of the Rita Blanca Aquifer because these two aquifers are hydraulically disconnected by the Canadian River valley.

Figure 4.2.3 shows the sensitivity to changes in the horizontal hydraulic conductivity of the Edwards-Trinity (High Plains) Aquifer with decreasing horizontal hydraulic conductivity increasing hydraulic heads in the Edwards-Trinity (High Plains) Aquifer which propagate to a lesser degree through the model. The Rita Blanca Aquifer is insensitive to changes in the hydraulic conductivity of the Edwards-Trinity (High Plains) Aquifer because the two aquifers are hydraulically disconnected by the Canadian River valley. As shown in Figure 4.2.4, there is little sensitivity to changes in the horizontal hydraulic conductivity of the upper Dockum Aquifer to hydraulic heads as the absolute mean head difference is less than one foot for all parameter perturbations. Figure 4.2.5 shows the sensitivity to variation in the horizontal hydraulic conductivity of the lower Dockum Aquifer, with decreasing horizontal hydraulic conductivity increasing hydraulic heads in the lower Dockum Aquifer, which in turn propagate to the other aquifers. Increasing the horizontal hydraulic conductivity of the lower Dockum Aquifer has the opposite effect. Comparatively little sensitivity is shown between the horizontal hydraulic conductivity of the lower Dockum Aquifer and hydraulic heads in the Ogallala and Edwards-Trinity (High Plains) aquifers.

Figure 4.2.6 shows the hydraulic head sensitivity to changes in vertical hydraulic conductivity in the Ogallala Aquifer. Overall, the hydraulic heads have low sensitivity to the vertical hydraulic conductivity of the Ogallala Aquifer as the absolute mean head difference is less than 0.8 feet for all parameter perturbations. Figure 4.2.7 depicts the hydraulic head sensitivity in response to changes in the vertical hydraulic conductivity in the Rita Blanca Aquifer, with increasing vertical hydraulic conductivity increasing hydraulic heads in the Rita Blanca Aquifer. Little hydraulic head sensitivity is observed in the other aquifers from changes in the vertical hydraulic conductivity of the Rita Blanca Aquifer. Figure 4.2.8 shows the hydraulic head sensitivity to changes in the vertical hydraulic conductivity of the Edwards-Trinity (High Plains) Aquifer with increasing vertical hydraulic conductivity increasing heads. The opposite trend occurs for the Ogallala Aquifer but the sensitivity is not pronounced, at less than 1 foot. Similar to the sensitivities for the horizontal hydraulic conductivity, varying the vertical hydraulic conductivity of the Edwards-Trinity (High Plains) Aquifer has very little impact on heads in the Rita Blanca Aquifer.

Figure 4.2.9 shows the hydraulic head response to changes in the vertical hydraulic conductivity of the upper Dockum Aquifer, with increasing vertical hydraulic conductivity increasing heads in the upper and lower Dockum Aquifer. The upper and lower Dockum Aquifer lines on the plot are so similar in magnitude they are almost overlain. The opposite trend is shown for the Rita Blanca Aquifer. Very little hydraulic head sensitivity is shown in the Ogallala or Edwards-Trinity (High Plains) aquifers. The larger sensitivity of hydraulic heads to changes in the vertical hydraulic conductivity compared with changes in the horizontal hydraulic conductivity indicate that flow may be primarily vertical in the upper Dockum Aquifer. Figure 4.2.10 shows the hydraulic head sensitivity to changes in the vertical hydraulic conductivity of the lower Dockum Aquifer, with decreasing hydraulic conductivity decreasing heads in the lower Dockum Aquifer while the other aquifers exhibit small sensitivities with the opposite trend.

Figure 4.2.11 depicts the expected response of hydraulic heads to changes in recharge in the Ogallala Aquifer with increasing recharge increasing hydraulic heads. The Edwards-Trinity (High Plains), Ogallala, and upper Dockum aquifers show more response in hydraulic heads to variations in recharge compared to head responses in the lower Dockum and Rita Blanca aquifers. The sensitivity of hydraulic heads to changes in recharge in the Rita Blanca Aquifer is depicted in Figure 4.2.12. While heads in the Rita Blanca Aquifer increase with increases in recharge in the Rita Blanca Aquifer, the heads in the other aquifers are comparatively insensitive. Given the relative small portions of the upper Dockum Aquifer outcropping, little sensitivity of hydraulic head is observed for changes in the recharge to the upper Dockum Aquifer as shown in Figure 4.2.13. The lower Dockum Aquifer (Figure 4.2.14) has a larger outcrop, but the outcrop area is still only a fraction of the Ogallala Aquifer outcrop area, so the average heads vary in the lower Dockum Aquifer about 0.5 feet.

Figure 4.2.15 shows the sensitivity in hydraulic heads to the conductance of rivers and streams represented with the River package. For the Rita Blanca, upper Dockum, Ogallala, and lower Dockum aquifers, increasing river conductance increases hydraulic head. The Edwards-Trinity (High Plains) Aquifer shows little hydraulic head response to changes in river conductance. Figure 4.2.16 shows the sensitivity in hydraulic heads to the conductance of river cells that were applied to represent a general-head boundary in the Pecos Valley and Edwards-Trinity (Plateau) aquifers. Sensitivity of hydraulic heads to the conductance of these river is small (less than 2 feet) for all aquifers. Figure 4.2.17 shows the sensitivity in hydraulic heads to the conductance of the subset of drain cells that represent ephemeral streams. For the ephemeral streams, hydraulic heads in all aquifers decrease a small amount (less than 1 foot) with increasing drain conductance. Figure 4.2.18 shows the sensitivity in hydraulic heads to the conductance of the subset of drain cells that represent springs. Like the ephemeral streams, hydraulic heads decrease a small amount with an increase in the drain conductance of model cells representing springs.

Figure 4.2.19 depicts the sensitivity in hydraulic heads to the maximum evapotranspiration rate with increasing rate results in decreasing hydraulic heads. Figure 4.2.20 shows the sensitivity in hydraulic heads to the maximum evapotranspiration extinction depth with increasing extinction depth decreasing hydraulic heads by a small amount (less than 1 foot).

Figure 4.2.21 shows the sensitivity in boundary fluxes to the horizontal hydraulic conductivity of Ogallala Aquifer. The sensitivities in boundary fluxes are grouped into drain fluxes for springs and ephemeral streams (data series “Springs/Draws”), drain fluxes for the subset of drains that represent seeps along the escarpment (data series “Escarpment”), evapotranspiration fluxes (data series “EVT”), river fluxes, and the subset of river fluxes that function as proxies for general-head boundary fluxes (data series “GHB”). The sensitivity of fluxes is greatest for the drain fluxes that represent seeps along the escarpment and for rivers. Increases in the horizontal hydraulic conductivity of the Ogallala Aquifer decreases the river fluxes. The opposite trend occurs for the escarpment seeps, and the springs and draws. Figure 4.2.22 shows the very small (less than 0.1 acre-feet per year) sensitivity in boundary fluxes to the horizontal hydraulic conductivity of the Rita Blanca Aquifer. Figure 4.2.23 depicts the sensitivity in boundary fluxes to the horizontal hydraulic conductivity of the Edwards-Trinity (High Plains) Aquifer with increasing horizontal hydraulic conductivity resulting in increasing fluxes for seeps along the escarpments and relatively little sensitivity in the other boundary fluxes. Figure 4.2.24 shows the very small (less than 0.1 acre-feet per year) sensitivity in boundary fluxes to the horizontal hydraulic conductivity of the upper Dockum Aquifer. Figure 4.2.25 shows the sensitivity in boundary fluxes to the horizontal hydraulic conductivity of the lower Dockum Aquifer, with increases in the horizontal hydraulic conductivity decreasing fluxes to springs/draws, escarpment drains, and general-head boundaries, while increasing fluxes to evapotranspiration and rivers.

Figures 4.2.26 through 4.2.30 illustrate the sensitivity in boundary fluxes to the vertical hydraulic conductivity of the Ogallala, Rita Blanca, Edwards-Trinity (High Plains), upper Dockum, and lower Dockum aquifers, respectively. With the exception of the lower Dockum Aquifer, little flux change (less than an absolute value of 0.1 acre-feet per year) is shown for changes in the vertical hydraulic conductivity, so boundary fluxes would be considered insensitive to these parameters. As shown in Figure 4.2.30, increases in the vertical hydraulic conductivity of the lower Dockum Aquifer decrease the flux of the springs/draws and seeps along the escarpments. The opposite trend is observed for the rivers.

Figures 4.2.31 through 4.2.34 depict the sensitivity of boundary fluxes to changes in recharge where increases in recharge result in increase to all boundary flows apart from the general-head boundaries which are insensitive to recharge. The sensitivity of boundary flows is vastly greater to the recharge in the Ogallala Aquifer (Figure 4.2.31) than to recharge in the other aquifers.

Figures 4.2.35 through 4.2.38 illustrate the sensitivity of boundary fluxes to changes in the boundary conductance. In general, increasing conductance to a boundary increases flow to that boundary, but then decreases overall heads, so flow decreases to the remaining boundaries. This is the case for rivers, ephemeral streams, and springs. All boundary flows are insensitive to changes in general-head boundary conductance (less than 0.1 acre-feet per year change).

Figures 4.2.39 and 4.2.40 illustrate the sensitivity of boundary fluxes to changes in maximum evapotranspiration rate and extinction depth. In both cases, increasing the parameter increases flow to evapotranspiration, and decreases flow to the other boundaries.

To summarize the relative sensitivity of boundary flows to changes in the parameters, recharge and hydraulic conductivity in the Ogallala Aquifer have the largest overall effect (up to 15 acre-feet per year change), while the conductance of ephemeral streams and maximum evapotranspiration rate have a similar magnitude effect (6 to 8 acre-feet per year change). The conductance of rivers, springs, and evapotranspiration extinction depth still show significant effect (3 to 4 acre-feet per year change). The horizontal conductivity of the lower Dockum and Edwards-Trinity (High Plains) aquifers have a smaller effect (1 to 2 acre-feet per year change). The remaining parameters have an insignificant effect on boundary flow (less than 0.1 acre-feet per year).

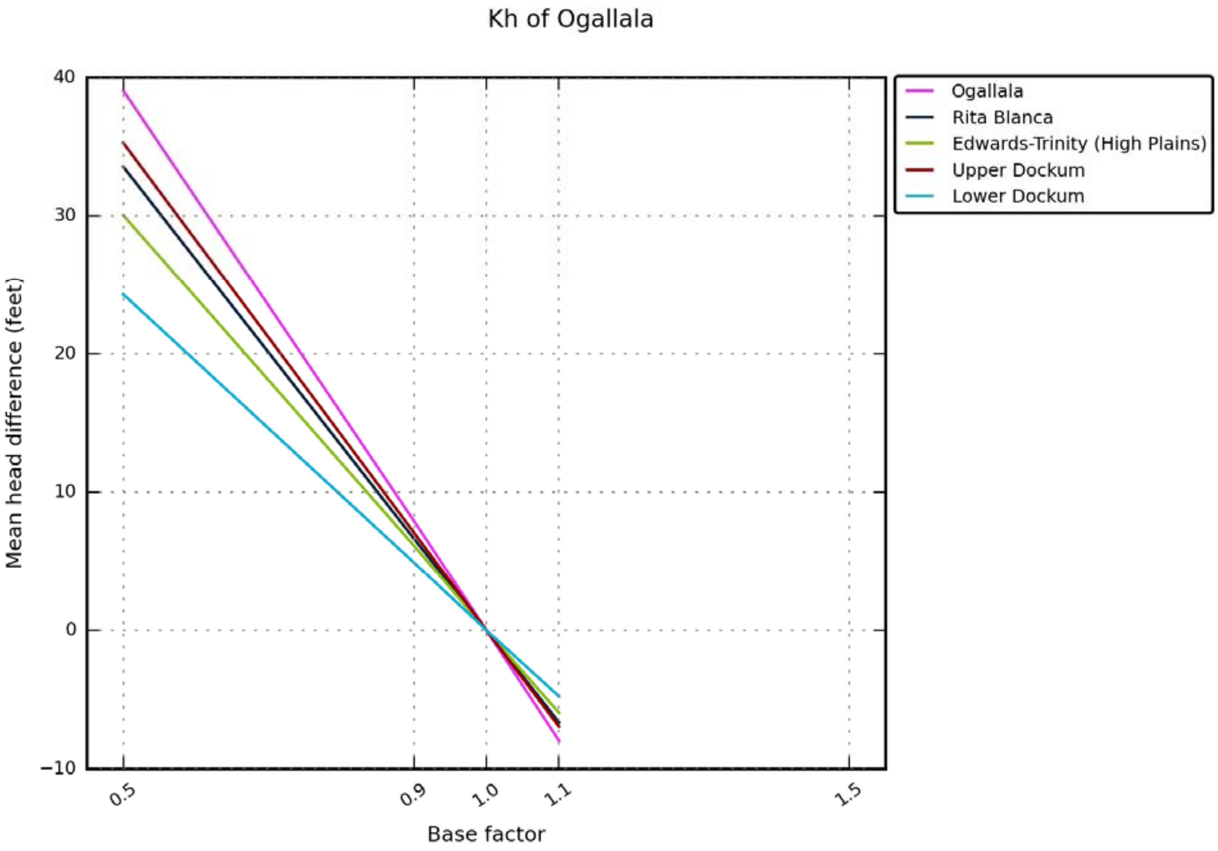


Figure 4.2.1 **Hydraulic head sensitivity in feet for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the Ogallala Aquifer.**

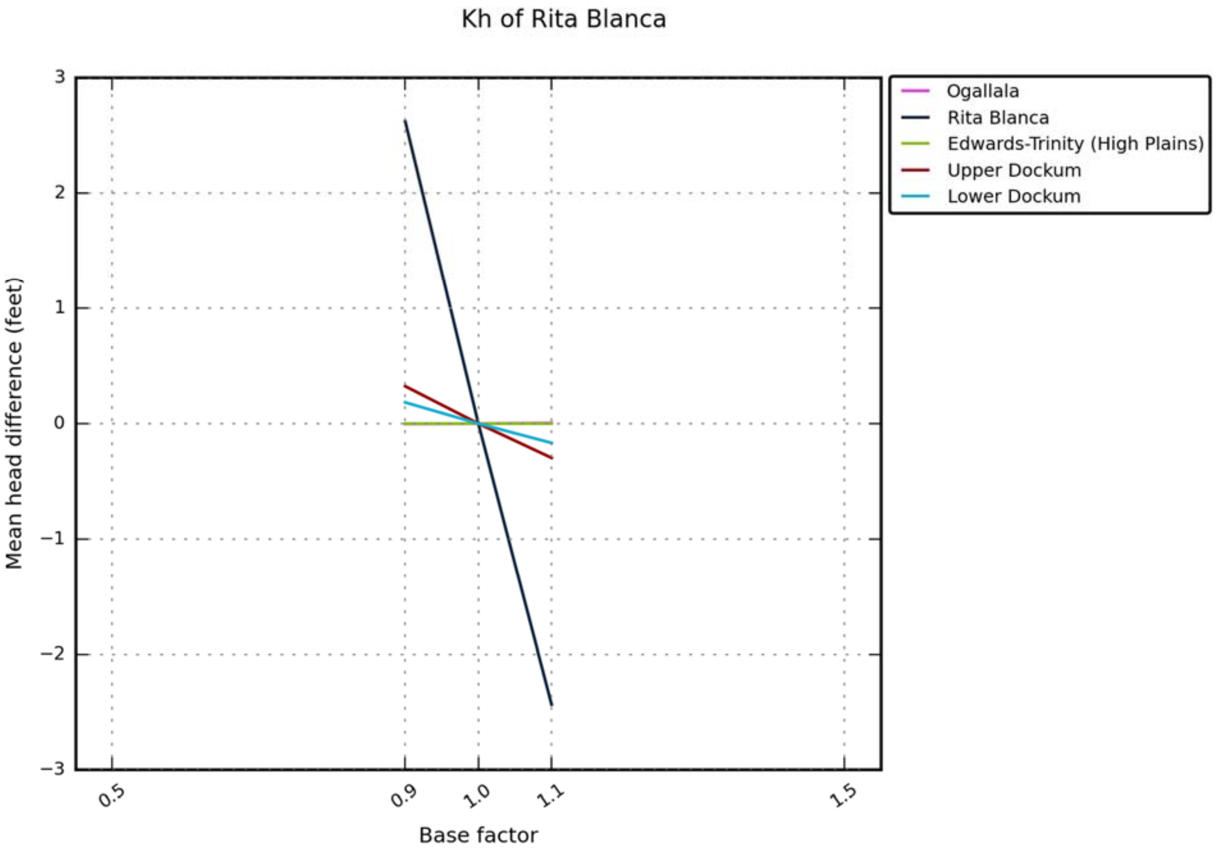


Figure 4.2.2 **Hydraulic head sensitivity in feet for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the Rita Blanca Aquifer.**

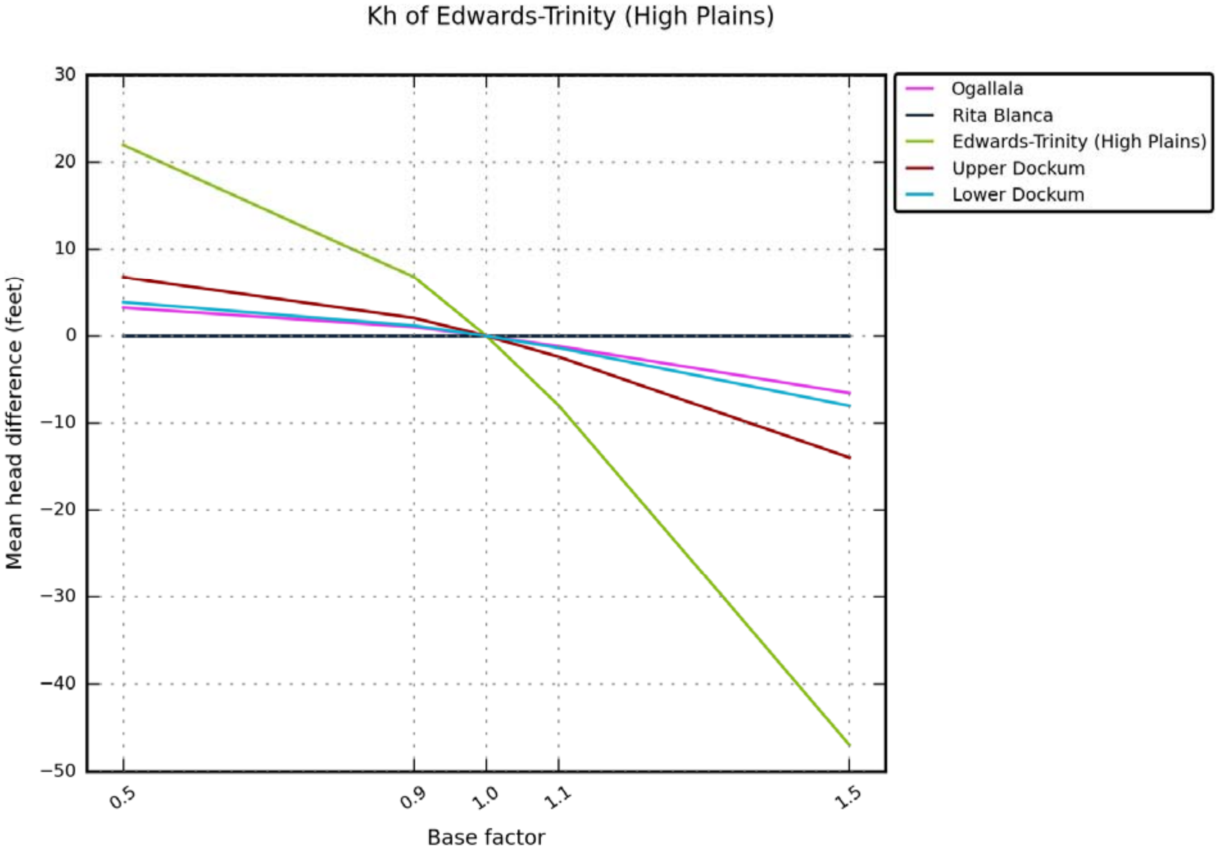


Figure 4.2.3 **Hydraulic head sensitivity in feet for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the Edwards-Trinity (High Plains) Aquifer.**

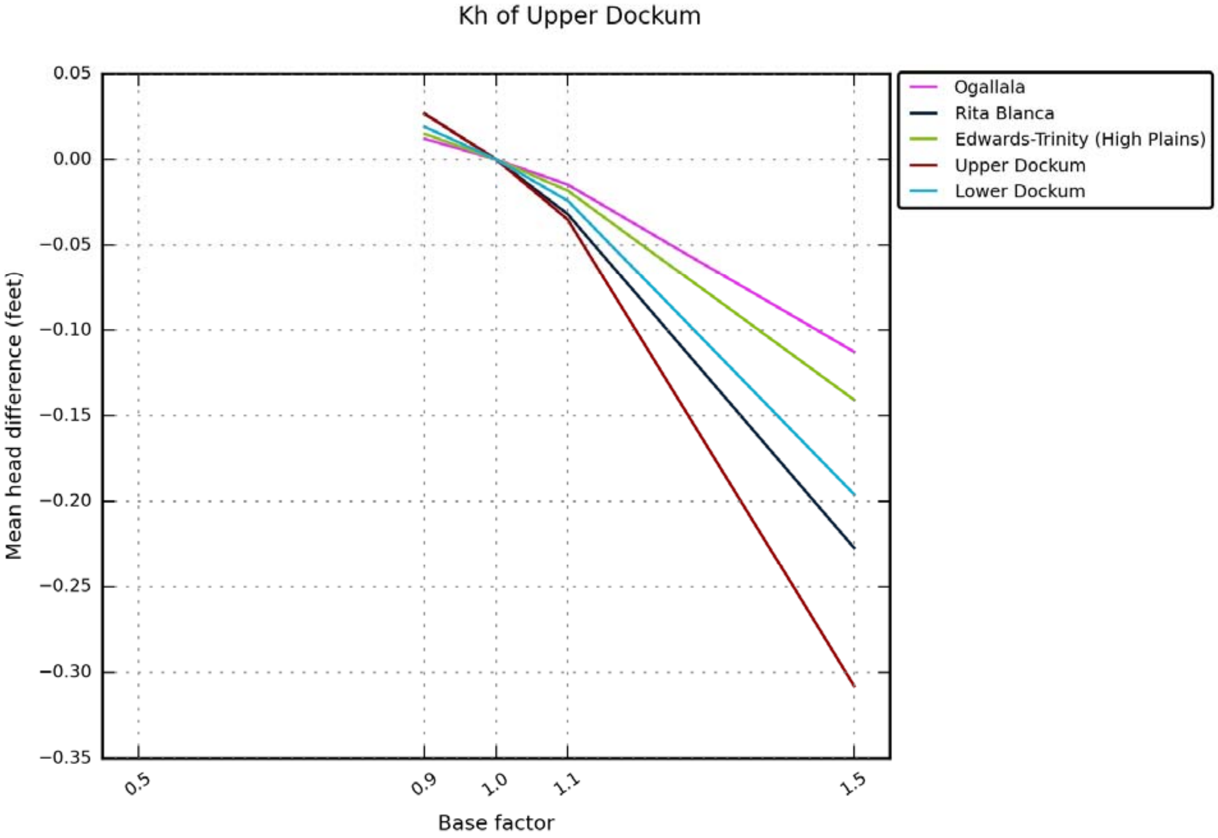


Figure 4.2.4 Hydraulic head sensitivity in feet for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the upper Dockum Aquifer.

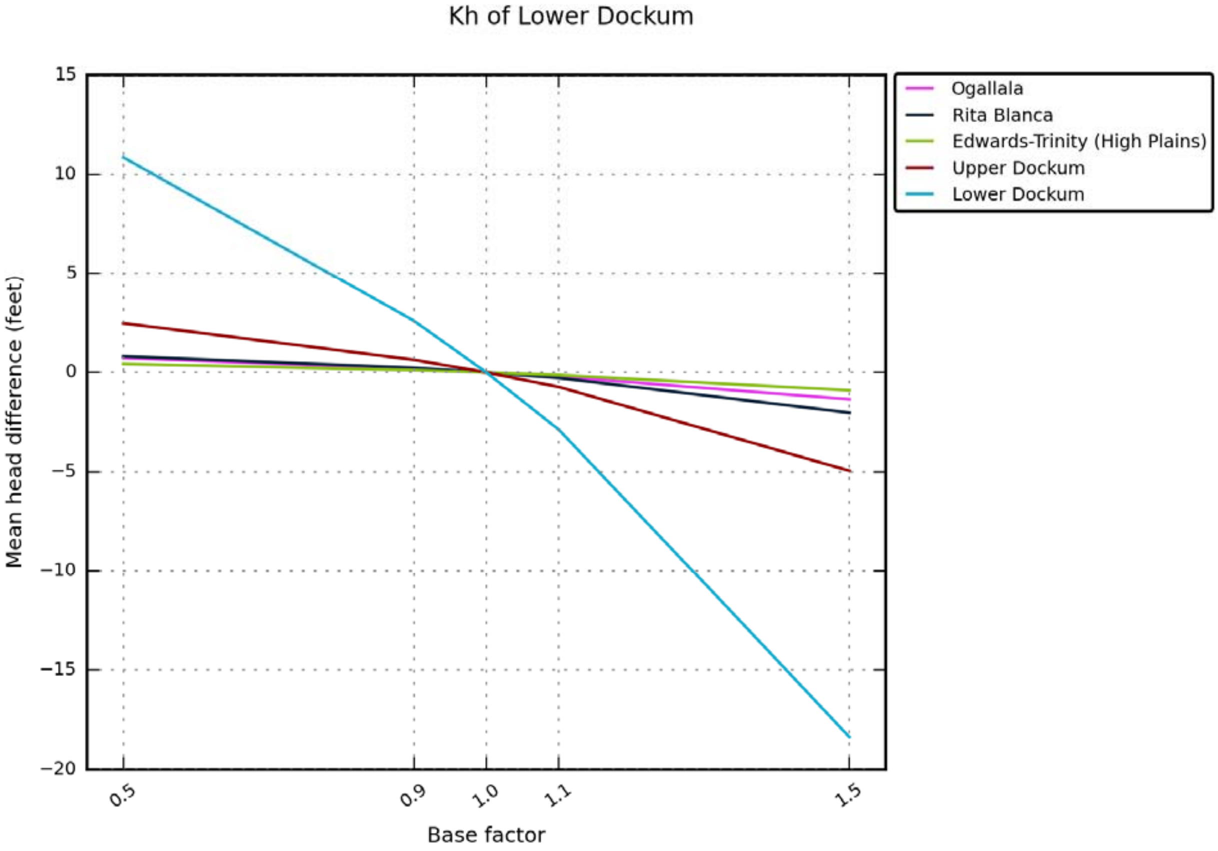


Figure 4.2.5 **Hydraulic head sensitivity in feet for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the lower Dockum Aquifer.**

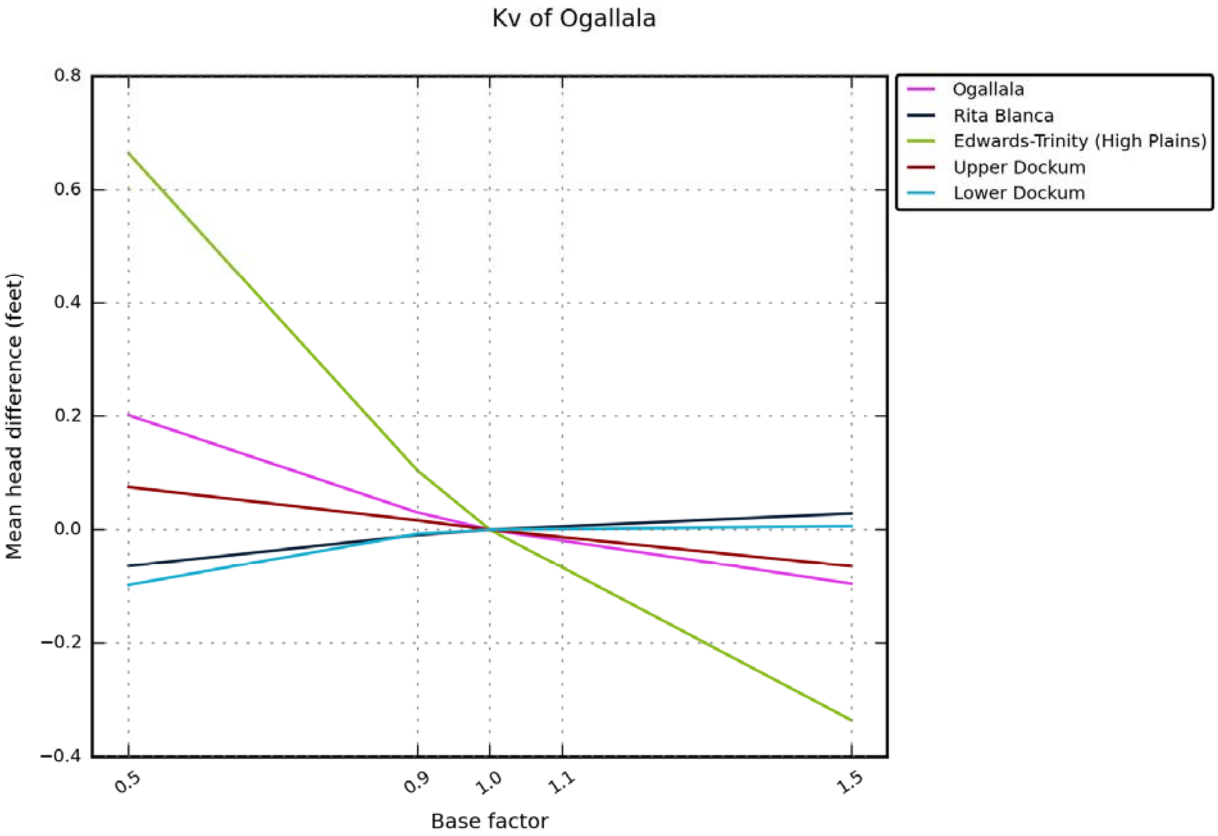


Figure 4.2.6 **Hydraulic head sensitivity in feet for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the Ogallala Aquifer.**

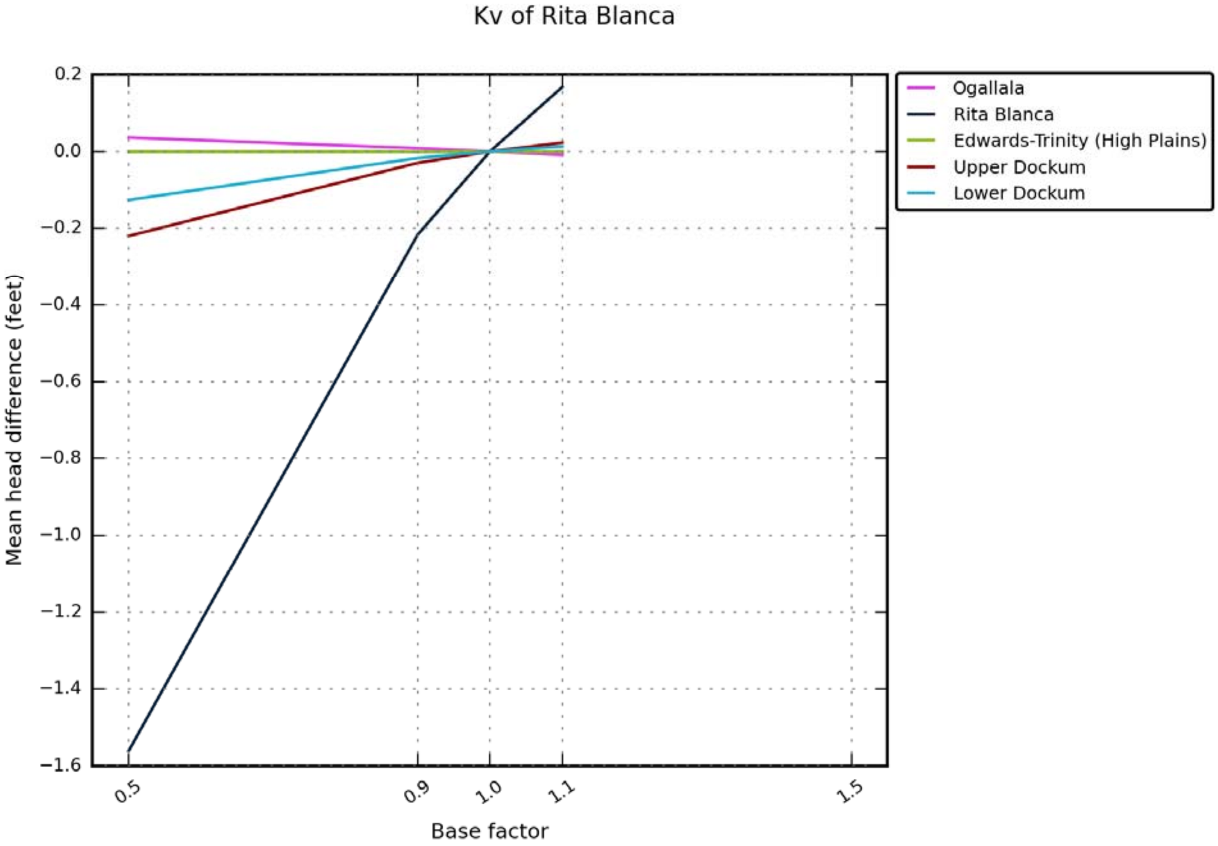


Figure 4.2.7 **Hydraulic head sensitivity in feet for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the Rita Blanca Aquifer.**

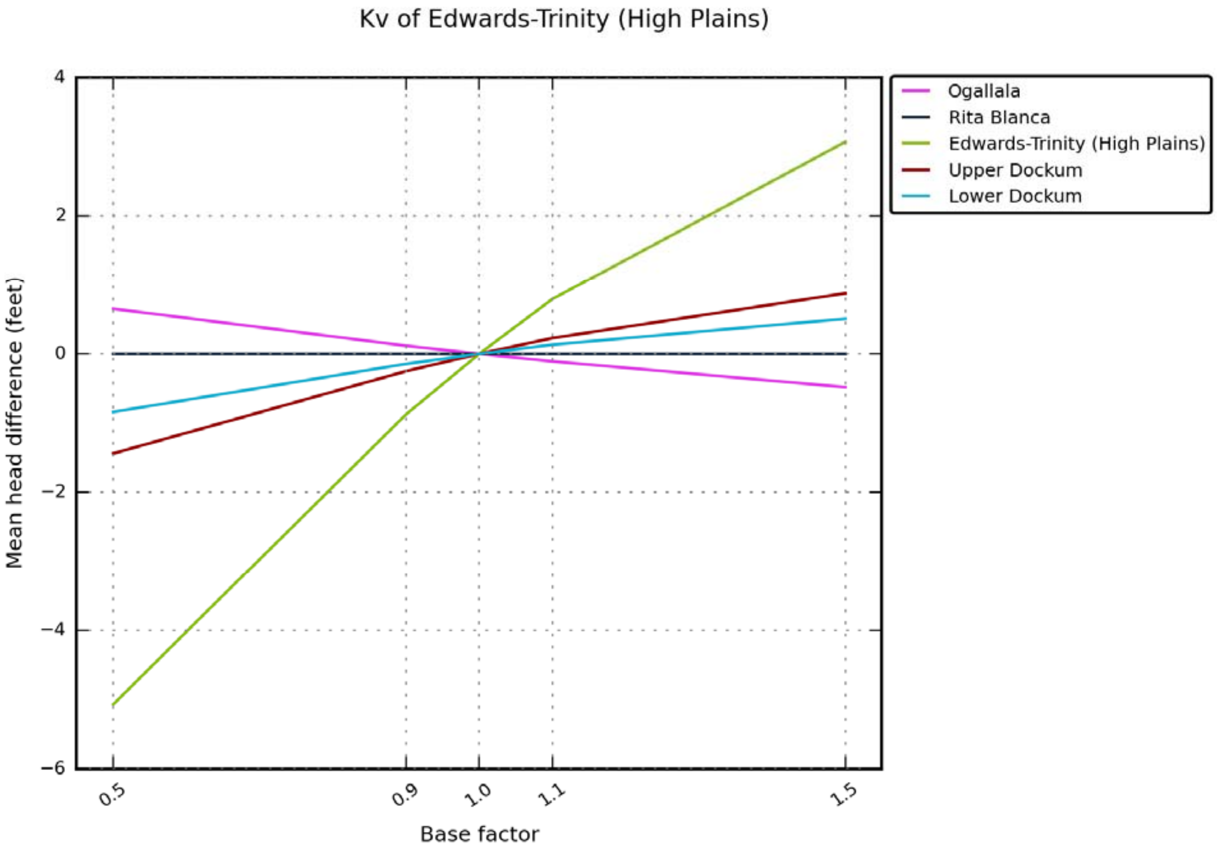


Figure 4.2.8 **Hydraulic head sensitivity in feet for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the Edwards-Trinity (High Plains) Aquifer.**

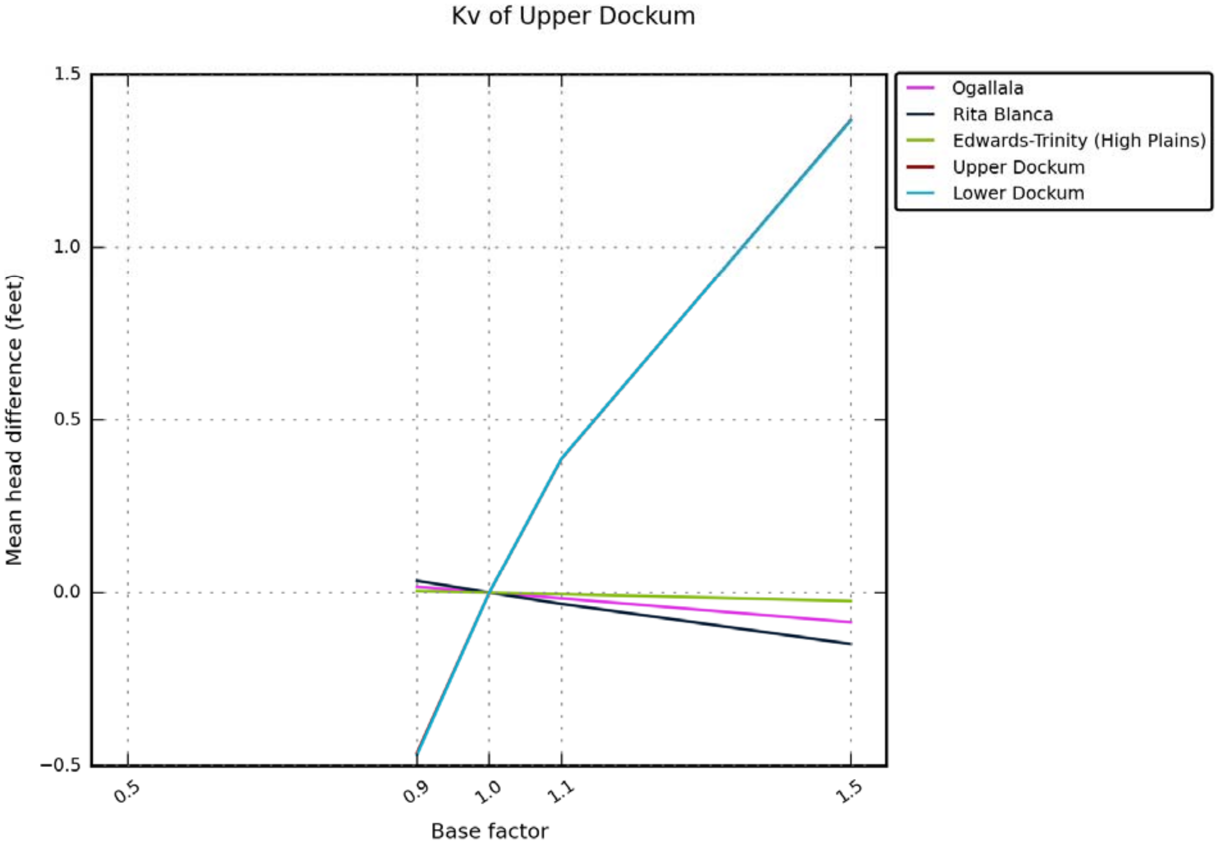


Figure 4.2.9 **Hydraulic head sensitivity in feet for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the upper Dockum Aquifer.**

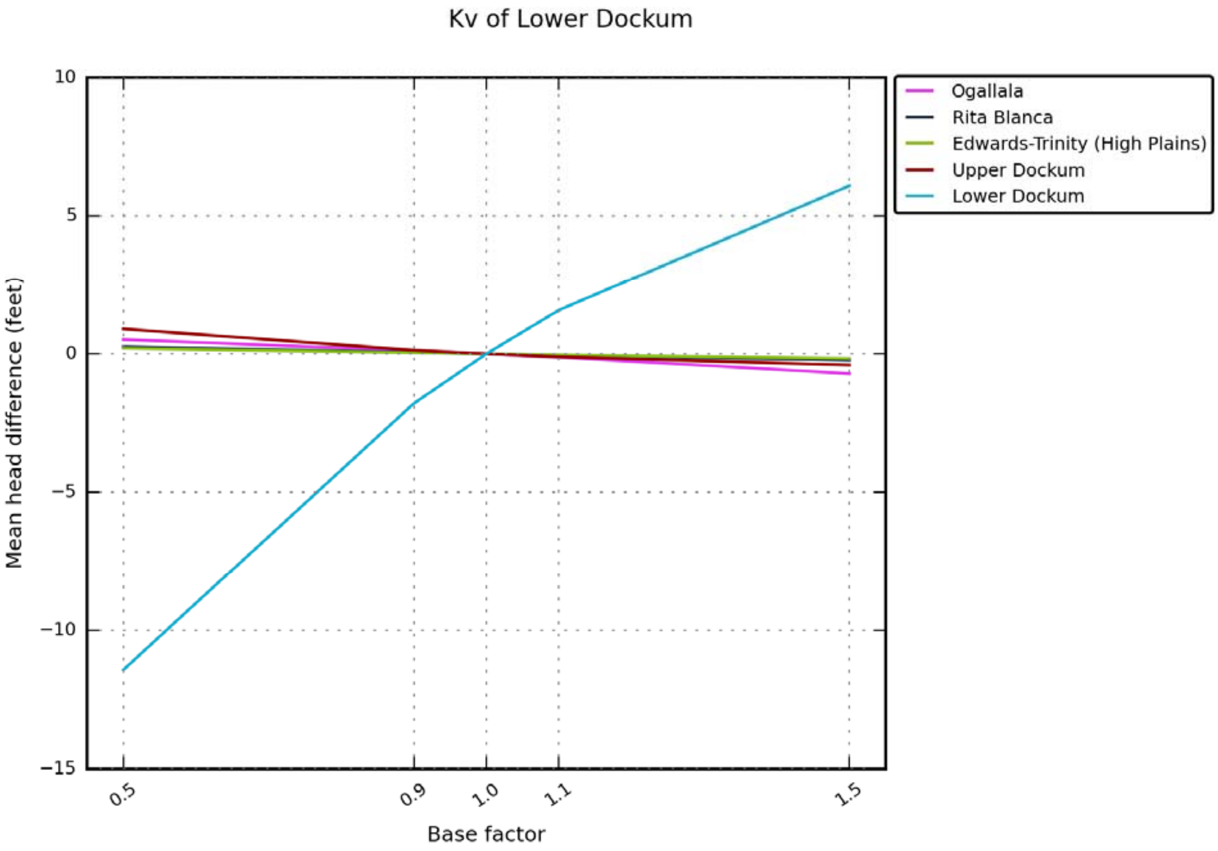


Figure 4.2.10 Hydraulic head sensitivity in feet for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the lower Dockum Aquifer.

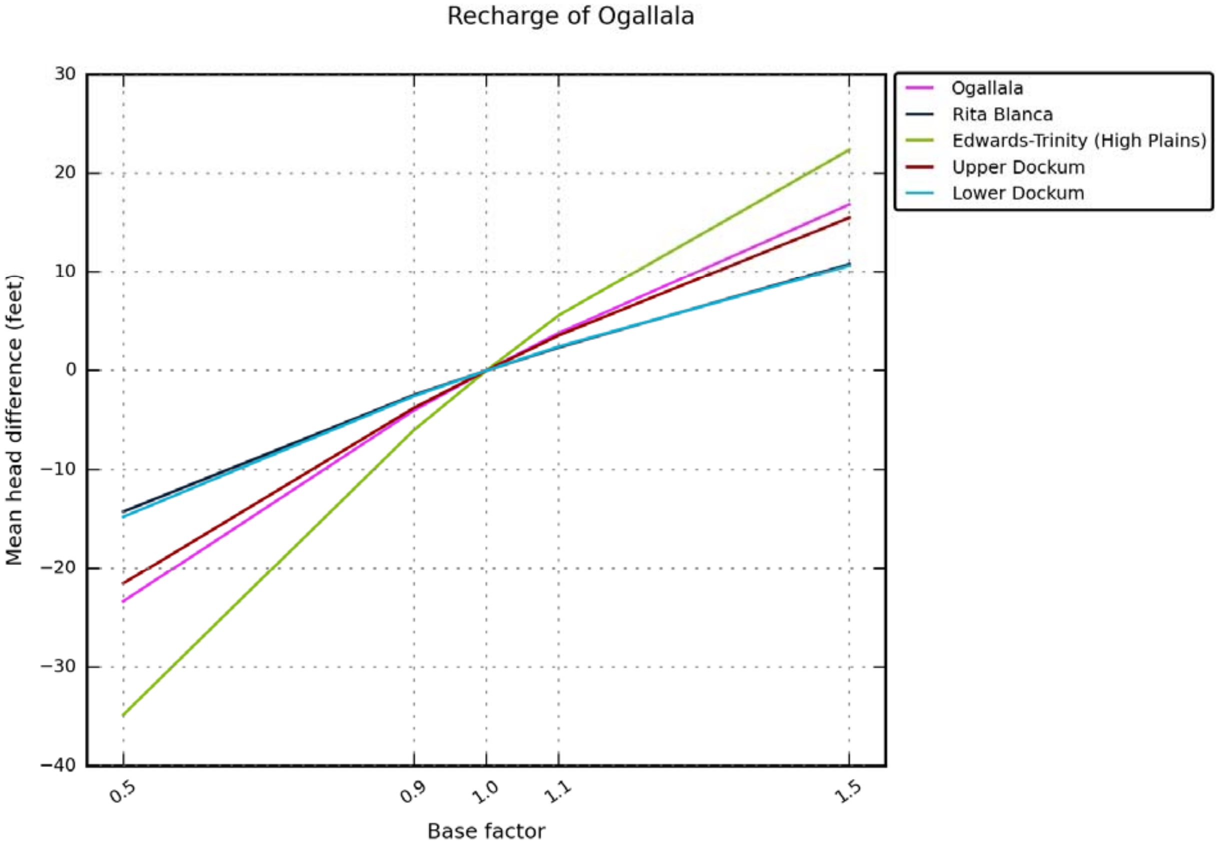


Figure 4.2.11 **Hydraulic head sensitivity in feet for the steady-state model to changes in recharge in the Ogallala Aquifer.**

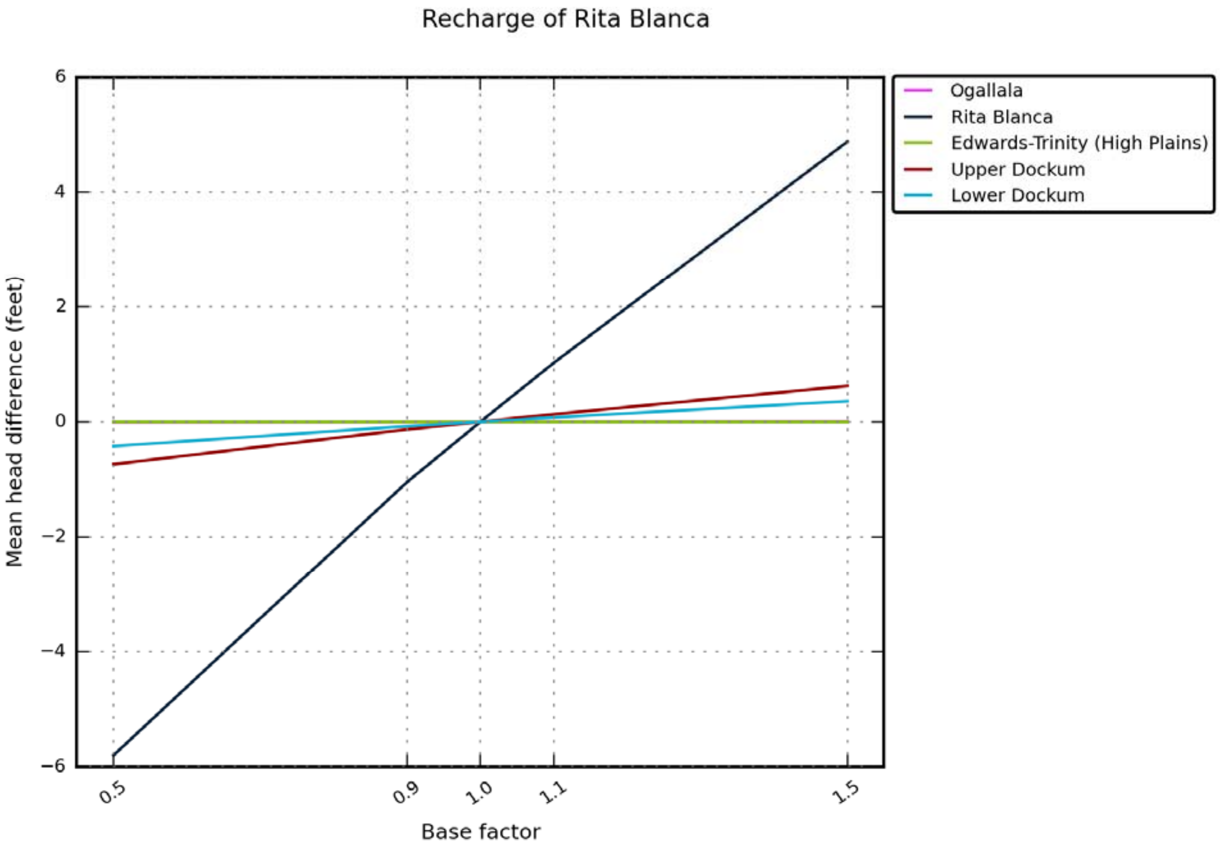


Figure 4.2.12 **Hydraulic head sensitivity in feet for the steady-state model to changes in recharge in the Rita Blanca Aquifer.**

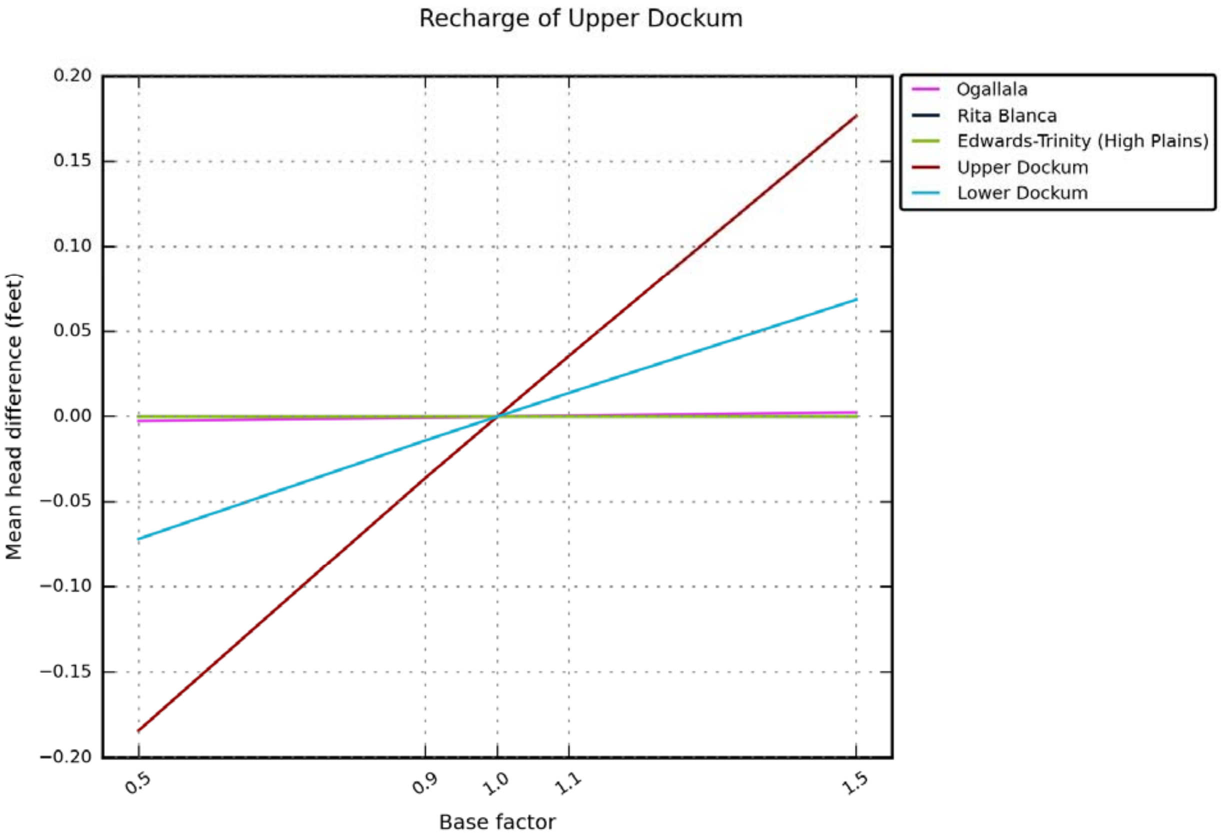


Figure 4.2.13 Hydraulic head sensitivity in feet for the steady-state model to changes in recharge in the upper Dockum Aquifer.

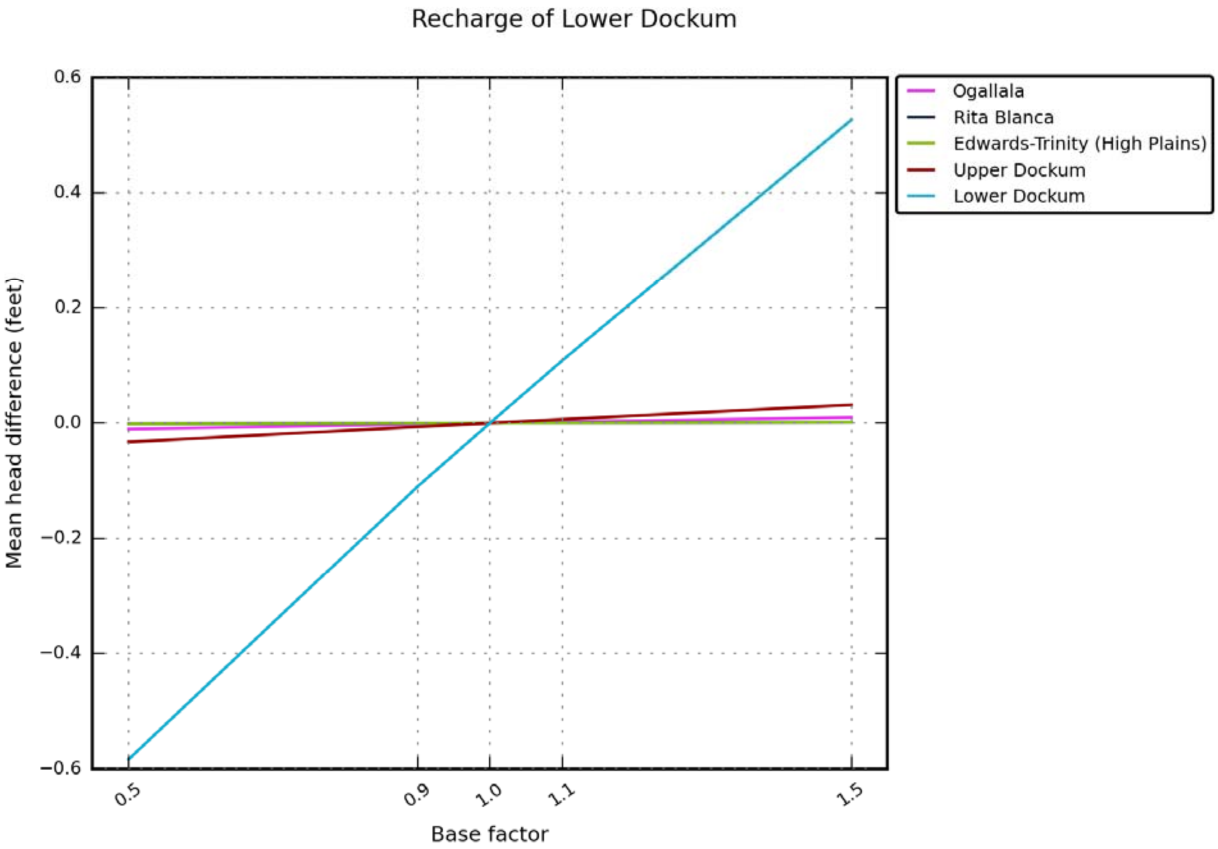


Figure 4.2.14 Hydraulic head sensitivity in feet for the steady-state model to changes in recharge in the lower Dockum Aquifer.

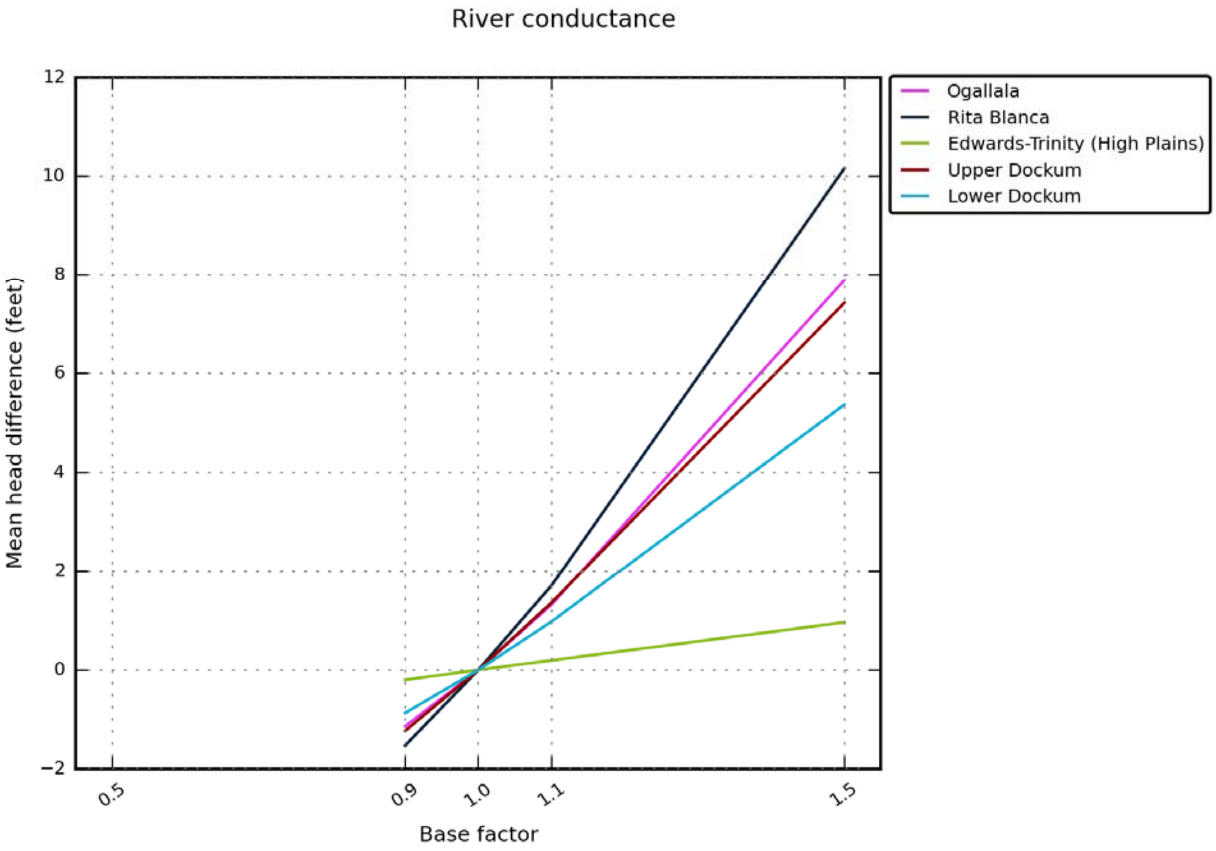


Figure 4.2.15 Hydraulic head sensitivity in feet for the steady-state model to changes in river boundary conductance.

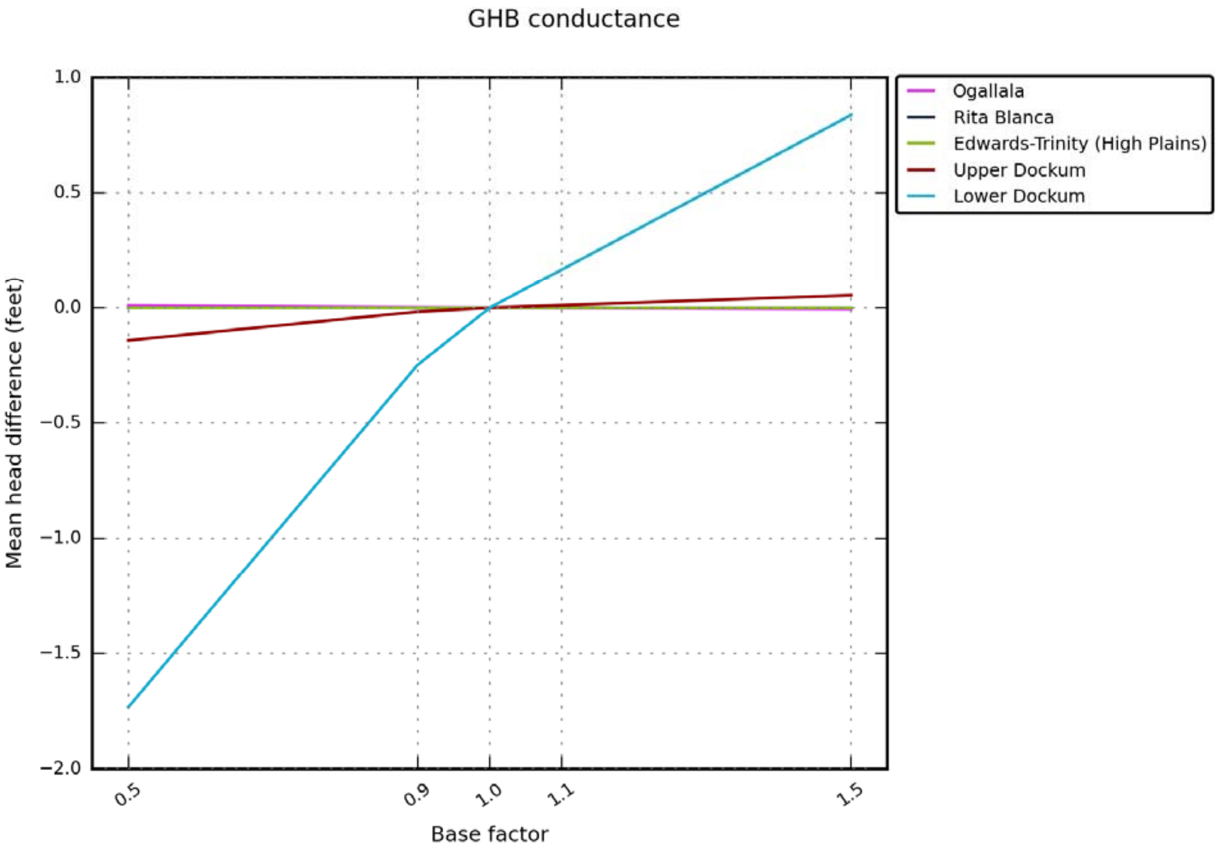


Figure 4.2.16 **Hydraulic head sensitivity in feet for the steady-state model to changes in river boundary conductance, representing river boundaries as general-head boundaries (GHB).**

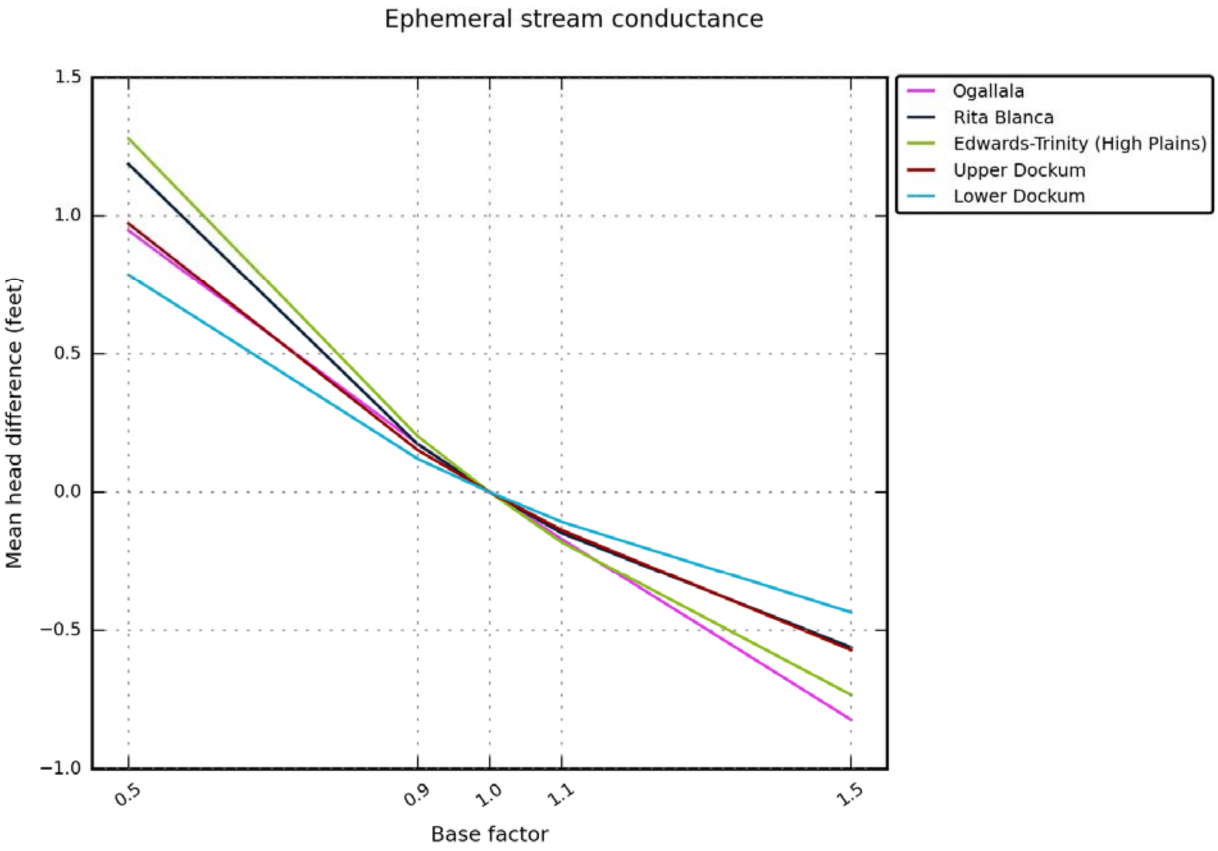


Figure 4.2.17 **Hydraulic head sensitivity in feet for the steady-state model to changes in drain boundary conductance, representing ephemeral streams.**

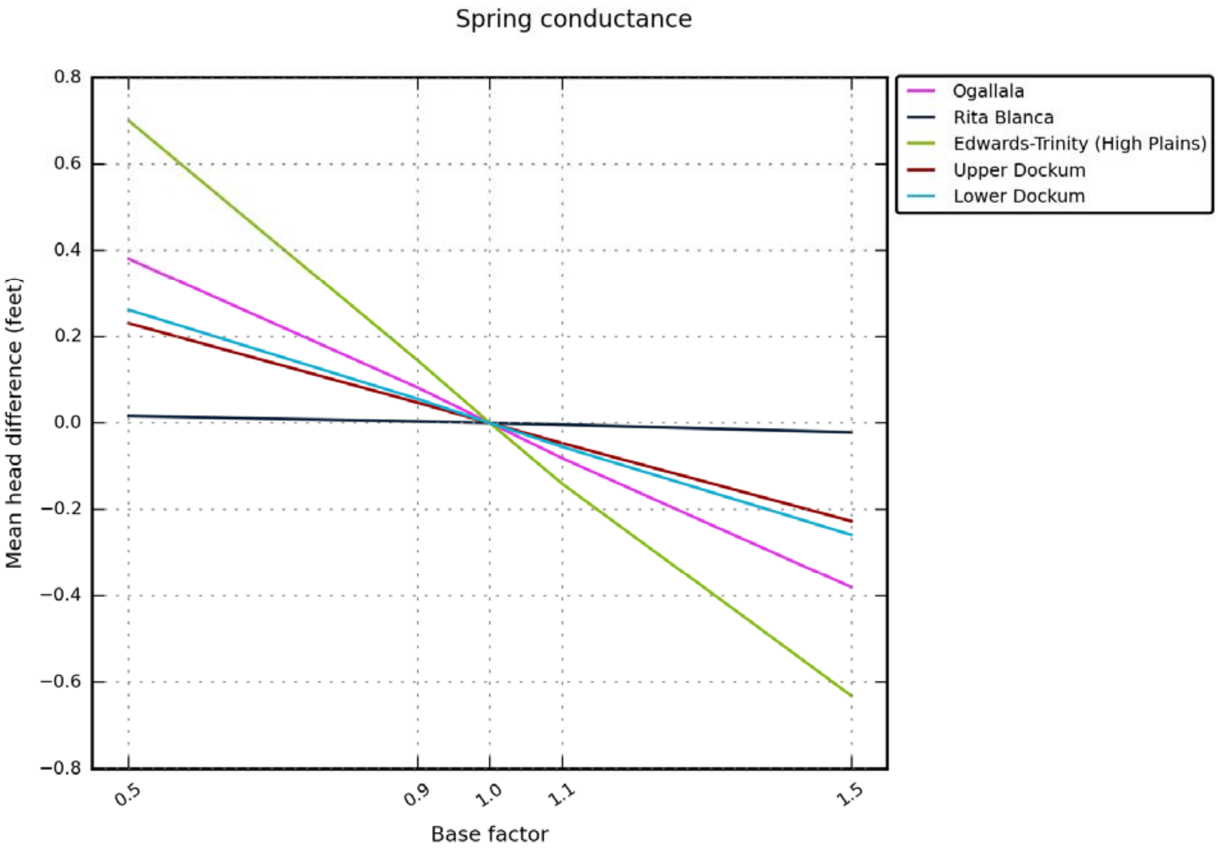


Figure 4.2.18 Hydraulic head sensitivity in feet for the steady-state model to changes in drain boundary conductance, representing springs.

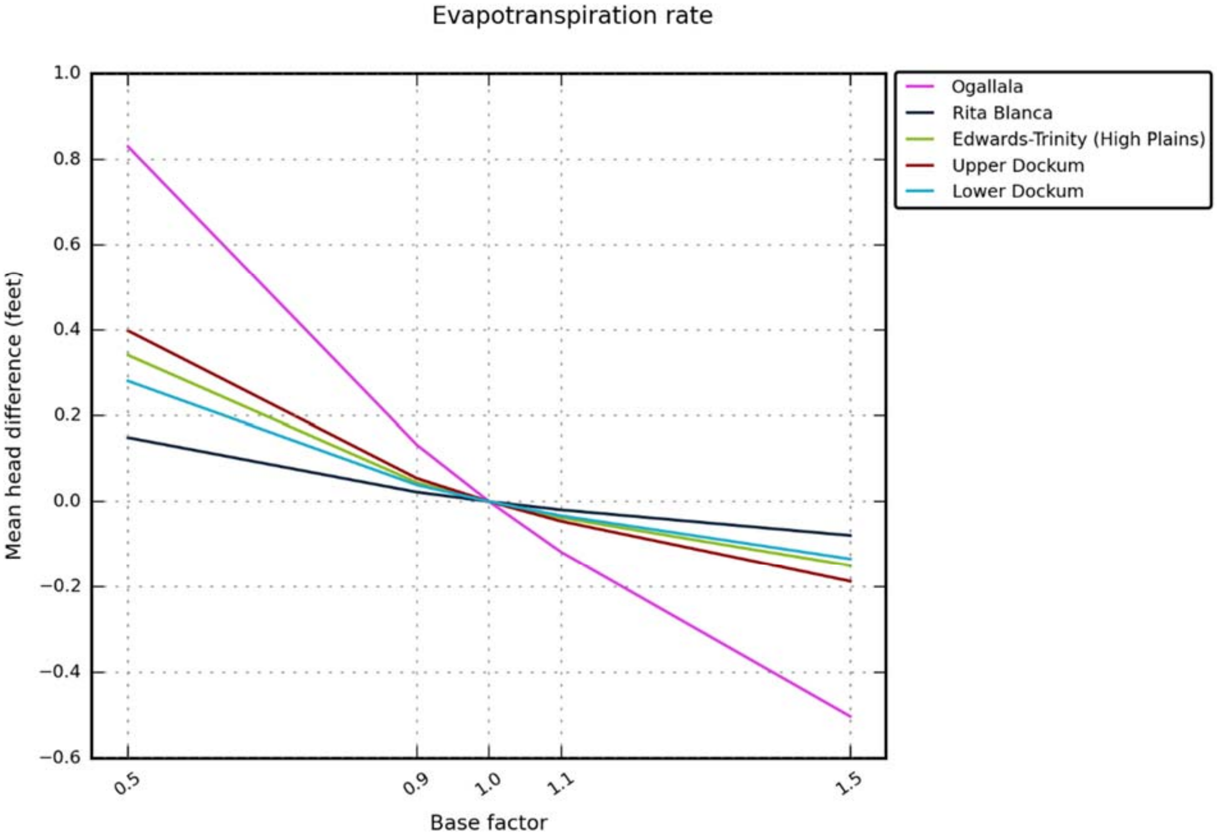


Figure 4.2.19 Hydraulic head sensitivity in feet for the steady-state model to changes in maximum evapotranspiration rate.

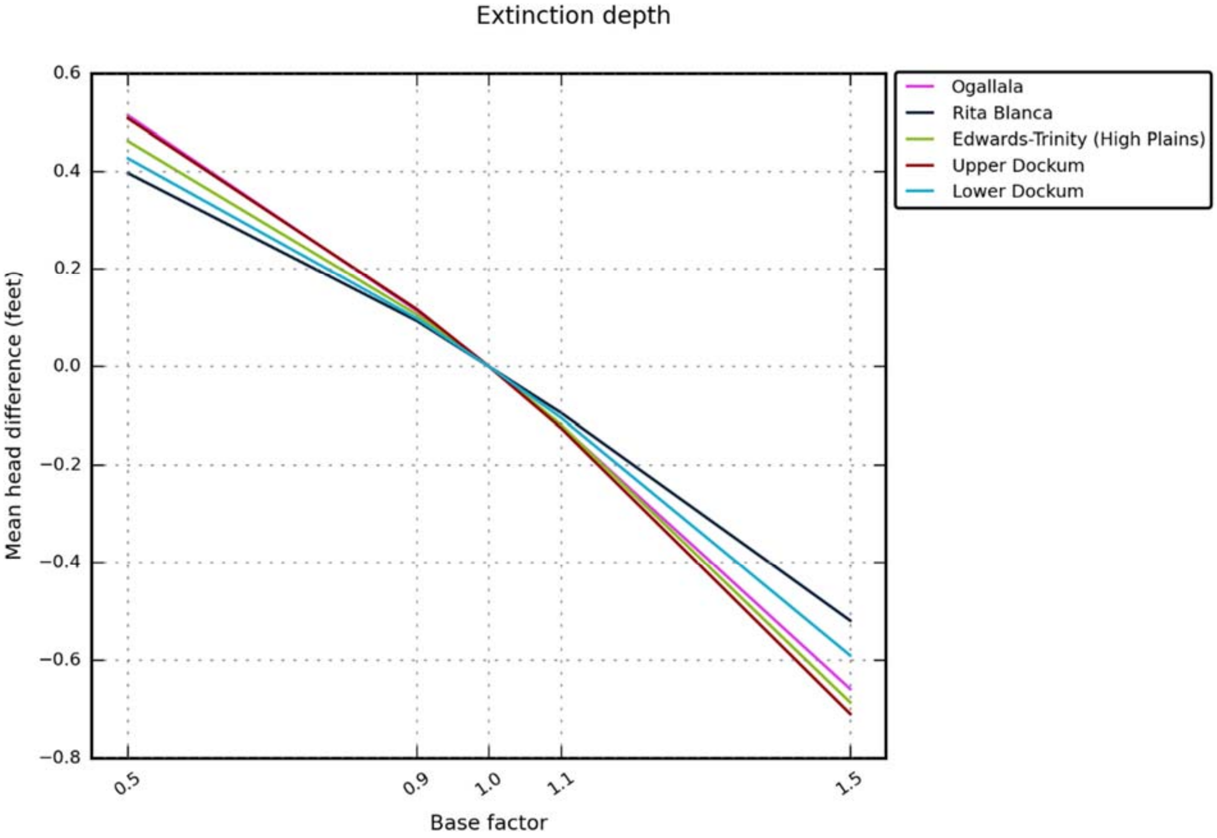


Figure 4.2.20 **Hydraulic head sensitivity in feet for the steady-state model to changes in evapotranspiration extinction depth.**

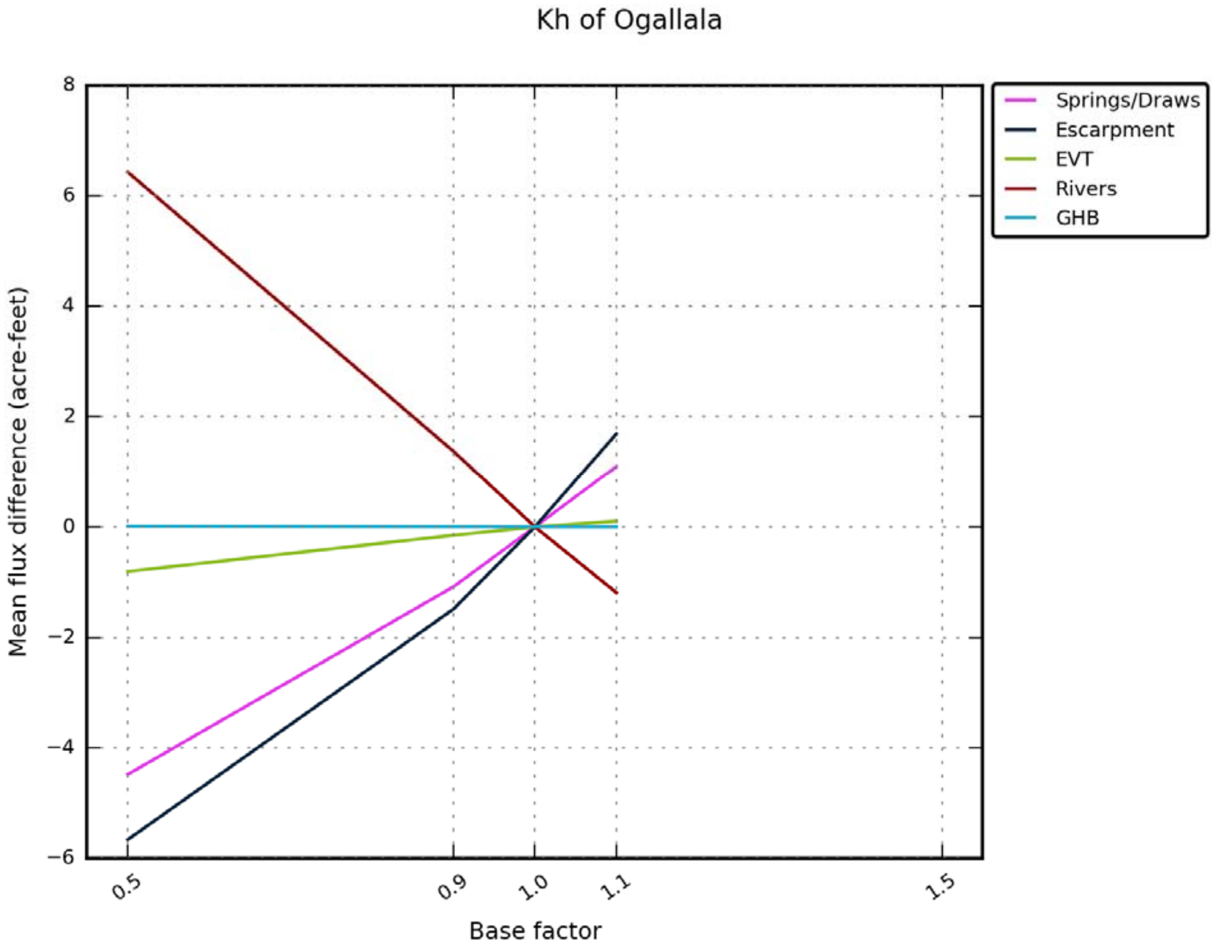


Figure 4.2.21 Flow sensitivity in acre-feet per year for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

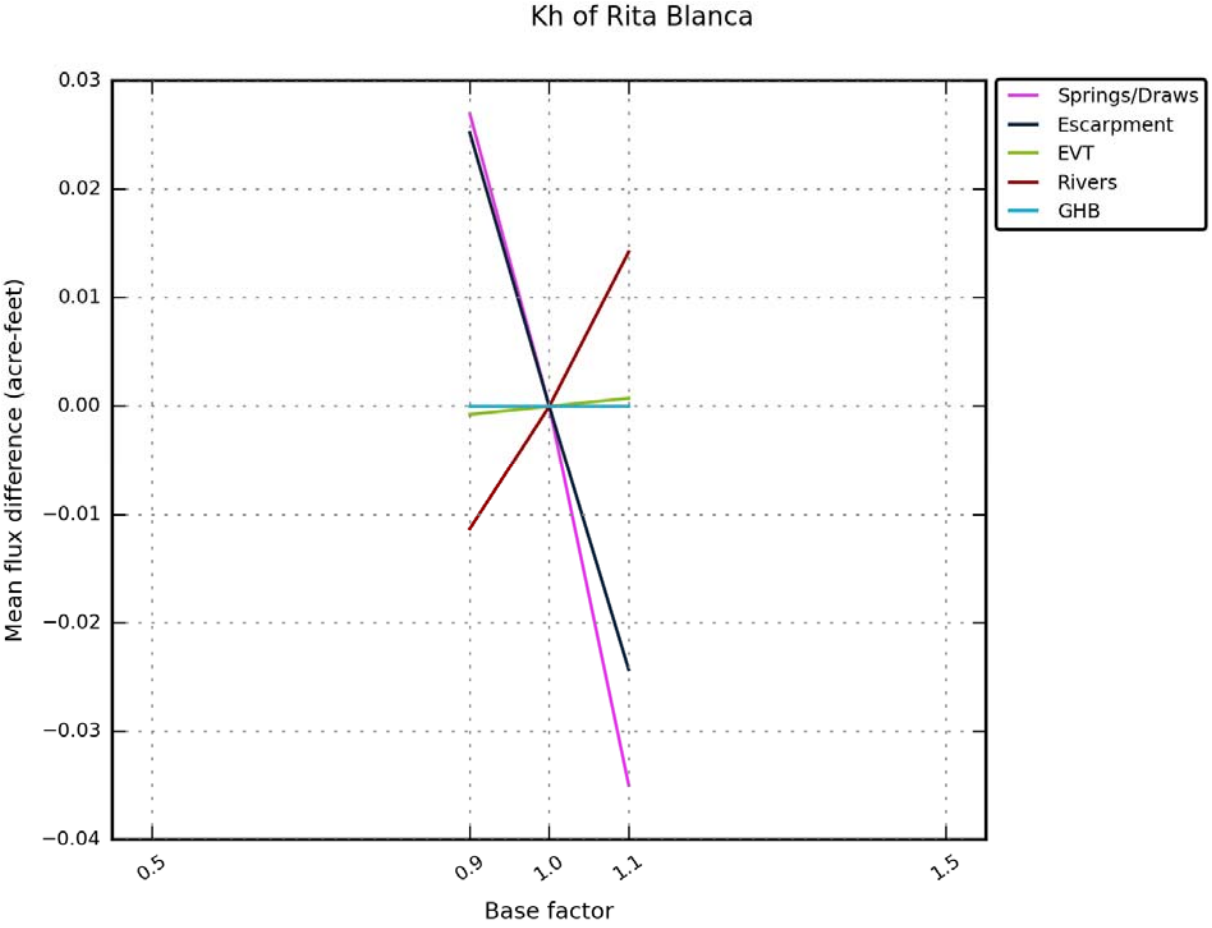


Figure 4.2.22 Flow sensitivity in acre-feet per year for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the Rita Blanca Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

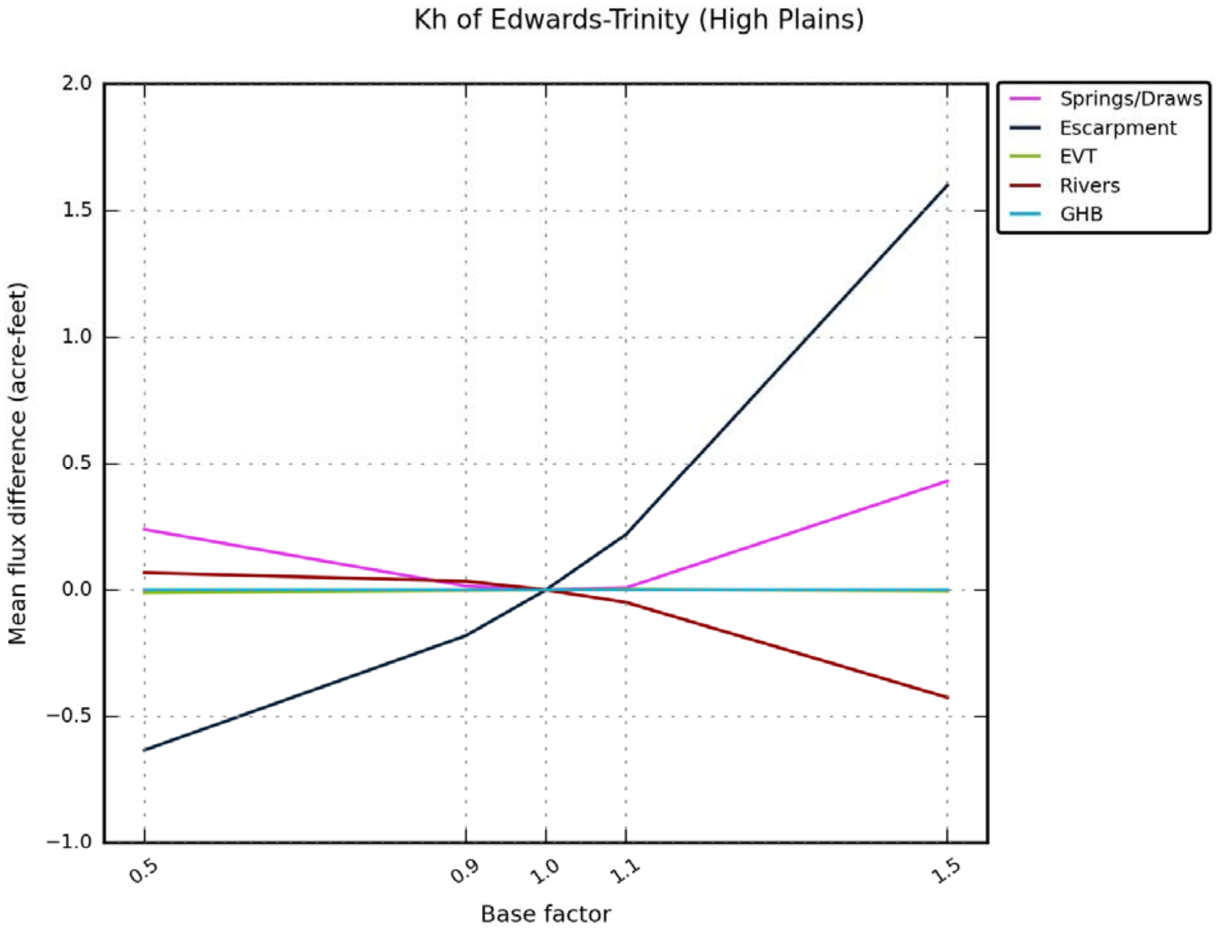


Figure 4.2.23 **Flow sensitivity in acre-feet per year for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the Edwards-Trinity (High Plains) Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

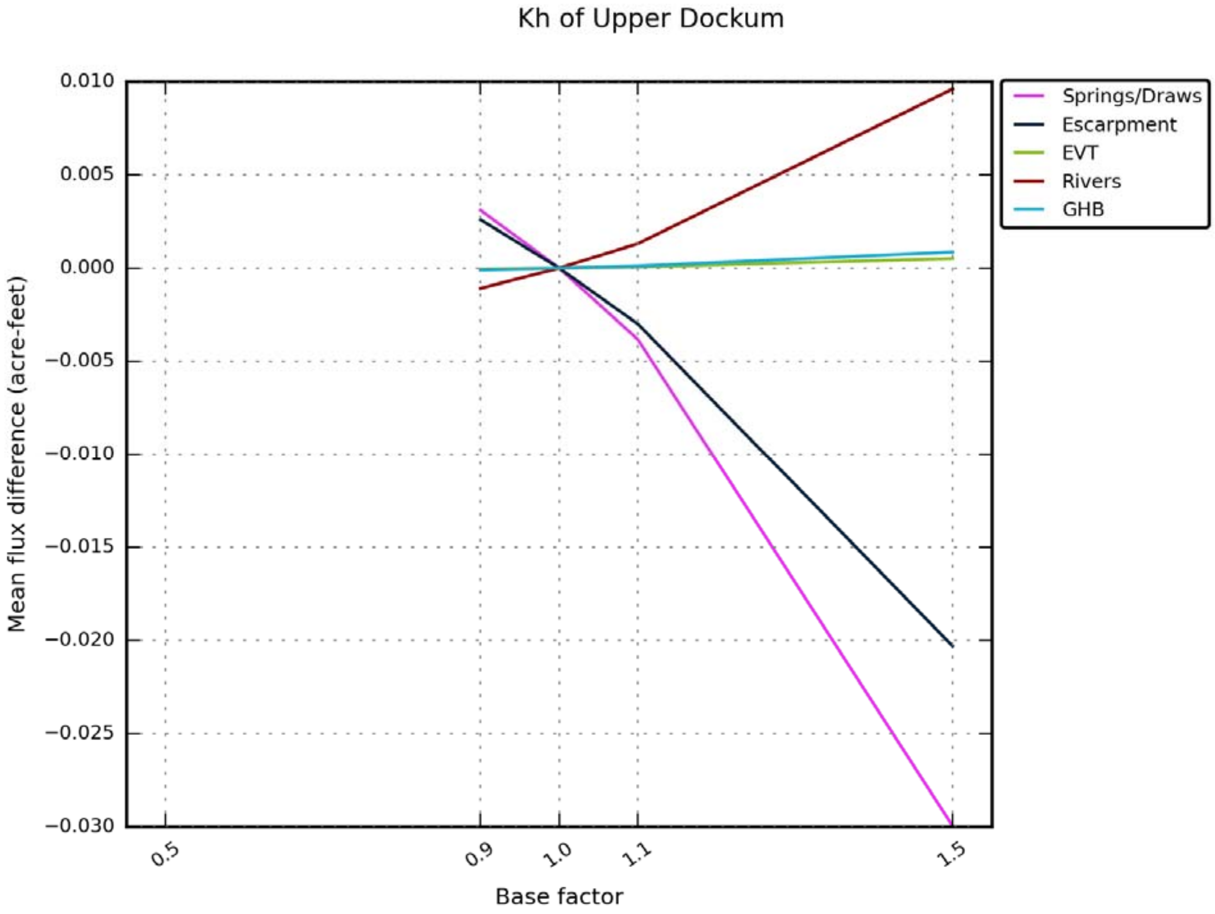


Figure 4.2.24 **Flow sensitivity in acre-feet per year for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the upper Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

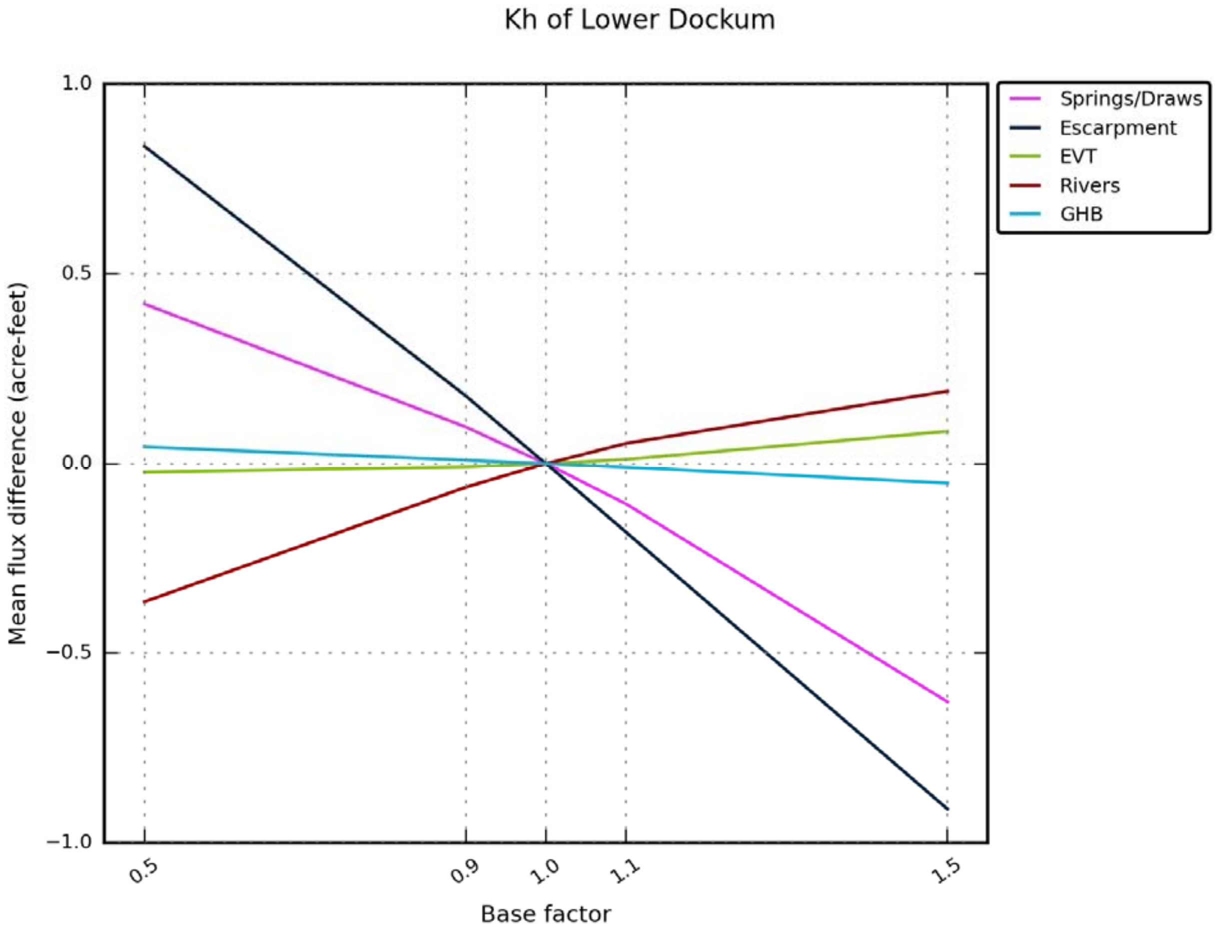


Figure 4.2.25 **Flow sensitivity in acre-feet per year for the steady-state model to changes in horizontal hydraulic conductivity (Kh) of the lower Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

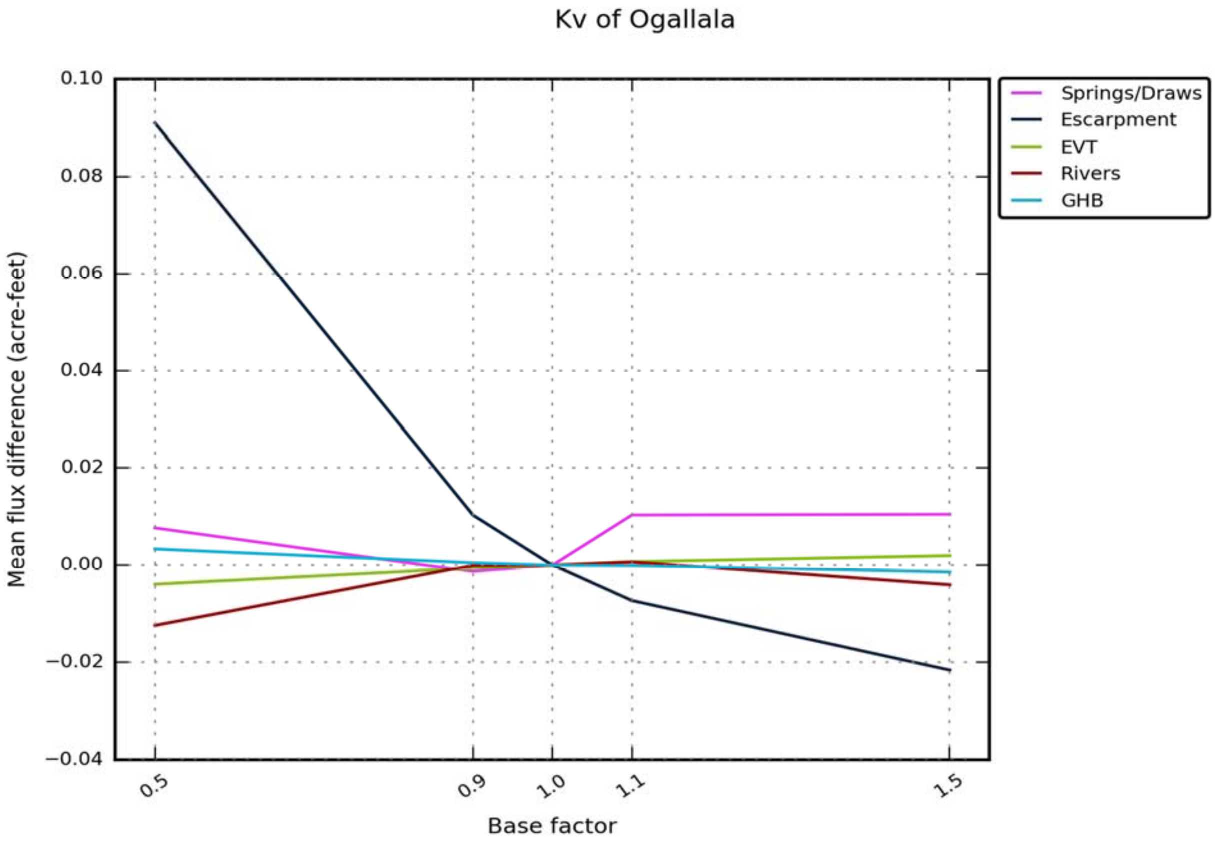


Figure 4.2.26 **Flow sensitivity in acre-feet per year for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

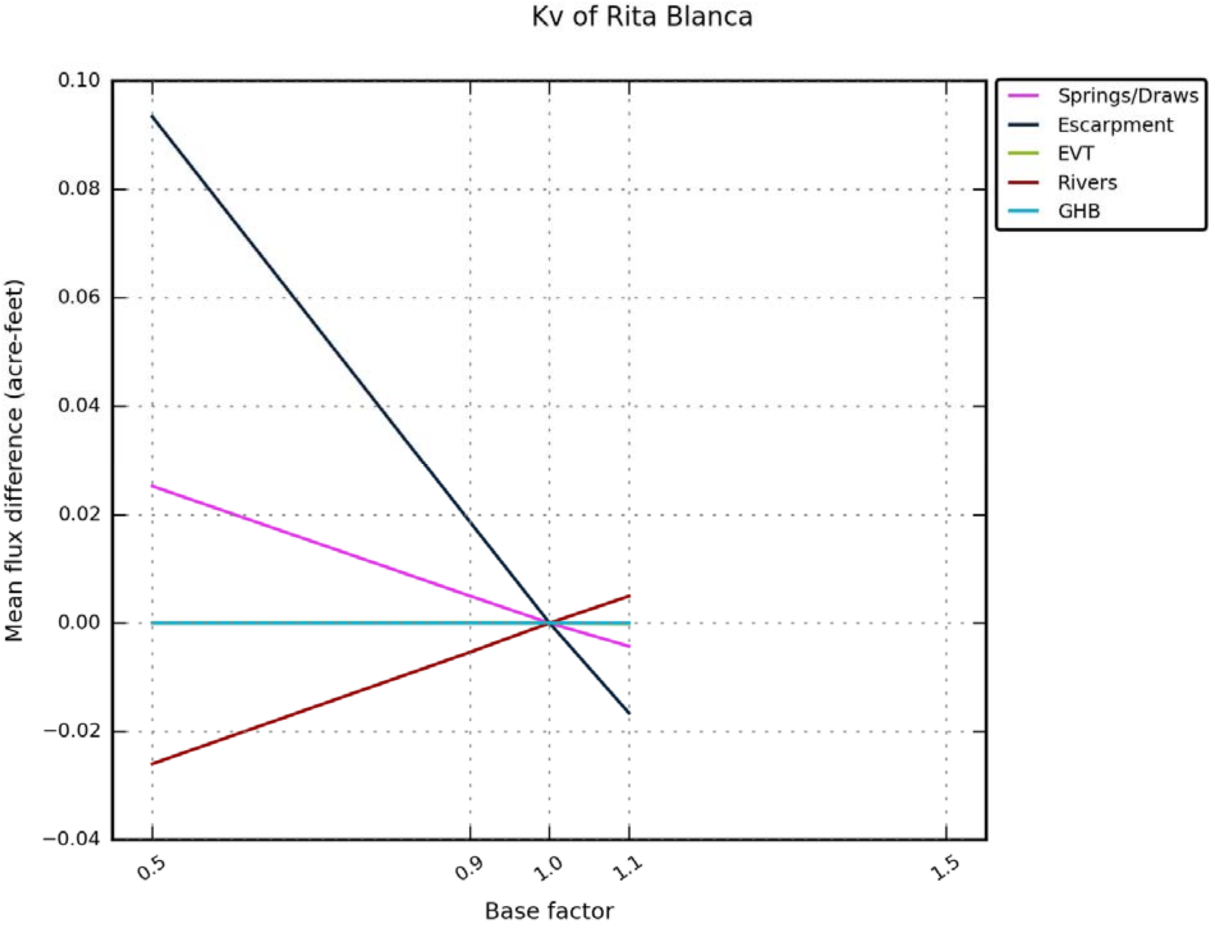


Figure 4.2.27 **Flow sensitivity in acre-feet per year for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the Rita Blanca Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

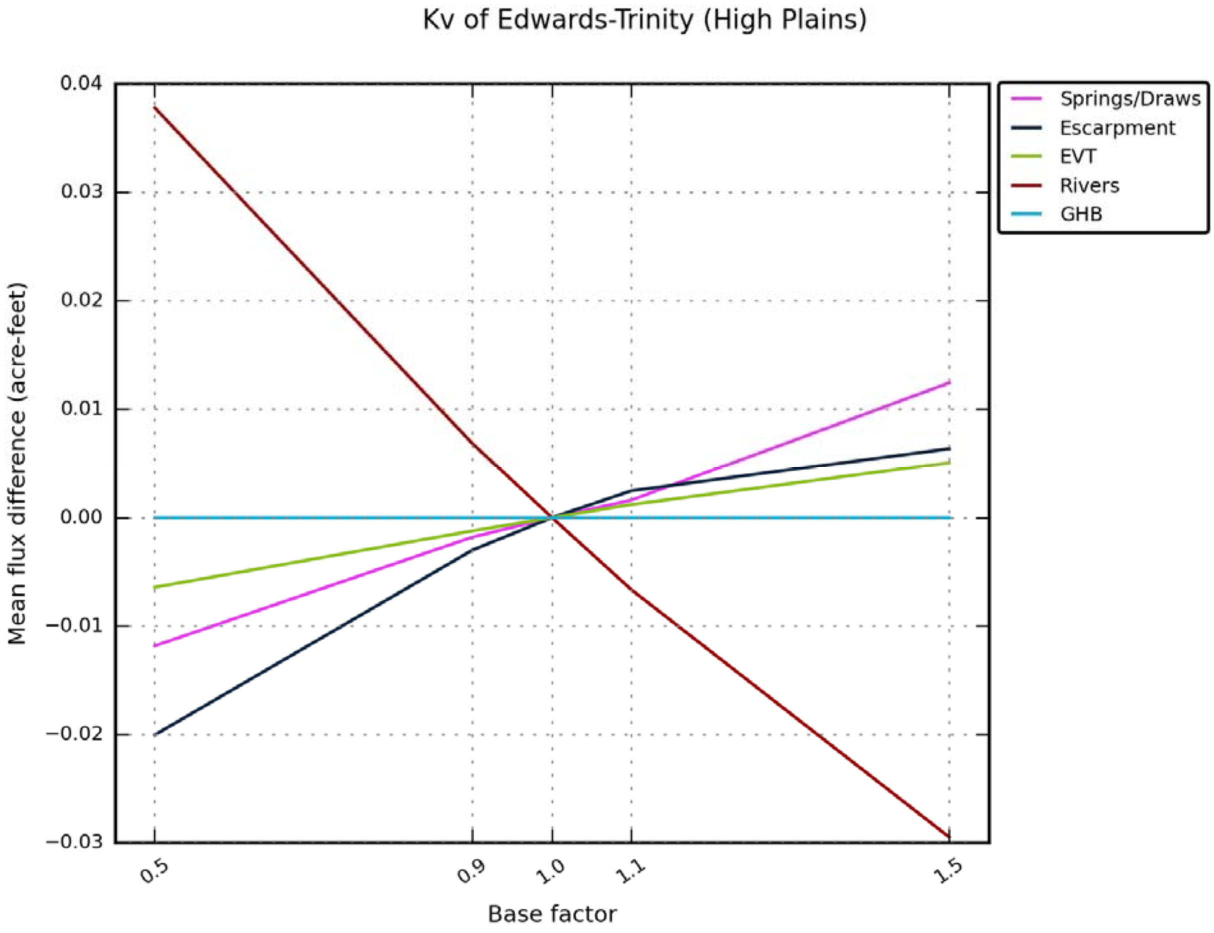


Figure 4.2.28 **Flow sensitivity in acre-feet per year for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the Edwards-Trinity (High Plains) Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

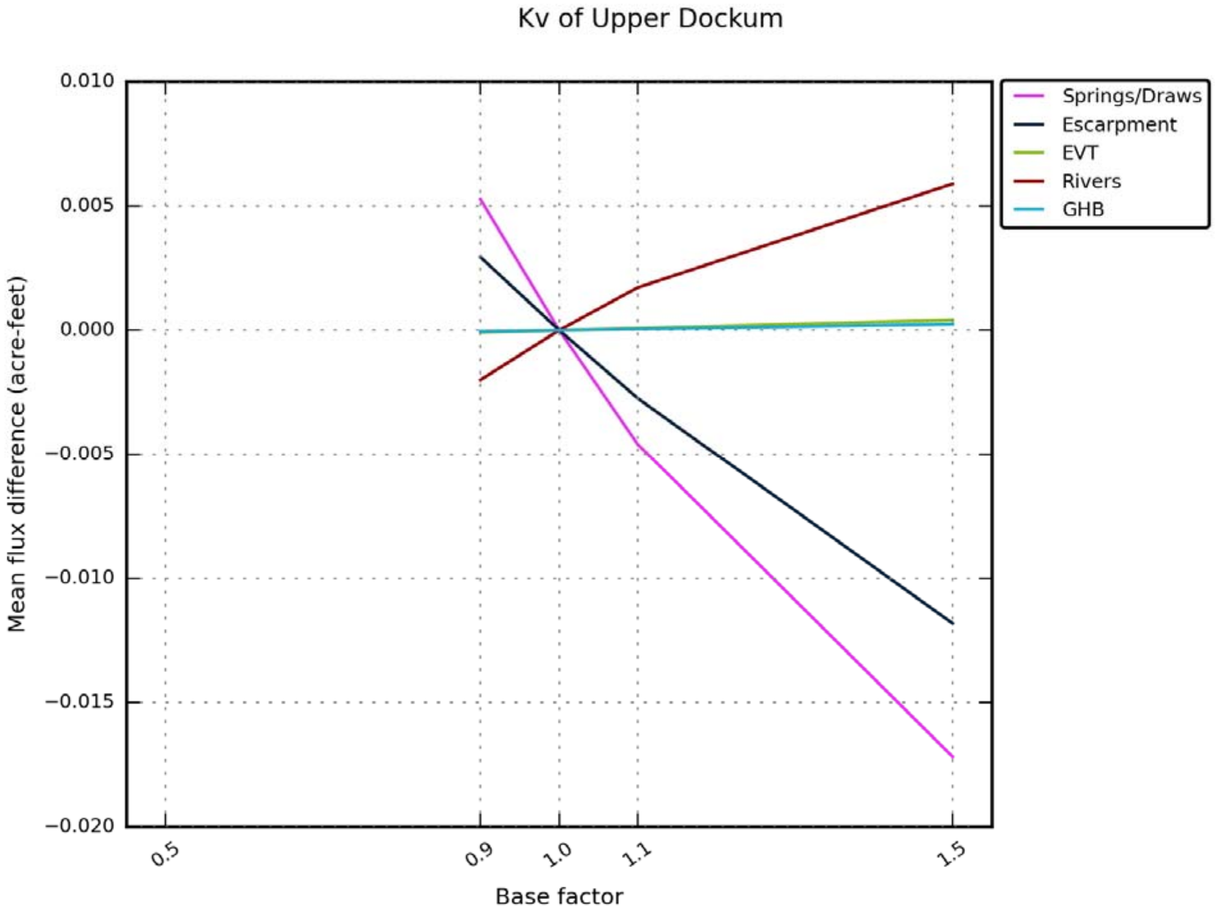


Figure 4.2.29 Flow sensitivity in acre-feet per year for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the upper Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

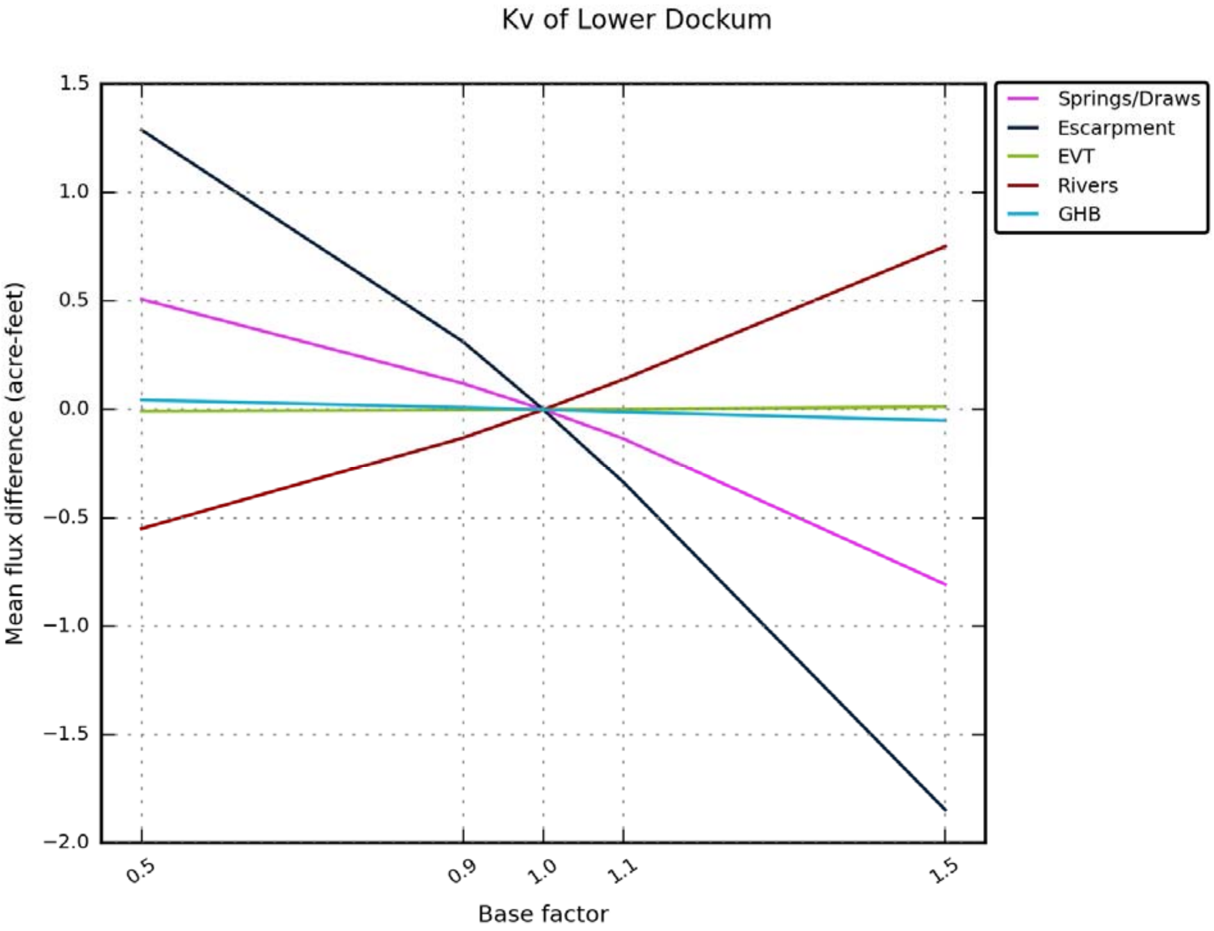


Figure 4.2.30 **Flow sensitivity in acre-feet per year for the steady-state model to changes in vertical hydraulic conductivity (Kv) of the lower Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

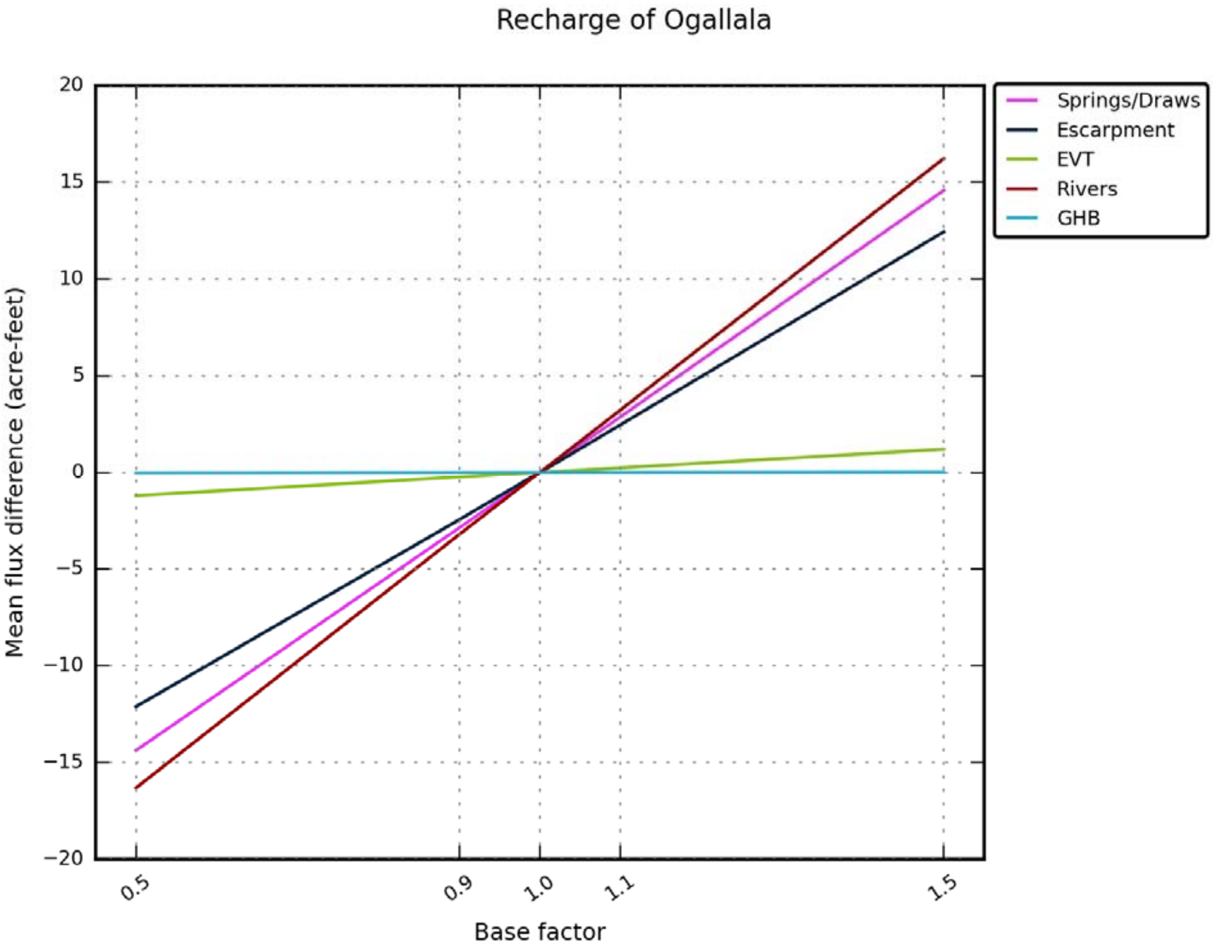


Figure 4.2.31 **Flow sensitivity in acre-feet per year for the steady-state model to changes in recharge in the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

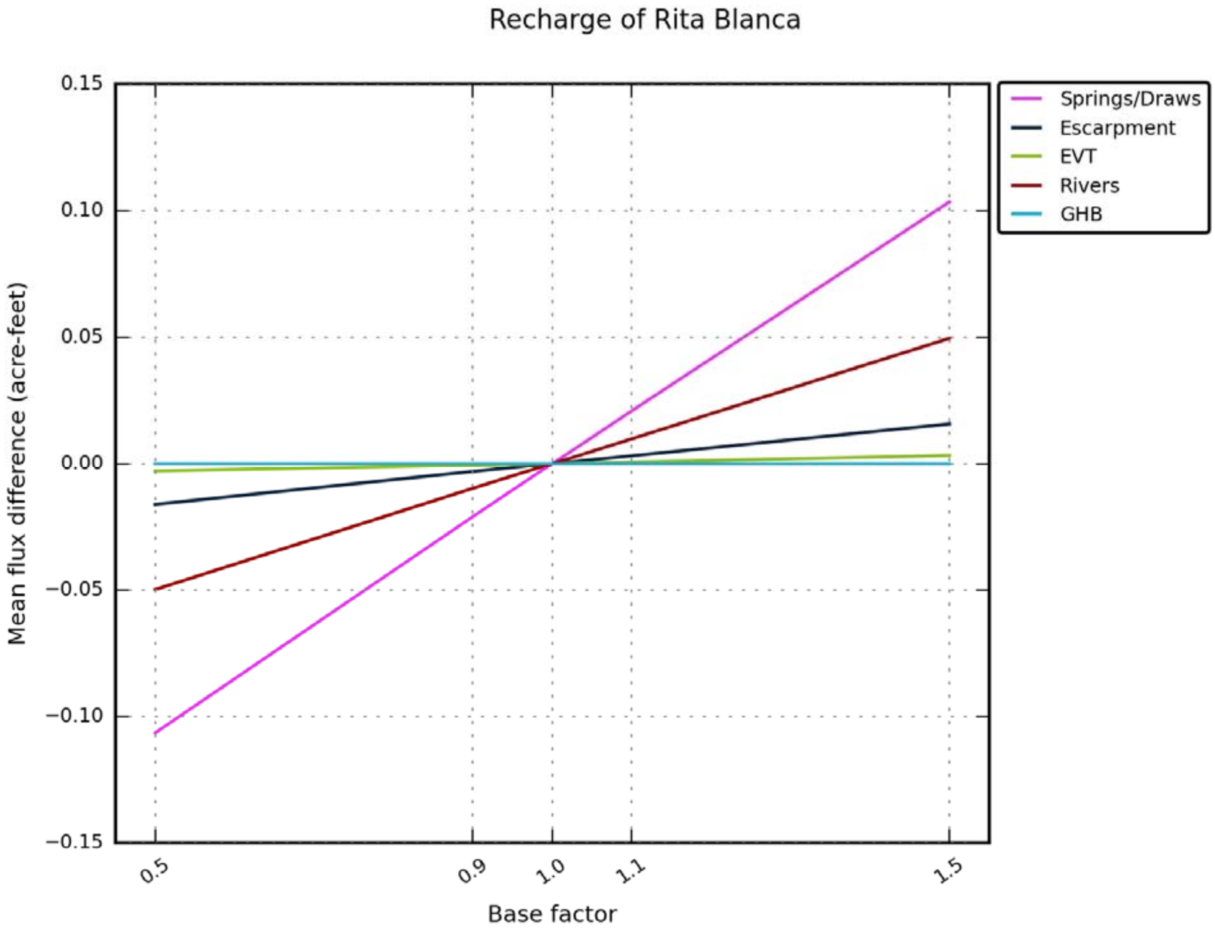


Figure 4.2.32 **Flow sensitivity in acre-feet per year for the steady-state model to changes in recharge in the Rita Blanca Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

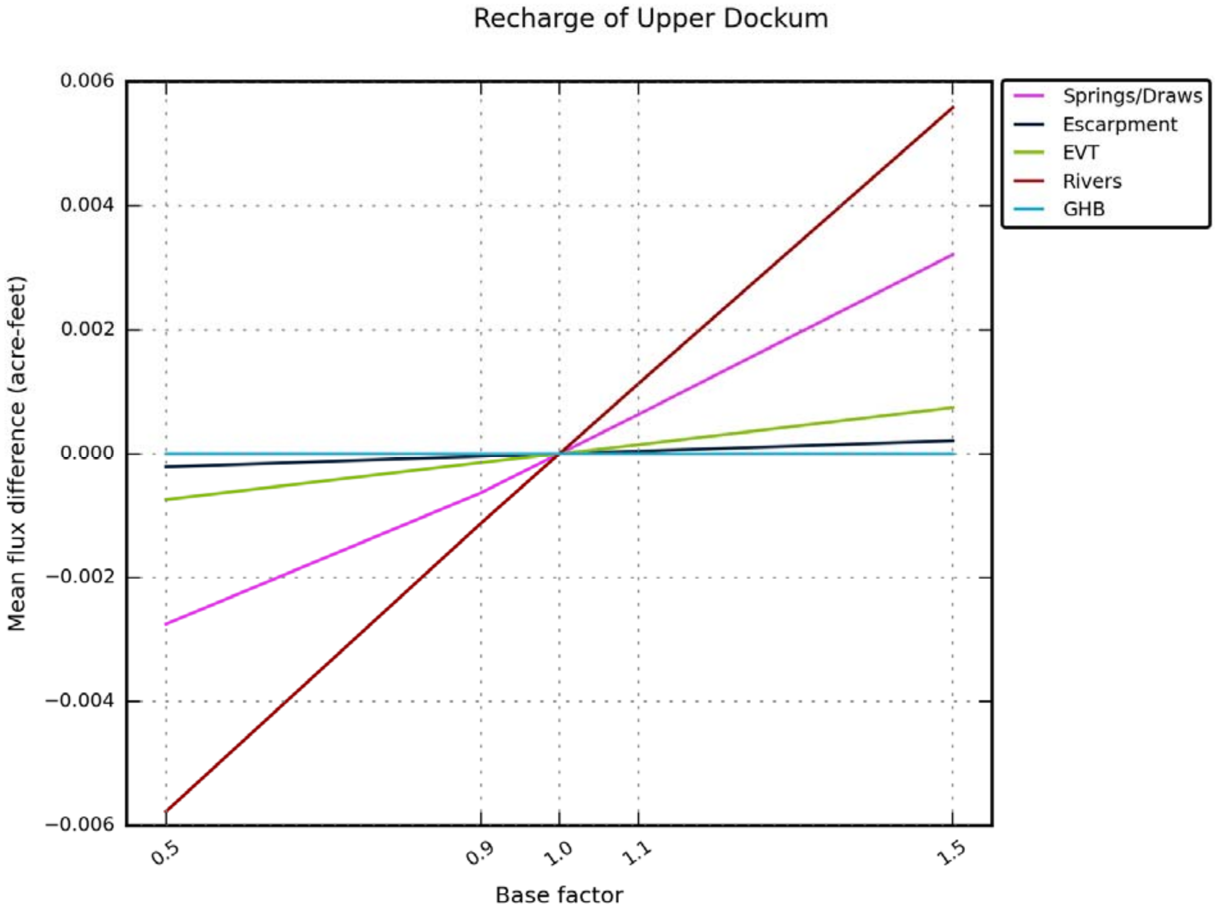


Figure 4.2.33 **Flow sensitivity in acre-feet per year for the steady-state model to changes in recharge in the upper Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

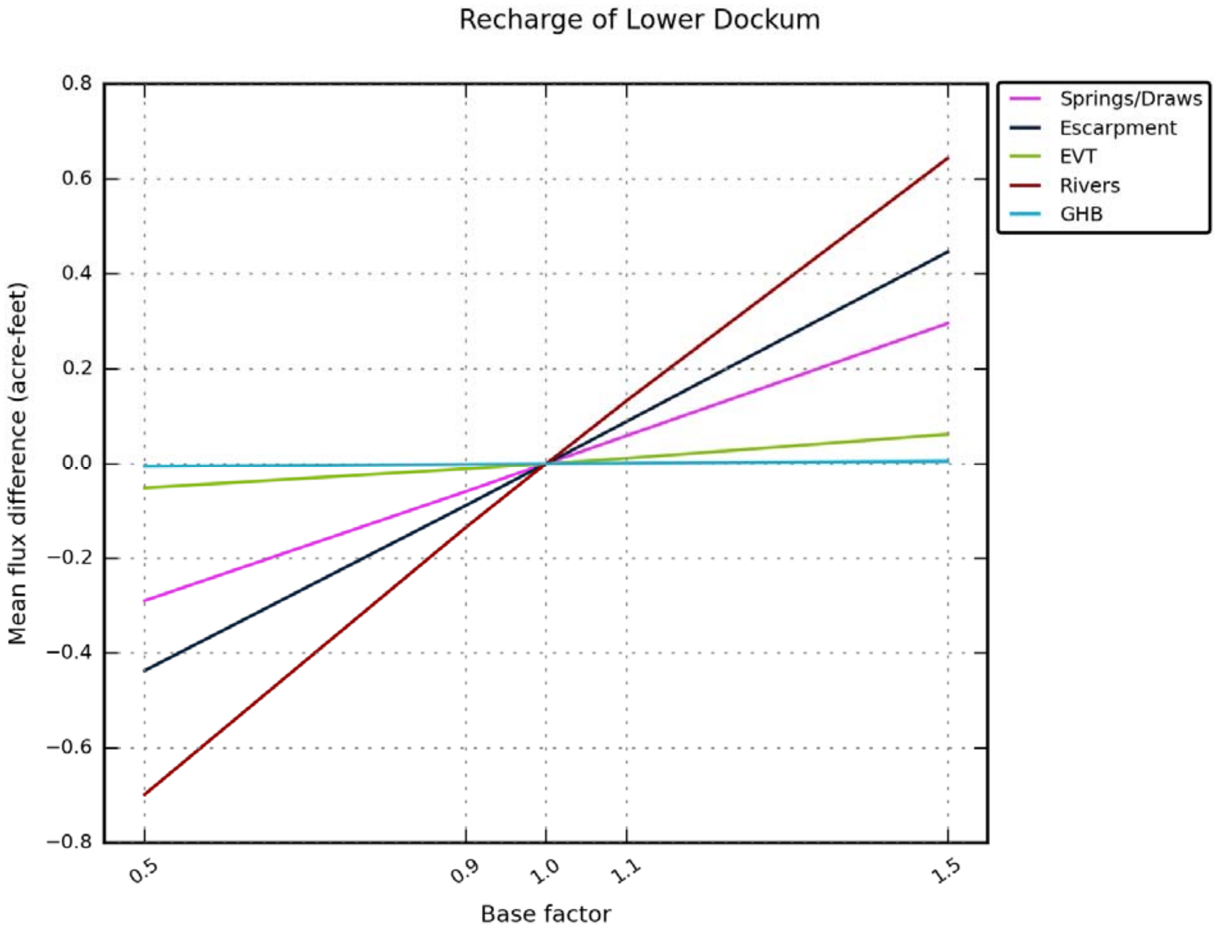


Figure 4.2.34 **Flow sensitivity in acre-feet per year for the steady-state model to changes in recharge in the lower Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

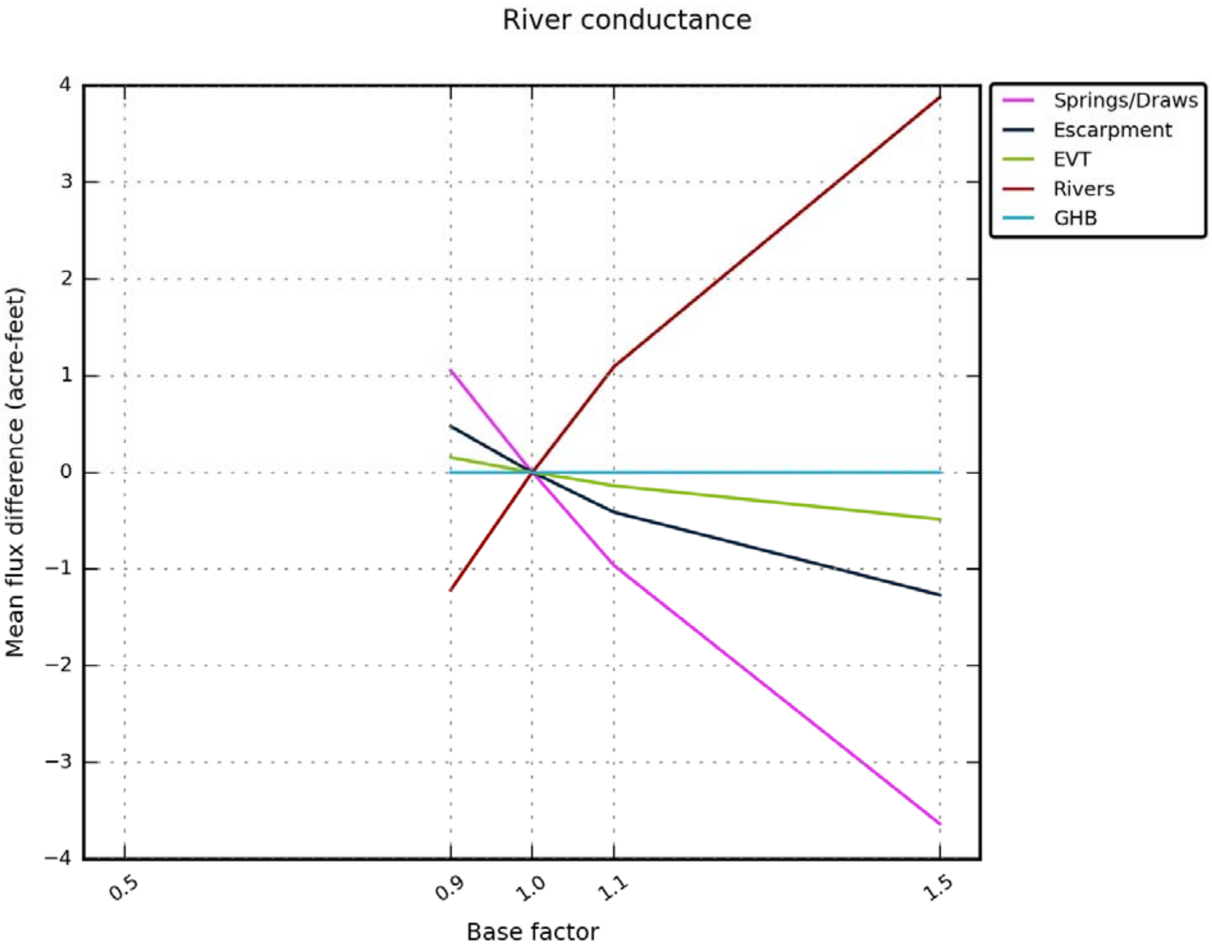


Figure 4.2.35 **Flow sensitivity in acre-feet per year for the steady-state model to changes in river boundary conductance. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

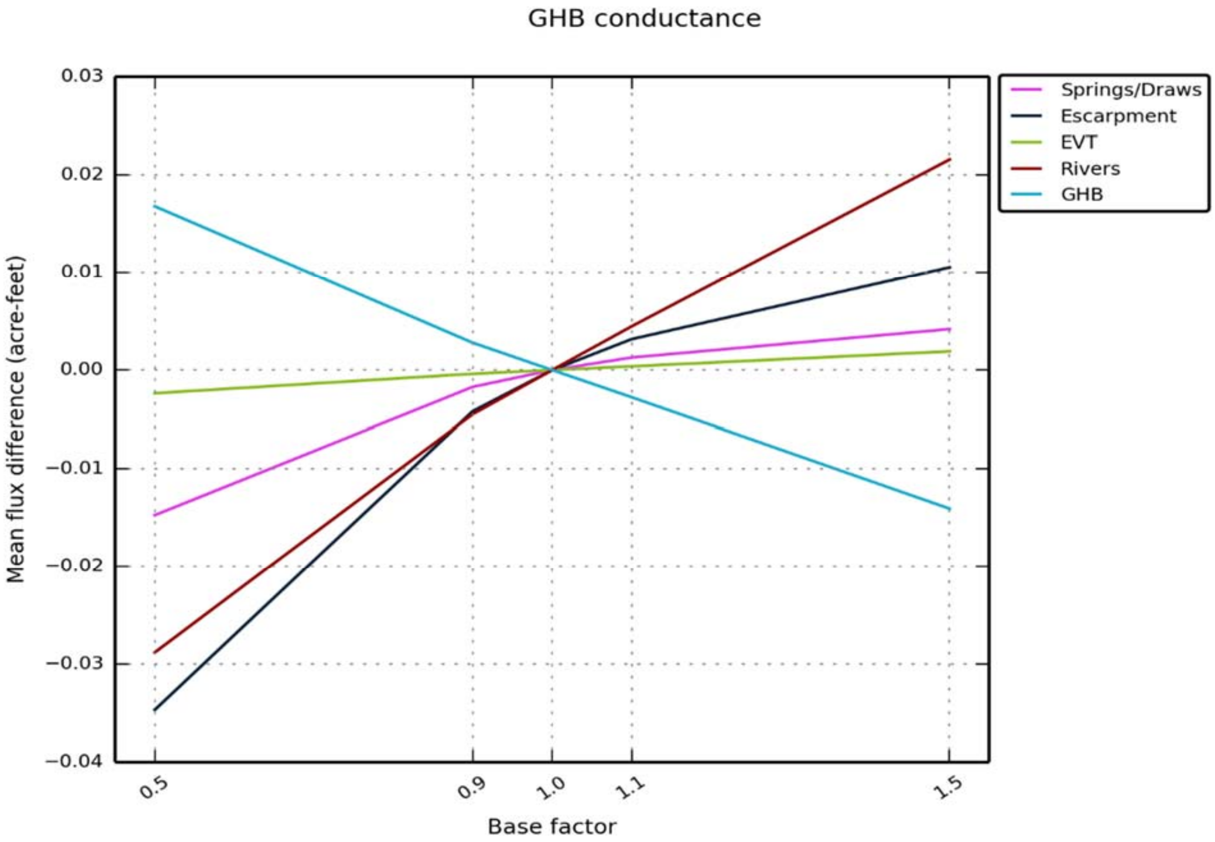


Figure 4.2.36 **Flow sensitivity in acre-feet per year for the steady-state model to changes in river boundary conductance, representing river boundaries as general-head boundaries. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

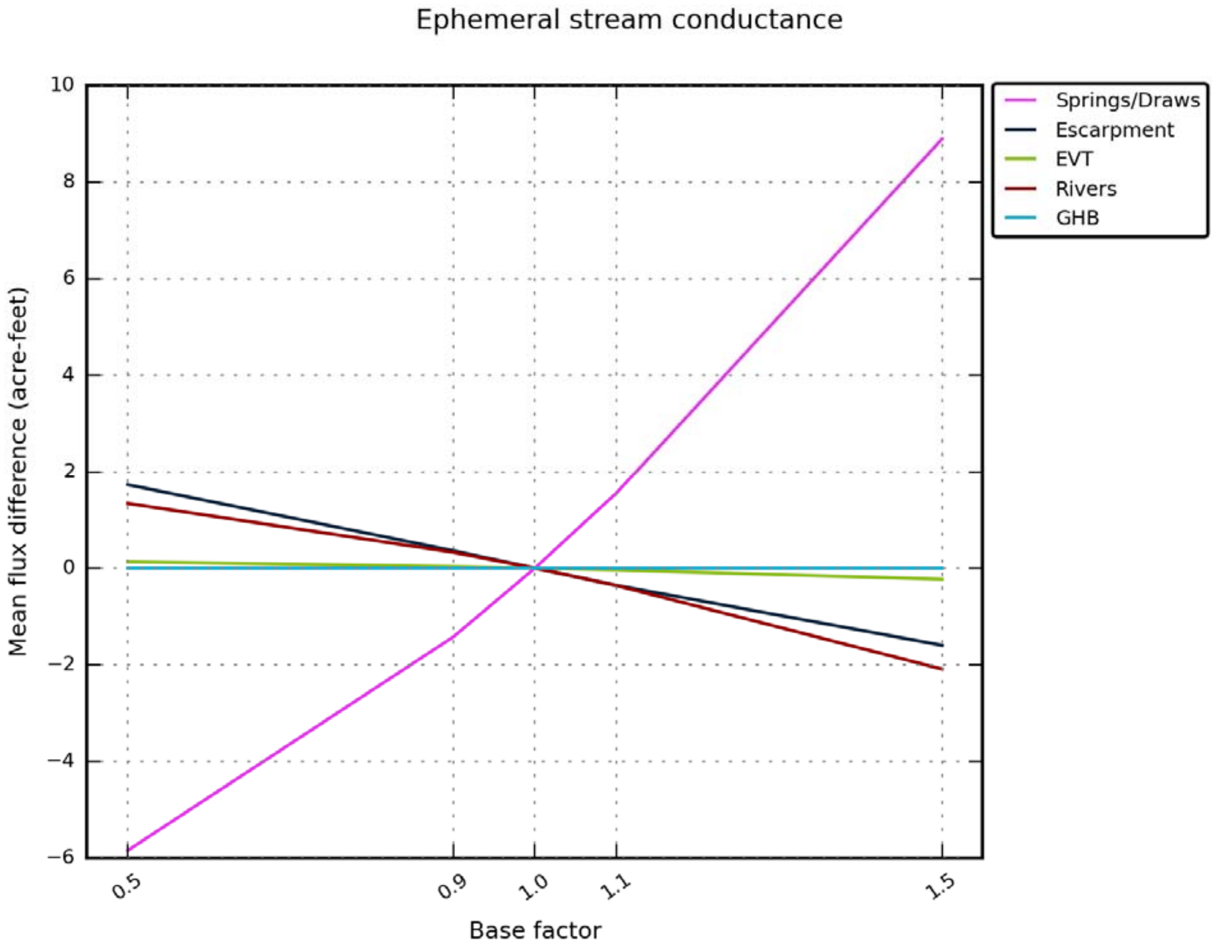


Figure 4.2.37 Flow sensitivity in acre-feet per year for the steady-state model to changes in drain boundary conductance, representing ephemeral streams. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

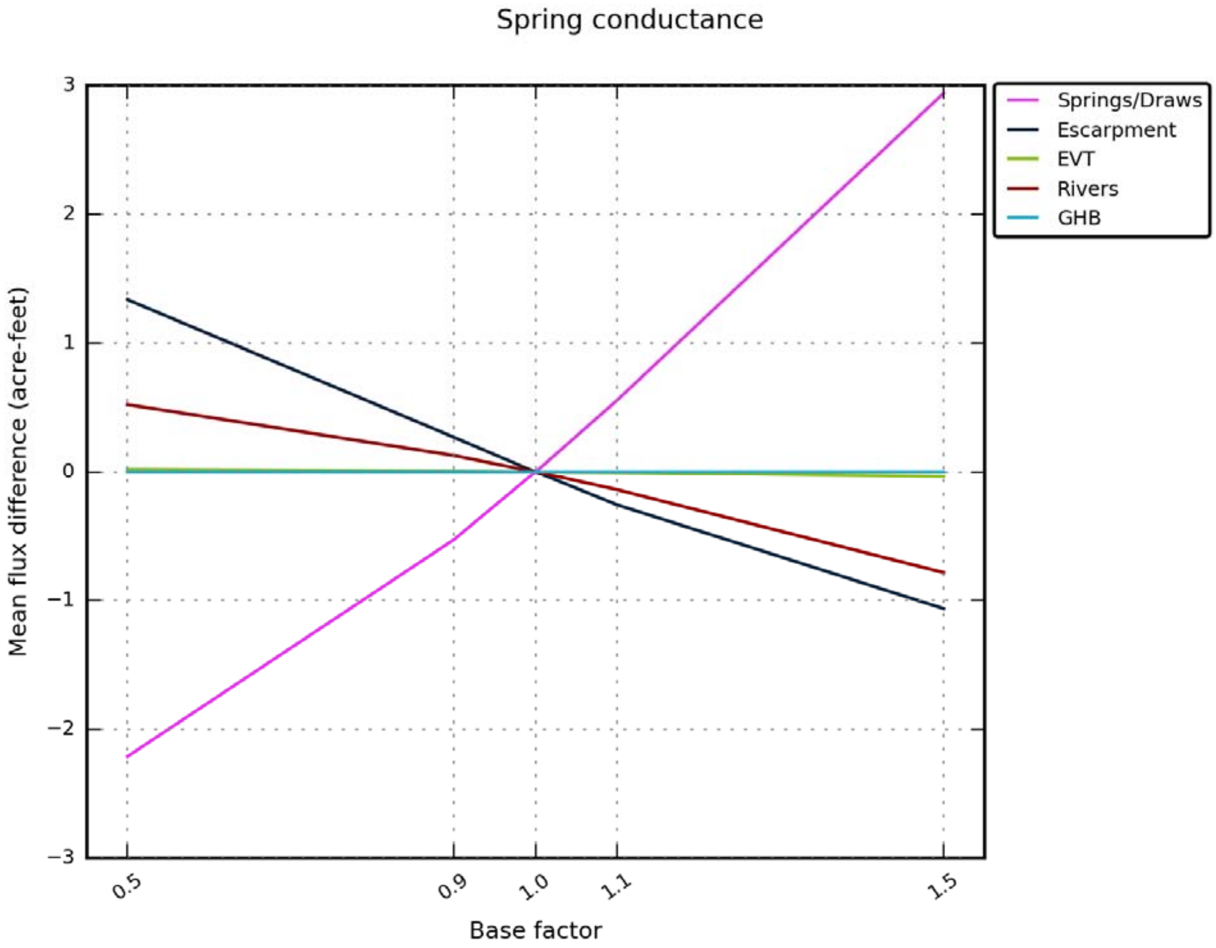


Figure 4.2.38 **Flow sensitivity in acre-feet per year for the steady-state model to changes in drain boundary conductance, representing springs. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

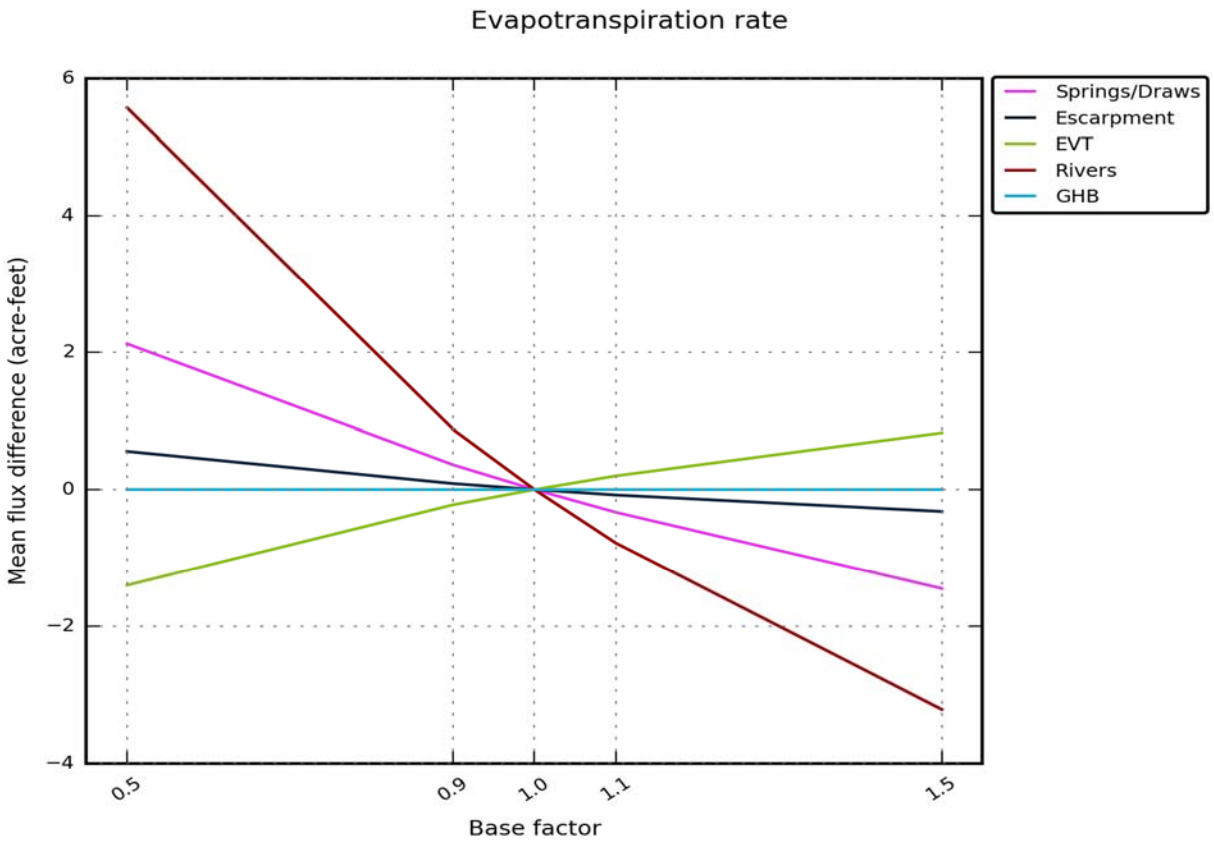


Figure 4.2.39 **Flow sensitivity in acre-feet per year for the steady-state model to changes in maximum evapotranspiration rate. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

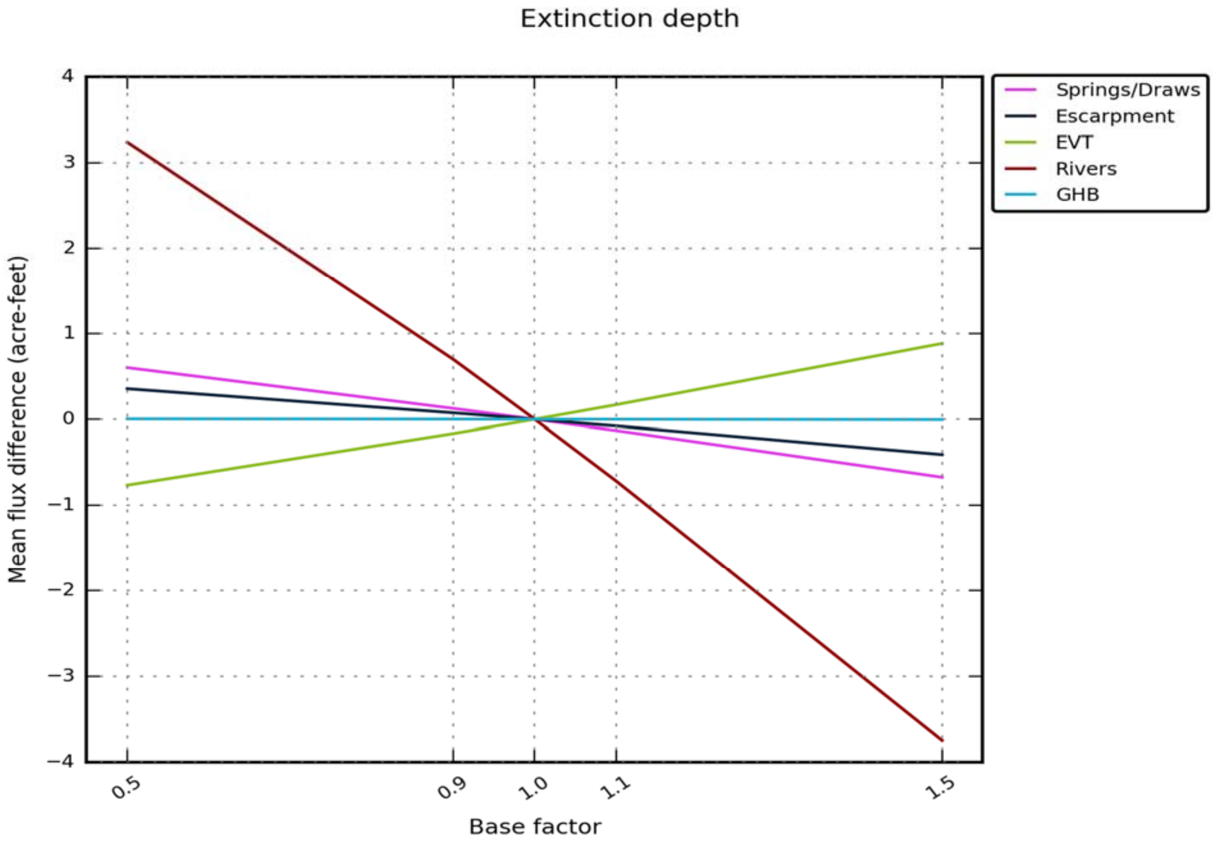


Figure 4.2.40 Flow sensitivity in acre-feet per year for the steady-state model to changes in evapotranspiration extinction depth. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

4.2.2 Transient Sensitivities

In general, hydraulic head sensitivity responses for the transient model are nearly identical to the corresponding sensitivity responses for the steady-state model. Figures 4.2.41 through 4.2.48 for the transient model head sensitivity to horizontal vertical hydraulic conductivity are very similar to Figures 4.2.1 through 4.2.8 for the steady-state model. For the vertical conductivity of the upper Dockum Aquifer (Figure 4.2.49), the trend in the head response in the upper Dockum Aquifer changes from being positively correlated for steady-state to being negatively correlated for transient. This is due to the response to pumping in transient, where drawdown in the Ogallala Aquifer above the upper Dockum Aquifer causes corresponding drawdown in the upper Dockum Aquifer. Increasing the vertical connection between the Ogallala Aquifer and the upper Dockum Aquifer increases drawdown in the upper Dockum Aquifer, and so the negative change in upper Dockum Aquifer head occurs. Figure 4.2.50 shows a similar head response in transient to steady-state (Figure 4.1.10) where increasing the vertical conductivity of the lower Dockum Aquifer causes increasing head elevation in the lower Dockum Aquifer (several feet of change), but causes only a fraction of a foot in head change in any other unit.

In addition to the parameter sensitivities considered in the steady-state model, the transient model adds additional parameters for perturbation including storage properties, reservoirs, and pumping. Figure 4.2.51 shows the sensitivity in hydraulic heads to the specific yield of the Ogallala Aquifer with increases in specific yield resulting in increases in hydraulic heads for all aquifers. The increase in heads is due to the decrease in drawdown that occurs for a given amount of pumping in the aquifer. Because pumping is the dominant discharge mechanism, heads in the Ogallala Aquifer are sensitivity to specific yield. An increase in specific storage results in an increase in hydraulic heads as shown in Figure 4.2.52 for the specific storage of the Rita Blanca Aquifer, in Figure 4.2.53 for the Edwards-Trinity (High Plains) Aquifer, in Figure 4.2.54 for the upper Dockum Aquifer, and in Figure 4.2.55 for the lower Dockum Aquifer. Varying specific storage for the Rita Blanca Aquifer has the least effect on heads.

Figures 4.2.56 through 4.2.65 for the transient model head sensitivity to recharge and boundary conductance are very similar to Figures 4.2.11 through 4.2.20 for the steady-state model. Figure 4.2.66 illustrates the sensitivity of hydraulic heads to pumping, with increases in pumping resulting in decreases in hydraulic heads. Figure 4.2.67 shows almost no sensitivity of hydraulic heads to the conductance of reservoirs, with the maximum change well below the previously noted convergence limitation of approximately 0.8 acre-feet per year.

Figures 4.2.68 through 4.2.77 for the transient model flow sensitivity to horizontal and vertical hydraulic conductivity are very similar to Figures 4.2.21 to 4.2.30 for the steady-state model. Figure 4.2.71 shows a different trend for change in flow to rivers than Figure 4.2.24, but in both cases the change in flow is well below a significant level of 0.8 acre-feet per year. Figure 4.2.72 shows that the change in boundary flow to reservoirs is the largest of any of the boundary flows when the horizontal hydraulic conductivity of the lower Dockum Aquifer is varied. Figure 4.2.73 shows that flows are basically insensitive to change in vertical conductivity of the Ogallala Aquifer.

Figure 4.2.78 shows the sensitivity of boundary flows to changes in the specific yield of the Ogallala Aquifer. River boundary flow is most sensitive, and all flows are positively correlated (general-head boundary flows are insensitive), where increasing the specific yield of the Ogallala Aquifer increases flows to the boundaries. This positive correlation occurs because drawdown is less (as discussed with Figure 4.2.51) with higher specific yield, and higher heads result in more outflow to boundaries.

Figures 4.2.79 through 4.2.88 for the transient model flow sensitivity to recharge and boundary conductance are similar in most cases to Figures 4.2.31 through 4.2.40 for the steady-state model. Figures 4.2.80 and 4.2.81 show that boundary flows are insensitive to recharge in the Rita Blanca and upper Dockum aquifers. Figure 4.2.84 shows that variation in general-head boundary conductance for the transient model has a larger effect on general-head boundary flows than in the steady-state model, although the overall change is still small, on the order of 0.8 feet. The change from steady-state is due to the simulated drawdown in the general-head boundary regions (Pecos Valley and Edwards-Trinity (Plateau) aquifers). The increased gradient caused by the decrease in boundary elevation increases the importance of the conductance term. Figures 4.2.87 and 4.2.88 show that river and reservoir flows are sensitive to changes in maximum evapotranspiration rate and rooting depth, and are negatively correlated in both cases (increasing maximum evapotranspiration rate or rooting depth decreases average heads and decreases flow to reservoirs and rivers.)

Figure 4.2.89 depicts the sensitivity of boundary flows to changes in pumping with increases in pumping resulting in decreases in boundary flows. Figure 4.2.90 shows the sensitivity of boundary flows to changes in reservoir conductance with increases in reservoir conductance resulting in increases in the rate of flow out of reservoirs. All other boundary flows are insensitive to reservoir conductance.

After reviewing the spider plots discussed to this point, sensitivity hydrographs were plotted for several key parameters. First, consider the sensitivity of Ogallala Aquifer and lower Dockum Aquifer heads to the vertical hydraulic conductivity of the region where the Ogallala Aquifer overlies the Santa Rosa Formation. The purpose was to determine whether a different parameterization in this zone (Figure 2.4.5) would result in a more effective simulation of the vertical connection between the two units, as judged by the head calibration. Wells were chosen in this region from the Ogallala and lower Dockum aquifers, and sample hydrographs are shown in Figure 4.2.91. In Moore County for the Ogallala Aquifer, little change in heads occurs due to the variation in vertical conductivity. In Armstrong County for the Ogallala Aquifer, heads change in steady-state by between 5 and 10 feet (lower heads with increased conductivity) while the transient variation does not change. The “base” (that is, calibrated model) appears to provide a fit that is as good, or better, than the 0.3 multiplier and 3.0 multiplier cases.

For the lower Dockum Aquifer hydrographs in Hartley and Carson counties, little sensitivity is evident. However, in Floyd and Armstrong counties, much larger variations in head occur with the variation in vertical conductivity. From the Floyd and Armstrong county plots, it appears that the vertical conductivity is reasonably well parameterized for this zone, so that a change in the value is not justified. This means that no special approach is required for parameterizing this zone versus the rest of the lower Dockum Aquifer. The basic approach for estimating the vertical conductivity of the lower Dockum Aquifer was driven by clay percentage in the unit and depth of burial. The conductance term calculated by MODFLOW between two layers is dependent on vertical conductivity of the two layers and layer thickness. Because the lower Dockum Aquifer in this zone is relatively sandy, is shallow, and thin compared to areas more basinward, the vertical connection calculated from the basic approach results in a vertical conductance that creates satisfactory calibration to heads in the area.

Figure 4.2.92 shows the sensitivity of hydrographs to changes in horizontal hydraulic conductivity. In general, decreasing horizontal hydraulic conductivity brings an increase in steady-state head. In the Ogallala Aquifer, where significant historical pumping occurs, the shape of the drawdown curves are similar, with the offset in heads from steady-state. Where relatively little pumping has occurred (Hemphill County), the curves are offset and flat. The rate of drawdown in the Ogallala Aquifer is sensitive to specific yield and pumping rate, but not as sensitive to horizontal hydraulic conductivity. The Rita Blanca Aquifer, which is confined, is less sensitive in steady-state, but the slope of the drawdown is sensitive in transient. The hydrographs for the Edwards-Trinity (High Plains) Aquifer show increased heads in steady-state with decreased horizontal conductivity, and increased drawdown in transient. The curve for the lowest hydraulic conductivity shows evidence of curtailment due to excessive drawdown from 1950 to 1990. The lower Dockum Aquifer hydrographs show a similar trend, again with the lowest hydraulic conductivity curve in the Moore County hydrograph showing signs of curtailment of pumping in 1950.

Figure 4.2.93 shows the sensitivity of hydrographs in the Ogallala Aquifer to changes in specific yield. Where pumping occurs, specific yield has a direct effect on the slope of the curve. Where little pumping occurs (Hemphill County), no effect is seen, since storage parameters have no effect on steady-state heads.

Figure 4.2.94 shows the sensitivity of upper Dockum Aquifer hydrographs to changes in vertical hydraulic conductivity. The upper Dockum Aquifer is impacted primarily through vertical communication with the formations above and below. When conductivity is decreased, heads decrease because less pressure support is communicated from the aquifer above and below. Similarly, under pumping conditions, decreased vertical hydraulic conductivity will increase drawdown somewhat, due to decreased pressure support.

Figure 4.2.95 shows the sensitivity of hydrographs to changes in recharge rate. Relative to the Ogallala Aquifer, the other aquifers with outcrops are not very sensitive to recharge, due to outcrop size. The Ogallala Aquifer is sensitive to recharge in steady-state, but not particularly sensitive in transient. The Edwards-Trinity (High Plains) Aquifer hydrograph was plotted to show sensitivity to recharge in the Ogallala Aquifer.

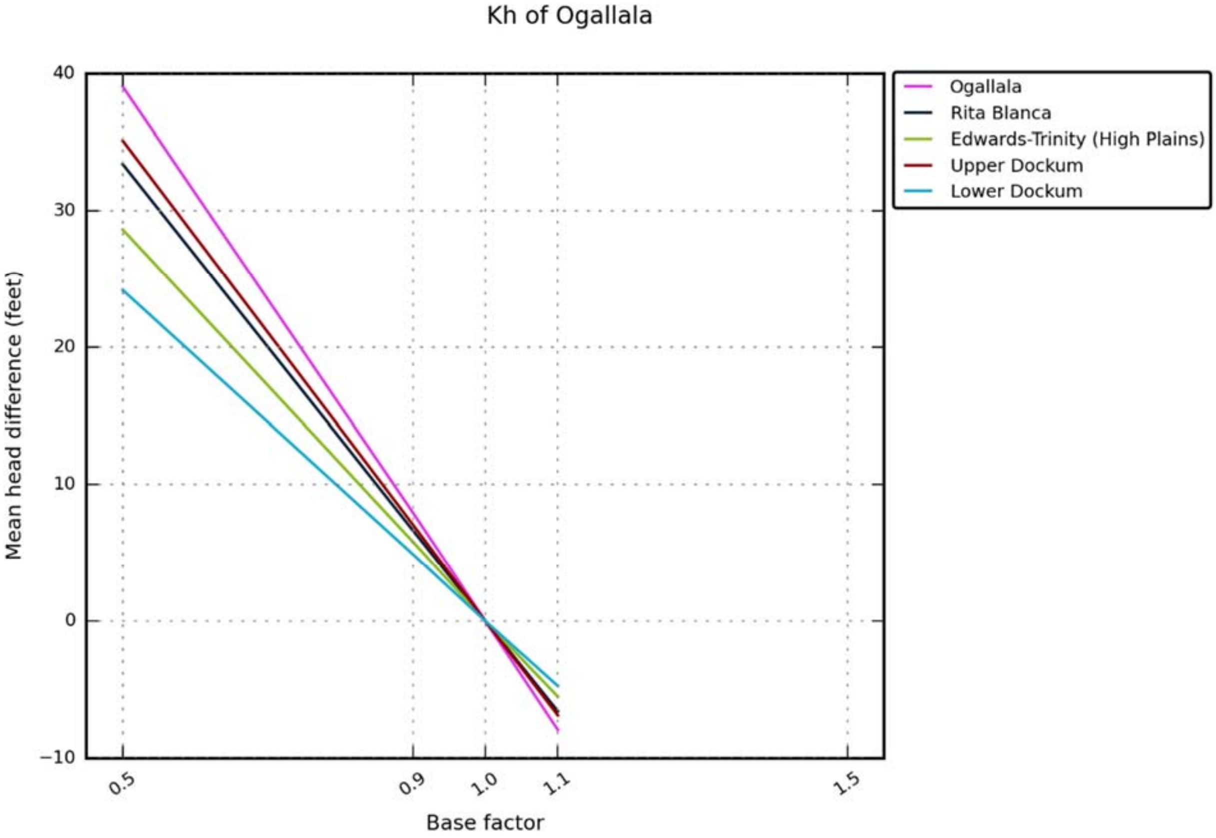


Figure 4.2.41 Hydraulic head sensitivity in feet for the transient model to changes in horizontal hydraulic conductivity (Kh) of the Ogallala Aquifer.

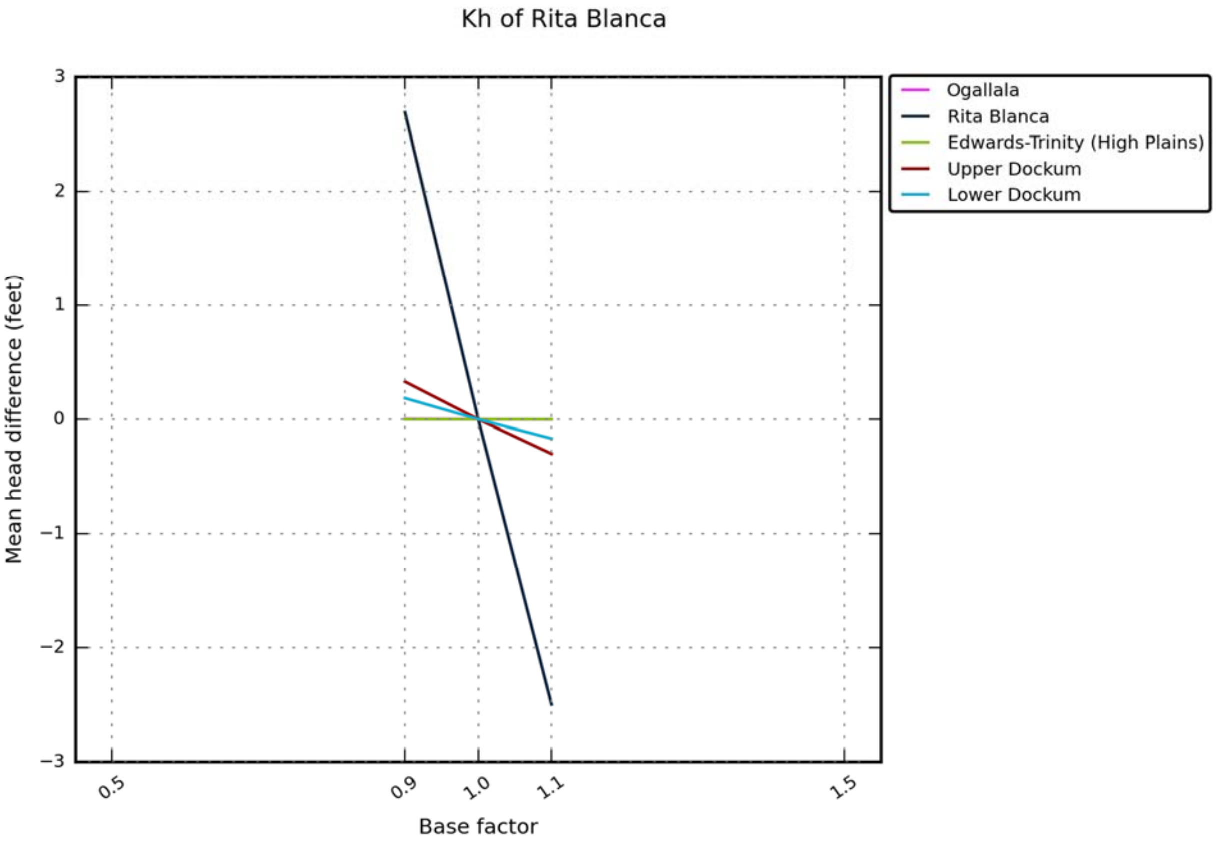


Figure 4.2.42 **Hydraulic head sensitivity in feet for the transient model to changes in horizontal hydraulic conductivity (Kh) of the Rita Blanca Aquifer.**

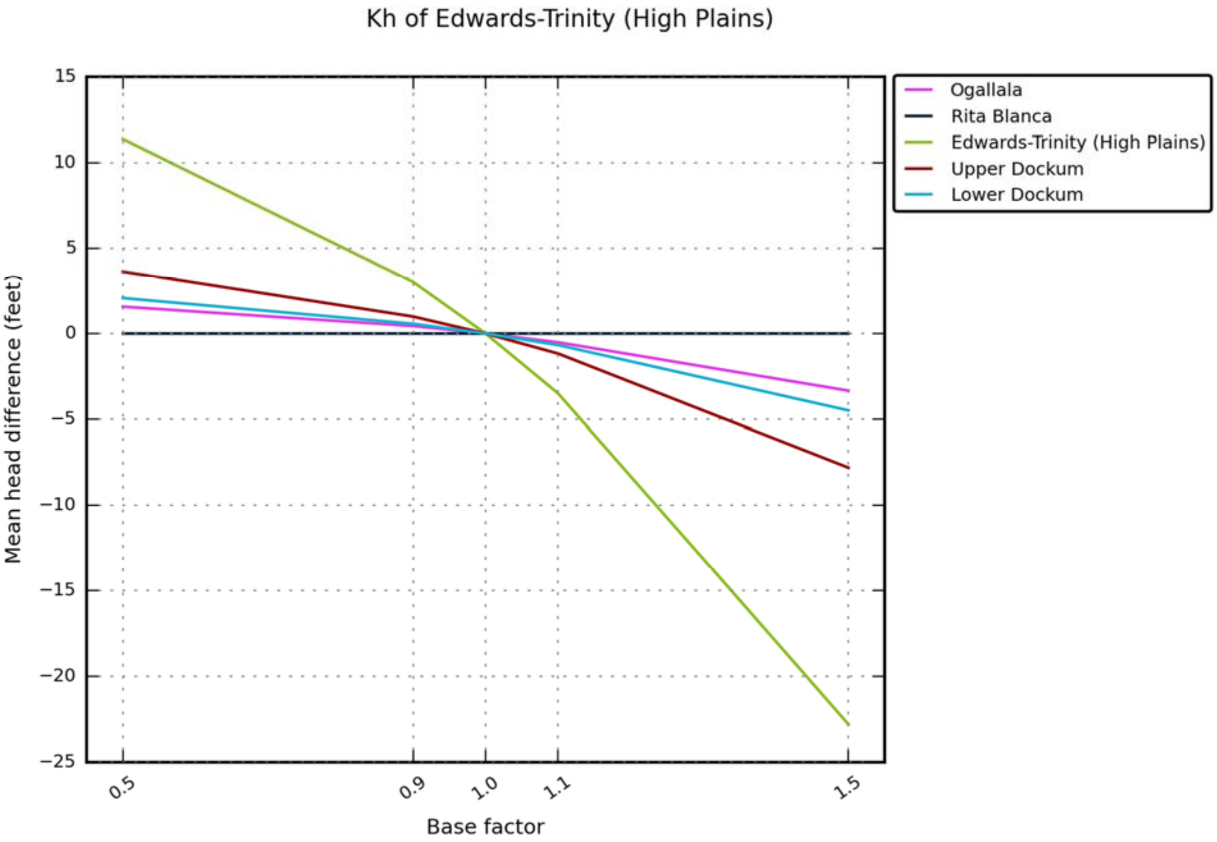


Figure 4.2.43 **Hydraulic head sensitivity in feet for the transient model to changes in horizontal hydraulic conductivity (Kh) of the Edwards-Trinity (High Plains) Aquifer.**

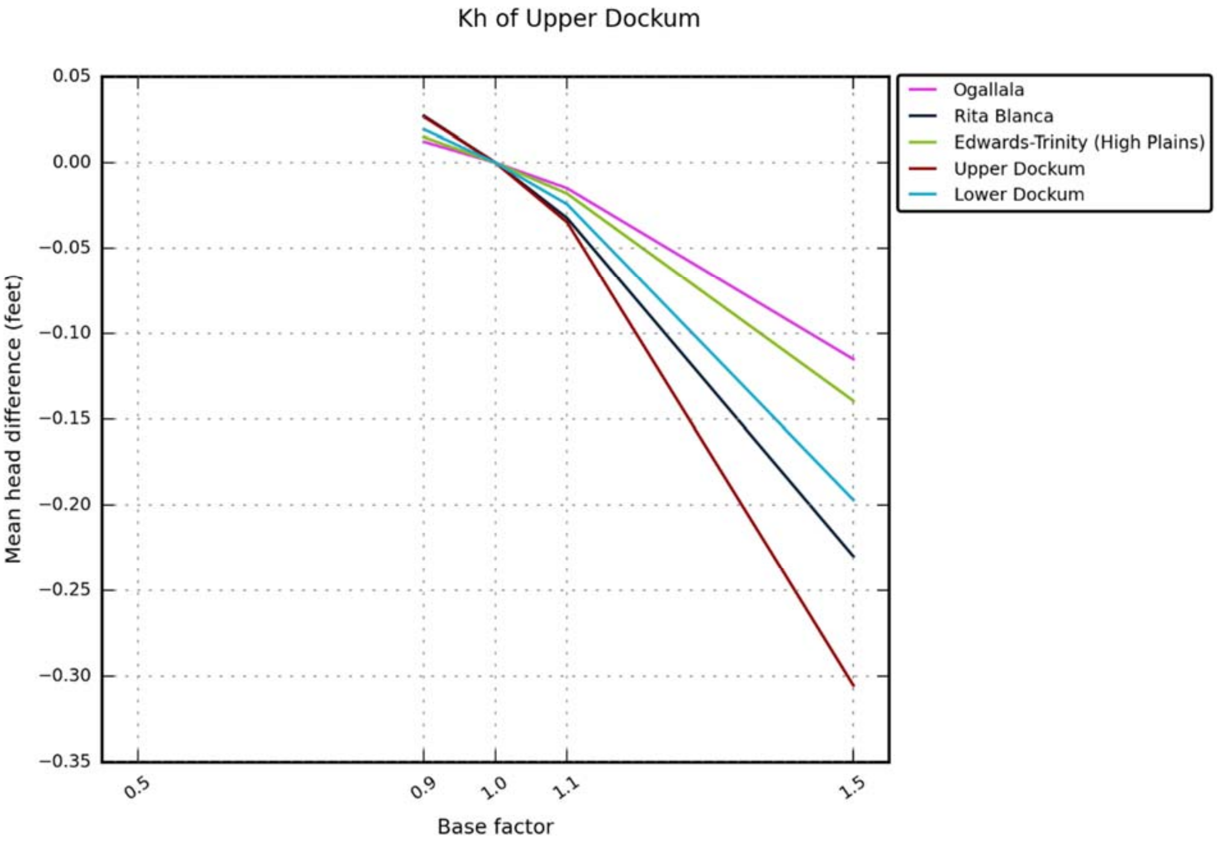


Figure 4.2.44 **Hydraulic head sensitivity in feet for the transient model to changes in horizontal hydraulic conductivity (Kh) of the upper Dockum Aquifer.**

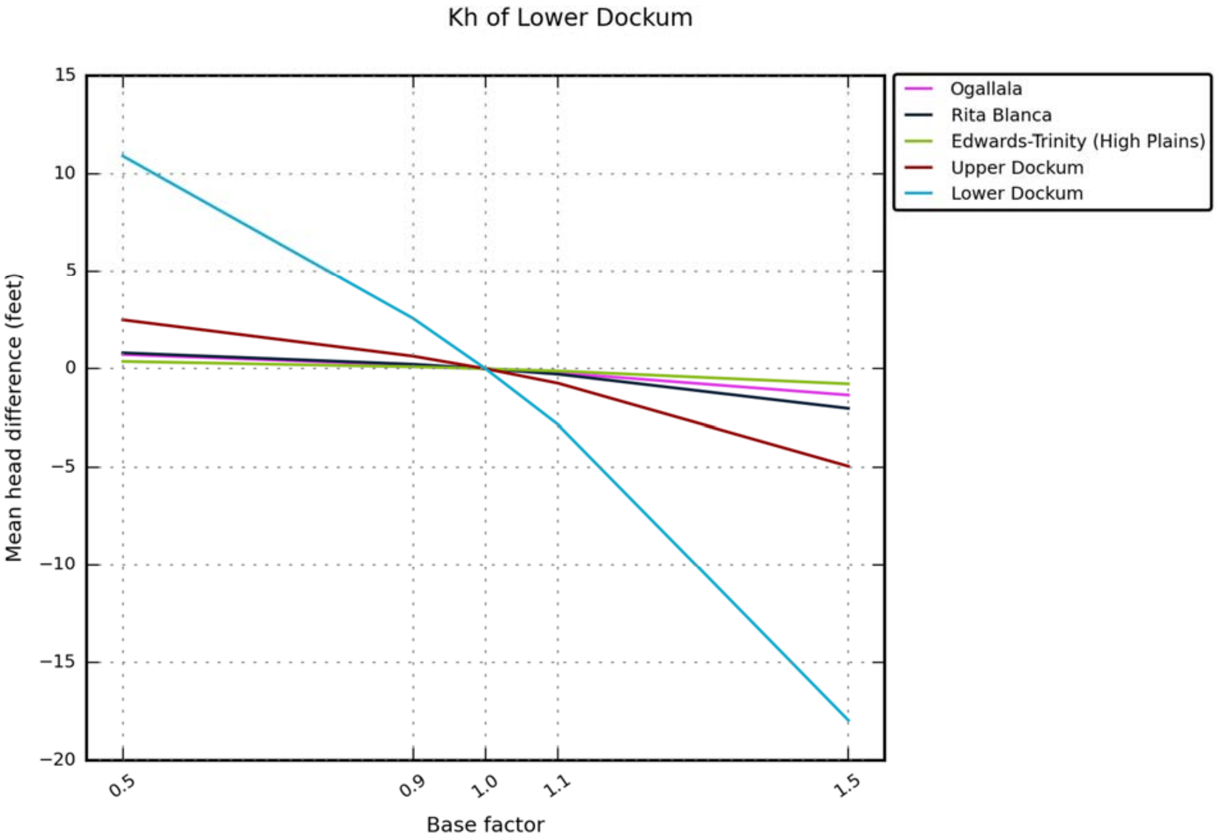


Figure 4.2.45 Hydraulic head sensitivity in feet for the transient model to changes in horizontal hydraulic conductivity (Kh) of the lower Dockum Aquifer.

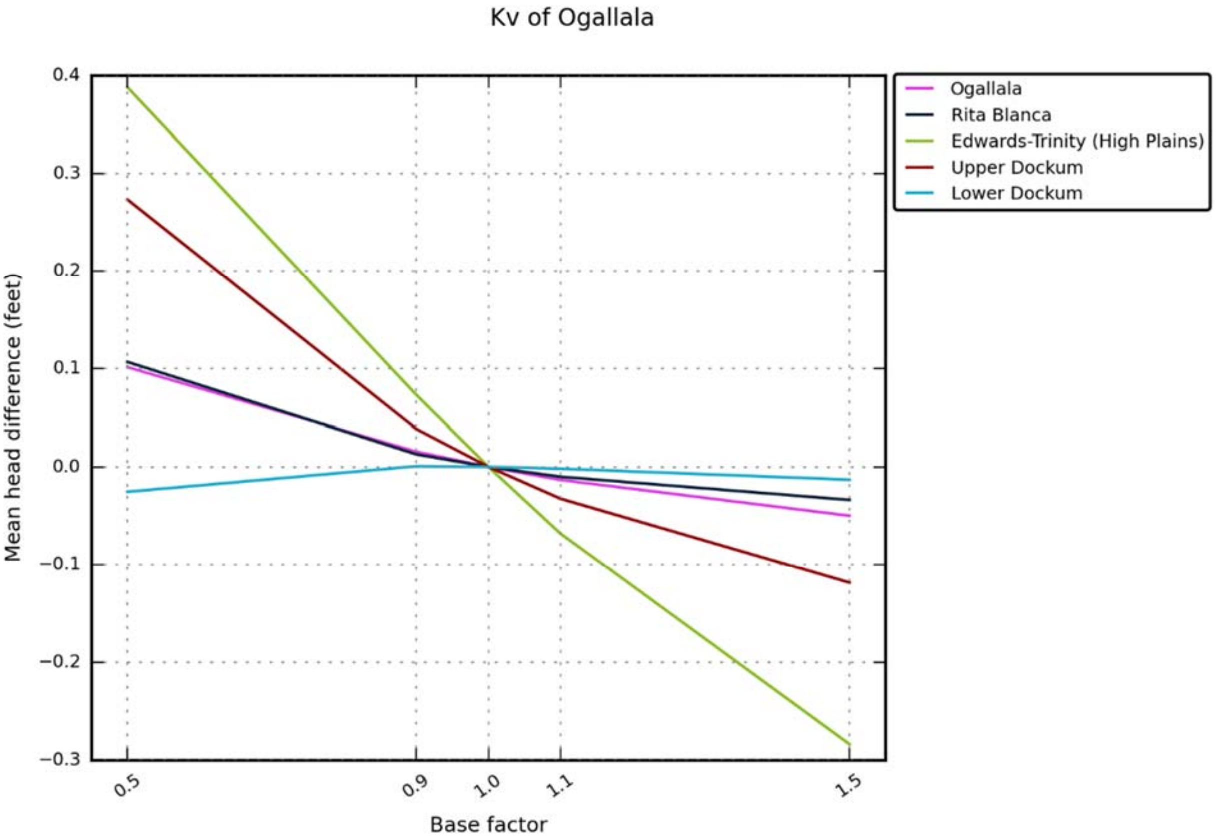


Figure 4.2.46 **Hydraulic head sensitivity in feet for the transient model to changes in vertical hydraulic conductivity (Kv) of the Ogallala Aquifer.**

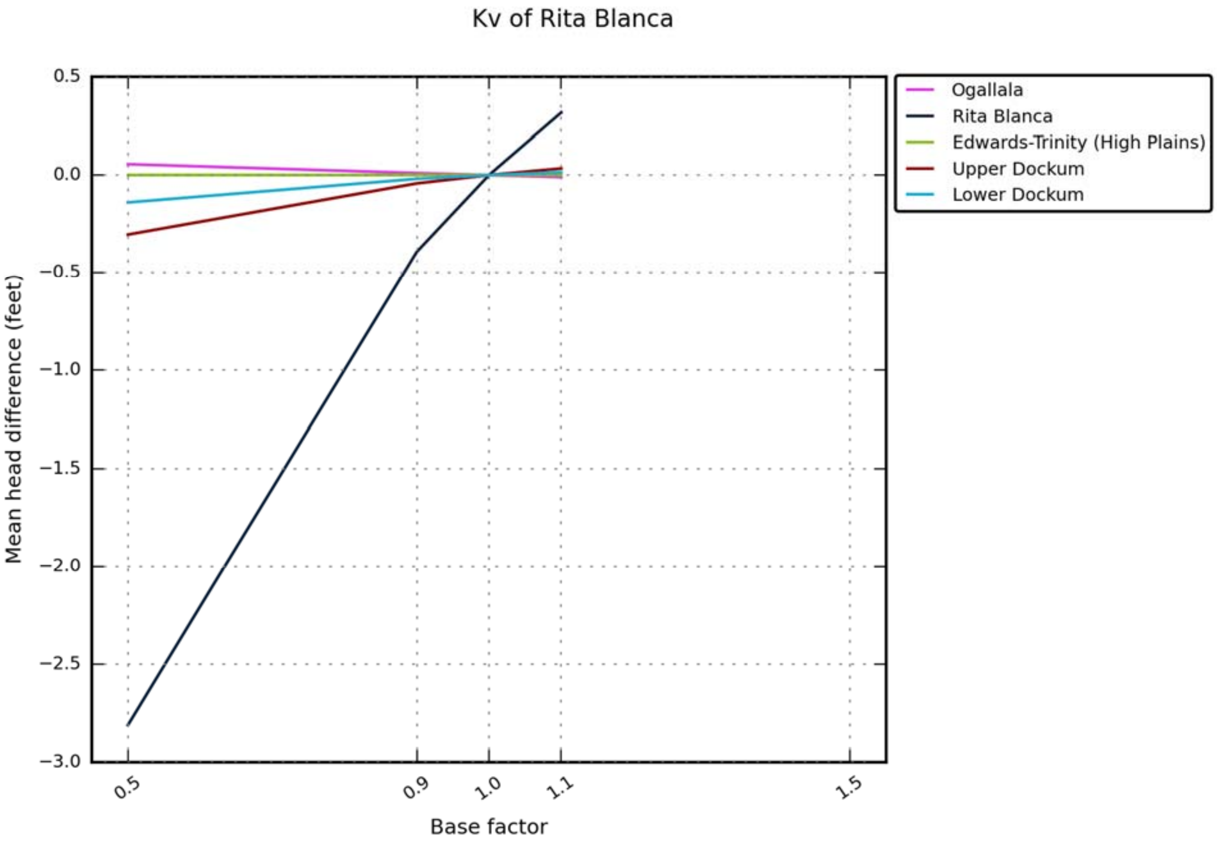


Figure 4.2.47 Hydraulic head sensitivity in feet for the transient model to changes in vertical hydraulic conductivity (Kv) of the Rita Blanca Aquifer.

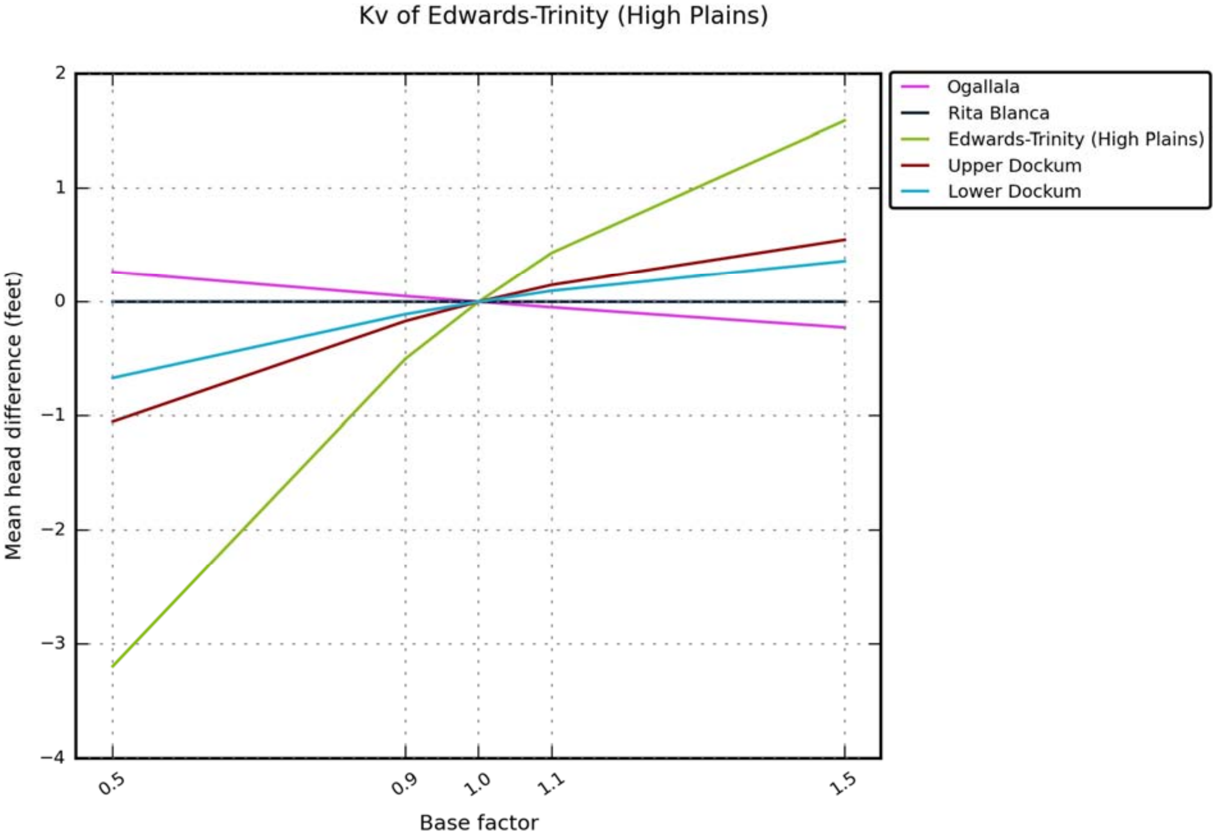


Figure 4.2.48 Hydraulic head sensitivity in feet for the transient model to changes in vertical hydraulic conductivity (Kv) of the Edwards-Trinity (High Plains) Aquifer.

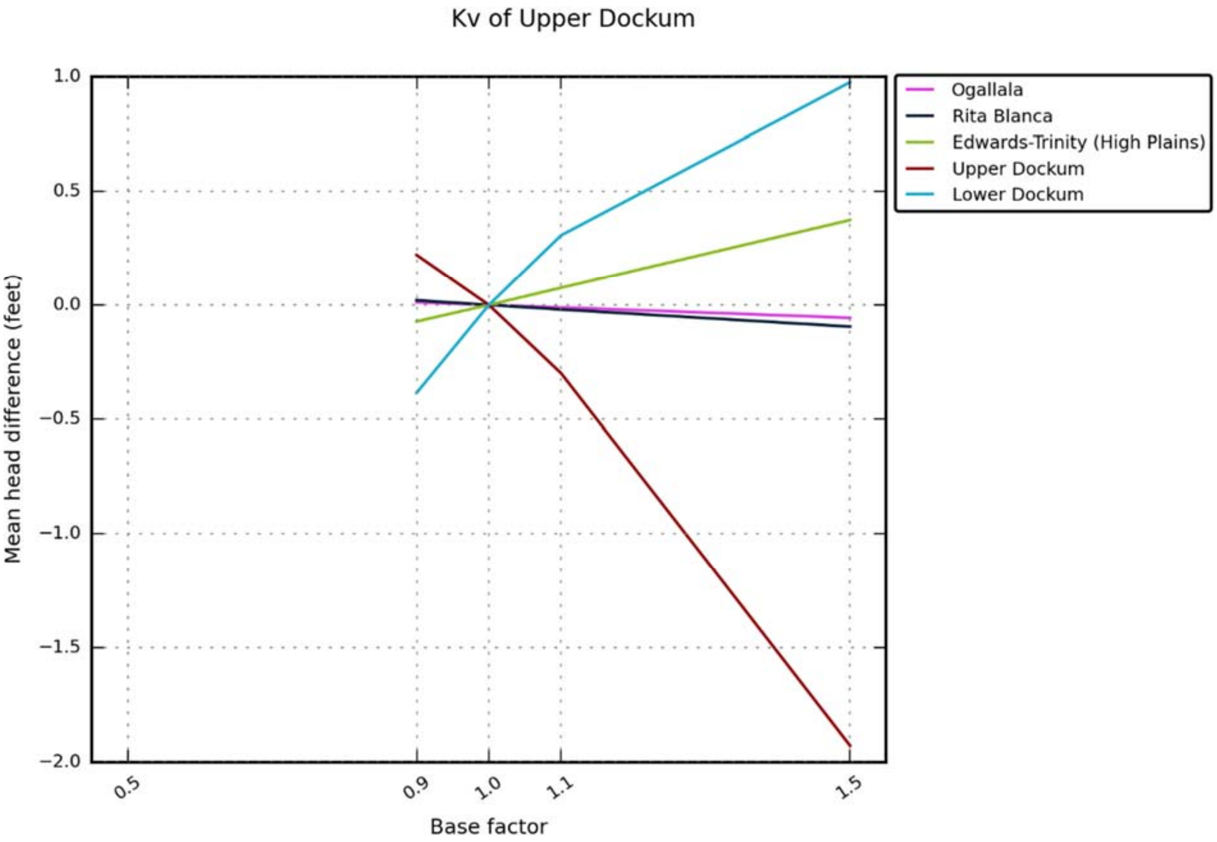


Figure 4.2.49 **Hydraulic head sensitivity in feet for the transient model to changes in vertical hydraulic conductivity (Kv) of the upper Dockum Aquifer.**

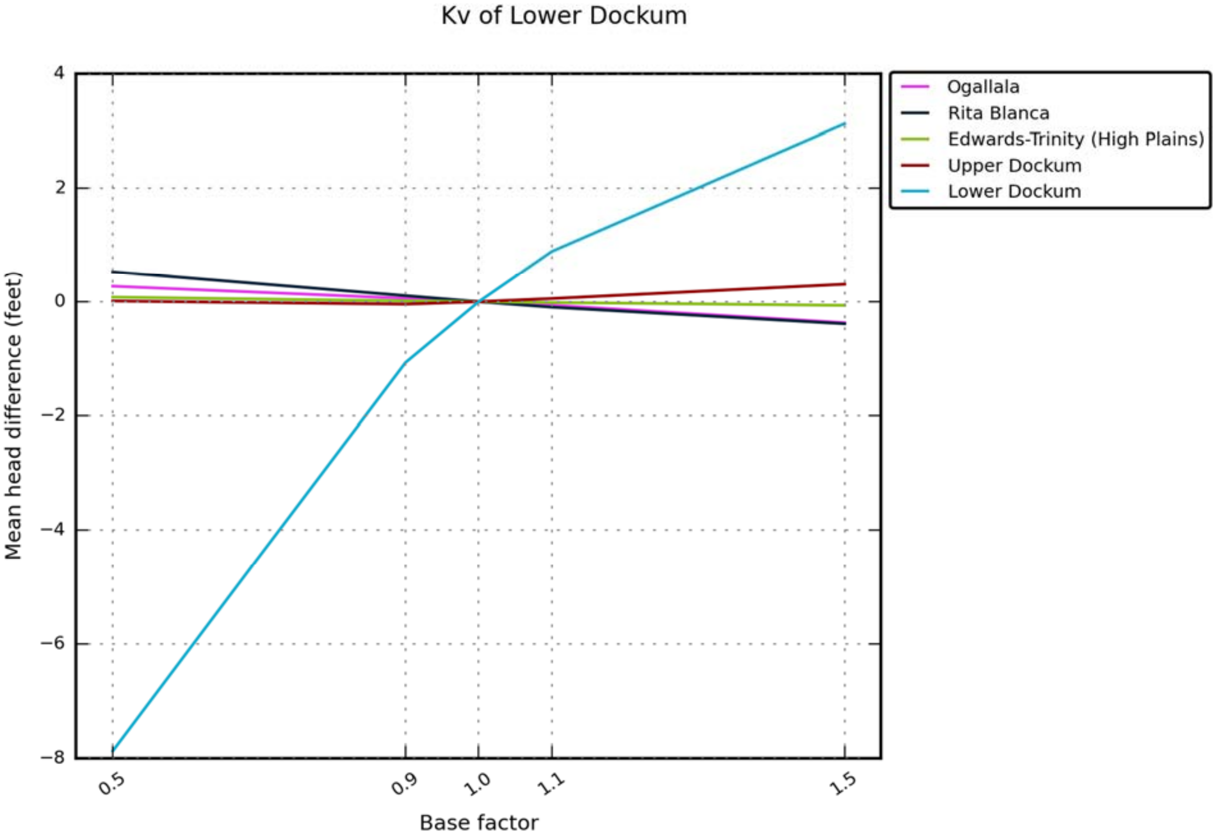


Figure 4.2.50 **Hydraulic head sensitivity in feet for the transient model to changes in vertical hydraulic conductivity (Kv) of the lower Dockum Aquifer.**

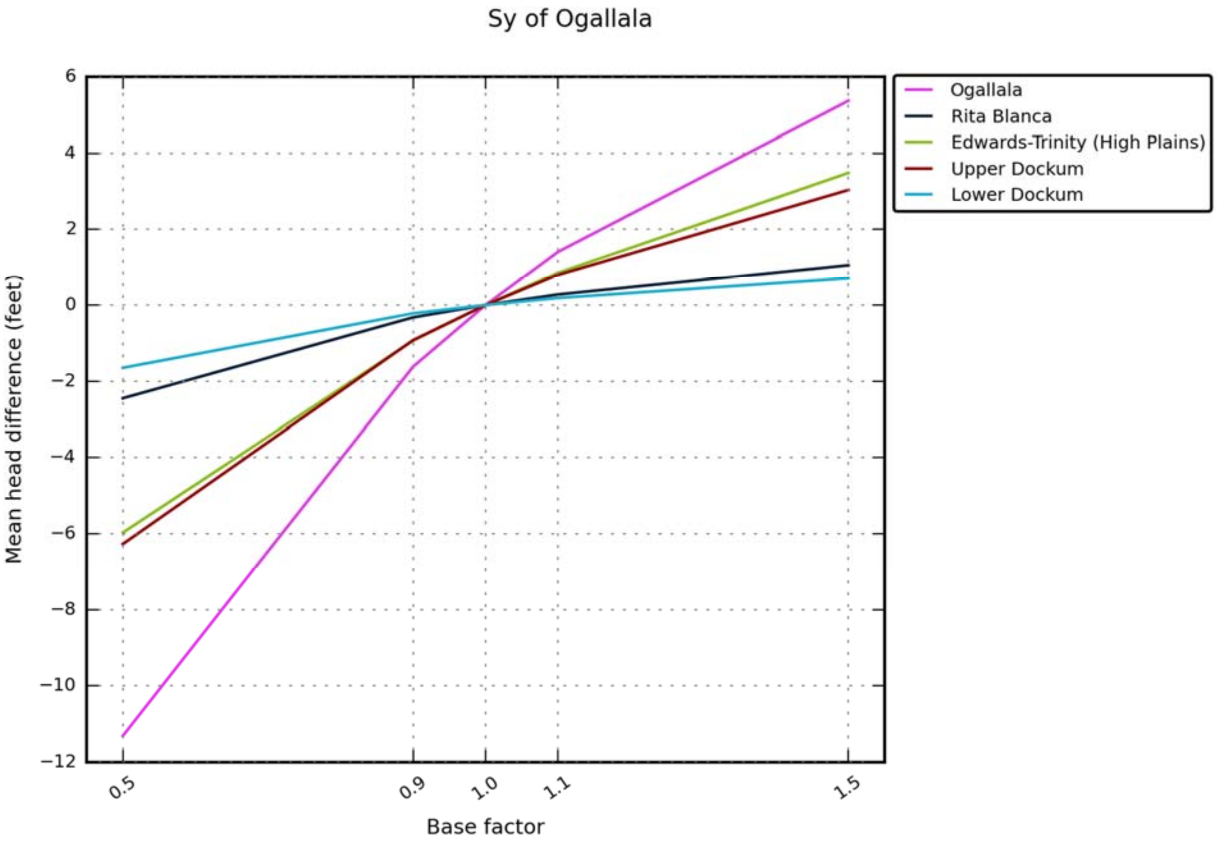


Figure 4.2.51 Hydraulic head sensitivity in feet for the transient model to changes in specific yield (Sy) of the Ogallala Aquifer.

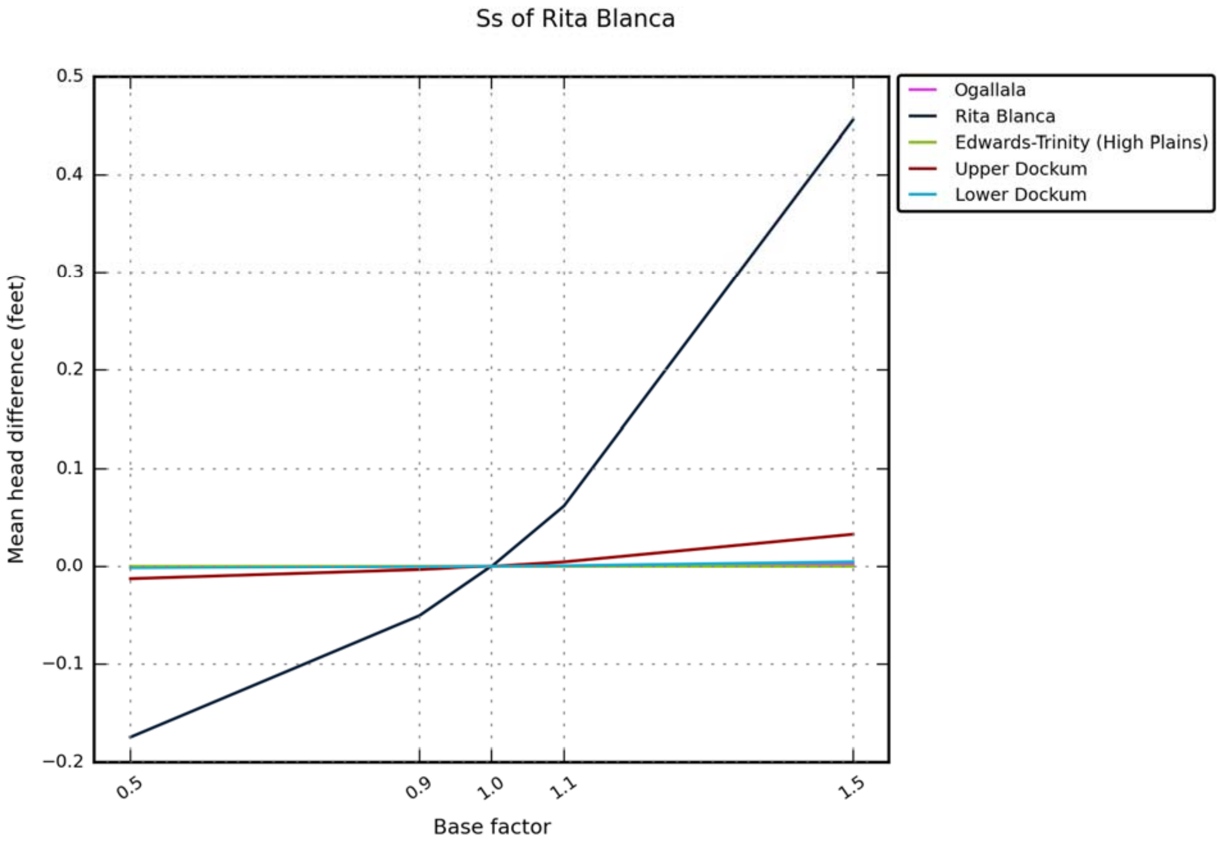


Figure 4.2.52 Hydraulic head sensitivity in feet for the transient model to changes in specific storage (Ss) of the Rita Blanca Aquifer.

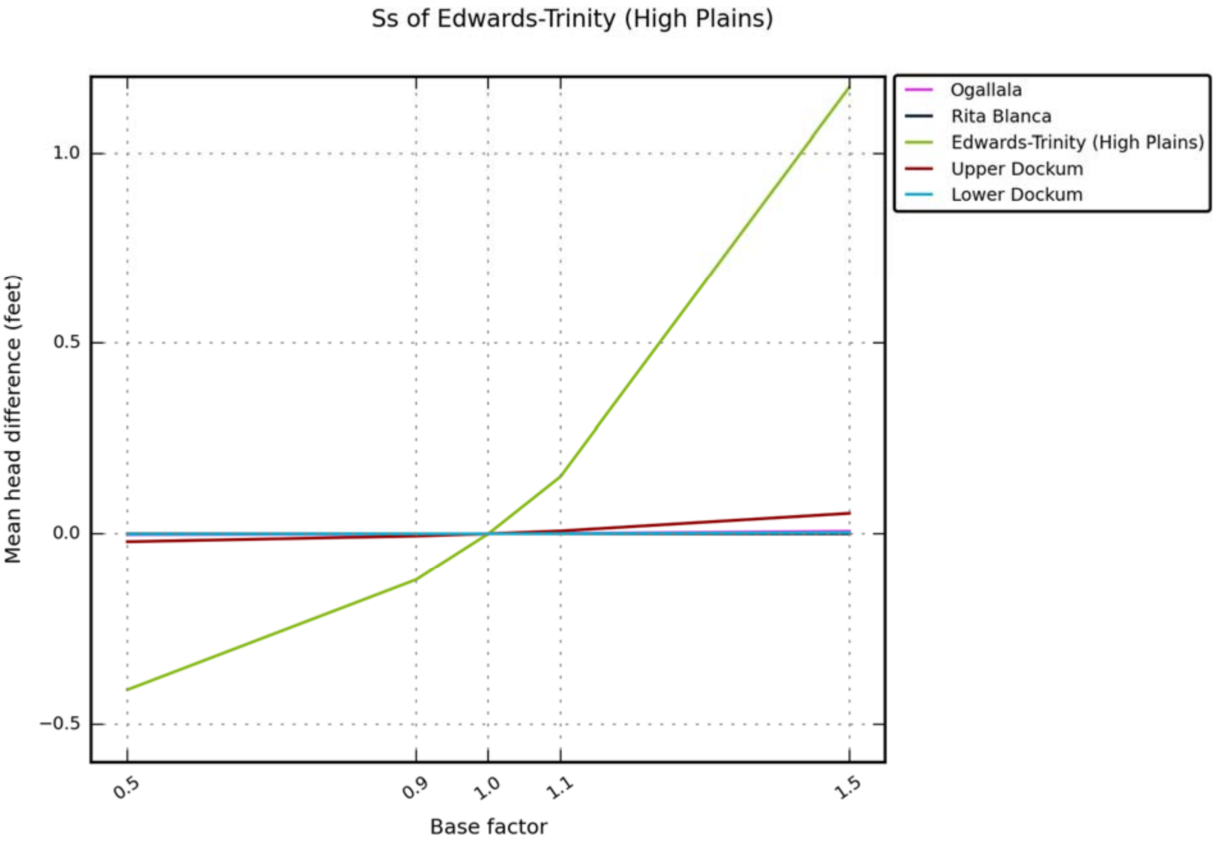


Figure 4.2.53 Hydraulic head sensitivity in feet for the transient model to changes in specific storage (Ss) of the Edwards-Trinity (High Plains) Aquifer.

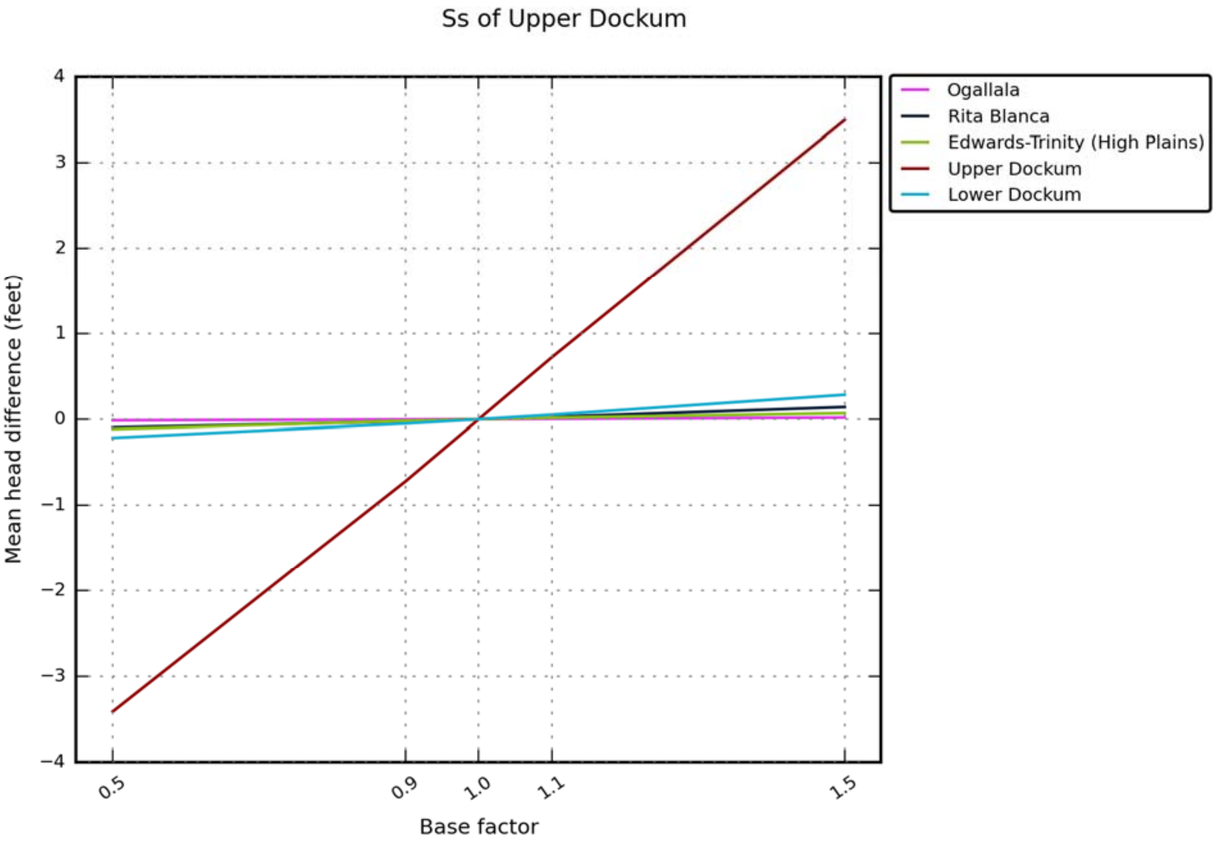


Figure 4.2.54 **Hydraulic head sensitivity in feet for the transient model to changes in specific storage (Ss) of the upper Dockum Aquifer.**

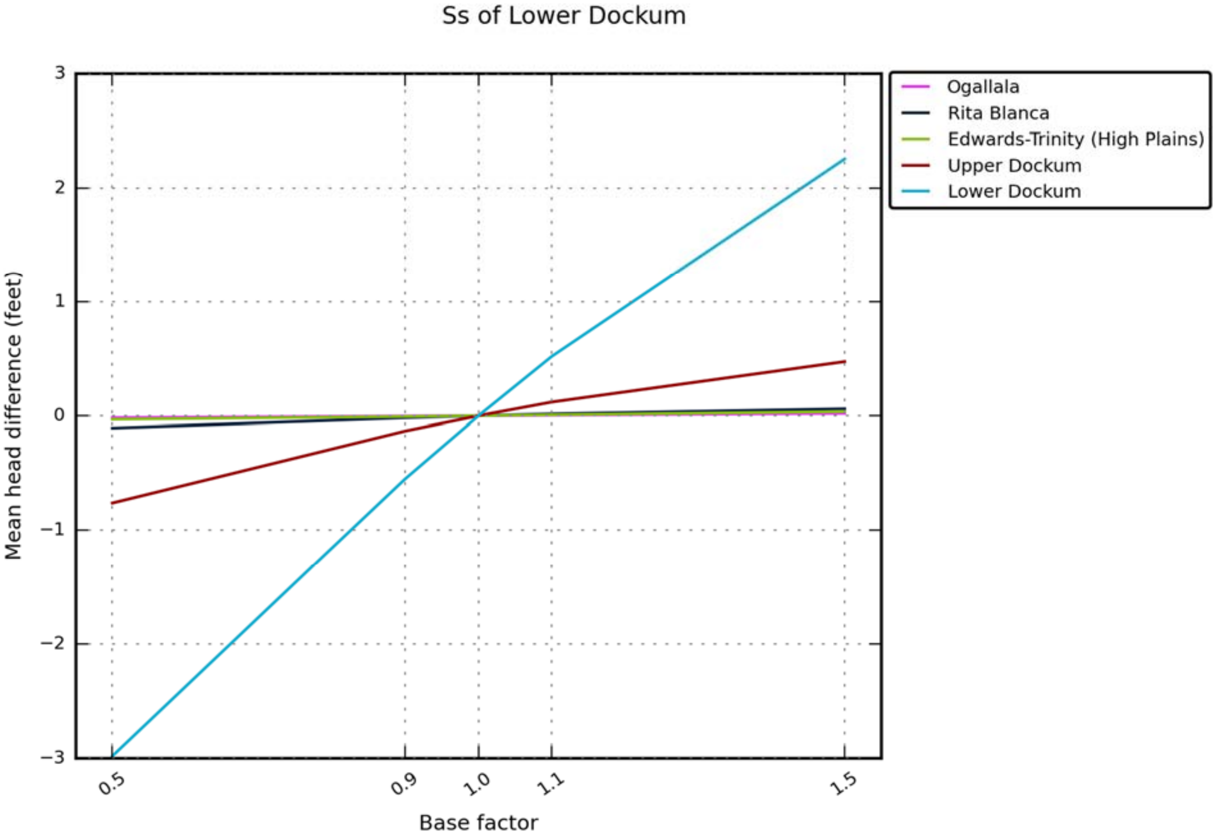


Figure 4.2.55 Hydraulic head sensitivity in feet for the transient model to changes in specific storage (Ss) of the lower Dockum Aquifer.

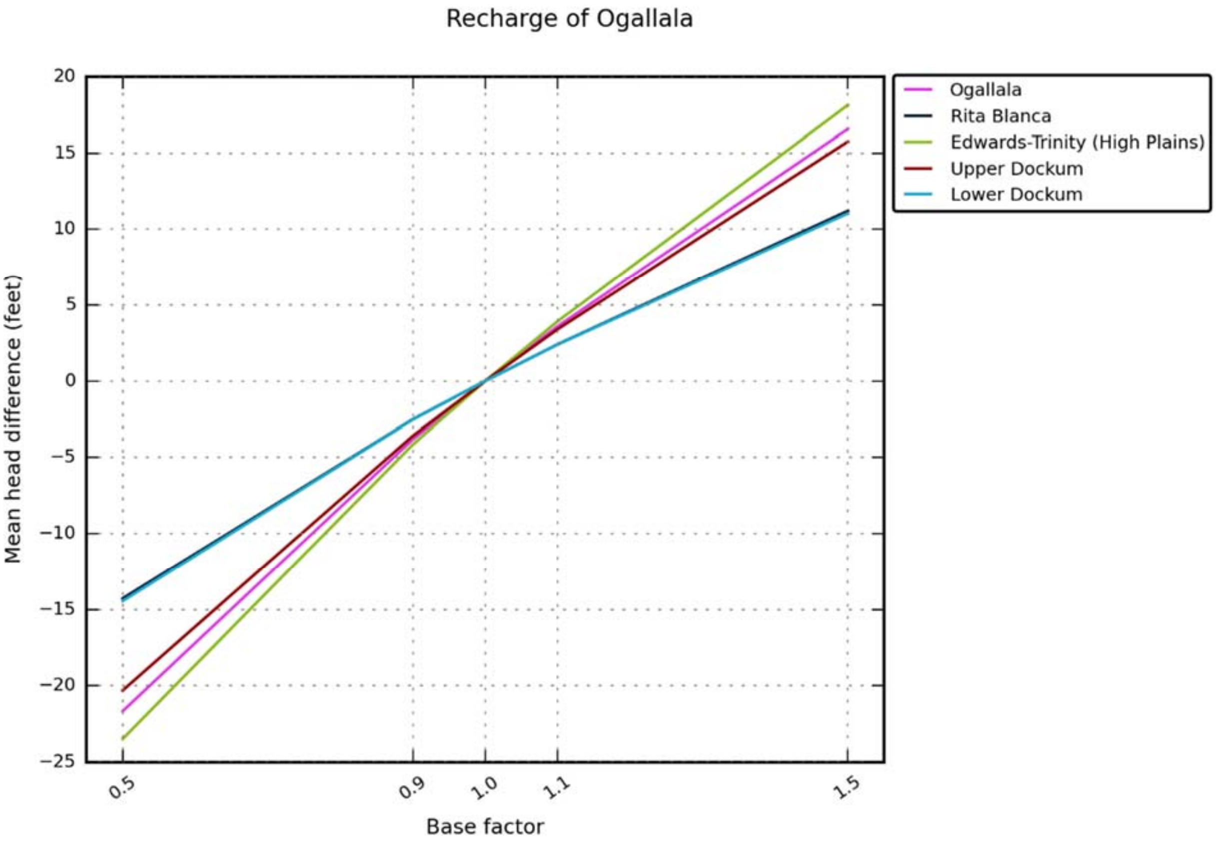


Figure 4.2.56 Hydraulic head sensitivity in feet for the transient model to changes in recharge in the Ogallala Aquifer.

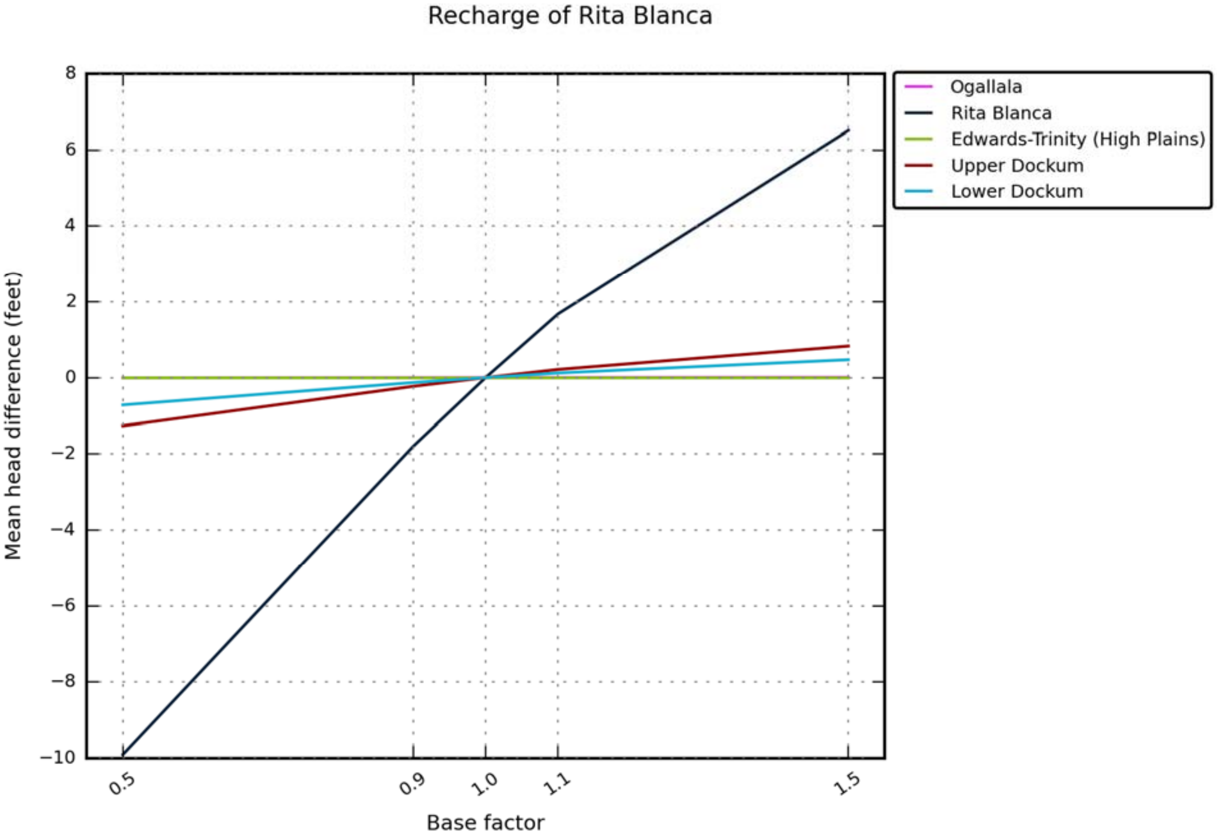


Figure 4.2.57 **Hydraulic head sensitivity in feet for the transient model to changes in recharge in the Rita Blanca Aquifer.**

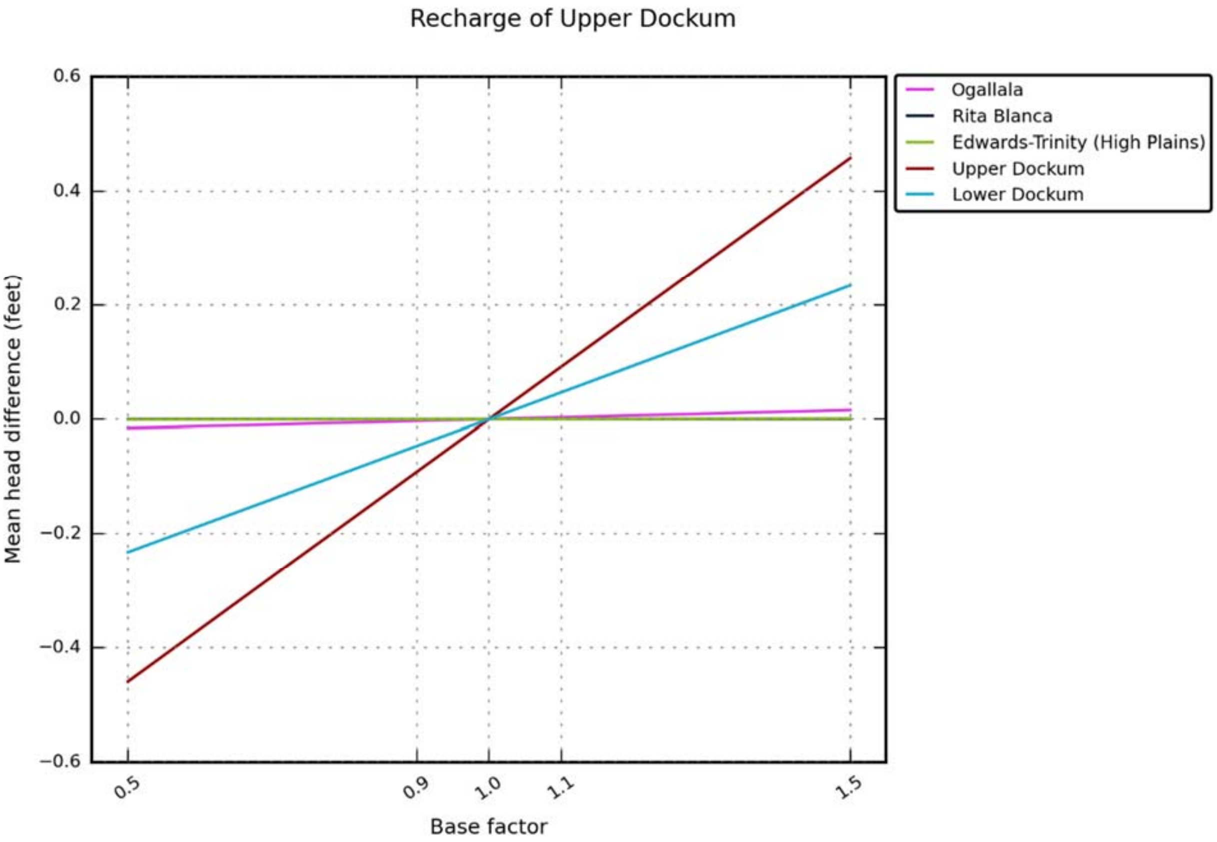


Figure 4.2.58 **Hydraulic head sensitivity in feet for the transient model to changes in recharge in the upper Dockum Aquifer.**

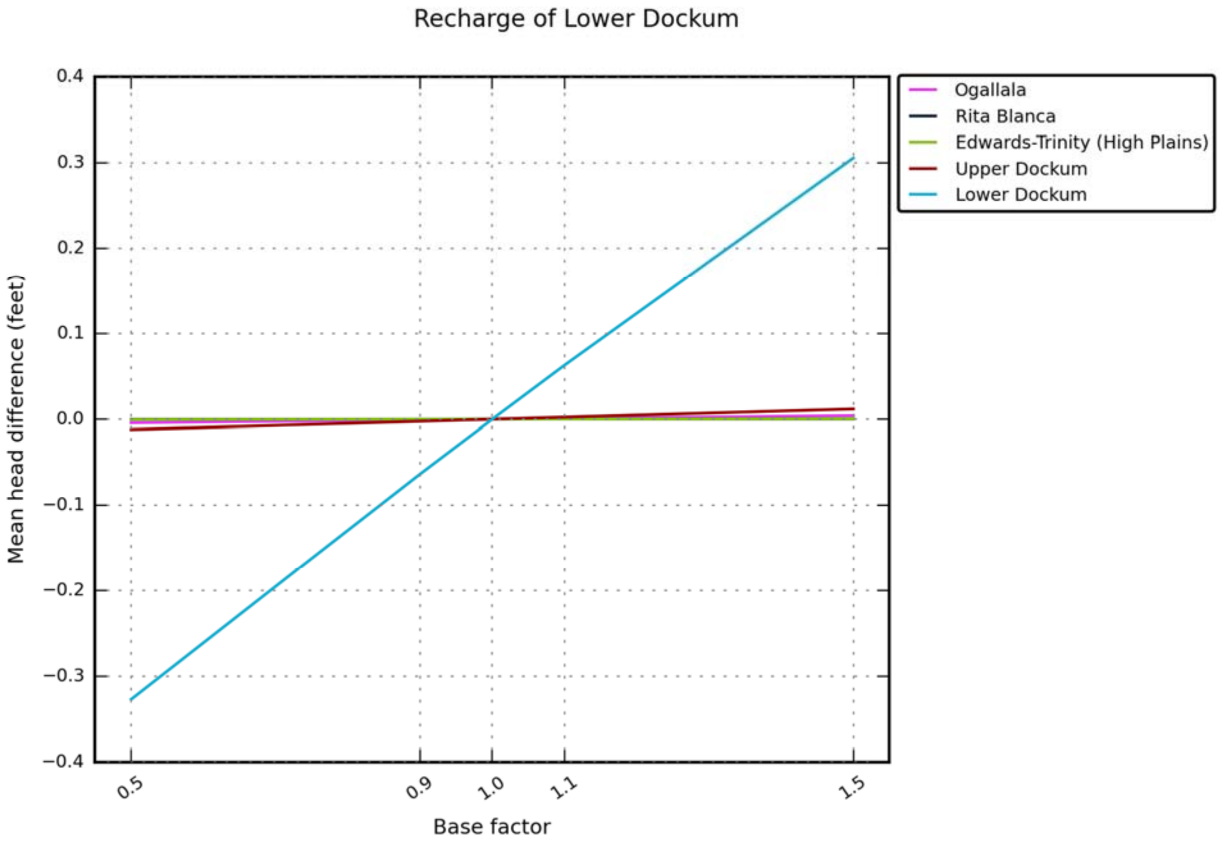


Figure 4.2.59 Hydraulic head sensitivity in feet for the transient model to changes in recharge in the lower Dockum Aquifer.

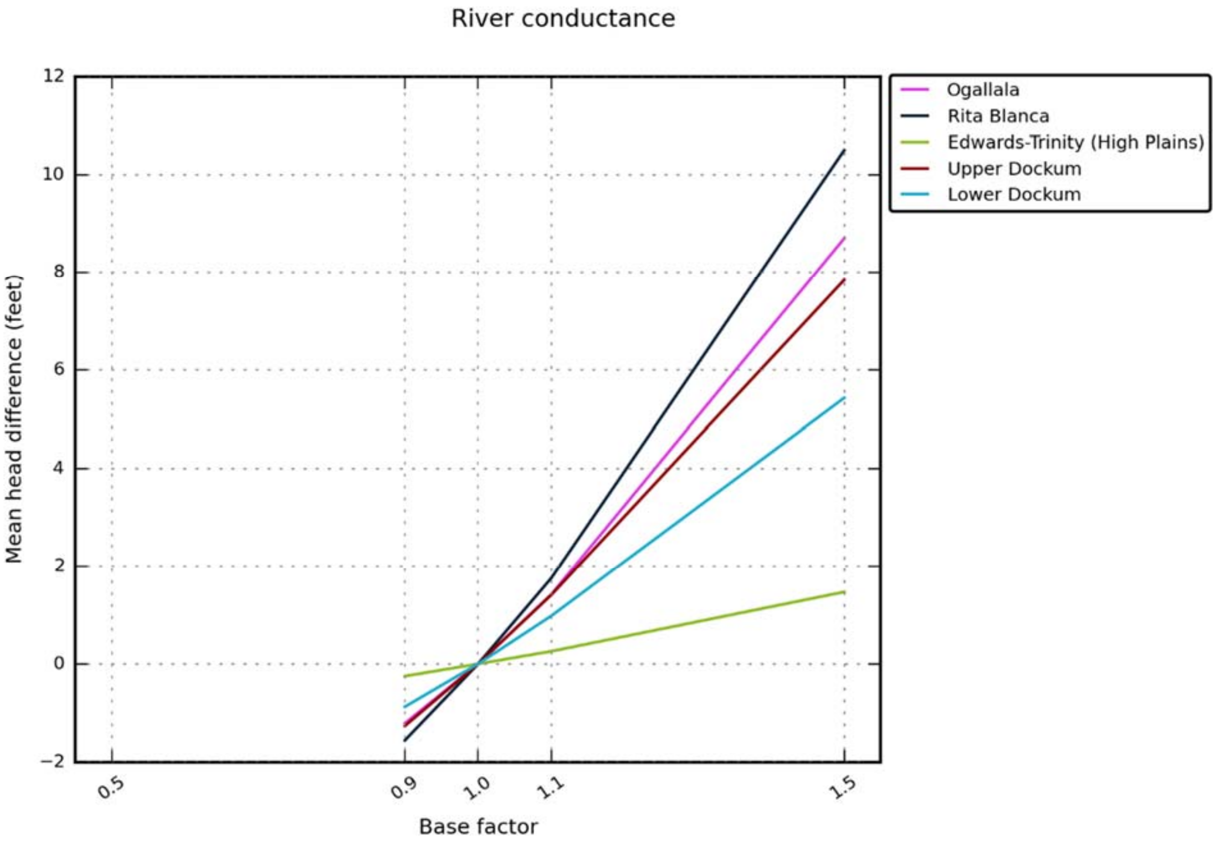


Figure 4.2.60 Hydraulic head sensitivity in feet for the transient model to changes in river boundary conductance.

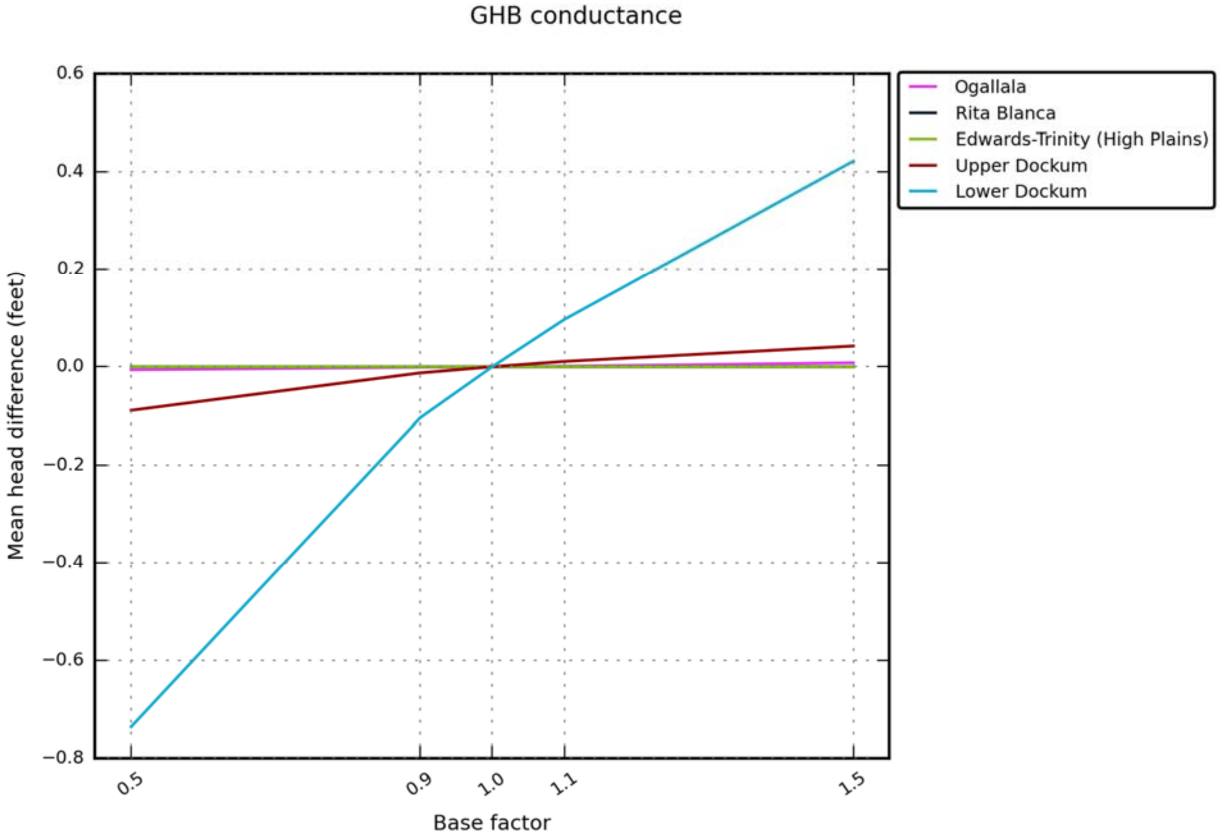


Figure 4.2.61 **Hydraulic head sensitivity in feet for the transient model to changes in river boundary conductance, representing river boundaries as general-head boundaries (GHB).**

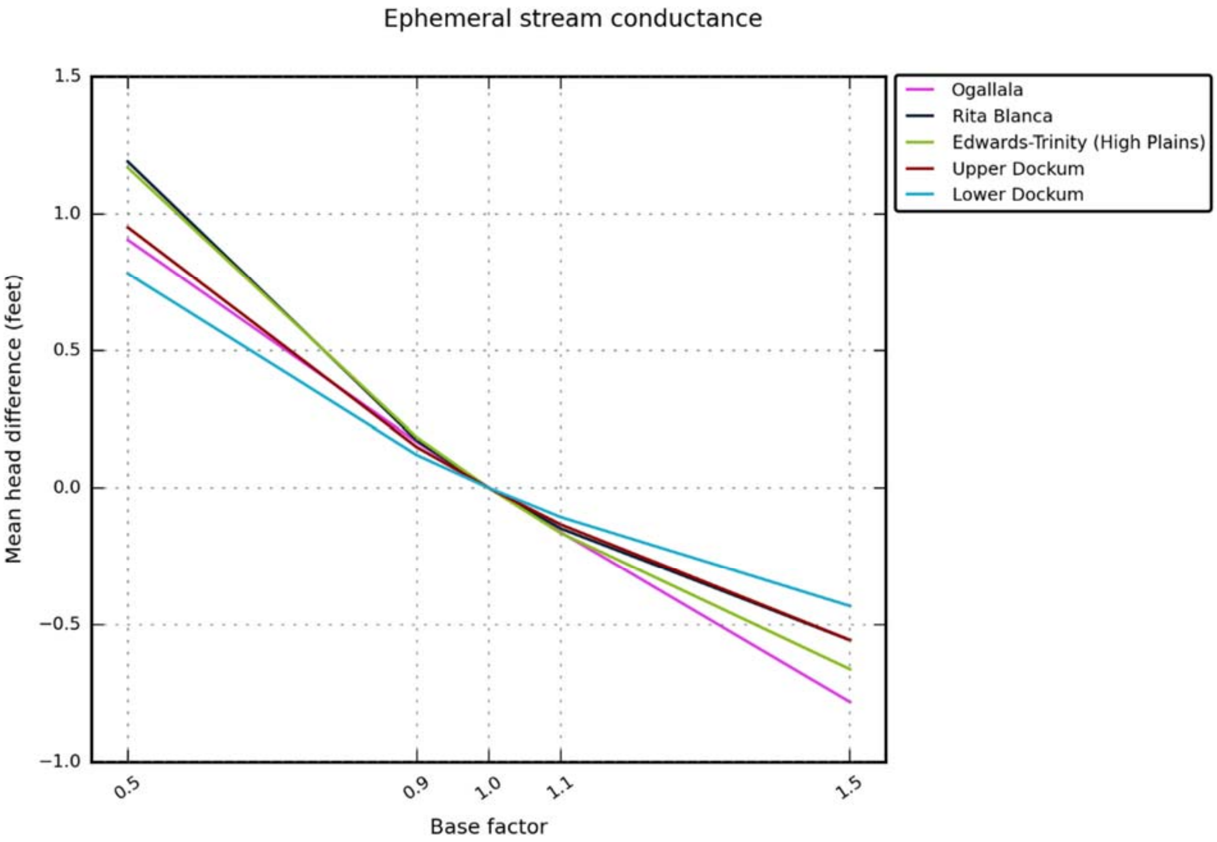


Figure 4.2.62 Hydraulic head sensitivity in feet for the transient model to changes in drain boundary conductance, representing ephemeral streams.

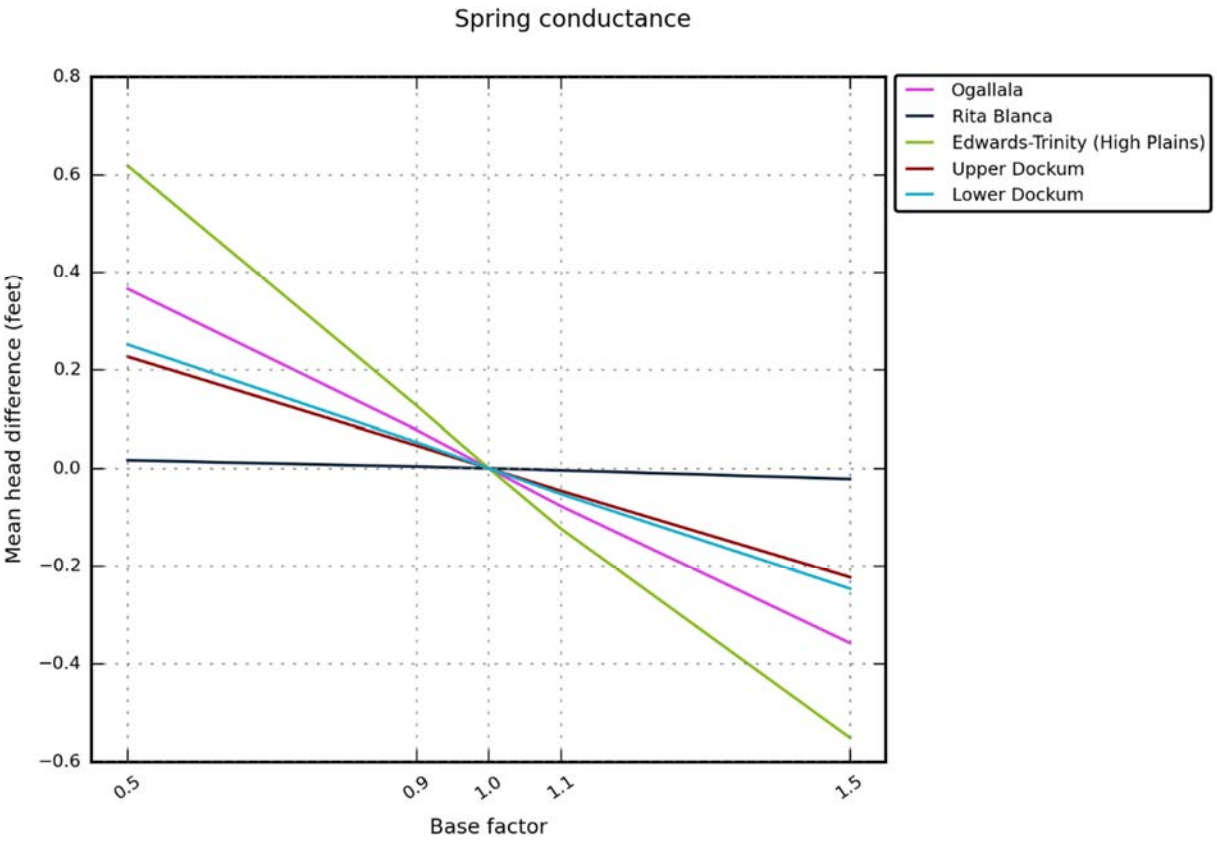


Figure 4.2.63 **Hydraulic head sensitivity in feet for the transient model to changes in drain boundary conductance, representing springs.**

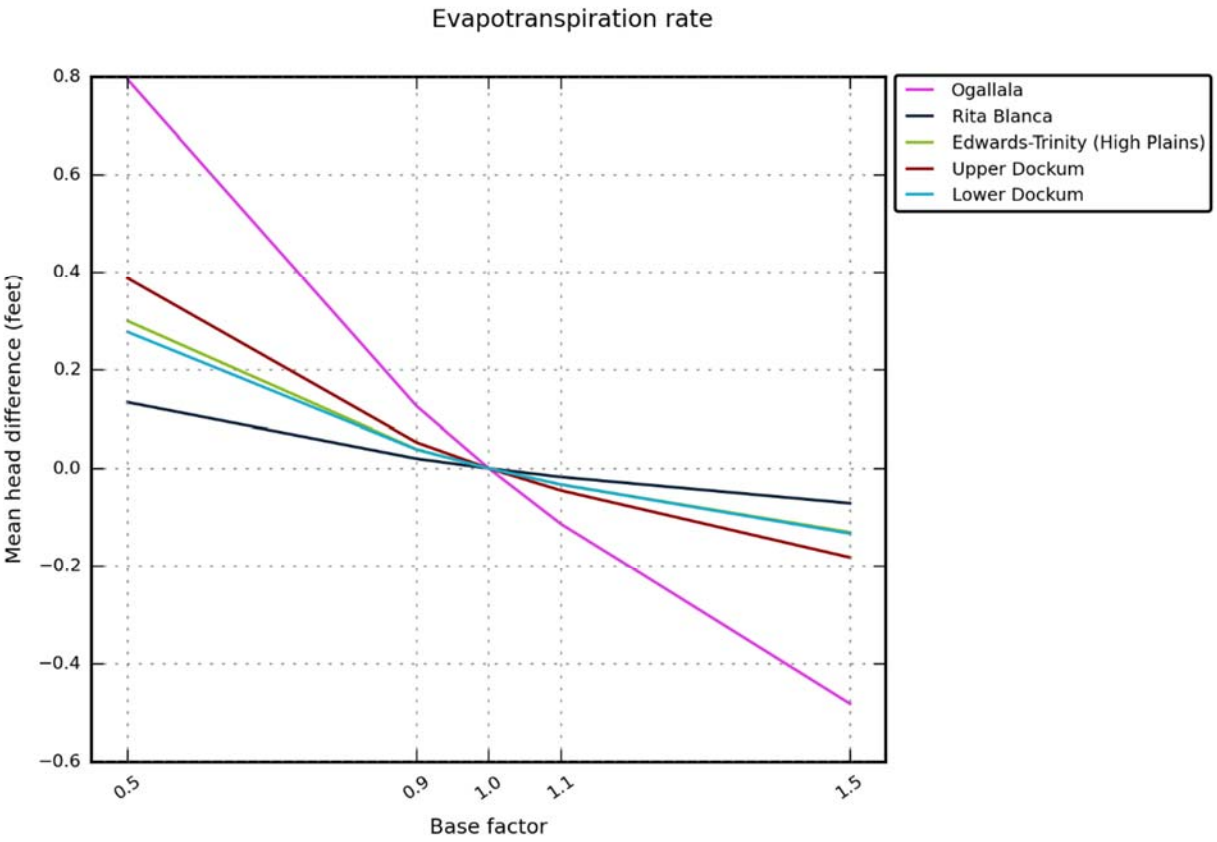


Figure 4.2.64 Hydraulic head sensitivity in feet for the transient model to changes in maximum evapotranspiration rate.

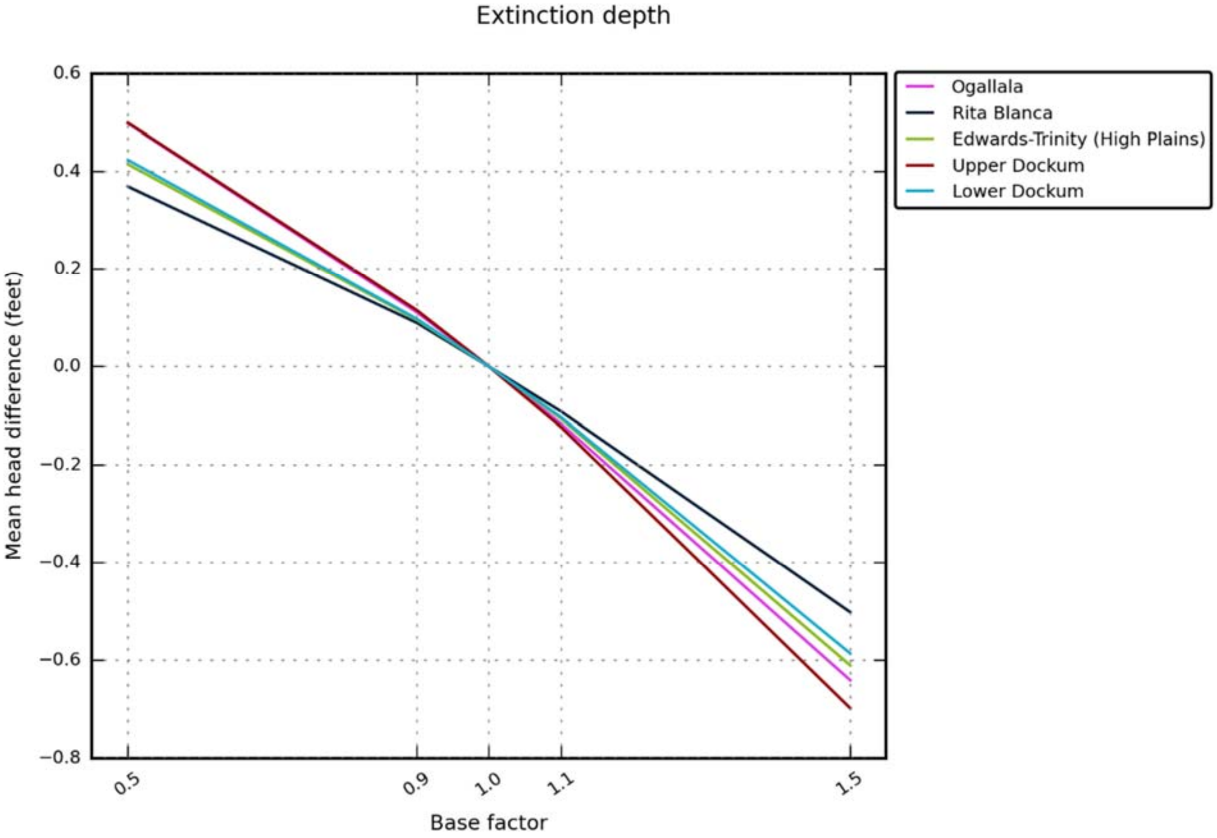


Figure 4.2.65 Hydraulic head sensitivity in feet for the transient model to changes in evapotranspiration extinction depth.

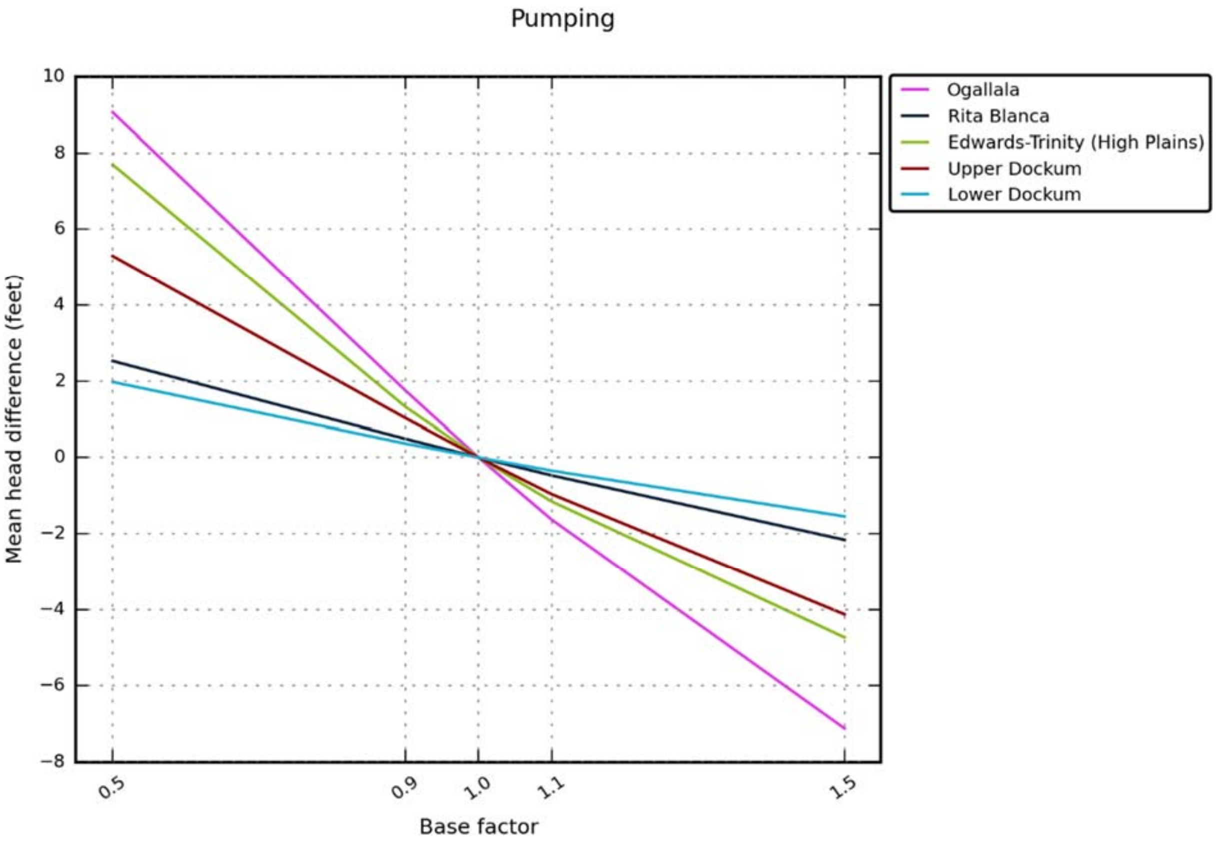


Figure 4.2.66 Hydraulic head sensitivity in feet for the transient model to changes in well boundary discharge.

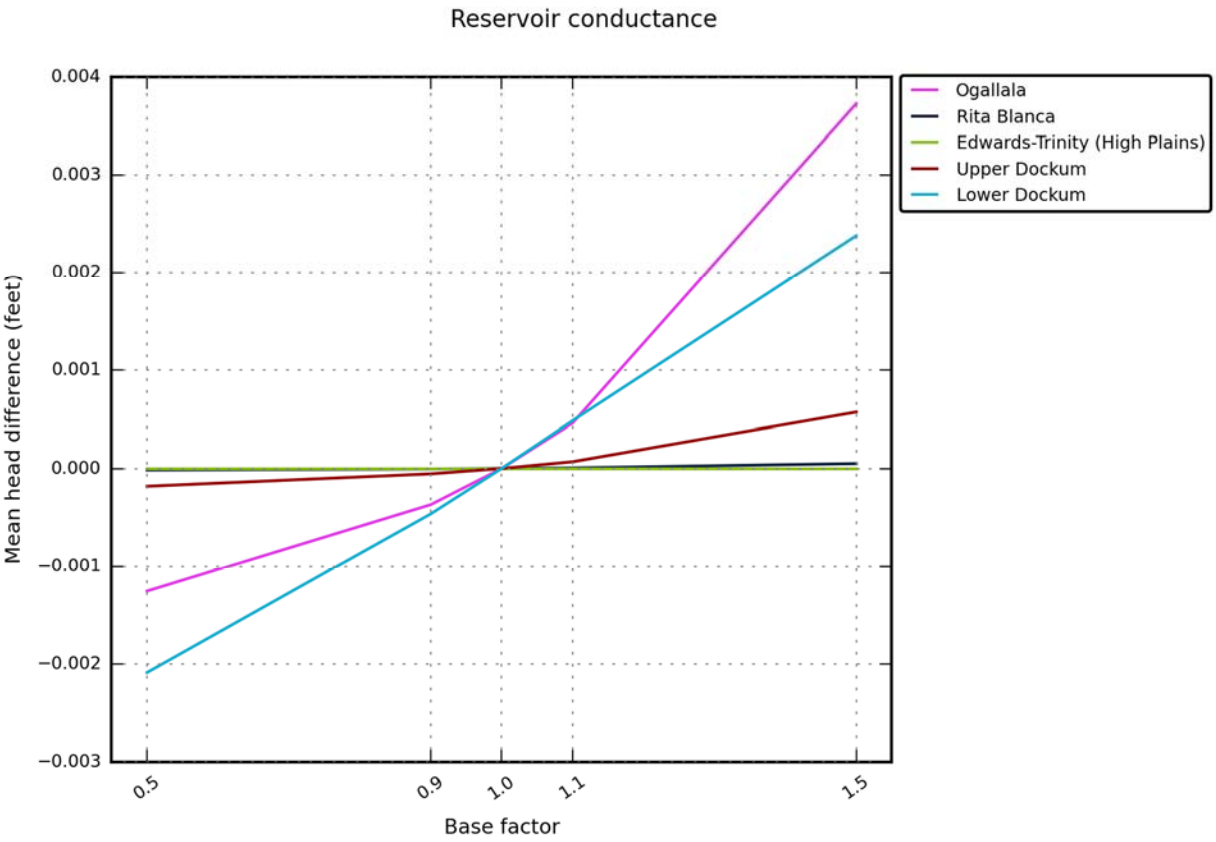


Figure 4.2.67 Hydraulic head sensitivity in feet for the transient model to changes in drain boundary conductance, representing reservoirs.

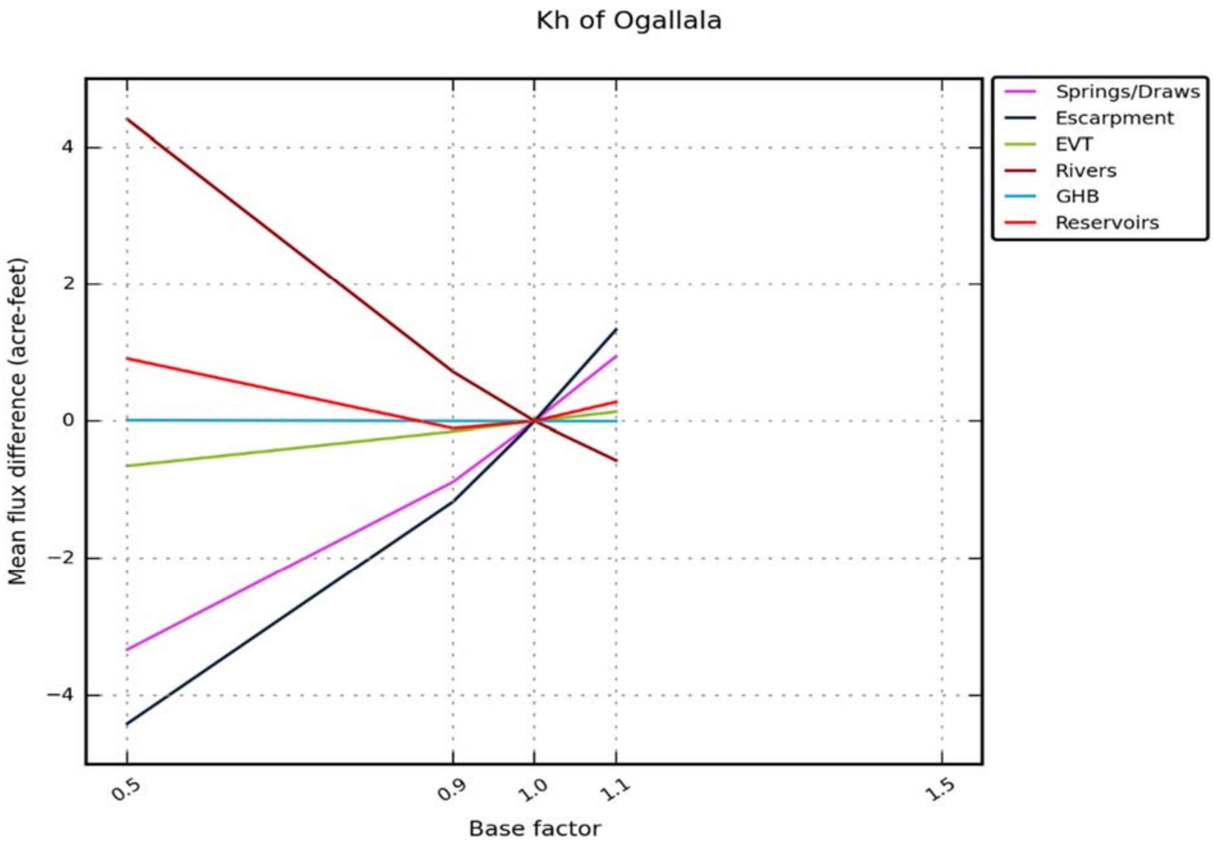


Figure 4.2.68 **Flow sensitivity in acre-feet per year for the transient model to changes in horizontal hydraulic conductivity (Kh) of the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

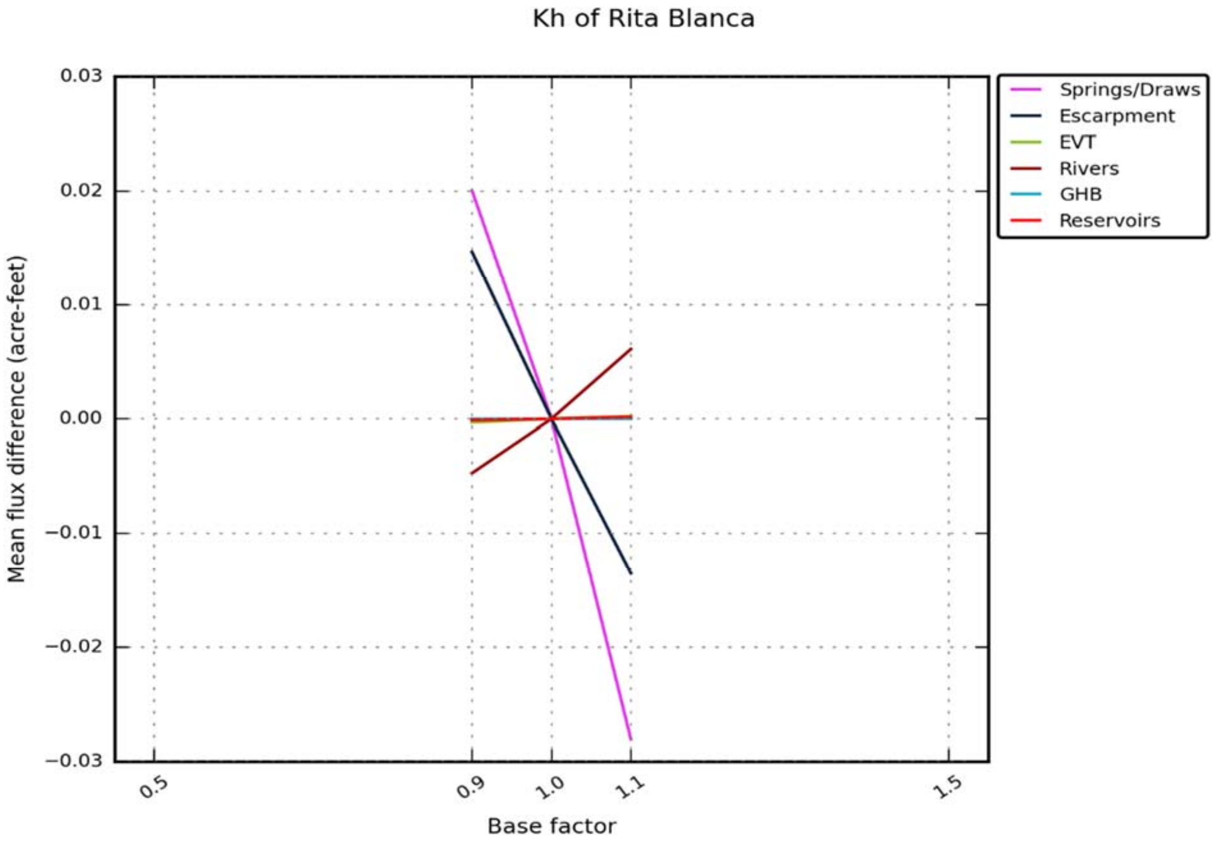


Figure 4.2.69 **Flow sensitivity in acre-feet per year for the transient model to changes in horizontal hydraulic conductivity (Kh) of the Rita Blanca Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

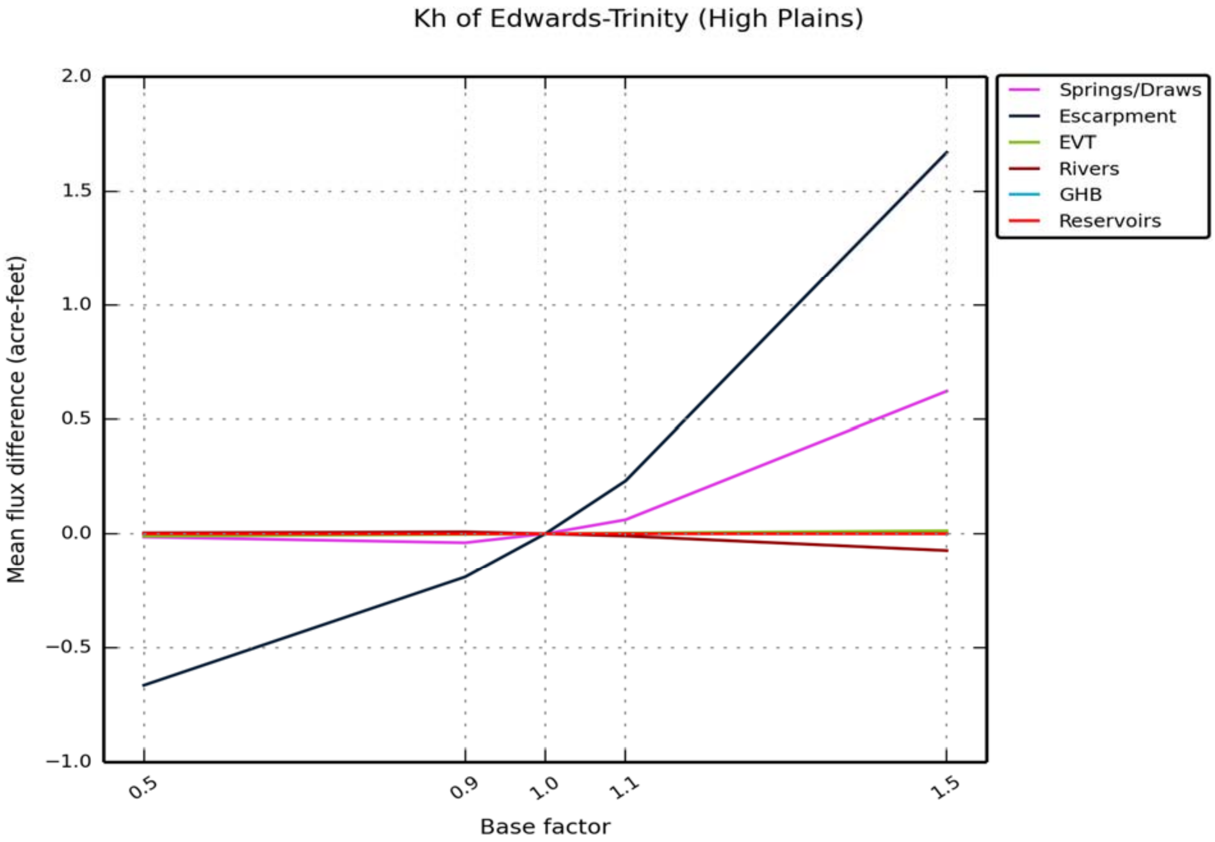


Figure 4.2.70 **Flow sensitivity in acre-feet per year for the transient model to changes in horizontal hydraulic conductivity (Kh) of the Edwards-Trinity (High Plains) Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

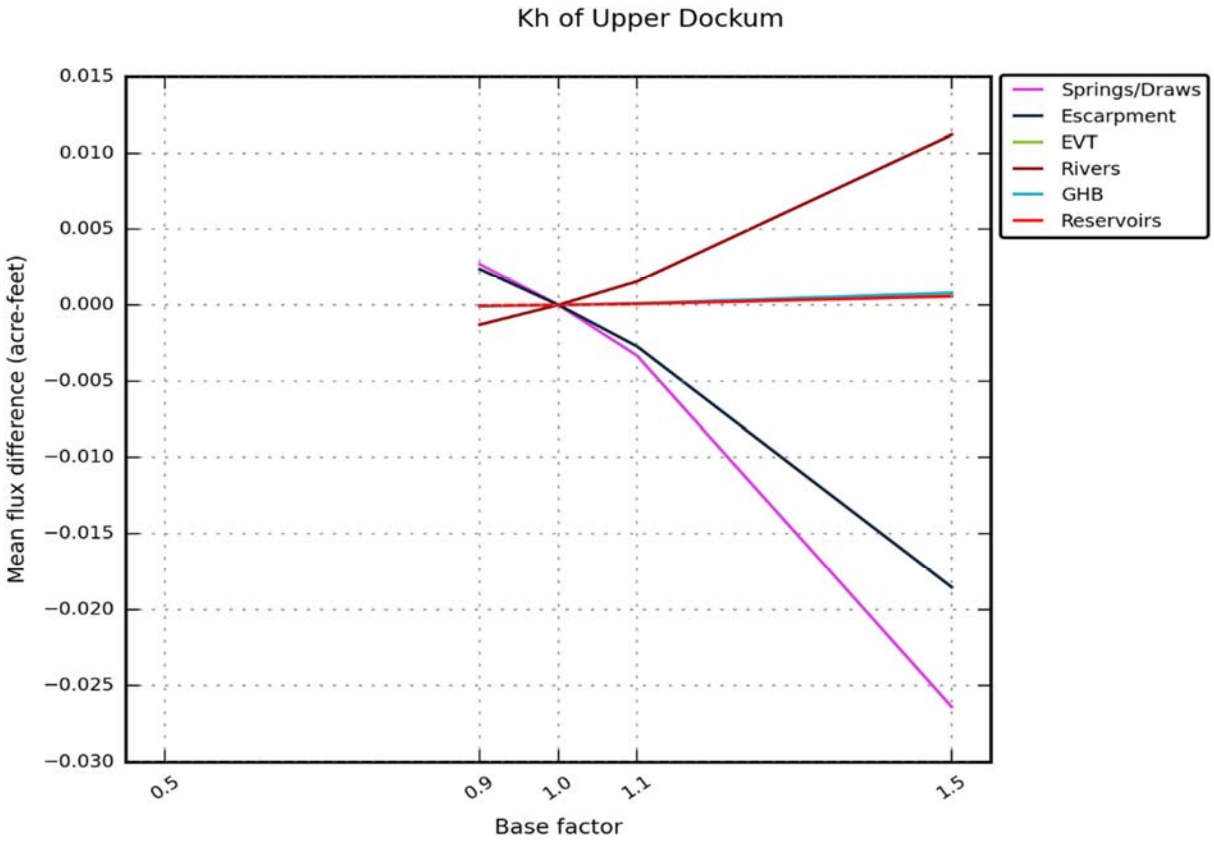


Figure 4.2.71 **Flow sensitivity in acre-feet per year for the transient model to changes in horizontal hydraulic conductivity (Kh) of the upper Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

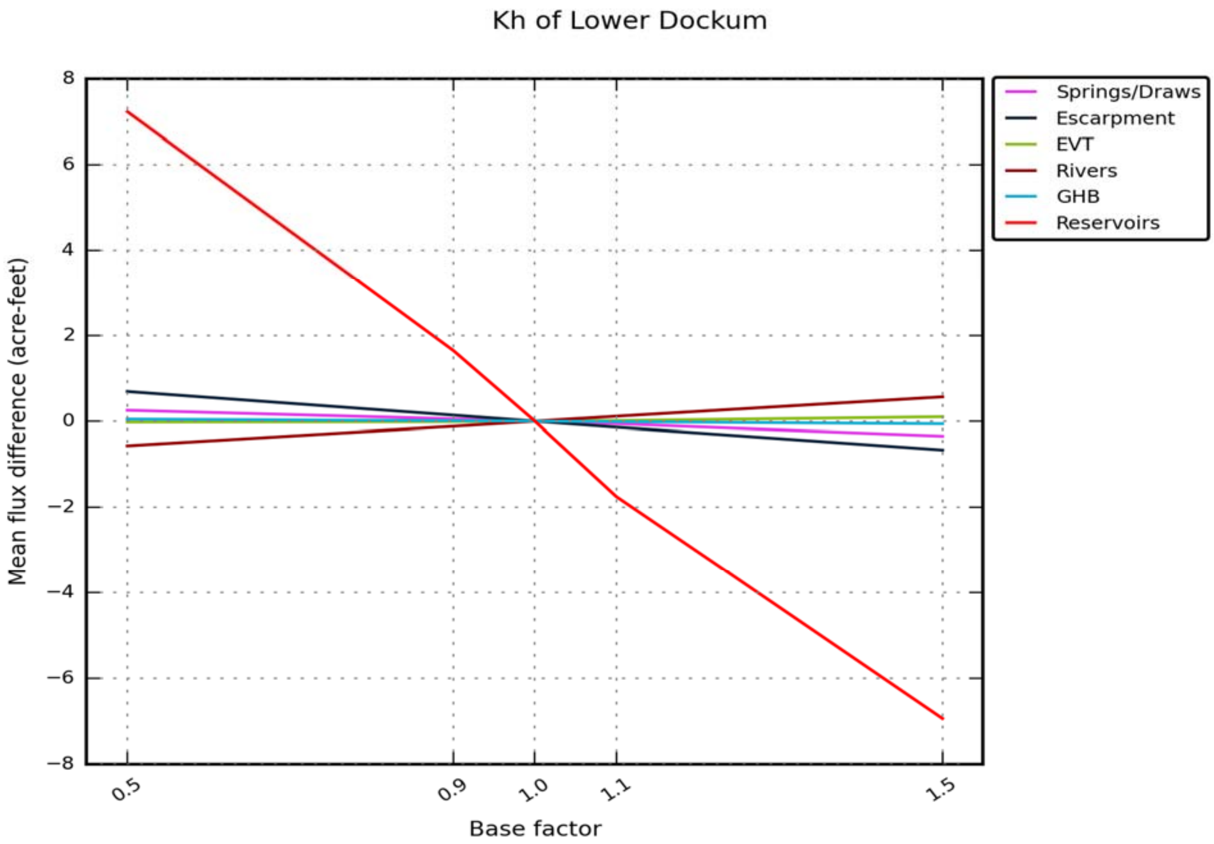


Figure 4.2.72 **Flow sensitivity in acre-feet per year for the transient model to changes in horizontal hydraulic conductivity (Kh) of the lower Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

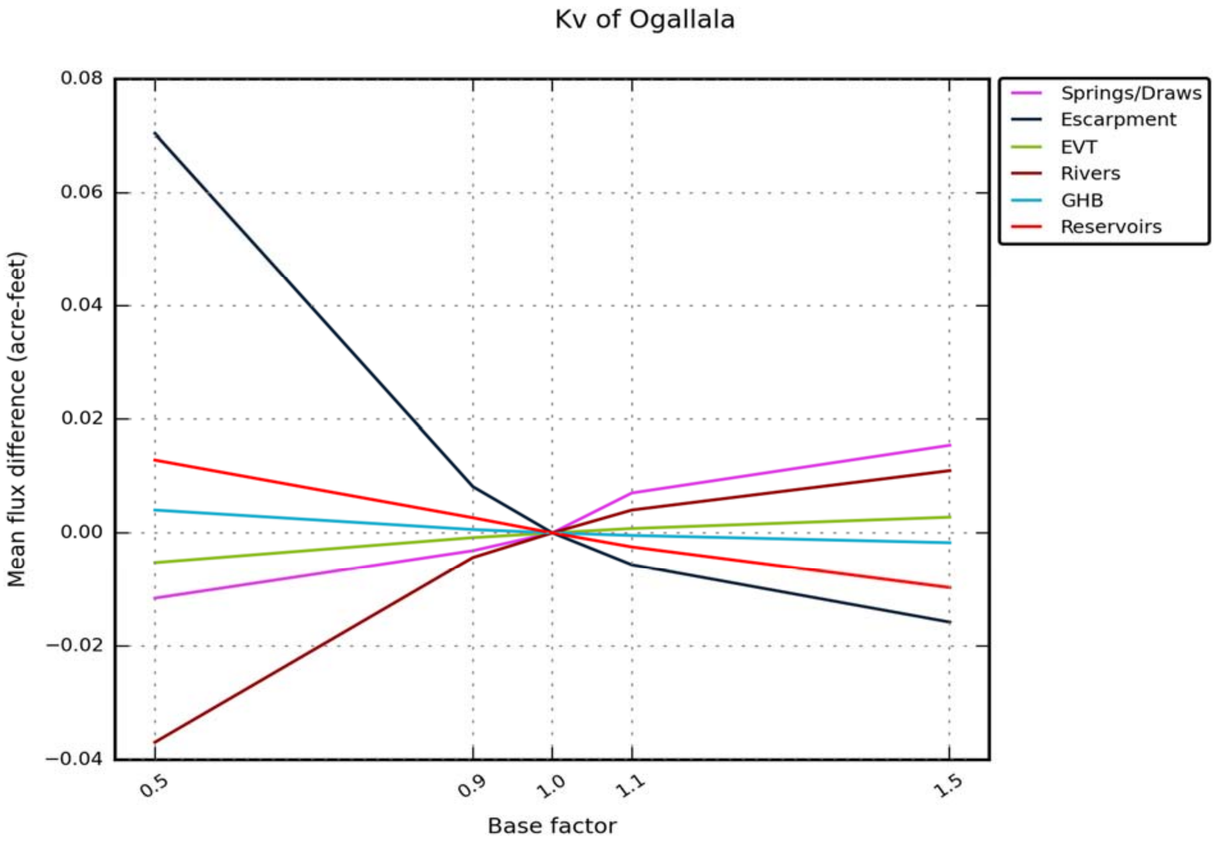


Figure 4.2.73 **Flow sensitivity in acre-feet per year for the transient model to changes in vertical hydraulic conductivity (Kv) of the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

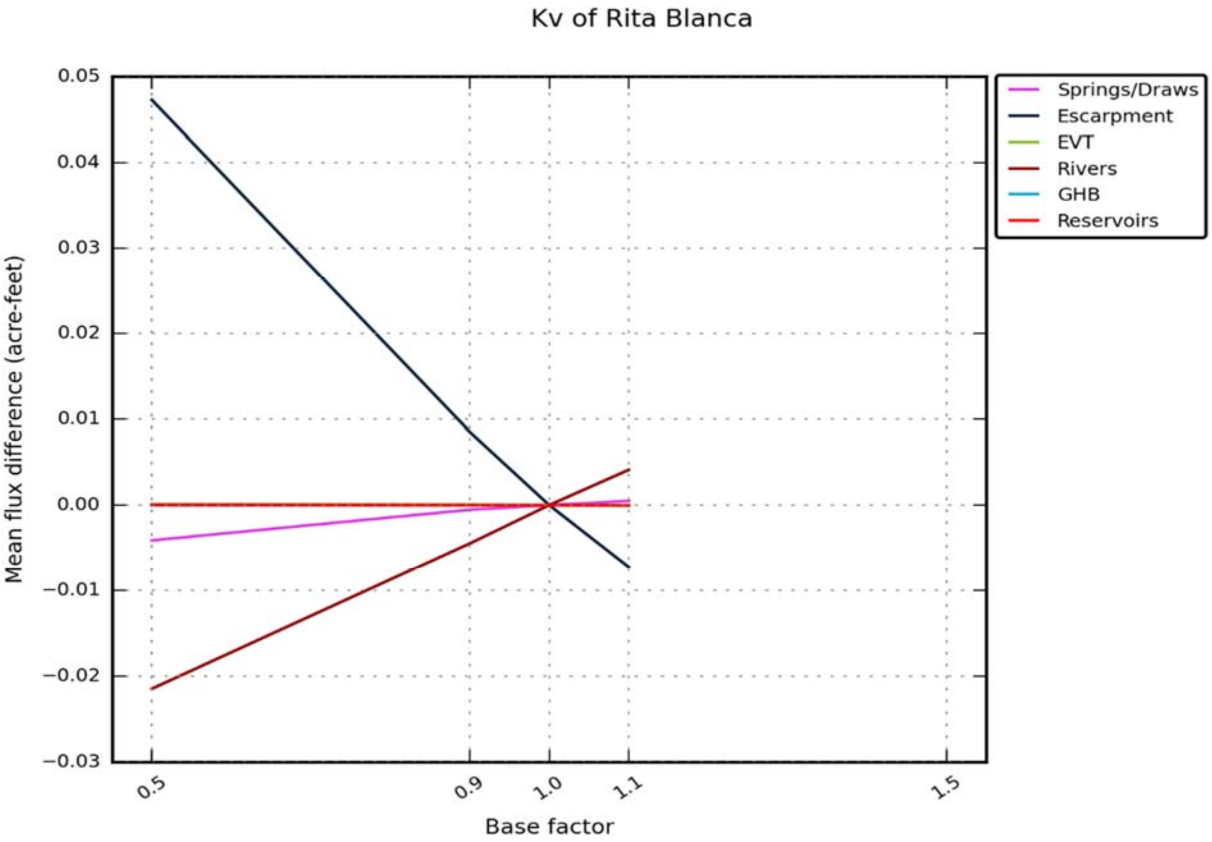


Figure 4.2.74 **Flow sensitivity in acre-feet per year for the transient model to changes in vertical hydraulic conductivity (Kv) of the Rita Blanca Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

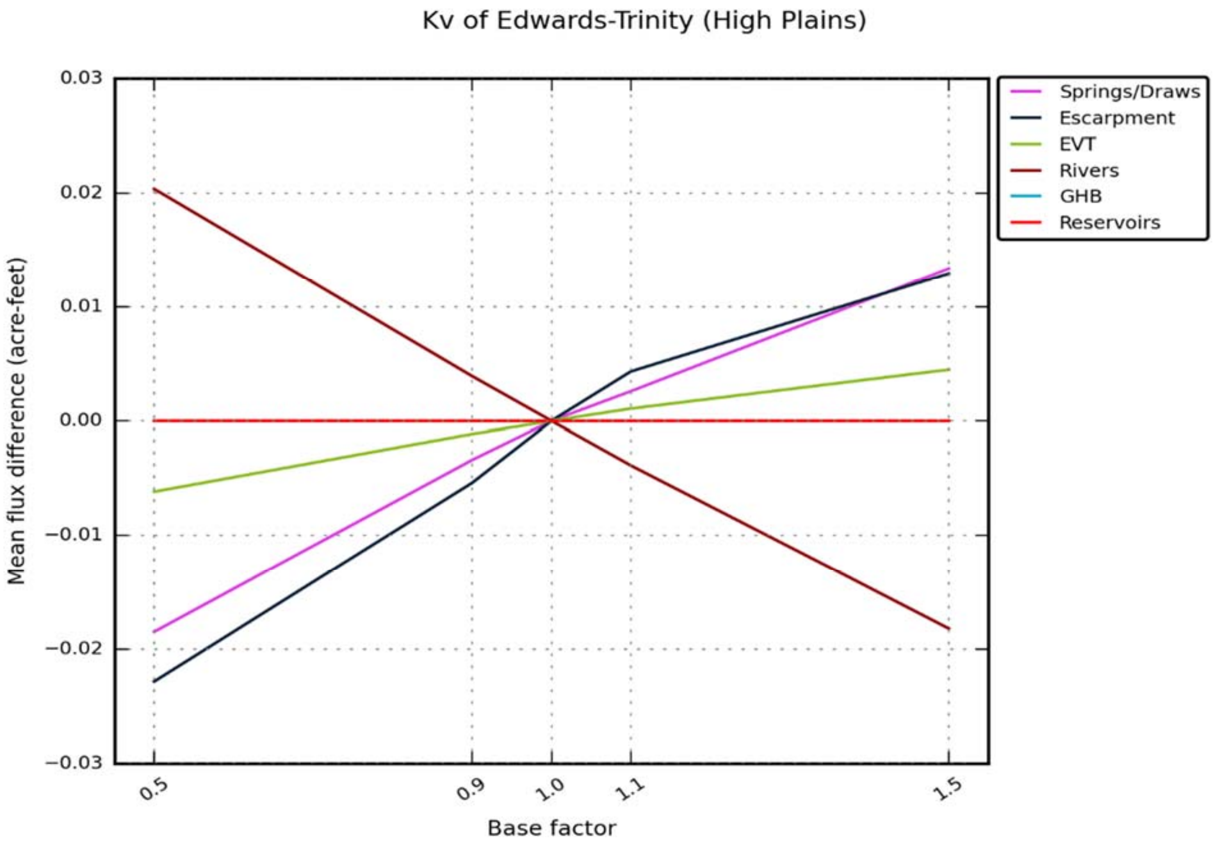


Figure 4.2.75 Flow sensitivity in acre-feet per year for the transient model to changes in vertical hydraulic conductivity (Kv) of the Edwards-Trinity (High Plains) Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

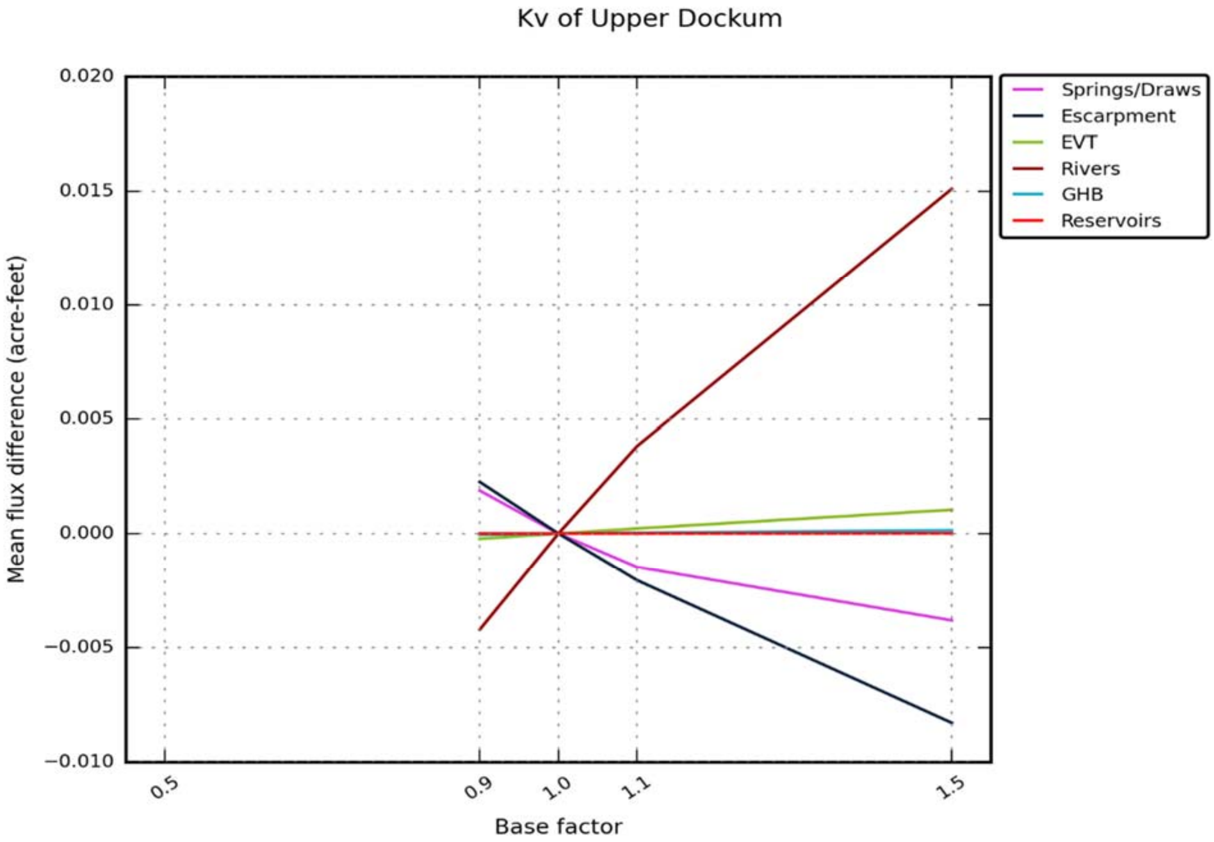


Figure 4.2.76 **Flow sensitivity in acre-feet per year for the transient model to changes in vertical hydraulic conductivity (Kv) of the upper Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

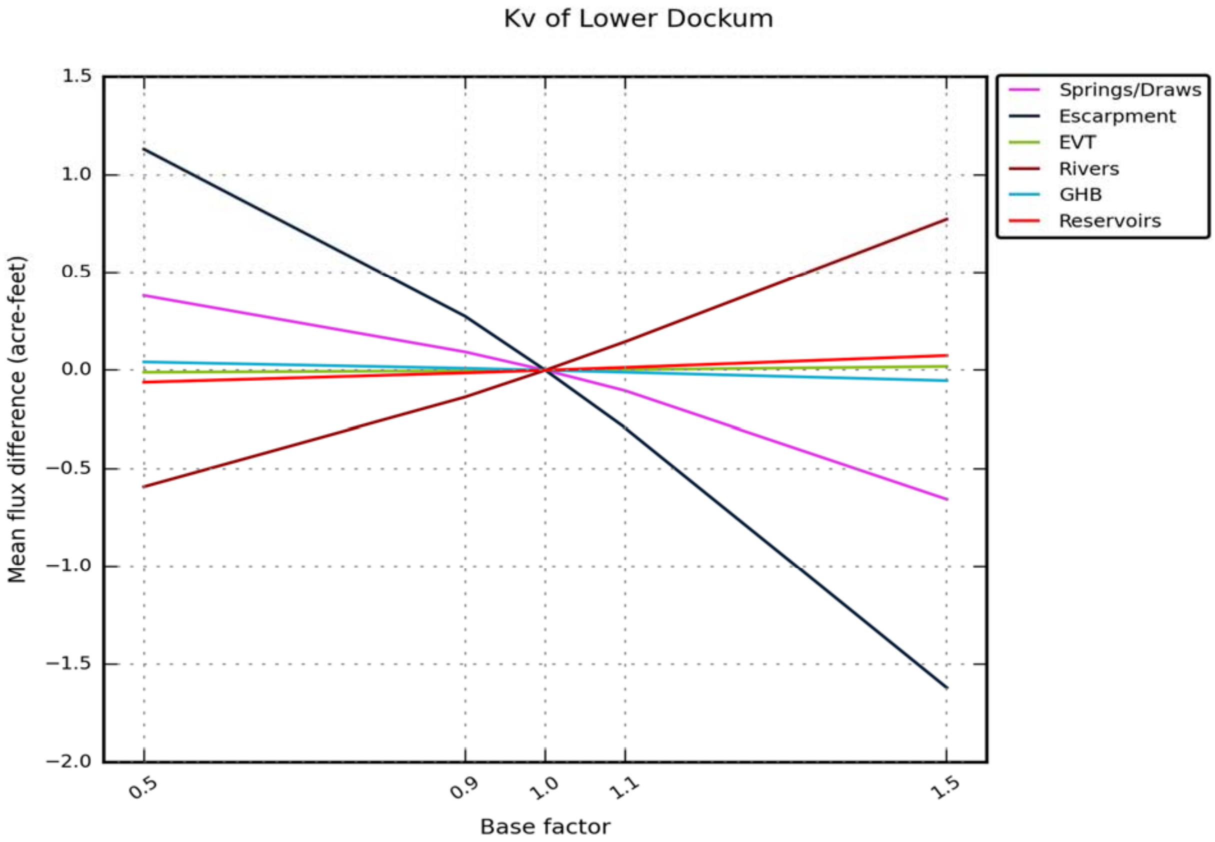


Figure 4.2.77 **Flow sensitivity in acre-feet per year for the transient model to changes in vertical hydraulic conductivity (Kv) of the lower Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

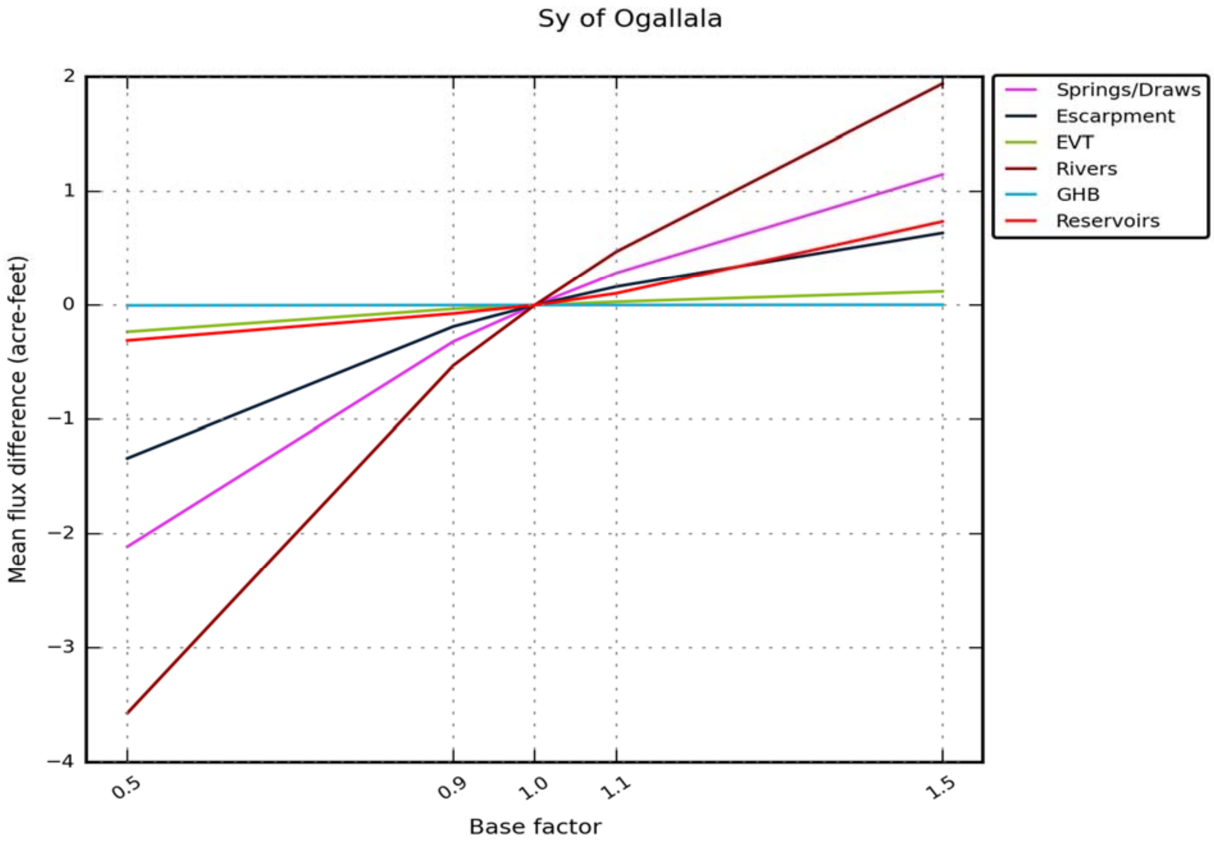


Figure 4.2.78 **Flow sensitivity in acre-feet per year for the transient model to changes in specific yield (Sy) of the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

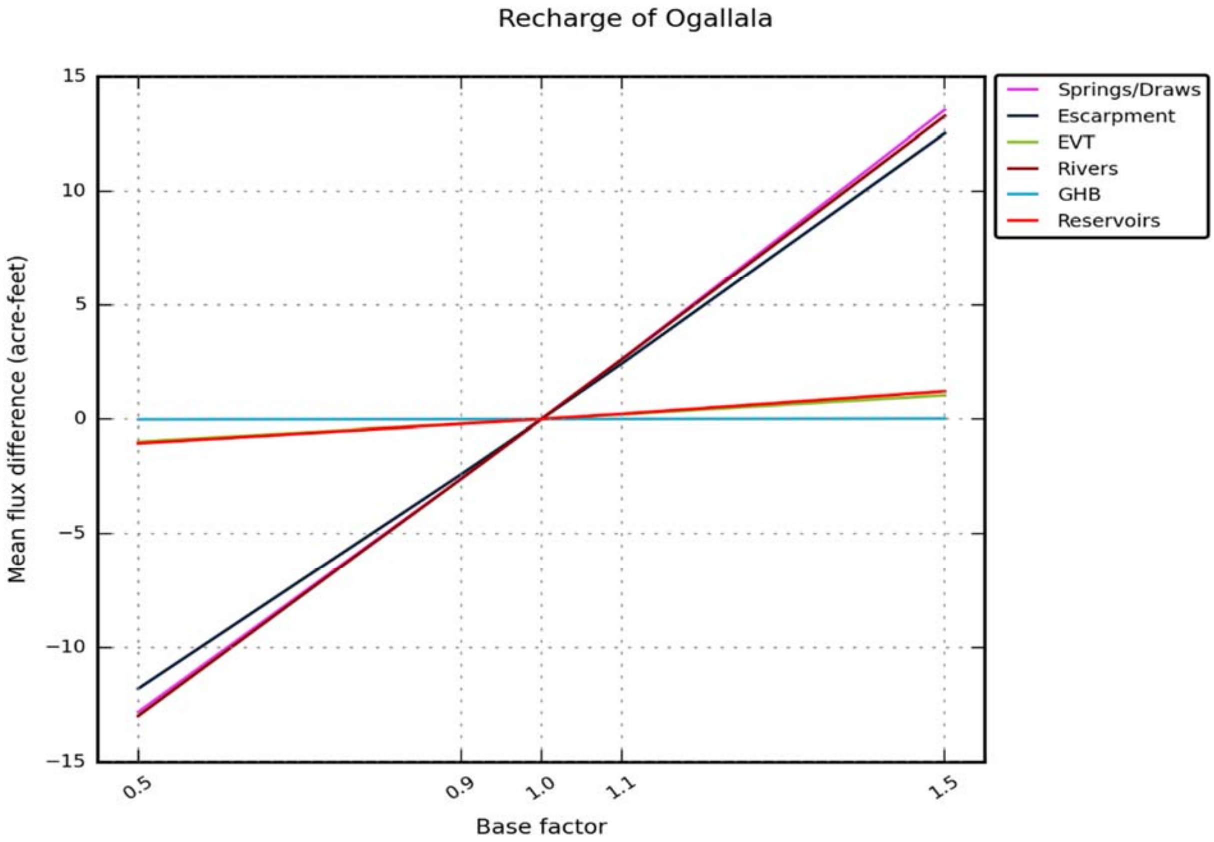


Figure 4.2.79 **Flow sensitivity in acre-feet per year for the transient model to changes in recharge in the Ogallala Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

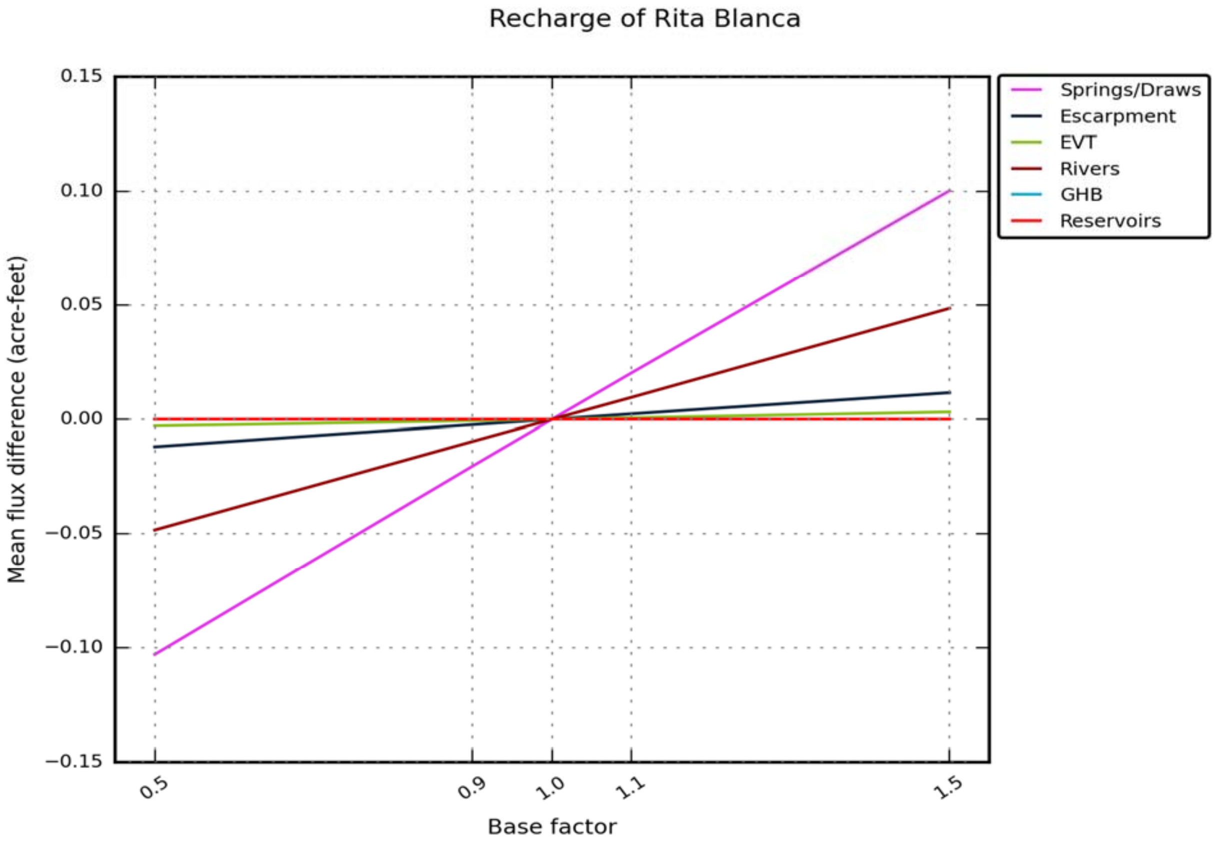


Figure 4.2.80 **Flow sensitivity in acre-feet per year for the transient model to changes in recharge in the Rita Blanca Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

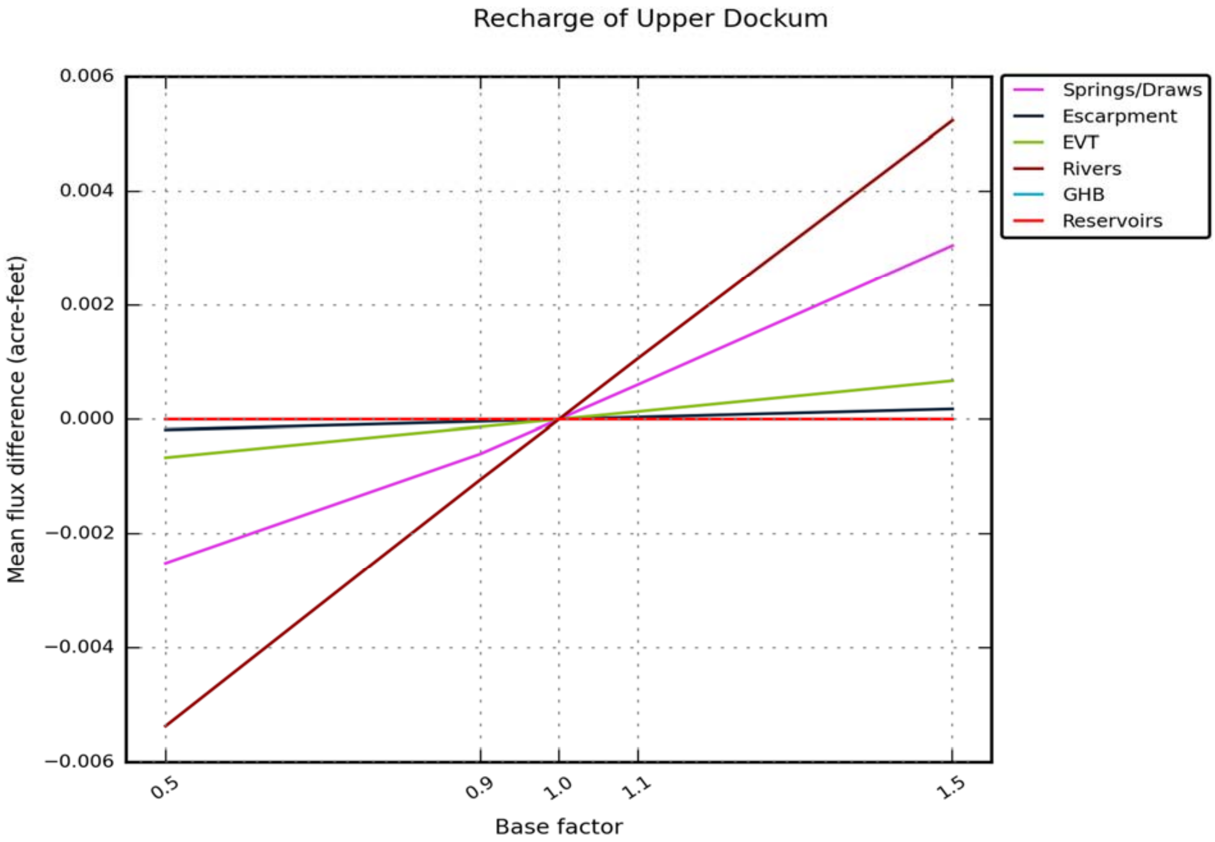


Figure 4.2.81 **Flow sensitivity in acre-feet per year for the transient model to changes in recharge in the upper Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

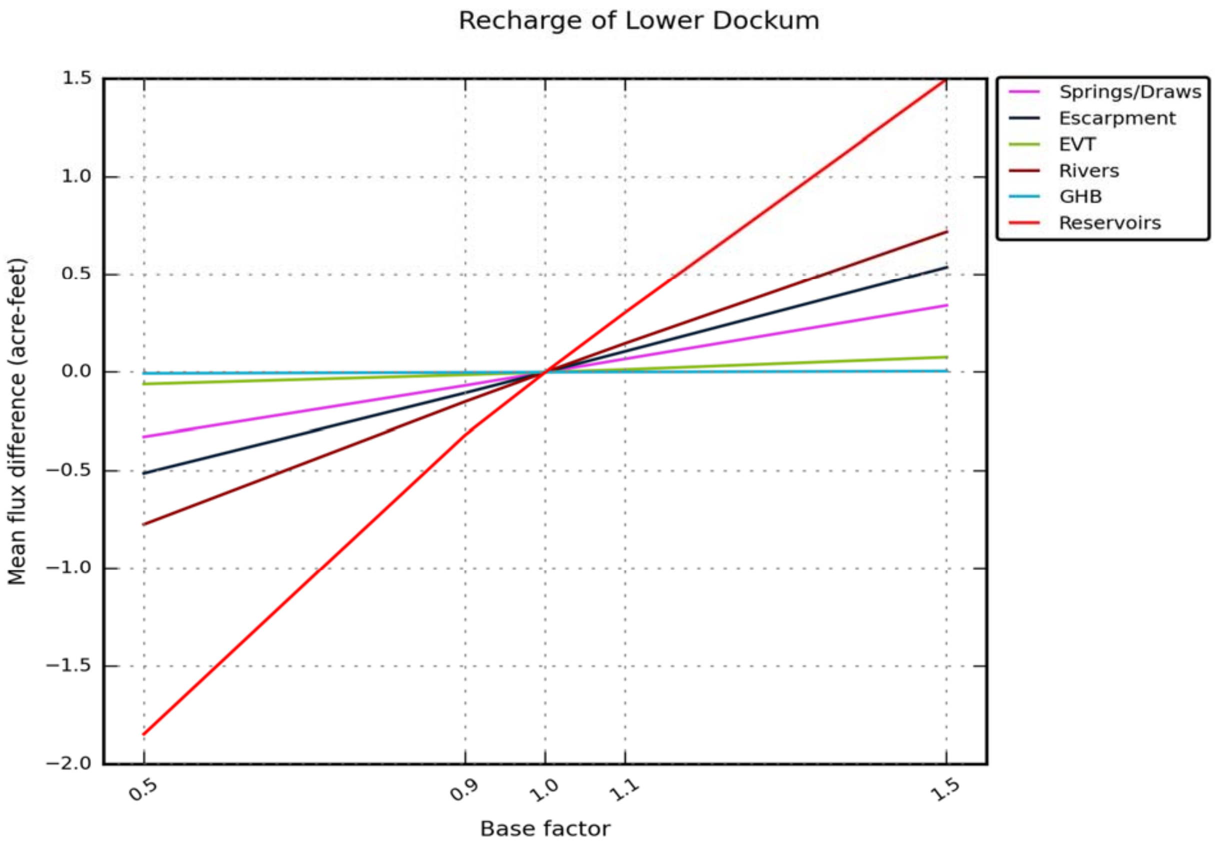


Figure 4.2.82 **Flow sensitivity in acre-feet per year for the transient model to changes in recharge in the lower Dockum Aquifer. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

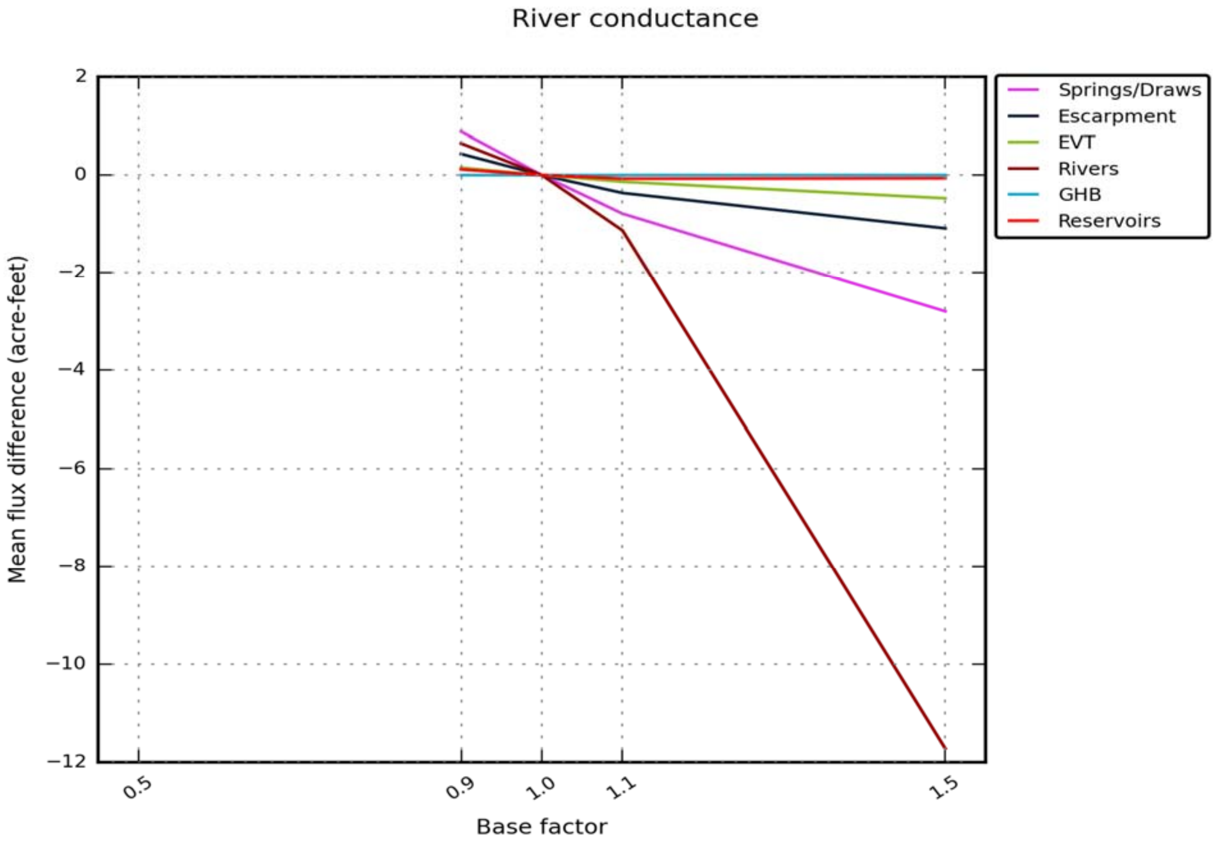


Figure 4.2.83 **Flow sensitivity in acre-feet per year for the transient model to changes in river boundary conductance. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

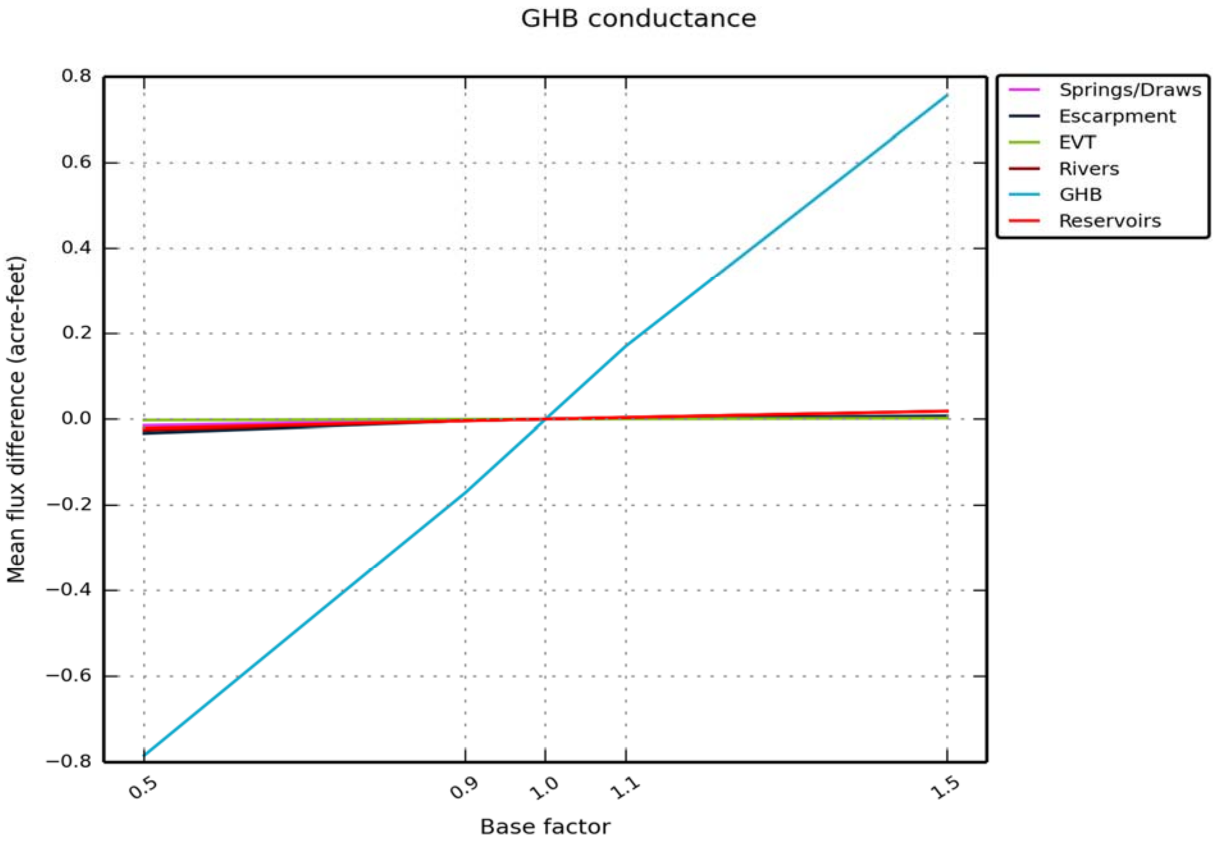


Figure 4.2.84 **Flow sensitivity in acre-feet per year for the transient model to changes in river boundary conductance, representing river boundaries as general-head boundaries. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

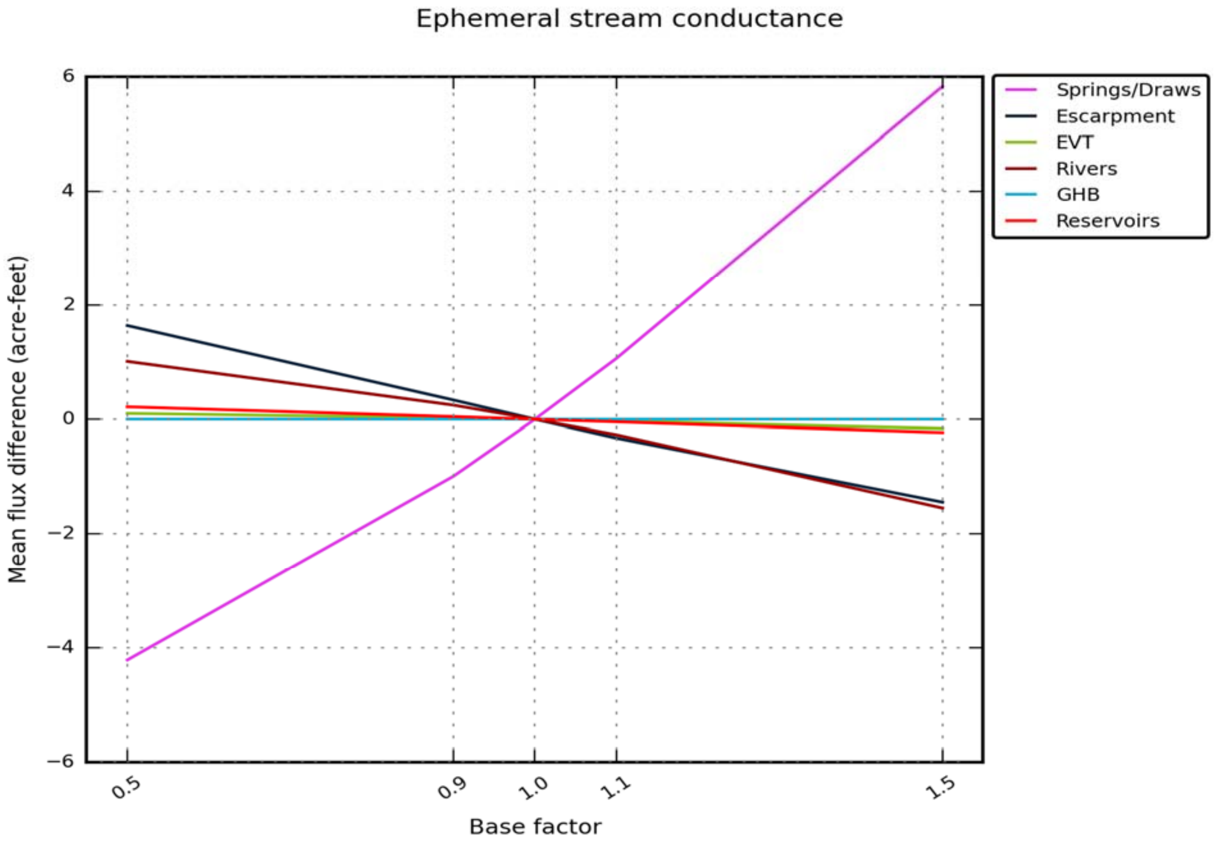


Figure 4.2.85 Flow sensitivity in acre-feet per year for the transient model to changes in drain boundary conductance, representing ephemeral streams. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

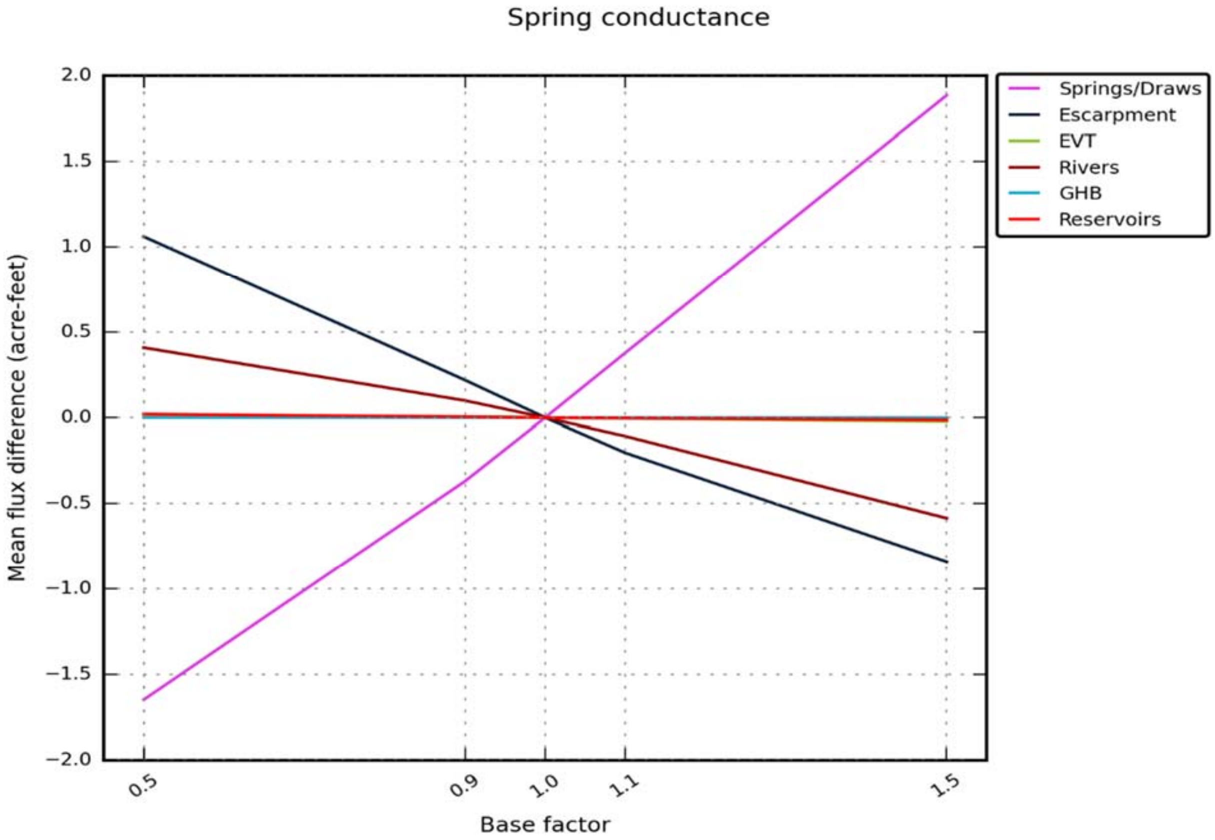


Figure 4.2.86 **Flow sensitivity in acre-feet per year for the transient model to changes in drain boundary conductance, representing springs. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

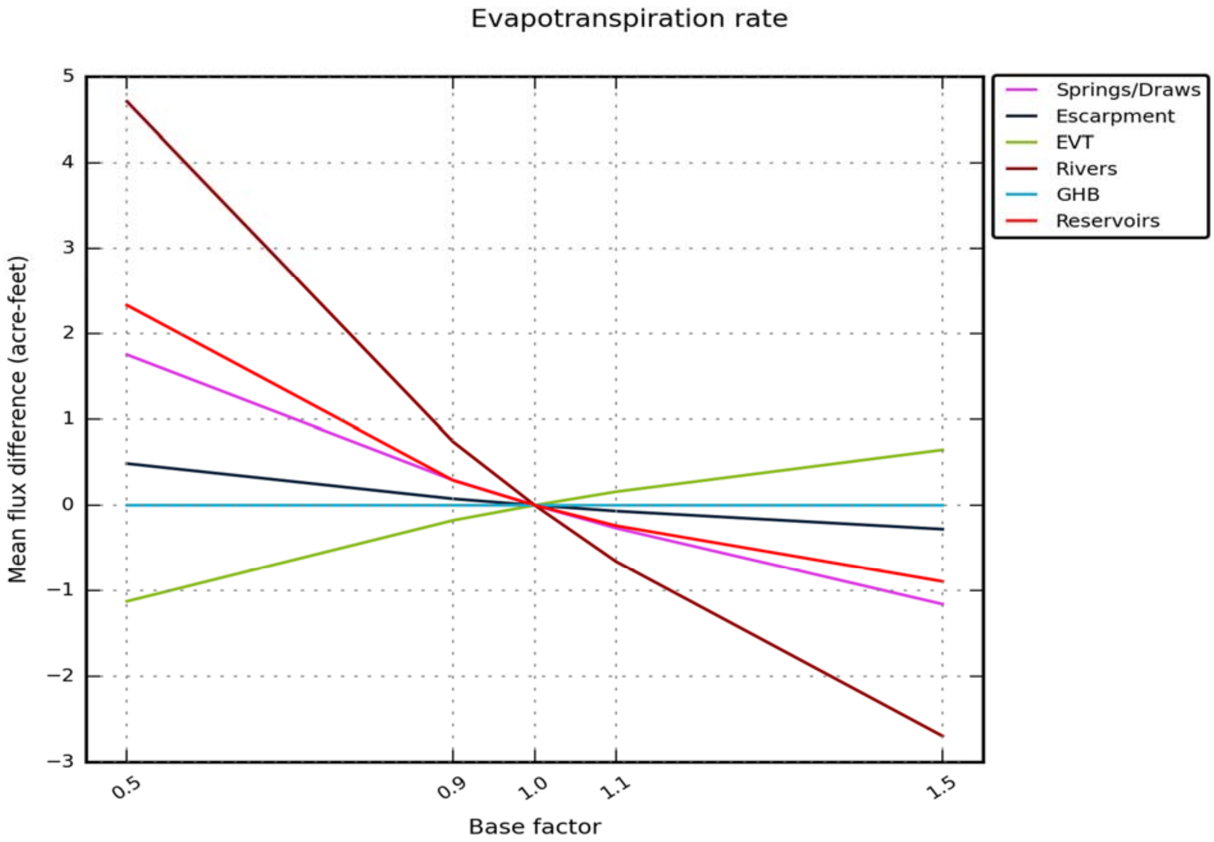


Figure 4.2.87 **Flow sensitivity in acre-feet per year for the transient model to changes in maximum evapotranspiration rate. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

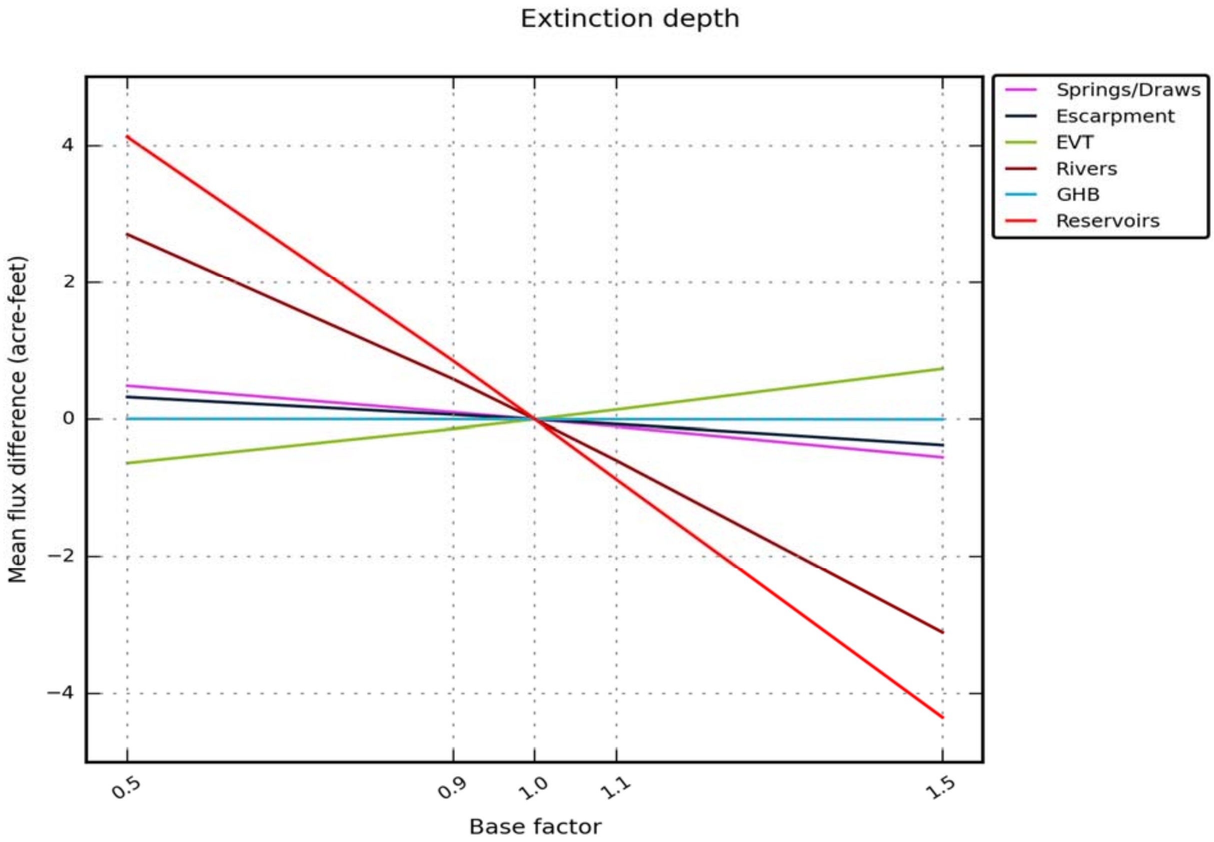


Figure 4.2.88 Flow sensitivity in acre-feet per year for the transient model to changes in evapotranspiration extinction depth. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)

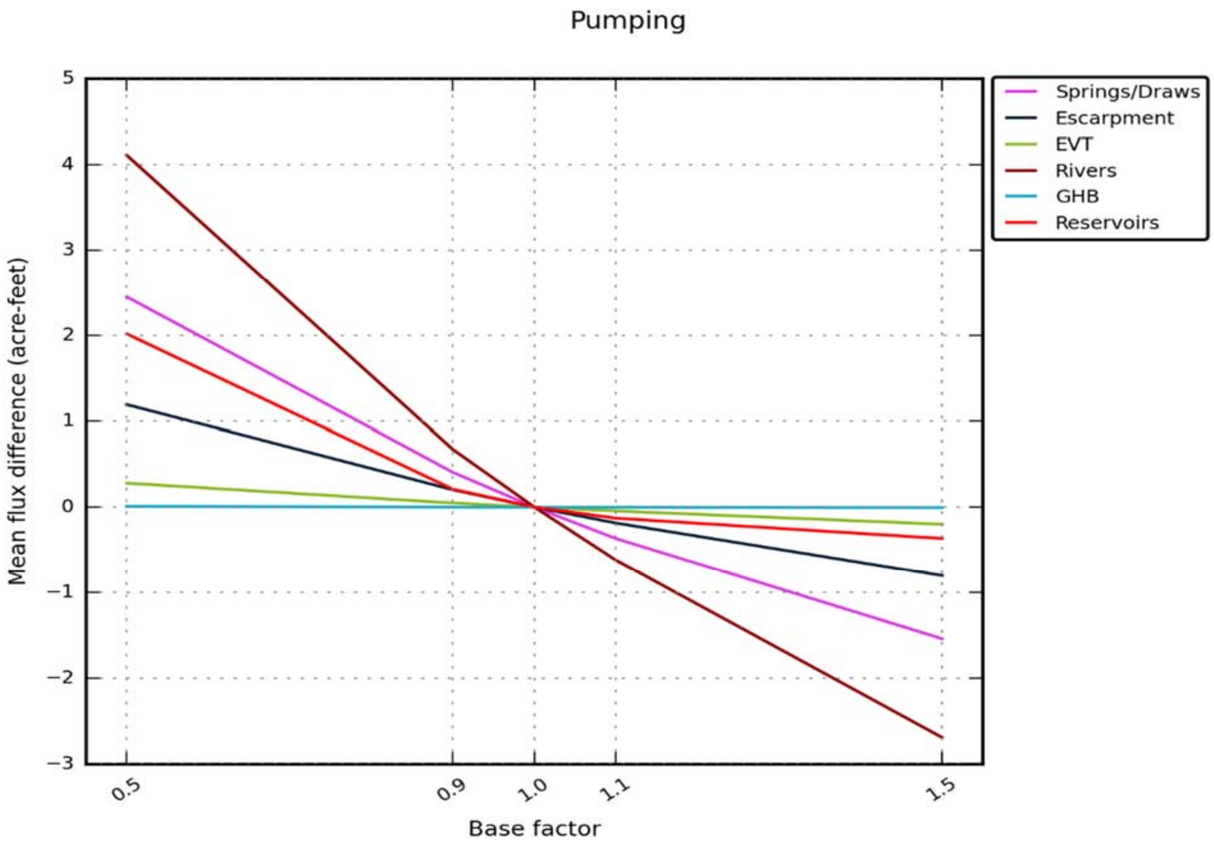


Figure 4.2.89 **Flow sensitivity in acre-feet per year for the transient model to changes in well boundary discharge. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

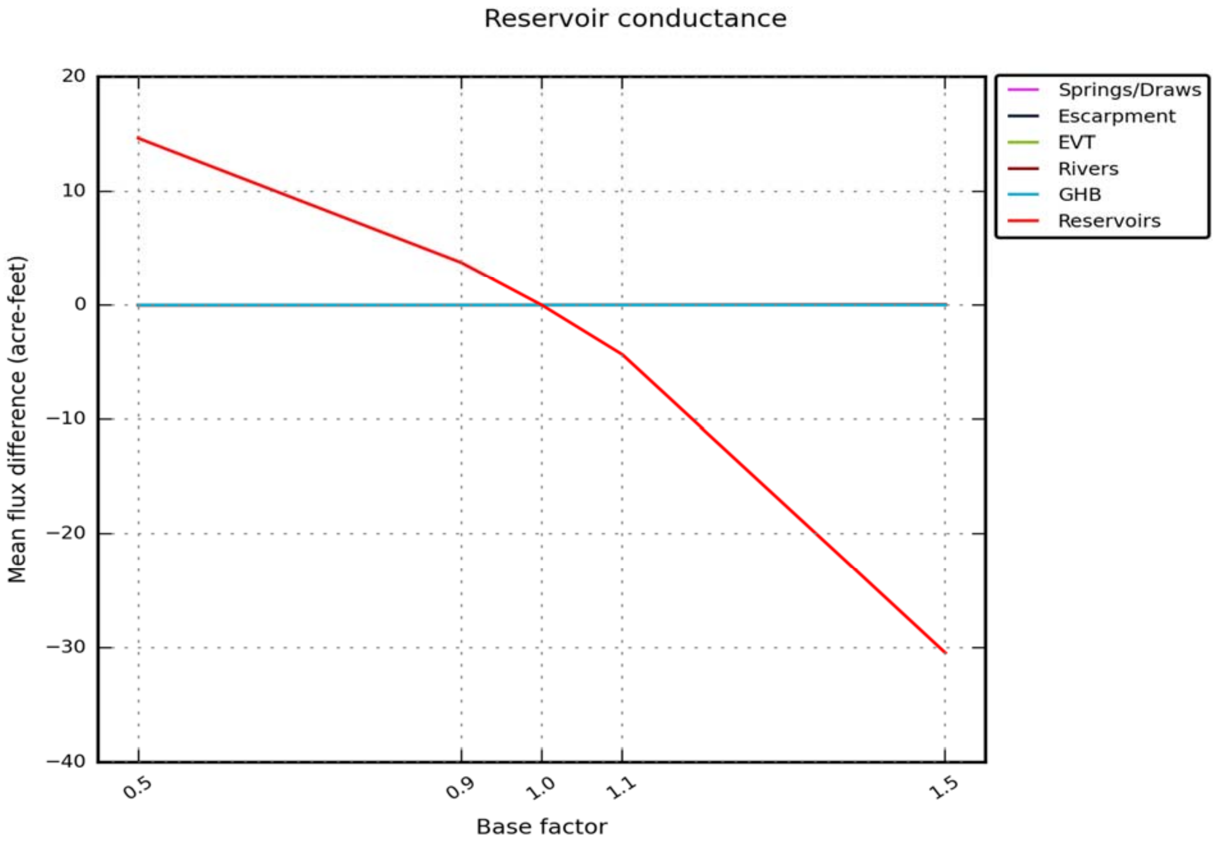


Figure 4.2.90 **Flow sensitivity in acre-feet per year for the transient model to changes in River package boundary conductance, representing reservoirs. (Abbreviation key: EVT = evapotranspiration fluxes, GHB = general-head boundary fluxes.)**

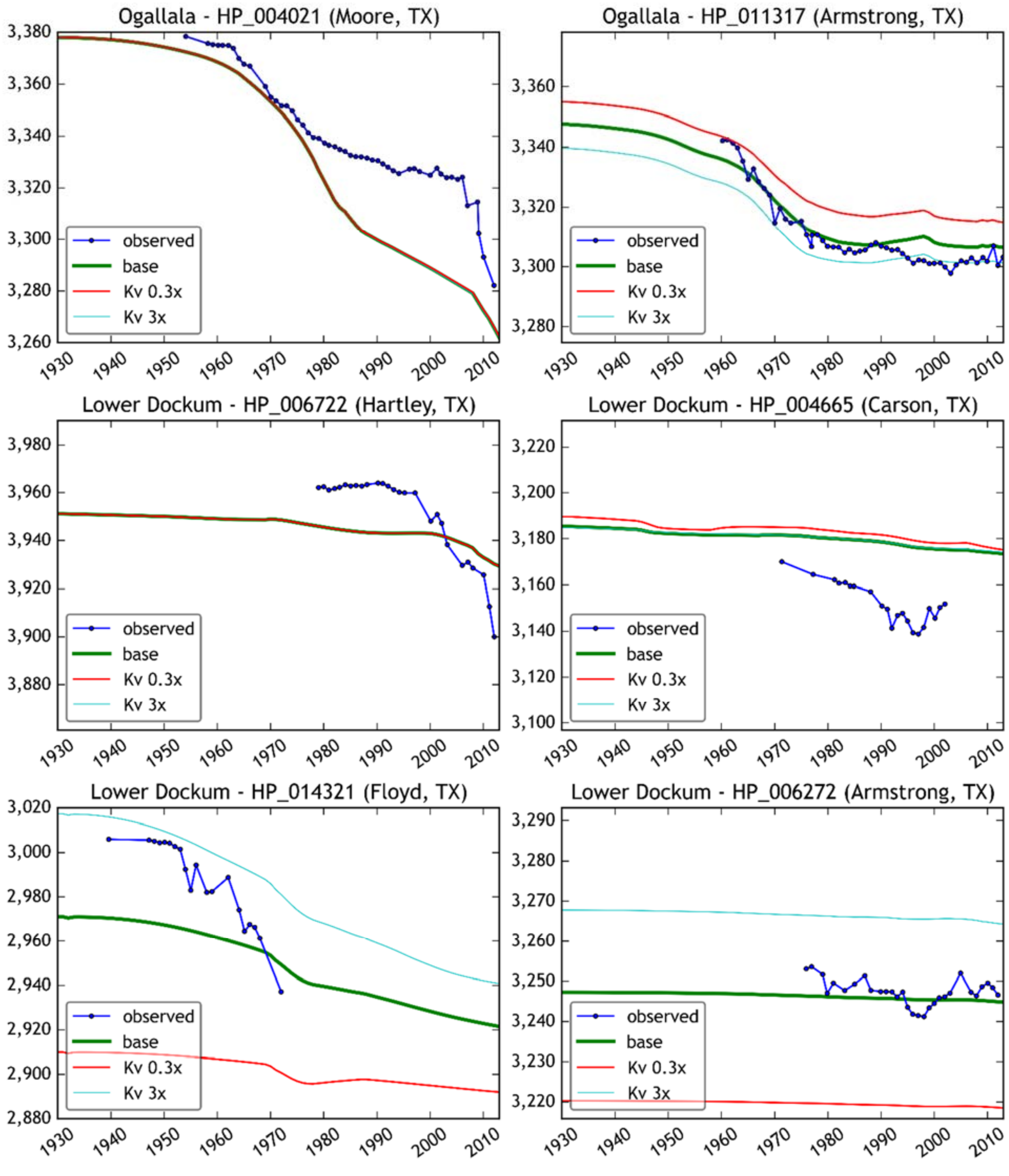


Figure 4.2.91 Example hydrographs showing sensitivity of heads (feet above mean sea level) to change in the vertical conductance (Kv) between the Ogallala Aquifer and the region of the lower Dockum Aquifer where the Santa Rosa Formation is in contact with the Ogallala Aquifer.

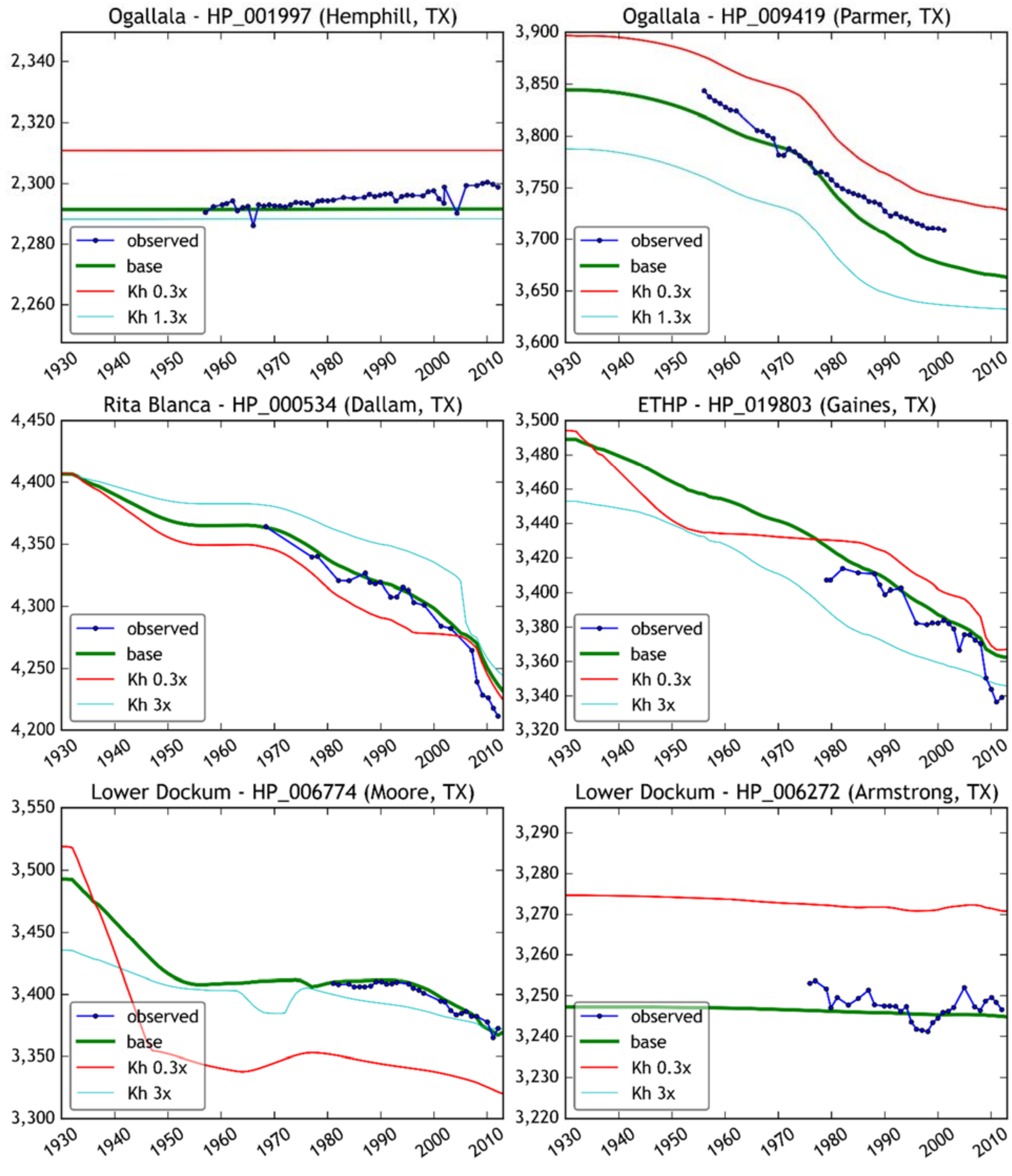


Figure 4.2.92 **Example hydrographs showing sensitivity of heads (feet above mean sea level) to changes in the horizontal hydraulic conductivity (Kh).**

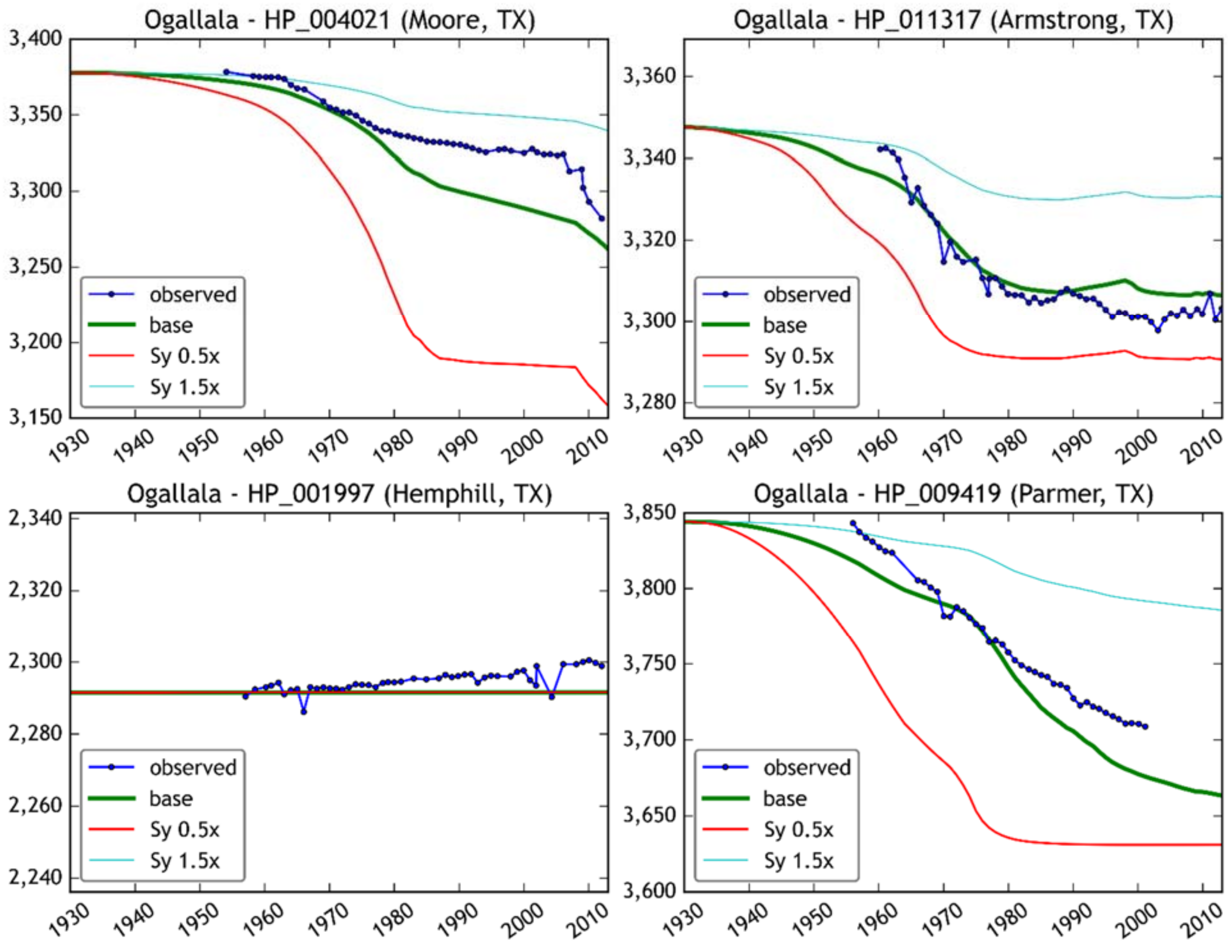


Figure 4.2.93 Example hydrographs showing sensitivity of heads (feet above mean sea level) to changes in specific yield (Sy).

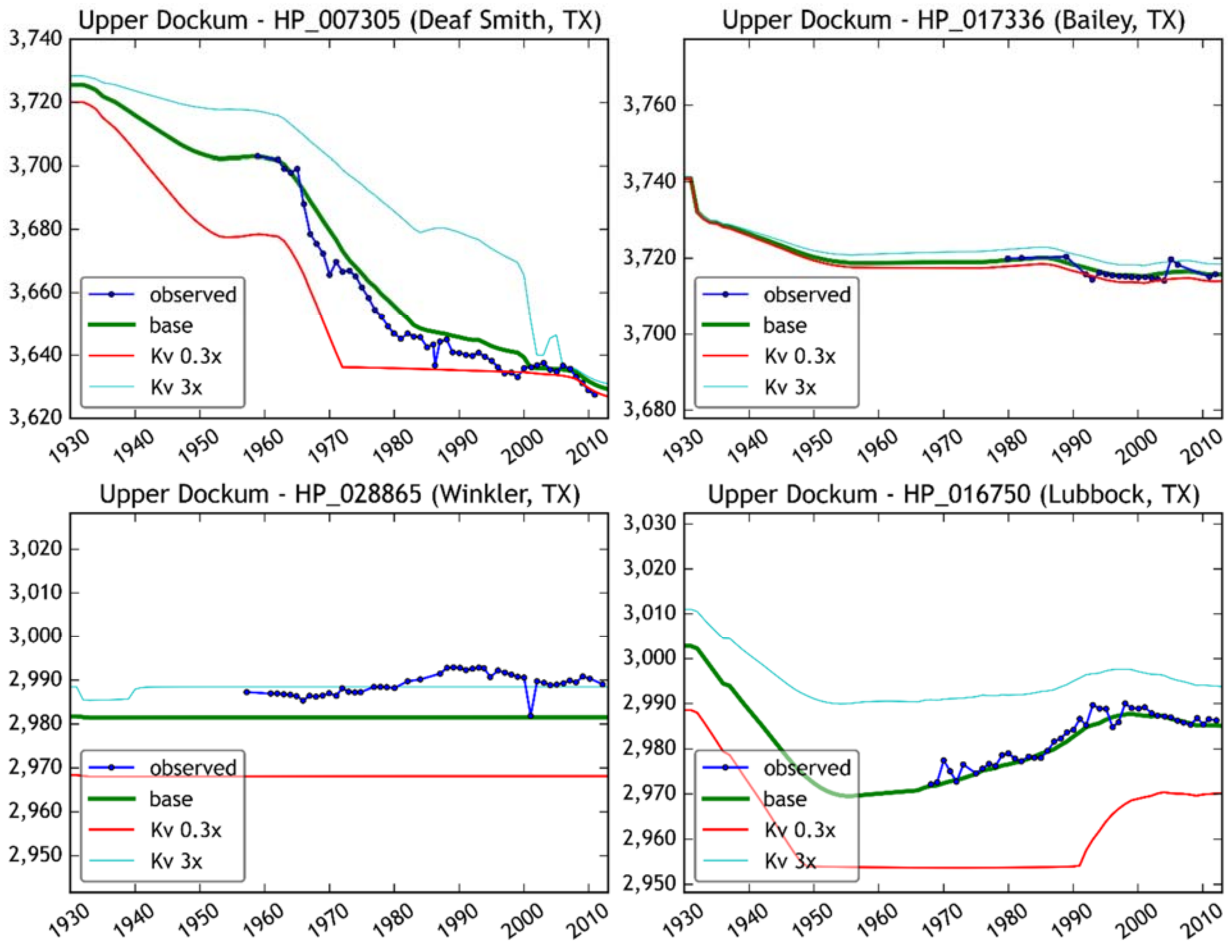


Figure 4.2.94 Example hydrographs showing sensitivity of upper Dockum Aquifer heads (feet above mean sea level) to changes in vertical hydraulic conductivity (Kv).

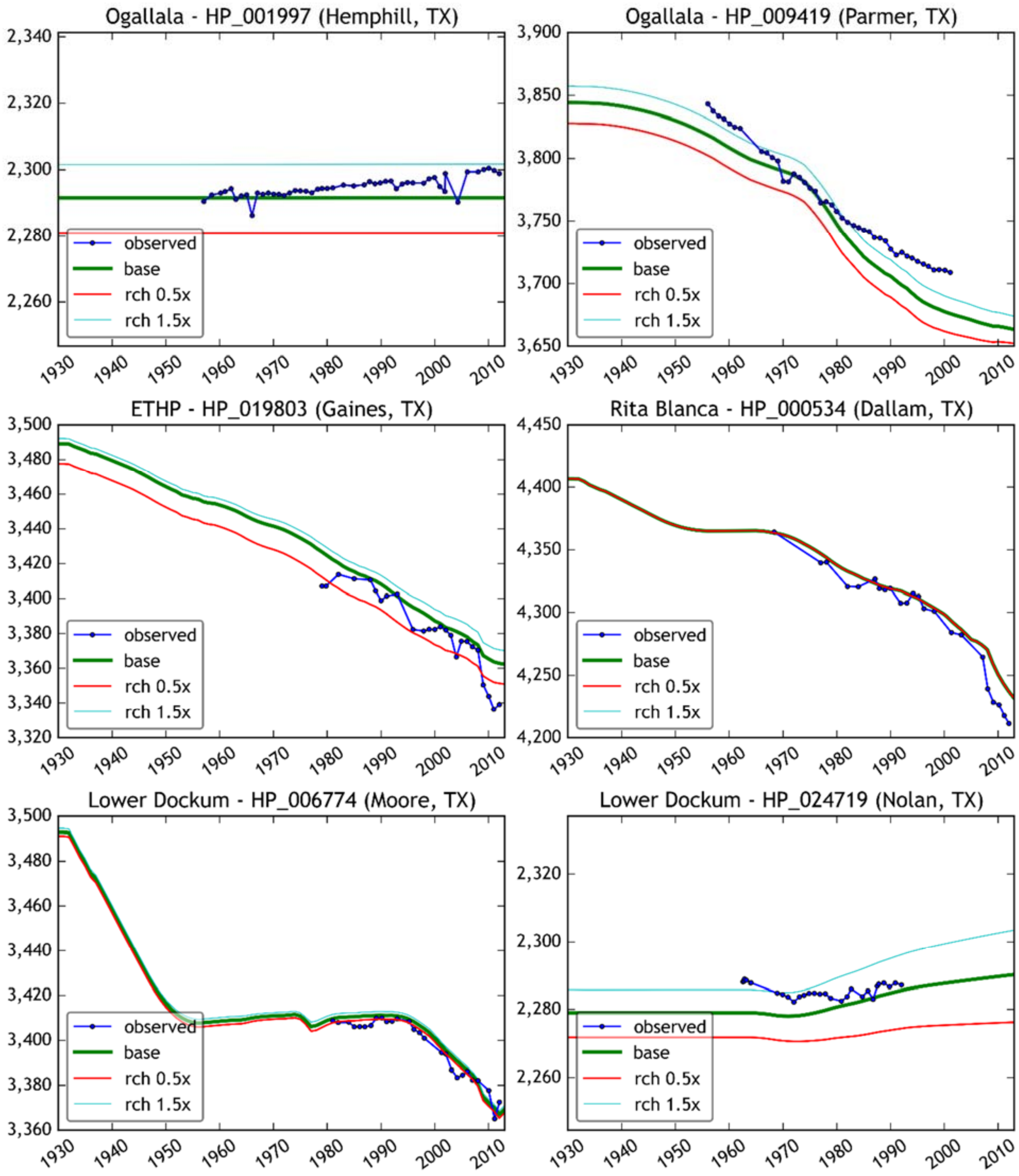


Figure 4.2.95 **Example hydrographs showing sensitivity of heads (feet above mean sea level) to changes in recharge (rch). For the Edwards-Trinity (High Plains) Aquifer, the response is to changes in the Ogallala Aquifer recharge. In the five other cases, the recharge has been varied only in the outcrop of the stated aquifer.**

5.0 Model Limitations

A model can be defined as a representation of reality that attempts to explain the behavior of some aspect of it, but is always less complex than the real system it represents (Domenico, 1972). As a result, limitations are intrinsic to models. Model limitations can be grouped into several categories including: (1) limitations in the data supporting a model, (2) limitations in the implementation of a model which may include assumptions inherent to the model application, and (3) limitations regarding model applicability. The limitations of this modeling study are discussed in the following paragraphs consistent with the groupings above.

5.1 Limitations of Supporting Data

Development of the supporting data for a regional model of the size and complexity of the High Plains Aquifer System groundwater availability model is a challenge. The primary limitations in supporting data for the model are:

- Limited hydraulic head targets spatially and temporally in the minor aquifers,
- Limited applicability of stream gain/loss estimates
- Limited hydraulic conductivity data for the minor aquifers
- Limited data quantifying cross-formational flow between the aquifers,
- Uncertain estimates of pumping in the Ogallala Aquifer.

Each of these data limitations is discussed briefly below.

The primary type of calibration target used in most models, including this groundwater availability model, is hydraulic head. Wells in the Rita Blanca and Edwards-Trinity (High Plains) aquifers are often screened at least partially in the Ogallala Aquifer, which may impact the applicability of water level measurements in describing actual water levels in those aquifers. Although development of the Dockum Aquifer is increasing, the available head data in many areas is sparse or has little temporal consistency.

No long-term stream gain/loss estimates or spring flow estimates were available. One or two-day measurement periods for gain/loss estimates, which yield gaining and losing results at different times do not provide information that can be used to assess model performance, which is judged on annual stress periods. The spring flow estimates are typically only taken once, and are often uncertain due to crude measurement methods.

The same difficulty with water levels in the minor aquifers applies to estimates of hydraulic conductivity. High quality pump test information is unavailable in the Rita Blanca and Edwards-Trinity (High Plains) aquifers, and the spatial coverage in the Dockum Aquifer are confined to localized areas, making upscaling difficult.

Cross-formational flow, which can have serious implications both for water quality and availability in the system, is difficult to measure at the local scale and nearly impossible to measure at the regional scale. While the model predicts that cross-formational flow is small compared to the overall water budget, it can be important to the individual minor aquifers when considering water availability, and important to the Ogallala Aquifer in terms of water quality. The lack of empirical verification of the model estimates of cross-formational flow is, therefore, a limitation to the model.

Pumping, which is by far the largest source of discharge from the model, is uncertain because estimates of pumping are dependent on secondary sources, such as crop areas and application rates, which are themselves uncertain. Although some metering or more direct use reporting has occurred in recent years (for example, North Plains Groundwater Conservation District), the lack of historical data results in the pumping being revised during calibration. This occurred both in previous modeling efforts for the Ogallala Aquifer and in the current study. While change in storage calculations are helpful in estimating long term pumping rates in an area, they also carry uncertainty due to the uncertainty both in regional water level surfaces and specific yield of the aquifer.

5.2 Assessment of Assumptions

Many small assumptions are made about the hydrogeologic system during construction and calibration of a groundwater model. However, two assumptions stood out during construction and calibration of the model, that may impact the predictions made by the model.

- Hydraulic conductivity is constant when water levels change
- Irrigation return flow can be aggregated with overall recharge

Because the Ogallala Aquifer is modeled as a single layer, the hydraulic conductivity is considered to be constant throughout the vertical profile of the layer. In reality, the hydraulic conductivity varies vertically within the aquifer profile. If there are significant trends in the hydraulic conductivity (for example, if materials are far coarser-grained at the bottom of the aquifer), they are not being captured in the model. Under these example conditions, if water levels decline significantly, these coarser materials will have a higher effective conductivity than when the water was flowing throughout the entire vertical profile.

The conceptualization of recharge for the model included estimates of pre-development recharge rates, and post-development recharge rates. The increase in recharge in some areas is due to agricultural activity, which can both change vegetative and soil characteristics (make percolation more likely from precipitation) and increase the availability of percolation water because of irrigation return flow. The study also included estimates, based on evolution of water quality spatially and temporally, of approximately when this increased recharge “broke through” and encountered the water table.

The approach implemented in the numerical model assumed that the post-development recharge rates represented the current condition, post-breakthrough, in those areas where breakthrough was detected. This approach is appropriate for calibrating the model in the historical period. However, this increased recharge cannot, with the current evidence, be divided between enhanced natural recharge from precipitation, and irrigation return flow. If it is primarily irrigation return flow, then it will decrease over time since agricultural practices have become much more efficient from the 1940s to current day. If it is primarily enhanced recharge from precipitation, then it will continue into the future unless land-use practices change.

In addition, some areas show no evidence of enhanced recharge having occurred, but may show such evidence in the future. If a predictive simulation is run decades into the future, then either this eventual breakthrough must be estimated or assumed, or conservatively left out of the calculation. This topic has further discussion in Section 7.0 where model improvements are discussed.

5.3 Limitations of Model Applicability

The purpose of the TWDB groundwater availability model program is the development of models to determine how regional water availability is effected on a large scale by water resource development. While the current model uses a half-mile square grid, its applicability is representative at a larger scale, such as tens of miles. The model should not be used to predict drawdown at a particular well. The model may be applicable at the scale of a large wellfield, depending on the data support that was available in that area of the model.

The mean absolute error for calibration of the model to observed heads ranged from approximately 30 to 50 feet. This means that, on average, simulated heads deviate from observed heads by this amount. However, the model performs better in some areas and worse in others, so care must be taken in using the model to estimate absolute head elevation. As a predictive tool, the model will be better at predicting changes in heads due to changes in stresses than absolute head values.

During calibration, pumping estimates for some counties were revised downward prior to 1980, based on calculations of storage change using head measurements and estimates of specific yield. Because the model is calibrated to these same head measurements, that built-in correlation has the potential to reduce calibration constraint for those years, which has the potential to reduce certainty in model predictions. However, because pumping from 1980 to 2012 was not based on storage change estimates, there is over 30 years of calibration where this reduced constraint is not applicable. Given the overall uncertainty in pumping estimates prior to 1980, we are confident that the approach that was taken provides the most reliable predictive tool under the given data limitations.

While the overall mean error of the model for the Ogallala Aquifer was only a few feet, the mean error for a given county at the end of the historical period may be tens of feet. Because the Ogallala Aquifer is unconfined, these tens of feet can translate to large volumes of water when estimating future availability. Predictive simulations with the model may want to include at least a partial accounting of mean errors in starting head surfaces.

The High Plains Aquifer System groundwater availability model should be used to estimate water availability for the Ogallala Aquifer, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, and the portion of the Dockum Aquifer that is represented in the model. Do not use the High Plains Aquifer System groundwater availability model for estimating water availability in the Pecos Valley or Edwards-Trinity (Plateau) aquifers. Portions of the Pecos Valley and Edwards-Trinity (Plateau) aquifers are represented as layers in the model. Although they are represented as layers, head-dependent flow boundary conditions were placed in the layers to emulate the historical response of these aquifers. Because realistic fixed flux boundaries (recharge and pumping, for example) were not used, the model is not appropriate for simulating water availability in the portions of these two aquifers represented in the model.

MODFLOW-NWT does not account for density-dependent flow. Therefore, the higher density of the groundwater in the high total dissolved solids portion of the Dockum Aquifer and, to a lesser extent, the other portions of the aquifer which exhibit relatively high total dissolved solids concentrations are not accounted for in the governing flow equations of the model. Currently, little recharge and pumping occurs within this region of the aquifer and therefore, this shortcoming likely has little impact. However, potential future predictive simulations involving development of the high total dissolved solids portions of the Dockum Aquifer could be impacted by this limitation.

This page intentionally left blank.

6.0 Summary and Conclusions

This report documents the development of a numerical groundwater model of the High Plains Aquifer System, which consists of the Ogallala Aquifer, the Rita Blanca Aquifer, the Edwards-Trinity (High Plains) Aquifer, and the Dockum Aquifer. The High Plains Aquifer System groundwater availability model combines aquifers that were treated separately in three current groundwater availability models. While the calibration of the aquifers modeled in the High Plains Aquifer System groundwater availability model is similar statistically to the three current groundwater availability models, the numerical model of the High Plains Aquifer System groundwater availability model represents an advance in four areas:

1. The Rita Blanca Aquifer is simulated separately from the Ogallala Aquifer.
2. A uniform approach to the implementation of input parameters, such as conductivity and recharge, is used.
3. No "overlap areas" exist where two models give conflicting results.
4. Simulation of cross-formational flow between the various aquifers that comprise the system is explicitly accounted for. Simulations supporting water planning will have this interaction "built-in".

Development of a numerical model includes model design and construction, model calibration, and sensitivity analyses. The development of the numerical model documented in this report was based on the conceptual model development documented in Deeds and others (2015). The purpose of the model is to provide a tool for groundwater planning in the State of Texas.

The code used to implement the numerical model was MODFLOW-NWT. The model consists of four layers, with the Ogallala Aquifer as layer 1, the Rita Blanca and Edwards-Trinity (High Plains) aquifers, which do not overlap spatially, as layer 2, and the upper and lower Dockum Aquifers as layers 3 and 4, respectively. The model grid is composed of uniformly spaced half-mile square grid cells. The model simulates the time period from 1930 to 2012, with an initial steady-state stress period that represents pre-development conditions.

The model was primarily calibrated to observed heads in the four aquifers. It was calibrated to both steady-state and transient conditions. Both the steady-state and transient calibration statistics are well within acceptable ranges. The primary parameters modified during calibration were horizontal and vertical conductivities, as well as recharge. The steady-state calibration was far more sensitive to recharge than the transient calibration. Uncertainty in historical pumping estimates for the Ogallala Aquifer provided a significant challenge during transient calibration. Estimated pumping rates prior to 1980 were reduced for some counties, in order to allow acceptable reproduction of water-level trends in those counties.

In the steady-state calibration, recharge is the major source of inflow to the Ogallala Aquifer, and discharge to rivers is the largest source of outflow. In the transient model, by 1940 pumping has become the largest outflow component, and by 1942 removal of water from storage has become the largest inflow component. Discharge to rivers decreases from over 500,000 acre-feet per year to less than 300,000 acre-feet per year over the course of the transient simulation. Although recharge increases through time due to agricultural activity, this does not significantly offset the increased production. Cross-formational flow is not a significant component of the Ogallala Aquifer water budget.

In contrast, cross-formational flow is a significant component of the minor aquifer water budgets. Cross-formational flow from the Ogallala Aquifer is the largest inflow component for both the Rita Blanca and Edwards-Trinity (High Plains) aquifers. Removal of water from storage is the largest component of the upper and lower Dockum Aquifers' water budgets.

A sensitivity analysis was performed, which indicated the horizontal hydraulic conductivity was an important parameter for all of the aquifers except the upper Dockum Aquifer, which was more sensitive to vertical hydraulic conductivity. Heads in the unconfined Ogallala Aquifer were sensitive to pumping rate and specific yield in places where significant pumping has occurred. Drawdown in the minor aquifers was more sensitive to hydraulic conductivity. Steady-state heads in the Ogallala Aquifer are sensitive to recharge rate.

7.0 Future Improvements

To use models to predict future conditions requires a commitment to improve the model as new data become available or when modeling assumptions or implementation issues change. This groundwater availability model is no different. Through the modeling process, one generally learns what can be done to improve the model's performance or what data would help better constrain the model calibration. Future improvements to the model, beyond the scope of the current groundwater availability model, are discussed below.

7.1 Additional Supporting Data or Studies

Several types of data could be collected to better support future enhancement of the High Plains Aquifer System groundwater availability model. These data limitations have been discussed in Section 5.1. Any studies that help to improve the quality and availability of these data could be used to provide additional constraint for future model updates.

Improving estimates of pumping data would be especially helpful. Although older historical pumping estimates cannot be easily revised, decades of remote-sensing data are now available that could help refine both earlier estimates of irrigated acreages and application rates. Recent advances in cloud-based Landsat image processing have made this type of analysis practical on a large scale with far fewer resources than previously required.

An additional study that attempts to answer some of the questions about agriculturally-enhanced recharge could both help constrain recharge estimates for future model updates, and allow better techniques for predicting future recharge. The current model has generated estimates of where and when agriculturally enhanced recharge has occurred. The next step would be to perform large-scale vadose zone flow and transport modeling to help evaluate the processes that drive the timing and occurrence of this recharge. The predictive estimates from this vadose zone flow and transport model could then be used as input for predictive estimates of water availability.

7.2 Future Model Implementation Improvements

As water levels decline, producers respond to decreasing per-well production by drilling additional wells, or increasing activity in areas where saturated thickness is more favorable. During model calibration, this process was emulated by iteratively distributing pumping to other wells in a county when MODFLOW-NWT limited the well production due to small saturated thickness. Iteratively meant running and rerunning the model multiple times. A relatively simple improvement would be to change the well package so that after each stress period, the code would assess which wells were going to be limited in pumping due to saturated thickness limits, and reallocate that pumping to other wells with better capacity. This would greatly streamline the calibration process.

Analysis of the model water budget indicated that a relatively small rate of flux occurs between the Ogallala Aquifer and the minor aquifers it overlays. However, in the case of the upper Dockum Aquifer and portions of the Edwards-Trinity (High Plains) and lower Dockum aquifers, even this small amount of flux could bring highly saline water into water lying at the base of the Ogallala Aquifer. Performing some basic transport calculations and estimating the impact on Ogallala Aquifer water quality would help constrain the model estimated flux rates.

A large portion of the modeled Dockum Group exhibits total dissolved solids concentrations in excess of 5,000 milligrams per liter. The greater density of this water is not accounted for in the governing equations of groundwater flow used in MODFLOW. If predictive simulations are going to include development of the aquifer within the high total dissolved solids region, use of a simulator with the capability of simulating density-dependent flow (for example, SEAWAT) may be warranted. It would be useful just to use SEAWAT with the current model to perform sensitivity analyses and answer the question of whether density dependence is even important for availability in the Dockum Aquifer.

8.0 Acknowledgements

We would like to acknowledge several organizations and individuals who contributed to the development of the conceptual model for the High Plains Aquifer System groundwater availability model, which provided the sound basis for development of the numerical model. The North Plains Groundwater Conservation District, Panhandle Groundwater Conservation District, and High Plains Underground Water Conservation District No. 1 all contributed financially to this project. These Districts, as well as the Hemphill County Underground Water Conservation District, Mesa Underground Water Conservation District, Permian Basin Underground Water Conservation District, South Plains Underground Water Conservation District, and Llano Estacado Underground Water Conservation District, provided valuable data and other support. Local knowledge from these Districts proved especially valuable in development of the conceptual model.

We would like to thank the cities of Amarillo, Lubbock, Canyon, and Morton, as well as the Canadian River Municipal Water Authority and the Red River Authority of Texas, for the data and support they provided.

We would like to thank the Mesa Underground Water Conservation District, city of Amarillo, High Plains Underground Water Conservation District, and the Panhandle Regional Planning Commission for hosting Stakeholder Advisory Forums.

This page intentionally left blank.

9.0 References

Anaya, R., 2001, Using GIS Projection Parameters for GAM: TWDB groundwater availability model technical memo 01-01.

Anderson, M.P., and Woessner, W.W., 1992, Applied groundwater modeling, simulation of flow and advective transport: New York, Academic Press, 381 p.

Ashworth, J.B., and Hopkins, J., 1995, Aquifers of Texas: TWDB, Report 345, website http://www.cctexas.com/Assets/Departments/Water/Files/TWDB%20Aquifer%20Report.pdf.

Blandford, T.N., Kuchanur, M., Standen, A., Ruggiero, R., Calhoun, K.C., Kirby, P., and Shah, G., 2008, Groundwater availability model of the Edwards-Trinity (High Plains) Aquifer in Texas and New Mexico: Groundwater availability model report prepared for the TWDB.

Borrelli, J., Fedler, C.B., and Gregory, J.M., 1998, Mean crop consumptive use and free-water evaporation for Texas: TWDB, contractor report, Grant No. 95-483-137.

Brune, G., 1969, How much underground water storage capacity does Texas have?: Presented at the 5th Annual American Water Resources Association Conference and the 14th Water for Texas Converence, San Antonio, Texas.

Deeds, N.E., Harding, J.J., Jones, T.L., and Singh, A., 2015, Final conceptual model report for the High Plains Aquifer System groundwater availability model: Groundwater availability model report prepared for the TWDB.

Daniel B. Stephens & Associates, Inc., 2007, City of Lubbock groundwater utilization study: contract report to the City of Lubbock, Texas.

Domenico, P.A., 1972, Concepts and models in groundwater hydrology: McGraw-Hill, New York, NY.

Dutton, A.R., Reedy, R.C., and Mace, R.E., 2001, Saturated thickness in the Ogallala Aquifer in the Panhandle Water Planning Area-Simulation of 2000 through 2050 withdrawal projections: Final Contract Report to the Panhandle Water Planning Group, Panhandle Regional Planning Commission, under contract no. UTA01-462, 61 p. plus appendices.

Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J-P., Scanlon, B.R., Ashworth, J.B., and Beach, J., 2008, Groundwater availability model for the Dockum Aquifer: Groundwater availability model report prepared for the TWDB.

Harbaugh, A.W., and McDonald, M.G., 1996, User's documentation for MODFLOW-96, An update to the U.S. Geological Survey modular finite-difference ground-water flow model: United States Geological Survey, Open-File Report 96-485.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, The U.S. Geological Survey modular ground-water model - User guide to modularization concepts and the ground-water flow process: United States Geological Survey, Open-File Report 00-92.

Harbaugh, A.W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model – the ground-water flow process: United States Geological Survey, Techniques and Methods 6-A16.

Hecox, G. R., Macfarlane, P. A., and Wilson, B. B., 2002, Calculation of yield for high plains wells: Relationship between saturated thickness and well yield: Kansas Geological Survey, Open File Report, 2002-25C.

Hutchinson, W.R., Jones, I., and Anaya, R., 2011, Update of the groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley aquifers of Texas: TWDB, 61 pp.

Louis, C., 1974, Rock hydraulics: in Muller, L., ed., Rock Mechanics, Springer, Vienna, Austria.

McDonald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model: United States Geological Survey, Techniques of Water-Resources Investigations, Book 6, chapter A1.

Niswonger, R.G., Panday, S., and Ibaraki, M., 2011, MODFLOW-NWT, a Newton formulation for MODFLOW-2005: United States Geological Survey, Techniques and Methods 6-A37, 44 p.

New Mexico Office of the State Engineer, 2014, OSE well data shapefile: website http://www.ose.state.nm.us/water_info_data.html, accessed August, 2014.

Oklahoma Water Resources Board, 2014, Oklahoma water well records, digital database: website http://www.owrb.ok.gov/wd/search/search.php, accessed August, 2014.

Scanlon, B., Keese, K., Bonal, N., Deeds, N., Kelley, V., and Litvak, M., 2005, Evapotranspiration estimates with emphasis on groundwater evapotranspiration in Texas: report prepared for the TWDB.

Scanlon, B.R., Reedy, R.C., and Gates, J.B., 2010, Effects of irrigated agroecosystems: 1. Quantity of soil water and groundwater in the southern High Plains, Texas: Water Resources Research, v. 46, W09537, doi:10/1029/2009WR008427.

TWDB, 2006a, Maps & GIS data, GIS data, Major aquifers: website http://www.twdb.state.tx.us/mapping/gisdata.asp.

TWDB, 2006b, Maps & GIS data, GIS data, Minor aquifers: website http://www.twdb.state.tx.us/mapping/gisdata.asp.

TWDB, 2007, Water for Texas – 2007: TWDB.

TWDB, 2014a, TWDB groundwater database: website http://www.twdb.state.tx.us/groundwater/data/gwdbrpt.asp, accessed March, 2014.

TWDB, 2014b. TWDB submitted driller's reports database, digital dataset: website http://www.twdb.state.tx.us/ groundwater/data/drillersdb.asp, accessed September 2014.

United States Geological Survey, 2013, National Water Information System data, water data for the Nation: website http://waterdata.usgs.gov/nwis/sw, accessed October, 2013.

This page intentionally left blank.

Appendix A

Water Budgets by County, Groundwater Conservation District, and Aquifer

This page intentionally left blank.

The tables of this appendix summarize the water budget in terms of volume in acre-feet per year for the steady-state model, for the stress period representing 1980 in the transient model, and for the stress period representing 2012 in the transient model. Water budgets are presented by aquifer and broken into counties and groundwater conservation districts. All values are reported in acre-feet per year. Negative numbers indicate flow out of the county or groundwater conservation district. In all tables, the abbreviation ET is evapotranspiration. In Tables A.4.1 through A.6.5, the abbreviation UWCD is underground water conservation district, GCD is groundwater conservation district, and WCD is water conservation district.

This page intentionally left blank.

Table A.1.1 Water budget for the Ogallala Aquifer by county for the steady-state model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Andrews	3,127	-320	-278	-635	-86	-11	-1,341	-456
Armstrong	9,499	-28	-227	-4,313	0	-2,822	127	-2,235
Baca	2,354	0	0	862	0	0	-3,217	1
Bailey	3,034	-9,254	-200	1,070	-308	0	6,208	-549
Beaver	47,454	-40,224	0	-31,915	-3,770	-123	28,578	0
Beckham	1,513	-9	0	-222	0	-1,258	-24	0
Borden	2,922	0	0	0	-334	-3,788	433	767
Briscoe	6,173	-549	-2,379	-1,857	0	-2,670	5,111	-3,828
Carson	12,471	-583	0	4,018	0	-206	-15,986	287
Castro	7,341	0	-53	2,796	0	0	-9,924	-160
Chaves	1,237	0	0	0	-628	0	-527	-82
Cimarron	48,926	-1,113	-73	7,000	-1,673	0	-53,233	167
Cochran	1,576	0	-82	0	-46	0	-1,230	-217
Collingsworth	647	0	0	0	0	-697	49	0
Crosby	8,634	-596	-115	-9,766	-445	-8,479	14,038	-3,272
Curry	6,217	0	0	6,244	0	0	-12,323	-138
Dallam	24,489	-2,416	0	11,778	-389	0	-33,912	451
Dawson	5,347	-1,620	-52	-1,073	-1,407	-3,220	867	1,159
De Baca	444	0	0	0	-985	0	399	141
Deaf Smith	17,381	-1,977	-238	-2,972	-390	0	-10,542	-1,263
Dewey	1,795	0	0	0	-111	-1,343	-341	0
Dickens	2,163	-98	0	-665	-47	-456	1,523	-2,421
Donley	17,217	-2,417	-1,567	-15,735	-129	-7,035	9,666	0
Ector	1,042	-171	-10	402	0	-45	-927	-290
Eddy	55	0	0	0	0	0	-55	0
Ellis	48,138	-22,581	-5,491	-22,619	-3,321	-11,653	17,528	0
Floyd	14,485	-217	-9,408	-3,557	0	-3,753	7,317	-4,867
Gaines	3,464	-6,846	-910	-1,147	-1,952	0	4,434	2,957
Garza	2,054	0	0	0	-1,021	-5,951	2,556	2,363
Glasscock	946	-464	0	-746	0	-164	-3	430
Grant	646	0	0	1,141	0	0	-1,787	0
Gray	26,145	-1,094	0	-4,840	0	-6,305	-13,907	0
Guadalupe	26	0	0	0	-5	0	-11	-9
Hale	9,967	-680	-228	-339	-556	0	-6,688	-1,476
Hansford	11,525	-4,540	0	-13,446	-133	0	6,594	0
Harding	3,327	0	0	0	-991	-454	-835	-1,047
Harper	14,584	-13,318	-107	-1,081	-438	-4,095	4,455	0
Hartley	29,125	-7,346	-69	-14,320	0	-1,825	-4,325	-1,240
Haskell	67	0	0	-368	0	0	301	0
Hemphill	33,925	-24,895	-196	-21,966	-112	-3,600	16,844	0

Table A.1.1, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Hockley	3,034	-2,726	-66	1,240	-293	0	-412	-777
Howard	3,213	-651	-16	-1,730	-1,833	-942	1,788	172
Hutchinson	6,962	-5,977	-426	-18,842	-3,728	-12,165	34,176	0
Lamb	4,877	-8,340	-771	709	-512	0	4,397	-360
Lea	11,549	-86	-135	106	-1,985	0	-5,396	-4,053
Lipscomb	29,600	-8,292	0	-3,849	0	0	-17,459	0
Lubbock	5,838	-903	-1,997	-5,536	-100	-2,631	2,749	2,581
Lynn	6,523	-632	-836	7	-1,730	-892	-2,060	-380
Martin	2,839	-3,865	-312	252	-908	0	2,109	-115
Meade	201	-2,506	0	-7,943	-805	0	11,054	0
Midland	1,415	-3,184	-154	1,142	-9	-377	1,871	-705
Moore	17,353	-1,054	0	-3,600	-1,056	-3,809	-7,535	-298
Morton	14,140	0	0	3,435	0	0	-17,575	0
Motley	1,749	0	-624	-1,731	0	-3,464	6,704	-2,634
Ochiltree	12,379	-487	0	1,938	0	0	-13,830	0
Oldham	18,225	-867	-262	-9,361	-1,183	-8,967	6,244	-3,830
Parmer	4,875	0	0	9,814	0	0	-14,686	-3
Potter	7,110	-577	-199	-184	-263	-2,874	-1,311	-1,703
Quay	8,761	-674	-97	3,134	-430	-3,061	-6,998	-635
Randall	10,140	-1,784	-346	-10,779	-1,070	-1,524	8,607	-3,243
Roberts	13,084	-29,422	-4	-18,220	-3,014	-2,785	40,361	0
Roger Mills	24,055	-1,785	0	-8,822	-1,284	-13,609	1,445	0
Roosevelt	7,662	0	0	-174	-3,975	0	-560	-2,952
Seward	12,373	-15,044	0	-34,941	-10,884	0	48,497	0
Sherman	17,547	-406	0	5,975	0	0	-23,170	54
Stevens	27,088	0	0	968	0	0	-28,056	0
Swisher	9,861	-161	-667	-3,979	-2,135	-121	66	-2,864
Terry	1,833	-81	-717	1,318	-757	0	-1,566	-29
Texas	67,101	-39,336	0	-58,145	-10,173	0	40,528	25
Union	34,293	-728	-148	3,231	-4,207	-637	-28,254	-3,550
Wheeler	28,093	-4,020	-1,194	-9,592	-2,223	-12,521	1,458	0
Winkler	60	-5	0	0	0	-4	25	-77
Woodward	18,768	-3,931	0	-247	-7,024	-9,254	1,688	0
Yoakum	2,039	-29	-91	578	0	0	-790	-1,707

Table A.1.2 Water budget for the Rita Blanca Aquifer by county for the steady-state model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Cimarron	0	0	0	0	0	0	198	-198
Colfax	371	0	0	0	0	0	-369	-2
Dallam	0	0	0	0	0	0	500	-500
Harding	133	-18	0	-29	-114	0	-201	230
Hartley	0	0	0	0	0	0	65	-65
Quay	0	0	0	0	0	0	9	-9
Union	2,637	-661	-13	-3,406	-1,048	0	-202	2,692

Table A.1.3 **Water budget for the Edwards-Trinity (High Plains) Aquifer by county for the steady-state model.**

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Bailey	0	0	0	0	0	0	-548	548
Borden	0	0	0	0	0	0	985	-985
Chaves	0	0	0	0	0	0	-71	71
Cochran	0	0	0	0	0	0	-222	222
Dawson	0	0	0	0	0	0	1,312	-1,312
Floyd	0	0	0	0	0	0	0	0
Gaines	0	0	0	0	0	0	2,943	-2,943
Garza	0	0	0	0	0	0	2,983	-2,983
Hale	0	0	0	0	0	0	-989	989
Hockley	0	0	0	0	0	0	-780	780
Lamb	0	0	0	0	0	0	-340	340
Lea	0	0	0	0	0	0	-3,401	3,401
Lubbock	0	0	0	0	0	0	2,798	-2,798
Lynn	0	0	0	0	0	0	-53	53
Roosevelt	0	0	0	0	0	0	-2,888	2,888
Terry	0	0	0	0	0	0	-26	26
Yoakum	0	0	0	0	0	0	-1,705	1,705

Table A.1.4 Water budget for the upper Dockum Group by county for the steady-state model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Andrews	0	0	0	0	0	0	-17	17
Bailey	0	0	0	0	0	0	3	-3
Borden	0	-6	0	-4	0	0	2	9
Castro	0	0	0	0	0	0	-1	1
Chaves	0	0	0	0	0	0	-5	5
Cimarron	0	0	0	0	0	0	1	-1
Cochran	0	0	0	0	0	0	4	-4
Colfax	0	0	0	0	0	0	0	0
Crane	0	0	0	0	0	0	4	-4
Crosby	2	0	0	1	0	0	0	-3
Curry	0	0	0	0	0	0	-25	25
Dallam	0	0	0	0	0	0	3	-3
Dawson	1	-7	0	-51	-22	0	1	78
De Baca	0	0	0	0	0	0	2	-2
Deaf Smith	54	0	0	22	0	0	-4	-72
Ector	0	0	0	0	0	0	-1	1
Floyd	0	0	0	0	0	0	1	-1
Gaines	0	0	0	0	0	0	11	-11
Garza	0	0	0	0	0	0	0	0
Guadalupe	0	0	0	0	0	0	-3	3
Hale	0	0	0	0	0	0	3	-3
Harding	0	0	0	0	0	0	-19	19
Hartley	0	0	0	0	0	0	4	-4
Hockley	0	0	0	0	0	0	1	-1
Howard	0	0	0	0	0	0	0	0
Lamb	0	0	0	0	0	0	-2	2
Lea	0	0	0	0	0	0	-11	11
Lubbock	0	-5	0	-33	0	0	6	31
Lynn	0	0	0	0	0	0	3	-3
Martin	0	0	0	0	0	0	17	-17
Midland	0	0	0	0	0	0	7	-7
Moore	0	0	0	0	0	0	0	0
Oldham	0	0	0	0	0	0	-1	1
Parmer	0	0	0	0	0	0	3	-3
Potter	0	0	0	0	0	0	0	0
Quay	243	-7	0	19	-16	0	12	-252
Randall	0	0	0	0	0	0	0	0
Roosevelt	0	0	0	0	0	0	-11	11
Sherman	0	0	0	0	0	0	0	0
Swisher	0	0	0	0	0	0	3	-3

Table A.1.4, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Terry	0	0	0	0	0	0	-2	2
Union	0	0	0	0	0	0	11	-11
Upton	0	0	0	0	0	0	0	0
Winkler	0	0	0	0	0	0	3	-3
Yoakum	0	0	0	0	0	0	-1	1

Table A.1.5 Water budget for the lower Dockum Group by county for the steady-state model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Andrews	0	0	0	0	0	0	-99	99
Armstrong	226	0	-295	-509	-2,276	0	619	2,235
Baca	0	0	0	0	0	0	1	-1
Bailey	0	0	0	0	0	0	-1	1
Borden	914	-1,350	0	38	0	0	121	277
Briscoe	279	-261	-698	-4,368	-1,858	0	3,079	3,828
Carson	0	0	0	0	0	0	287	-287
Castro	0	0	0	0	0	0	-159	159
Chaves	0	0	0	0	0	0	-6	6
Cimarron	0	0	0	0	0	0	-32	32
Cochran	0	0	0	0	0	0	0	0
Coke	133	-11	0	-24	0	-292	90	104
Colfax	0	0	0	0	0	0	-1	1
Crane	0	0	0	0	0	0	1,072	-1,072
Crockett	0	0	0	0	0	0	503	-503
Crosby	1,024	-241	0	-1,759	0	-635	-1,665	3,275
Curry	0	0	0	0	0	0	-113	113
Dallam	0	0	0	0	0	0	-51	51
Dawson	0	0	0	0	0	0	-75	75
De Baca	0	0	0	0	0	0	140	-140
Deaf Smith	145	0	0	61	0	0	-1,541	1,335
Dickens	1,057	0	-416	-959	0	-1,825	-278	2,421
Ector	0	0	0	0	0	0	-1,427	1,427
Eddy	0	0	0	0	0	0	327	-327
Fisher	478	-86	0	-136	0	-512	137	119
Floyd	309	-48	-294	-2,869	0	0	-1,966	4,868
Gaines	0	0	0	0	0	0	2	-2
Garza	2,034	-2,945	-41	-2,020	0	-681	3,027	626
Glasscock	2	0	0	0	0	0	-28	26
Guadalupe	0	0	0	0	0	0	-6	6
Hale	0	0	0	0	0	0	-490	490
Harding	0	0	0	0	0	0	-798	798
Hartley	205	-314	0	969	0	0	-2,170	1,310
Hockley	0	0	0	0	0	0	1	-1
Howard	3,022	-1,146	-16	-1,111	0	0	-1,167	418
Hutchinson	0	0	0	0	0	0	0	0
Irion	0	0	0	0	0	0	151	-151
Kent	1,048	-16	-112	-660	0	-508	248	0
Lamb	0	0	0	0	0	0	-18	18
Lea	0	0	0	0	0	0	-543	543

Table A.1.5, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Loving	0	0	0	0	0	0	-169	169
Lubbock	0	0	0	0	0	0	-185	185
Lynn	1	0	0	-46	0	0	-281	326
Martin	0	0	0	0	0	0	-53	53
Midland	0	0	0	0	0	0	-76	76
Mitchell	8,249	-3,435	-112	-6,914	0	-876	2,648	441
Moore	64	0	0	-65	0	0	-298	298
Motley	335	0	-171	-2,043	0	-2,555	1,800	2,634
Nolan	505	-79	0	-518	0	-743	-741	1,576
Oldham	5,786	-3,674	-120	-10,130	0	0	4,310	3,828
Parmer	0	0	0	0	0	0	-5	5
Pecos	0	0	0	0	0	0	-82	82
Potter	2,211	-1,106	-22	-3,561	-395	0	1,171	1,703
Quay	276	-182	0	-838	0	0	-152	896
Randall	80	0	0	-2,557	-748	0	-18	3,243
Reagan	0	0	0	0	0	0	-111	111
Reeves	0	0	0	0	0	0	80	-80
Roosevelt	0	0	0	0	0	0	-55	55
Scurry	4,584	-716	-91	-3,362	0	-818	-1,169	1,572
Sherman	0	0	0	0	0	0	53	-53
Sterling	457	-267	0	-284	0	0	-507	601
Swisher	0	0	0	-19	0	0	-2,848	2,867
Terry	0	0	0	0	0	0	0	0
Texas	0	0	0	0	0	0	25	-25
Tom Green	0	0	0	0	0	0	25	-25
Union	0	0	0	0	0	0	-869	869
Upton	0	0	0	8	0	0	-676	668
Ward	0	0	0	0	0	0	1,388	-1,388
Winkler	0	0	0	0	0	0	-374	374
Yoakum	0	0	0	0	0	0	-1	1

Table A.2.1 Water budget for the Ogallala Aquifer by county for year 1980 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Andrews	3,248	-173	-226	823	-85	0	0	-15,725	15,915	-3,413	-363
Armstrong	9,535	-21	-80	-2,196	0	-2,585	0	-11,601	11,894	-2,775	-2,170
Baca	2,354	0	0	862	0	0	0	0	16	-3,233	1
Bailey	4,409	0	-204	1,978	0	0	0	-144,724	162,119	-23,932	354
Beaver	48,118	-38,768	0	-27,850	-3,061	-116	0	-40,979	37,476	25,180	0
Beckham	1,559	-11	0	-222	0	-1,299	0	0	0	-26	0
Borden	5,343	0	0	0	-298	-3,322	0	-657	-1,642	81	495
Briscoe	6,184	-270	-1,947	-1,573	0	-2,253	0	-47,568	40,115	10,545	-3,232
Carson	12,471	-477	0	4,704	0	-184	0	-130,462	125,886	-12,183	245
Castro	7,341	0	0	4,107	0	0	0	-442,605	455,047	-26,009	2,119
Chaves	1,053	0	0	0	-621	0	0	0	602	-951	-82
Cimarron	49,430	-1,112	-36	7,681	-1,792	0	0	-90,581	65,172	-29,537	774
Cochran	1,576	0	-70	0	-31	0	0	-63,186	60,174	1,677	-141
Collingsworth	647	0	0	0	0	-678	0	0	9	22	0
Crosby	8,701	0	0	-1,634	-311	-6,536	0	-70,063	60,343	13,023	-3,524
Curry	5,942	0	0	6,307	0	0	0	-110,581	84,423	12,934	975
Dallam	24,600	-568	0	17,463	-133	0	0	-240,273	254,537	-53,776	-1,851
Dawson	54,728	-1,009	-100	4,653	-1,675	-3,756	0	-22,197	-31,574	70	860
De Baca	219	0	0	0	-815	0	0	-1,360	1,219	591	145
Deaf Smith	17,411	-481	-122	7,696	-63	0	0	-329,851	319,055	-14,106	461
Dewey	1,888	0	0	0	-119	-1,415	0	0	-17	-337	0
Dickens	2,168	-53	0	-524	0	-322	0	-3,036	2,254	1,862	-2,349
Donley	17,361	-2,052	-1,322	-13,937	-118	-6,958	0	-12,369	7,216	12,178	0
Ector	456	-18	0	843	0	-16	0	-3,658	2,163	249	-19
Eddy	55	0	0	0	0	0	0	0	103	-158	1
Ellis	49,811	-19,264	-5,287	-16,884	-3,296	-11,899	0	-24,216	12,991	18,043	0
Floyd	14,459	0	-4,780	3,861	0	-1,789	0	-225,157	217,336	-2,764	-1,166

Table A.2.1, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Gaines	17,287	-4,115	-713	13,947	-1,072	0	0	-410,515	388,865	2,596	-6,279
Garza	8,377	0	0	0	-786	-4,571	0	-9,335	-344	3,543	3,116
Glasscock	2,261	-407	0	351	0	-123	0	-4,184	1,185	367	550
Grant	646	0	0	1,141	0	0	0	0	6,505	-8,292	0
Gray	26,409	-876	0	-3,867	0	-6,403	0	-17,010	19,494	-17,748	0
Guadalupe	26	0	0	0	-5	0	0	0	0	-11	-9
Hale	9,969	0	0	8,437	0	0	0	-399,677	370,122	12,347	-1,197
Hansford	11,531	-1,259	0	6,513	-57	0	0	-185,400	164,777	3,894	0
Harding	2,751	0	0	0	-891	-431	0	0	34	-668	-795
Harper	15,416	-10,717	-107	-556	-278	-3,795	0	-11,422	6,461	4,997	0
Hartley	29,186	-5,641	-55	-11,245	0	-1,797	42	-254,606	252,128	-7,569	-442
Haskell	67	0	0	229	0	0	0	0	899	-1,194	0
Hemphill	34,367	-24,568	-198	-21,502	-101	-3,671	0	-2,333	3,620	14,385	0
Hockley	3,033	-635	-62	2,873	-248	0	0	-116,093	117,283	-5,344	-807
Howard	22,950	-691	-19	-1,771	-2,809	-1,302	0	-5,234	-12,703	1,438	141
Hutchinson	7,082	-3,484	-328	-11,145	-2,040	-9,275	0	-89,854	77,866	31,178	0
Lamb	4,827	-25	-322	7,003	-304	0	0	-363,730	346,816	4,108	1,626
Lea	10,746	-31	-35	429	-948	0	0	-112,843	100,791	3,813	-1,921
Lipscomb	29,621	-7,694	0	-2,334	0	0	0	-22,180	20,362	-17,775	0
Lubbock	18,791	-117	-1,476	323	-60	-2,019	0	-109,902	106,325	-13,501	1,635
Lynn	61,944	-690	-885	6	-1,606	-892	0	-37,024	-17,865	-2,214	-774
Martin	23,247	-2,699	-235	3,682	-986	0	0	-14,754	-10,181	1,881	44
Meade	282	-2,448	0	-7,695	-716	0	0	0	50	10,527	0
Midland	886	-1,633	-135	2,734	0	-319	0	-9,368	6,811	1,334	-310
Moore	17,436	-403	0	757	-485	-2,817	0	-250,594	238,494	508	-2,897
Morton	14,140	0	0	3,435	0	0	0	-10,136	6,109	-13,548	0
Motley	1,787	0	-479	-839	0	-2,784	0	-352	3,065	2,047	-2,446
Ochiltree	12,379	-310	0	3,022	0	0	126	-109,713	100,872	-6,376	0
Oldham	18,476	-844	-260	-8,908	-1,167	-8,645	0	-21,643	22,513	4,178	-3,701

Table A.2.1, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Parmer	4,875	0	0	9,814	0	0	0	-544,313	516,538	10,834	2,252
Potter	7,090	0	-103	210	-268	-1,977	0	-25,443	24,439	-2,475	-1,473
Quay	7,704	-672	-96	3,549	-194	-2,586	0	-6,557	4,178	-4,764	-562
Randall	10,169	-1,048	-166	-3,285	-343	-1,327	0	-93,838	78,029	14,414	-2,606
Roberts	13,328	-28,523	0	-16,414	-2,835	-2,426	0	-6,372	10,180	33,062	0
Roger Mills	25,028	-1,815	0	-8,845	-1,411	-14,138	0	-85	-192	1,459	0
Roosevelt	5,901	0	0	-135	-546	0	0	-64,699	58,928	2,714	-2,161
Seward	12,911	-9,315	0	-19,536	-5,170	0	0	-39,118	67,169	-6,941	0
Sherman	17,550	0	0	9,682	0	0	0	-323,195	293,807	2,309	-153
Stevens	27,088	0	0	968	0	0	0	-149,510	113,418	8,036	0
Swisher	9,870	0	-196	1,495	0	-113	0	-211,979	200,677	1,268	-1,023
Terry	12,980	0	-408	2,219	-450	0	0	-79,655	71,548	-5,108	-1,126
Texas	67,653	-20,592	0	-15,827	-2,911	0	1,154	-243,485	178,572	35,393	44
Union	32,555	-680	-154	4,224	-4,342	-453	0	-13,374	14,245	-25,159	-6,862
Wheeler	28,976	-4,028	-1,212	-9,218	-2,291	-12,868	0	-5,849	4,590	1,900	0
Winkler	7	0	0	0	0	0	0	0	25	6	-38
Woodward	19,761	-3,993	0	-350	-7,367	-9,685	132	0	-127	1,629	0
Yoakum	1,889	-16	-27	1,802	0	0	0	-120,354	120,227	-732	-2,788

Table A.2.2 Water budget for the Rita Blanca Aquifer by county for year 1980 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Cimarron	0	0	0	0	0	0	0	0	44	246	-290
Colfax	371	0	0	0	0	0	0	0	30	-400	-1
Dallam	0	0	0	0	0	0	0	-6,131	2,703	926	2,502
Harding	114	-18	0	-29	-99	0	0	0	223	-180	-11
Hartley	0	0	0	0	0	0	0	0	41	56	-97
Quay	0	0	0	0	0	0	0	0	2	12	-14
Union	2,616	-631	-13	-3,196	-1,005	0	0	-7,429	4,076	-660	6,242

Table A.2.3 Water budget for the Edwards-Trinity (High Plains) Aquifer by county for year 1980 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Bailey	0	0	0	0	0	0	0	-264	706	-645	203
Borden	0	0	0	0	0	0	0	-5	-313	1,031	-713
Chaves	0	0	0	0	0	0	0	0	0	-77	77
Cochran	0	0	0	0	0	0	0	-347	203	-114	257
Dawson	0	0	0	0	0	0	0	-340	-53	1,276	-883
Floyd	0	0	0	0	0	0	0	-1,883	3,317	0	-1,434
Gaines	0	0	0	0	0	0	0	-13,536	334	5,171	8,032
Garza	0	0	0	0	0	0	0	-15	-3	3,697	-3,679
Hale	0	0	0	0	0	0	0	-6,271	1,581	773	3,917
Hockley	0	0	0	0	0	0	0	-93	379	-1,381	1,095
Lamb	0	0	0	0	0	0	0	-299	144	221	-66
Lea	0	0	0	0	0	0	0	0	1,007	-3,587	2,580
Lubbock	0	0	0	0	0	0	0	-365	153	1,179	-966
Lynn	0	0	0	0	0	0	0	-402	884	-1,117	634
Roosevelt	0	0	0	0	0	0	0	0	312	-3,020	2,708
Terry	0	0	0	0	0	0	0	-766	555	-1,204	1,415
Yoakum	0	0	0	0	0	0	0	-2,179	1,334	-2,203	3,048

Table A.2.4 Water budget for the upper Dockum Group by county for year 1980 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Andrews	0	0	0	0	0	0	0	0	86	-23	-63
Bailey	0	0	0	0	0	0	0	-3	520	-1	-517
Borden	1	-6	0	-4	0	0	0	0	-2	2	10
Castro	0	0	0	0	0	0	0	-5	1,806	-4	-1,797
Chaves	0	0	0	0	0	0	0	0	5	-5	1
Cimarron	0	0	0	0	0	0	0	0	175	1	-176
Cochran	0	0	0	0	0	0	0	0	107	4	-111
Colfax	0	0	0	0	0	0	0	0	0	0	0
Crane	0	0	0	0	0	0	0	0	0	4	-4
Crosby	1	0	0	1	0	0	0	0	50	1	-52
Curry	0	0	0	0	0	0	0	0	1,013	-22	-992
Dallam	0	0	0	0	0	0	0	-14	668	3	-657
Dawson	2	-7	0	-51	-22	0	0	0	47	1	30
De Baca	0	0	0	0	0	0	0	0	6	2	-7
Deaf Smith	54	0	0	22	0	0	0	-13	1,060	-3	-1,120
Ector	0	0	0	0	0	0	0	-9	54	0	-45
Floyd	0	0	0	0	0	0	0	0	24	1	-25
Gaines	0	0	0	0	0	0	0	0	1,611	13	-1,624
Garza	0	0	0	0	0	0	0	0	0	0	-1
Guadalupe	0	0	0	0	0	0	0	0	0	-3	3
Hale	0	0	0	0	0	0	0	-9	1,572	5	-1,568
Harding	0	0	0	0	0	0	0	0	10	-19	9
Hartley	0	0	0	0	0	0	0	-3	440	4	-441
Hockley	0	0	0	0	0	0	0	0	263	1	-264
Howard	0	0	0	0	0	0	0	0	-2	0	2
Lamb	0	0	0	0	0	0	0	-7	1,327	-1	-1,319
Lea	0	0	0	0	0	0	0	0	778	-6	-773

Table A.2.4, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Lubbock	0	-5	0	-31	0	0	0	-1	495	4	-462
Lynn	0	0	0	0	0	0	0	0	107	3	-111
Martin	0	0	0	0	0	0	0	-8	125	17	-133
Midland	0	0	0	0	0	0	0	0	30	6	-37
Moore	0	0	0	0	0	0	0	0	12	0	-12
Oldham	0	0	0	0	0	0	0	-2	15	-2	-11
Parmer	0	0	0	0	0	0	0	0	1,887	1	-1,889
Potter	0	0	0	0	0	0	0	0	0	0	0
Quay	243	-6	0	20	-16	0	0	0	59	12	-313
Randall	0	0	0	0	0	0	0	-19	160	0	-141
Roosevelt	0	0	0	0	0	0	0	0	558	-9	-549
Sherman	0	0	0	0	0	0	0	0	0	0	0
Swisher	0	0	0	0	0	0	0	-1	645	4	-648
Terry	0	0	0	0	0	0	0	0	275	-4	-270
Union	0	0	0	0	0	0	0	0	136	10	-145
Upton	0	0	0	0	0	0	0	0	0	0	0
Winkler	0	0	0	0	0	0	0	0	3	3	-6
Yoakum	0	0	0	0	0	0	0	-2	248	-1	-245

Table A.2.5 Water budget for the lower Dockum Group by county for year 1980 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Andrews	0	0	0	0	0	0	0	-1	10	-99	90
Armstrong	228	0	-295	-509	-2,273	0	0	-117	156	641	2,170
Baca	0	0	0	0	0	0	0	0	0	1	-1
Bailey	0	0	0	0	0	0	0	0	45	-2	-43
Borden	4,000	-1,606	0	-657	0	0	408	-65	-2,548	193	275
Briscoe	282	-261	-697	-4,440	-1,858	0	84	-16	779	2,896	3,232
Carson	0	0	0	0	0	0	0	-348	271	322	-245
Castro	0	0	0	0	0	0	0	0	892	-569	-322
Chaves	0	0	0	0	0	0	0	0	3	-7	5
Cimarron	0	0	0	0	0	0	0	0	335	-28	-306
Cochran	0	0	0	0	0	0	0	0	5	0	-5
Coke	133	-11	0	-24	0	-292	0	0	0	90	104
Colfax	0	0	0	0	0	0	0	0	0	-1	1
Crane	0	0	0	0	0	0	0	-42	22	1,084	-1,064
Crockett	0	0	0	0	0	0	0	-3	21	503	-521
Crosby	1,533	-236	0	-1,547	0	-648	0	-3,588	2,110	-1,200	3,576
Curry	0	0	0	0	0	0	0	-545	633	-105	17
Dallam	0	0	0	0	0	0	0	-1,743	1,765	-23	1
Dawson	0	0	0	0	0	0	0	-1	82	-74	-7
De Baca	0	0	0	0	0	0	0	-24	22	140	-138
Deaf Smith	147	0	0	61	0	0	0	-3,099	3,555	-1,323	659
Dickens	1,592	0	-413	-890	0	-1,855	0	-12	-380	-391	2,349
Ector	0	0	0	0	0	0	0	-98	151	-1,436	1,382
Eddy	0	0	0	0	0	0	0	-3	1	328	-327
Fisher	734	-111	0	-137	0	-599	0	-17	-123	137	116
Floyd	313	-49	-293	-2,844	0	0	0	-1,628	3,374	-1,499	2,626

Table A.2.5, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Gaines	0	0	0	0	0	0	0	0	129	2	-132
Garza	6,145	-2,997	-43	-2,312	0	-712	0	-79	-3,591	3,018	569
Glasscock	2	0	0	0	0	0	0	0	273	-57	-218
Guadalupe	0	0	0	0	0	0	0	0	0	-6	6
Hale	0	0	0	0	0	0	0	-243	2,039	-643	-1,153
Harding	0	0	0	0	0	0	0	0	157	-954	797
Hartley	205	-314	0	973	0	0	0	-1,399	2,230	-2,678	983
Hockley	0	0	0	0	0	0	0	0	23	1	-23
Howard	5,236	-1,171	-16	-1,169	0	0	0	-28	-2,094	-1,213	455
Hutchinson	0	0	0	0	0	0	0	0	0	0	0
Irion	0	0	0	0	0	0	0	0	17	145	-162
Kent	1,297	-17	-112	-673	0	-529	0	-3	-209	245	0
Lamb	0	0	0	0	0	0	0	0	259	-19	-241
Lea	0	0	0	0	0	0	0	-2,902	2,889	-550	563
Loving	0	0	0	0	0	0	0	-8	18	-181	171
Lubbock	0	0	0	0	0	0	0	-2	448	-219	-227
Lynn	1	0	0	-46	0	0	0	0	65	-285	265
Martin	0	0	0	0	0	0	0	0	62	-53	-9
Midland	0	0	0	0	0	0	0	0	111	-133	22
Mitchell	18,103	-3,838	-122	-7,705	0	-908	227	-3,423	-5,259	2,485	440
Moore	64	0	0	-59	0	0	0	-4,315	1,226	175	2,909
Motley	403	0	-168	-1,955	0	-2,515	0	-10	277	1,522	2,446
Nolan	1,759	-136	0	-522	0	-749	0	-820	-425	-682	1,576
Oldham	5,906	-3,725	-120	-10,133	0	0	0	-458	567	4,251	3,712
Parmer	0	0	0	0	0	0	0	0	371	-8	-363
Pecos	0	0	0	0	0	0	0	-955	905	53	-3
Potter	2,217	-1,097	-22	-3,479	-395	0	0	-717	966	1,054	1,473
Quay	276	-152	0	-785	0	0	0	-5,050	4,752	71	888

Table A.2.5, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Randall	86	0	0	-2,512	-748	0	0	-1,060	1,283	205	2,746
Reagan	0	0	0	0	0	0	0	-749	863	33	-148
Reeves	0	0	0	0	0	0	0	-1,345	840	208	298
Roosevelt	0	0	0	0	0	0	0	-221	271	-56	6
Scurry	7,610	-868	-109	-3,682	0	-1,044	715	-8,917	5,622	-1,089	1,761
Sherman	0	0	0	0	0	0	0	-562	226	183	153
Sterling	457	-267	0	-284	0	0	0	-20	38	-514	589
Swisher	0	0	0	-19	0	0	0	-219	1,576	-3,008	1,670
Terry	0	0	0	0	0	0	0	0	19	0	-19
Texas	0	0	0	0	0	0	0	0	23	21	-44
Tom Green	0	0	0	0	0	0	0	0	3	25	-27
Union	0	0	0	0	0	0	0	0	207	-972	765
Upton	0	0	0	8	0	0	0	-282	346	-745	674
Ward	0	0	0	0	0	0	0	-114	431	982	-1,299
Winkler	0	0	0	0	0	0	0	-2,833	2,239	-190	784
Yoakum	0	0	0	0	0	0	0	0	16	-1	-15

Table A.3.1 Water budget for the Ogallala Aquifer by county for year 2012 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Andrews	7,361	-103	-198	2,993	-84	0	0	-18,918	12,921	-3,682	-290
Armstrong	9,535	0	-39	-1,227	0	-2,339	0	-8,805	11,286	-6,262	-2,150
Baca	2,354	0	0	862	0	0	0	0	27	-3,244	1
Bailey	24,897	0	-225	1,978	0	0	0	-79,667	57,308	-5,154	863
Beaver	48,118	-35,738	0	-23,080	-1,901	-114	0	-44,966	43,680	14,000	0
Beckham	1,559	-11	0	-222	0	-1,300	0	0	0	-26	0
Borden	5,343	0	0	0	-324	-3,419	0	-4,999	2,258	592	549
Briscoe	6,184	-20	-796	-796	0	-1,281	0	-27,149	20,156	6,509	-2,807
Carson	12,471	-367	0	5,470	0	-143	0	-129,816	124,865	-12,826	347
Castro	7,341	0	0	4,107	0	0	0	-203,291	202,812	-13,919	2,951
Chaves	1,053	0	0	0	-520	0	0	0	1,078	-1,534	-77
Cimarron	49,430	-1,069	-19	7,954	-1,821	0	0	-91,135	73,520	-37,576	716
Cochran	26,528	0	-46	0	-12	0	0	-67,076	38,115	1,421	1,071
Collingsworth	647	0	0	0	0	-664	0	0	8	9	0
Crosby	14,786	0	0	1,105	-249	-4,722	0	-125,768	106,982	10,391	-2,525
Curry	13,011	0	0	6,379	0	0	0	-101,306	78,505	2,346	1,066
Dallam	24,600	-61	0	19,836	0	0	0	-429,574	379,136	7,428	-1,365
Dawson	54,728	-983	-118	5,528	-1,850	-4,031	0	-120,554	73,573	-5,456	-838
De Baca	219	0	0	0	-650	0	0	-189	516	-49	153
Deaf Smith	17,411	-97	-61	9,047	0	0	0	-164,560	144,035	-6,266	492
Dewey	1,888	0	0	0	-120	-1,421	0	0	-10	-338	0
Dickens	2,168	-8	0	-425	0	-180	0	-3,395	3,759	200	-2,119
Donley	17,361	-1,688	-1,286	-11,948	-35	-6,715	0	-39,308	26,676	16,943	0
Ector	503	0	0	881	0	-15	0	-157	-1,020	-100	-91
Eddy	55	0	0	0	0	0	0	0	102	-155	-2
Ellis	49,811	-13,221	-5,065	-8,680	-3,045	-11,684	0	-48,475	22,106	18,252	0

Table A.3.1, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Floyd	14,459	0	-2,720	3,961	0	-776	0	-124,703	119,929	-10,979	830
Gaines	84,951	-2,610	-498	19,560	-733	0	0	-253,549	144,985	8,037	-144
Garza	8,522	0	0	0	-771	-4,261	0	-14,718	4,954	3,177	3,098
Glasscock	3,295	-399	0	475	0	-99	0	-5,350	1,186	541	351
Grant	646	0	0	1,141	0	0	0	0	7,610	-9,397	0
Gray	26,409	-764	0	-2,979	0	-6,240	0	-41,569	40,077	-14,934	0
Guadalupe	26	0	0	0	-5	0	0	0	0	-11	-9
Hale	12,376	0	0	8,437	0	0	0	-275,388	254,119	939	-482
Hansford	11,531	-483	0	10,052	0	0	419	-242,130	217,629	2,981	0
Harding	2,751	0	0	0	-872	-428	0	0	23	-643	-832
Harper	15,416	-9,898	-107	-176	-162	-3,522	0	-12,231	3,950	6,729	0
Hartley	29,186	-3,213	-2	-5,377	0	-1,636	42	-488,903	486,978	-17,996	920
Haskell	67	0	0	229	0	0	0	0	917	-1,213	0
Hemphill	34,367	-24,400	-198	-20,587	-101	-3,673	0	-21,951	21,931	14,614	0
Hockley	42,932	-309	-44	3,222	-97	0	0	-145,756	101,659	-1,593	-14
Howard	23,087	-1,104	-26	-2,288	-3,834	-2,438	-212	-12,685	-2,599	2,058	41
Hutchinson	7,082	-2,367	-185	-4,744	-798	-6,860	0	-85,118	82,617	10,373	0
Lamb	32,714	0	-294	7,060	-302	0	0	-244,161	196,168	5,115	3,699
Lea	17,873	-29	-15	418	-846	0	0	-58,689	46,851	-3,171	-2,391
Lipscomb	29,621	-5,733	0	1,567	0	0	0	-56,294	47,145	-16,307	0
Lubbock	74,766	0	-1,116	2,765	-22	-1,779	0	-130,551	50,590	2,558	2,790
Lynn	68,028	-717	-992	5	-1,402	-890	0	-80,395	23,791	-6,181	-1,246
Martin	29,730	-4,132	-315	2,481	-1,308	0	0	-42,275	16,499	-477	-203
Meade	282	-2,225	0	-7,149	-513	0	0	0	73	9,533	0
Midland	3,857	-1,123	-137	3,462	0	-269	0	-14,840	7,750	1,526	-225
Moore	17,436	0	0	5,266	-164	-1,730	0	-282,841	256,336	7,024	-1,326
Morton	14,140	0	0	3,435	0	0	0	-11,577	7,504	-13,502	0
Motley	1,787	0	-340	-174	0	-2,291	0	-273	2,585	971	-2,266

Table A.3.1, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Ochiltree	12,379	-170	0	3,738	0	0	126	-113,704	100,672	-3,040	0
Oldham	18,476	-758	-258	-8,550	-1,015	-7,868	0	-14,397	11,621	6,315	-3,567
Parmer	5,378	0	0	9,814	0	0	0	-150,240	129,843	1,958	3,248
Potter	7,090	0	-64	597	-267	-1,655	0	-8,573	12,040	-7,587	-1,580
Quay	10,665	-745	-97	3,460	-245	-2,587	0	-1,159	-2,464	-6,162	-666
Randall	10,169	-559	-104	-45	-231	-991	0	-44,304	30,515	7,810	-2,258
Roberts	13,328	-26,681	0	-13,211	-2,354	-2,103	0	-79,392	84,930	25,483	0
Roger Mills	25,028	-1,825	0	-8,863	-1,419	-14,201	0	-98	-85	1,463	0
Roosevelt	33,679	0	0	-107	-254	0	0	-48,712	17,493	452	-2,551
Seward	12,911	-4,540	0	-6,585	-1,072	0	0	-53,762	87,729	-34,679	0
Sherman	17,550	0	0	9,682	0	0	0	-397,598	370,112	246	9
Stevens	27,088	0	0	968	0	0	0	-204,512	158,088	18,368	0
Swisher	9,870	0	-35	2,492	0	-82	0	-119,415	98,092	9,399	-321
Terry	73,870	0	-134	2,927	-173	0	0	-204,762	127,914	-41	397
Texas	67,653	-12,972	0	2,354	-1,067	0	1,271	-280,410	184,592	38,533	46
Union	32,555	-663	-153	4,809	-4,279	-430	0	-13,429	17,458	-27,352	-8,517
Wheeler	28,976	-3,969	-1,184	-8,133	-2,274	-12,809	0	-13,605	8,623	4,376	0
Winkler	7	0	0	0	0	0	0	0	15	3	-24
Woodward	19,761	-3,993	0	-349	-7,402	-9,716	132	0	-52	1,621	0
Yoakum	34,562	0	-17	2,496	0	0	0	-132,277	93,892	1,557	-214

Table A.3.2 Water budget for the Rita Blanca Aquifer by county for year 2012 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Cimarron	0	0	0	0	0	0	0	0	64	122	-187
Colfax	371	0	0	0	0	0	0	0	48	-417	-1
Dallam	0	0	0	0	0	0	0	-6,202	2,054	945	3,203
Harding	114	-18	0	-29	-95	0	0	0	172	-172	26
Hartley	0	0	0	0	0	0	0	0	92	1	-93
Quay	0	0	0	0	0	0	0	0	0	10	-10
Union	2,616	-606	-13	-3,080	-975	0	0	-9,775	4,350	-489	7,971

Table A.3.3 Water budget for the Edwards-Trinity (High Plains) Aquifer by county for year 2012 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Bailey	0	0	0	0	0	0	0	0	688	-727	39
Borden	0	0	0	0	0	0	0	-15	-254	1,034	-764
Chaves	0	0	0	0	0	0	0	0	1	-79	78
Cochran	0	0	0	0	0	0	0	-20	281	527	-788
Dawson	0	0	0	0	0	0	0	-2,147	5	1,117	1,025
Floyd	0	0	0	0	0	0	0	0	2,640	0	-2,640
Gaines	0	0	0	0	0	0	0	-12,225	2,356	7,227	2,641
Garza	0	0	0	0	0	0	0	-184	1	3,828	-3,645
Hale	0	0	0	0	0	0	0	-7,923	2,869	991	4,064
Hockley	0	0	0	0	0	0	0	-84	948	-1,485	621
Lamb	0	0	0	0	0	0	0	0	314	515	-829
Lea	0	0	0	0	0	0	0	0	1,106	-4,157	3,051
Lubbock	0	0	0	0	0	0	0	-972	529	1,841	-1,398
Lynn	0	0	0	0	0	0	0	-1,137	2,541	-2,448	1,044
Roosevelt	0	0	0	0	0	0	0	0	206	-3,280	3,074
Terry	0	0	0	0	0	0	0	-42	1,550	-1,643	135
Yoakum	0	0	0	0	0	0	0	-6	2,586	-3,261	681

Table A.3.4 Water budget for the upper Dockum Group by county for year 2012 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Andrews	0	0	0	0	0	0	0	0	170	-28	-142
Bailey	0	0	0	0	0	0	0	-7	760	-3	-749
Borden	1	-6	0	-4	0	0	0	0	-1	2	9
Castro	0	0	0	0	0	0	0	0	1,721	-2	-1,720
Chaves	0	0	0	0	0	0	0	0	9	-7	-1
Cimarron	0	0	0	0	0	0	0	0	169	0	-169
Cochran	0	0	0	0	0	0	0	0	256	4	-261
Colfax	0	0	0	0	0	0	0	0	0	0	0
Crane	0	0	0	0	0	0	0	0	0	4	-4
Crosby	2	0	0	1	0	0	0	0	26	1	-30
Curry	0	0	0	0	0	0	0	0	935	-19	-917
Dallam	0	0	0	0	0	0	0	-23	1,131	5	-1,113
Dawson	2	-7	0	-50	-23	0	0	0	241	-2	-161
De Baca	0	0	0	0	0	0	0	0	8	1	-9
Deaf Smith	54	0	0	22	0	0	0	-56	802	-4	-818
Ector	0	0	0	0	0	0	0	-7	11	0	-4
Floyd	0	0	0	0	0	0	0	0	74	1	-75
Gaines	0	0	0	0	0	0	0	0	2,041	28	-2,068
Garza	1	0	0	0	0	0	0	0	1	0	-2
Guadalupe	0	0	0	0	0	0	0	0	0	-3	3
Hale	0	0	0	0	0	0	0	-5	1,216	3	-1,215
Harding	0	0	0	0	0	0	0	0	12	-19	6
Hartley	0	0	0	0	0	0	0	-2	706	4	-708
Hockley	0	0	0	0	0	0	0	0	513	-1	-512
Howard	0	0	0	0	0	0	0	0	1	1	-1
Lamb	0	0	0	0	0	0	0	-4	2,020	0	-2,016

Table, A.3.4, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments		Reservoirs	Wells	Storage	Lateral	Cross-Formational
Lea	0	0	0	0	0	0	0	0	715		-9	-707
Lubbock	0	-4	0	-30	0	0	0	0	535		7	-508
Lynn	0	0	0	0	0	0	0	0	141		1	-142
Martin	0	0	0	0	0	0	0	-6	45		16	-55
Midland	0	0	0	0	0	0	0	0	27		7	-34
Moore	0	0	0	0	0	0	0	0	14		0	-14
Oldham	0	0	0	0	0	0	0	-1	7		-2	-4
Parmer	0	0	0	0	0	0	0	0	2,199		3	-2,202
Potter	0	0	0	0	0	0	0	0	0		0	0
Quay	243	-5	0	30	-14	0	0	0	128		12	-395
Randall	0	0	0	0	0	0	0	-22	240		-1	-218
Roosevelt	0	0	0	0	0	0	0	0	441		-10	-431
Sherman	0	0	0	0	0	0	0	0	0		0	0
Swisher	0	0	0	0	0	0	0	-21	417		6	-402
Terry	0	0	0	0	0	0	0	0	475		-7	-468
Union	0	0	0	0	0	0	0	0	158		9	-166
Upton	0	0	0	0	0	0	0	0	0		0	0
Winkler	0	0	0	0	0	0	0	0	5		3	-8
Yoakum	0	0	0	0	0	0	0	-9	426		-2	-415

Table A.3.5 Water budget for the lower Dockum Group by county for year 2012 of the transient model.

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Andrews	0	0	0	0	0	0	0	-4	38	-100	66
Armstrong	228	0	-295	-509	-2,261	0	0	-173	274	586	2,150
Baca	0	0	0	0	0	0	0	0	0	1	-1
Bailey	0	0	0	0	0	0	0	0	161	-3	-159
Borden	4,000	-1,781	0	-1,048	0	0	376	-114	-1,977	271	273
Briscoe	282	-260	-689	-4,421	-1,853	0	84	-76	1,465	2,662	2,807
Carson	0	0	0	0	0	0	0	-138	310	174	-347
Castro	0	0	0	0	0	0	0	-323	2,206	-653	-1,231
Chaves	0	0	0	0	0	0	0	0	14	-14	0
Cimarron	0	0	0	0	0	0	0	0	406	-49	-357
Cochran	0	0	0	0	0	0	0	0	22	0	-22
Coke	133	-11	0	-24	0	-293	0	0	0	90	105
Colfax	0	0	0	0	0	0	0	0	0	-1	1
Crane	0	0	0	0	0	0	0	-158	44	1,069	-954
Crockett	0	0	0	0	0	0	0	-4	36	499	-530
Crosby	2,988	-245	0	-1,622	0	-926	0	-2,931	1,650	-1,470	2,555
Curry	0	0	0	0	0	0	0	-549	822	-124	-148
Dallam	0	0	0	0	0	0	0	-2,757	3,466	22	-731
Dawson	0	0	0	0	0	0	0	-2	101	-73	-26
De Baca	0	0	0	0	0	0	0	-17	19	141	-143
Deaf Smith	147	0	0	61	0	0	0	-2,100	2,728	-1,162	326
Dickens	3,604	-17	-494	-1,023	0	-3,109	0	-93	-587	-400	2,119
Ector	0	0	0	0	0	0	0	-492	558	-1,437	1,371
Eddy	0	0	0	0	0	0	0	-51	41	334	-324
Fisher	734	-124	0	-139	0	-635	0	-53	-30	130	116
Floyd	313	-48	-289	-2,733	0	0	0	-2,451	4,186	-862	1,886

Table A.3.5, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Gaines	0	0	0	0	0	0	0	0	427	3	-430
Garza	6,947	-3,364	-50	-3,480	0	-788	-95	-190	-2,696	3,167	554
Glasscock	2	0	0	0	0	0	0	0	502	-111	-393
Guadalupe	0	0	0	0	0	0	0	0	0	-6	6
Hale	0	0	0	0	0	0	0	-130	3,184	-687	-2,367
Harding	0	0	0	0	0	0	0	0	124	-923	799
Hartley	205	-313	0	985	0	0	0	-2,022	3,826	-2,566	-115
Hockley	0	0	0	0	0	0	0	-28	123	0	-95
Howard	5,236	-1,202	-16	-1,288	0	0	-39	-414	-1,493	-1,330	547
Hutchinson	0	0	0	0	0	0	0	0	0	0	0
Irion	0	0	0	0	0	0	0	0	20	126	-146
Kent	1,299	-20	-112	-706	0	-544	0	-19	-143	245	0
Lamb	0	0	0	0	0	0	0	0	873	-20	-853
Lea	0	0	0	0	0	0	0	-2,975	2,950	-561	587
Loving	0	0	0	0	0	0	0	-19	41	-194	173
Lubbock	0	0	0	0	0	0	0	-3	1,047	-263	-781
Lynn	1	0	0	-46	0	0	0	-81	195	-306	237
Martin	0	0	0	0	0	0	0	-323	323	-42	42
Midland	0	0	0	0	0	0	0	0	140	-93	-47
Mitchell	18,103	-4,485	-146	-8,837	0	-952	75	-11,470	5,552	1,714	444
Moore	64	0	0	-55	0	0	0	-1,605	222	34	1,340
Motley	403	0	-161	-1,823	0	-2,413	0	-62	398	1,393	2,266
Nolan	1,759	-256	0	-726	0	-754	0	-11,660	9,688	254	1,695
Oldham	5,906	-3,719	-120	-9,813	0	0	0	-1,129	1,112	4,192	3,571
Parmer	0	0	0	0	0	0	0	0	1,057	-11	-1,046
Pecos	0	0	0	0	0	0	0	-777	639	83	55
Potter	2,217	-1,078	-22	-3,392	-395	0	0	-1,472	1,443	1,120	1,580
Quay	276	-141	0	-766	0	0	0	-3,997	3,477	82	1,070

Table A.3.5, continued

County	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Randall	86	0	0	-2,328	-747	0	0	-2,634	2,811	336	2,476
Reagan	0	0	0	0	0	0	0	-71	243	63	-235
Reeves	0	0	0	0	0	0	0	-1,204	717	283	204
Roosevelt	0	0	0	0	0	0	0	-204	352	-61	-87
Scurry	7,610	-956	-130	-4,283	0	-1,212	686	-7,803	5,502	-1,219	1,804
Sherman	0	0	0	0	0	0	0	-485	252	241	-8
Sterling	457	-267	0	-284	0	0	0	-18	48	-526	590
Swisher	0	0	0	-17	0	0	0	-1,177	3,550	-3,077	722
Terry	0	0	0	0	0	0	0	0	65	0	-64
Texas	0	0	0	0	0	0	0	0	30	16	-46
Tom Green	0	0	0	0	0	0	0	0	3	23	-27
Union	0	0	0	0	0	0	0	0	294	-1,007	712
Upton	0	0	0	8	0	0	0	-308	440	-714	575
Ward	0	0	0	0	0	0	0	-116	564	1,003	-1,451
Winkler	0	0	0	0	0	0	0	-2,057	1,559	-286	784
Yoakum	0	0	0	0	0	0	0	0	53	-1	-52

Table A.4.1 **Water budget for the Ogallala Aquifer by groundwater conservation district for the steady-state model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Garza County UWCD	2,044	0	0	0	-1,021	-5,951	2,568	2,360
Gateway GCD	1,749	0	-624	-1,731	0	-3,464	6,704	-2,634
Glasscock GCD	945	-464	0	-746	0	-164	-5	434
High Plains UWCD No.1	96,837	-25,448	-14,852	-13,000	-6,647	-13,316	-8,835	-14,740
Llano Estacado UWCD	3,460	-6,846	-910	-1,147	-1,952	0	4,445	2,950
Mesa UWCD	5,346	-1,620	-52	-1,073	-1,407	-3,220	867	1,159
North Plains GCD	136,985	-23,119	-69	-3,149	-1,450	-179	-108,714	-305
Panhandle GCD	112,392	-37,564	-2,964	-48,748	-5,629	-34,729	20,042	-2,799
Permian Basin UWCD	5,898	-4,278	-328	-1,190	-2,742	-942	3,751	-169
Sandy Land UWCD	2,035	-29	-91	578	0	0	-795	-1,698
South Plains UWCD	1,904	-81	-717	1,318	-757	0	-1,616	-50
Hemphill County UWCD	34,037	-24,895	-196	-21,966	-112	-3,600	16,732	0
Mesquite GCD	647	0	0	0	0	-697	49	0

Table A.4.2 **Water budget for the Rita Blanca Aquifer by groundwater conservation district for the steady-state model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
North Plains GCD	0	0	0	0	0	0	560	-560

Table A.4.3 **Water budget for the Edwards-Trinity (High Plains) Aquifer by groundwater conservation district for the steady-state model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Garza County UWCD	0	0	0	0	0	0	2,979	-2,979
High Plains UWCD No.1	0	0	0	0	0	0	-95	95
Llano Estacado UWCD	0	0	0	0	0	0	2,935	-2,935
Mesa UWCD	0	0	0	0	0	0	1,312	-1,312
Sandy Land UWCD	0	0	0	0	0	0	-1,696	1,696
South Plains UWCD	0	0	0	0	0	0	-47	47

Table A.4.4 Water budget for the upper Dockum Group by groundwater conservation district for the steady-state model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Garza County UWCD	0	0	0	0	0	0	0	0
High Plains UWCD No.1	0	-5	0	-33	0	0	19	18
Llano Estacado UWCD	0	0	0	0	0	0	12	-12
Mesa UWCD	1	-7	0	-51	-22	0	1	78
North Plains GCD	0	0	0	0	0	0	7	-7
Permian Basin UWCD	0	0	0	0	0	0	17	-17
Sandy Land UWCD	0	0	0	0	0	0	-1	1
South Plains UWCD	0	0	0	0	0	0	-2	2

Table A.4.5 Water budget for the lower Dockum Group by groundwater conservation district for the steady-state model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Lateral	Cross-Formational
Clear Fork GCD	478	-86	0	-136	0	-512	137	119
Coke County UWCD	129	-11	0	-24	0	-261	62	104
Crockett County GCD	0	0	0	0	0	0	492	-492
Garza County UWCD	2,055	-2,945	-41	-2,020	0	-681	3,008	624
Gateway GCD	335	0	-171	-2,043	0	-2,555	1,800	2,634
Glasscock GCD	2	0	0	0	0	0	-61	60
High Plains UWCD No.1	271	0	0	43	-184	0	-14,749	14,619
Irion County WCD	0	0	0	0	0	0	148	-148
Llano Estacado UWCD	0	0	0	0	0	0	2	-2
Lone Wolf GCD	8,249	-3,435	-112	-6,892	0	-907	2,655	443
Mesa UWCD	0	0	0	0	0	0	-75	75
Middle Pecos GCD	0	0	0	0	0	0	-85	85
North Plains GCD	49	0	0	189	0	0	-1,110	872
Panhandle GCD	2,325	-1,106	-318	-4,150	-2,487	0	2,936	2,799
Permian Basin UWCD	3,024	-1,167	-16	-1,111	0	0	-1,183	453
Sandy Land UWCD	0	0	0	0	0	0	-1	1
Santa Rita UWCD	0	0	0	0	0	0	-78	78
South Plains UWCD	0	0	0	0	0	0	0	0
Sterling County UWCD	457	-267	0	-284	0	0	-494	587
Wes-Tex GCD	505	-79	0	-518	0	-743	-739	1,574

Table A.5.1 Water budget for the Ogallala Aquifer by groundwater conservation district for year 1980 of the transient model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Garza County UWCD	8,354	0	0	0	-786	-4,571	0	-9,004	-356	3,296	3,068
Gateway GCD	1,787	0	-479	-839	0	-2,784	0	-352	3,065	2,047	-2,446
Glasscock GCD	2,241	-407	0	351	0	-123	0	-4,071	1,151	303	554
High Plains UWCD No.1	166,630	-1,635	-8,101	48,003	-2,657	-9,420	0	-3,124,756	2,958,995	-26,320	-739
Llano Estacado UWCD	17,246	-4,115	-713	13,947	-1,072	0	0	-410,413	388,364	3,036	-6,280
Mesa UWCD	54,724	-1,009	-100	4,653	-1,675	-3,756	0	-22,197	-31,573	74	860
North Plains GCD	137,167	-14,796	-55	35,924	-541	-63	168	-1,467,159	1,378,519	-64,557	-4,607
Panhandle GCD	113,935	-35,976	-2,636	-40,747	-5,512	-33,692	0	-193,656	189,713	11,252	-2,679
Permian Basin UWCD	45,855	-3,137	-255	2,251	-3,795	-1,302	0	-19,965	-22,714	3,109	-48
Sandy Land UWCD	1,886	-16	-27	1,802	0	0	0	-119,556	119,703	-1,005	-2,786
South Plains UWCD	13,056	0	-408	2,219	-450	0	0	-80,068	72,215	-5,402	-1,162
Hemphill County UWCD	34,479	-24,568	-198	-21,502	-101	-3,671	0	-2,333	3,621	14,273	0
Mesquite GCD	647	0	0	0	0	-678	0	0	9	22	0

Table A.5.2 Water budget for the Rita Blanca Aquifer by groundwater conservation district for year 1980 of the transient model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
North Plains GCD	0	0	0	0	0	0	0	-6,131	2,744	978	2,409

Table A.5.3 **Water budget for the Edwards-Trinity (High Plains) Aquifer by groundwater conservation district for year 1980 of the transient model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Garza County UWCD	0	0	0	0	0	0	0	-15	-3	3,647	-3,629
High Plains UWCD No.1	0	0	0	0	0	0	0	-9,916	7,338	-932	3,509
Llano Estacado UWCD	0	0	0	0	0	0	0	-13,536	334	5,172	8,031
Mesa UWCD	0	0	0	0	0	0	0	-340	-53	1,276	-883
Sandy Land UWCD	0	0	0	0	0	0	0	-2,179	1,333	-2,200	3,045
South Plains UWCD	0	0	0	0	0	0	0	-766	562	-1,251	1,455

Table A.5.4 **Water budget for the upper Dockum Group by groundwater conservation district for year 1980 of the transient model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Garza County UWCD	0	0	0	0	0	0	0	0	0	0	-1
High Plains UWCD No.1	0	-5	0	-31	0	0	0	-37	9,867	17	-9,811
Llano Estacado UWCD	0	0	0	0	0	0	0	0	1,609	14	-1,622
Mesa UWCD	2	-7	0	-51	-22	0	0	0	47	1	29
North Plains GCD	0	0	0	0	0	0	0	-17	1,120	7	-1,110
Permian Basin UWCD	0	0	0	0	0	0	0	-8	123	17	-132
Sandy Land UWCD	0	0	0	0	0	0	0	-2	247	-1	-244
South Plains UWCD	0	0	0	0	0	0	0	0	279	-4	-275

Table A.5.5 Water budget for the lower Dockum Group by groundwater conservation district for year 1980 of the transient model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Clear Fork GCD	734	-111	0	-137	0	-599	0	-17	-123	137	116
Coke County UWCD	129	-11	0	-24	0	-261	0	0	0	62	104
Crockett County GCD	0	0	0	0	0	0	0	-3	21	491	-509
Garza County UWCD	6,166	-2,997	-43	-2,312	0	-712	0	-79	-3,591	2,999	568
Gateway GCD	403	0	-168	-1,955	0	-2,515	0	-10	277	1,522	2,446
Glasscock GCD	2	0	0	0	0	0	0	-389	518	63	-194
High Plains UWCD No.1	271	0	0	43	-184	0	0	-9,354	15,620	-13,428	7,033
Irion County WCD	0	0	0	0	0	0	0	0	19	141	-160
Llano Estacado UWCD	0	0	0	0	0	0	0	0	129	2	-131
Lone Wolf GCD	18,104	-3,838	-122	-7,677	0	-939	227	-3,423	-5,257	2,483	442
Mesa UWCD	0	0	0	0	0	0	0	-1	82	-74	-7
Middle Pecos GCD	0	0	0	0	0	0	0	-955	905	49	2
North Plains GCD	49	0	0	194	0	0	0	-7,868	5,117	-796	3,305
Panhandle GCD	2,333	-1,097	-318	-4,068	-2,484	0	0	-752	959	2,746	2,679
Permian Basin UWCD	5,249	-1,212	-16	-1,169	0	0	0	-27	-2,034	-1,220	427
Sandy Land UWCD	0	0	0	0	0	0	0	0	16	-1	-15
Santa Rita UWCD	0	0	0	0	0	0	0	-359	617	-85	-173
South Plains UWCD	0	0	0	0	0	0	0	0	19	0	-19
Sterling County UWCD	457	-267	0	-284	0	0	0	-20	38	-500	576
Wes-Tex GCD	1,759	-136	0	-522	0	-749	0	-820	-427	-679	1,574

Table A.6.1 Water budget for the Ogallala Aquifer by groundwater conservation district for year 2012 of the transient model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Garza County UWCD	8,498	0	0	0	-771	-4,261	0	-14,466	4,931	3,028	3,040
Gateway GCD	1,787	0	-340	-174	0	-2,291	0	-273	2,585	971	-2,266
Glasscock GCD	3,240	-399	0	475	0	-99	0	-5,236	1,202	462	356
High Plains UWCD No.1	349,939	-1,026	-5,512	56,240	-2,097	-6,779	0	-1,903,166	1,503,728	-2,108	10,781
Llano Estacado UWCD	84,920	-2,610	-498	19,560	-733	0	0	-253,504	144,743	8,265	-143
Mesa UWCD	54,724	-983	-118	5,528	-1,850	-4,031	0	-120,554	73,572	-5,450	-838
North Plains GCD	137,167	-8,782	-2	54,089	-34	0	587	-2,085,798	1,909,608	-5,782	-1,053
Panhandle GCD	113,935	-33,469	-2,534	-31,468	-4,931	-32,430	0	-319,899	308,730	4,792	-2,725
Permian Basin UWCD	52,461	-4,939	-341	723	-5,143	-2,438	-212	-54,609	13,963	917	-384
Sandy Land UWCD	34,477	0	-17	2,496	0	0	0	-131,538	93,795	1,025	-237
South Plains UWCD	74,236	0	-134	2,927	-173	0	0	-209,619	132,400	-5	368
Hemphill County UWCD	34,479	-24,400	-198	-20,587	-101	-3,673	0	-21,951	21,930	14,503	0
Mesquite GCD	647	0	0	0	0	-664	0	0	8	9	0

Table A.6.2 Water budget for the Rita Blanca Aquifer by groundwater conservation district for year 2012 of the transient model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
North Plains GCD	0	0	0	0	0	0	0	-6,202	2,147	941	3,114

Table A.6.3 **Water budget for the Edwards-Trinity (High Plains) Aquifer by groundwater conservation district for year 2012 of the transient model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Garza County UWCD	0	0	0	0	0	0	0	-184	1	3,769	-3,586
High Plains UWCD No.1	0	0	0	0	0	0	0	-10,131	10,793	-654	-8
Llano Estacado UWCD	0	0	0	0	0	0	0	-12,225	2,356	7,231	2,638
Mesa UWCD	0	0	0	0	0	0	0	-2,147	5	1,117	1,025
Sandy Land UWCD	0	0	0	0	0	0	0	-6	2,586	-3,283	703
South Plains UWCD	0	0	0	0	0	0	0	-42	1,553	-1,684	173

Table A.6.4 **Water budget for the upper Dockum Group by groundwater conservation district for year 2012 of the transient model.**

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Garza County UWCD	1	0	0	0	0	0	0	0	1	0	-2
High Plains UWCD No.1	0	-4	0	-30	0	0	0	-66	10,578	20	-10,499
Llano Estacado UWCD	0	0	0	0	0	0	0	0	2,038	28	-2,065
Mesa UWCD	2	-7	0	-50	-23	0	0	0	241	-2	-161
North Plains GCD	0	0	0	0	0	0	0	-26	1,851	9	-1,835
Permian Basin UWCD	0	0	0	0	0	0	0	-6	46	17	-56
Sandy Land UWCD	0	0	0	0	0	0	0	-9	425	-2	-414
South Plains UWCD	0	0	0	0	0	0	0	0	483	-7	-476

Table A.6.5 Water budget for the lower Dockum Group by groundwater conservation district for year 2012 of the transient model.

Groundwater Conservation District	Recharge	ET	Springs	Rivers	Draws	Escarpments	Reservoirs	Wells	Storage	Lateral	Cross-Formational
Clear Fork GCD	734	-124	0	-139	0	-635	0	-53	-30	130	116
Coke County UWCD	129	-11	0	-24	0	-262	0	0	0	62	105
Crockett County GCD	0	0	0	0	0	0	0	-4	36	487	-518
Garza County UWCD	6,968	-3,364	-50	-3,480	0	-788	-95	-113	-2,734	3,108	553
Gateway GCD	403	0	-161	-1,823	0	-2,413	0	-62	398	1,393	2,266
Glasscock GCD	2	0	0	0	0	0	0	-68	408	31	-373
High Plains UWCD No.1	274	0	0	45	-183	0	0	-11,368	23,997	-12,479	-284
Irion County WCD	0	0	0	0	0	0	0	0	22	121	-143
Llano Estacado UWCD	0	0	0	0	0	0	0	0	426	3	-429
Lone Wolf GCD	18,104	-4,485	-146	-8,802	0	-982	75	-11,470	5,656	1,603	447
Mesa UWCD	0	0	0	0	0	0	0	-2	101	-73	-26
Middle Pecos GCD	0	0	0	0	0	0	0	-777	642	76	59
North Plains GCD	49	0	0	194	0	0	0	-6,642	7,214	-585	-228
Panhandle GCD	2,333	-1,078	-317	-3,981	-2,473	0	0	-1,342	1,582	2,552	2,725
Permian Basin UWCD	5,249	-1,260	-16	-1,288	0	0	-39	-736	-1,164	-1,314	569
Sandy Land UWCD	0	0	0	0	0	0	0	0	53	-1	-52
Santa Rita UWCD	0	0	0	0	0	0	0	-3	337	-78	-255
South Plains UWCD	0	0	0	0	0	0	0	0	66	0	-65
Sterling County UWCD	457	-267	0	-284	0	0	0	-18	48	-513	577
Wes-Tex GCD	1,759	-256	0	-726	0	-754	0	-11,660	9,583	361	1,693

Appendix B

Observed and Simulated Hydrographs

This page intentionally left blank.

Due to the large volume of transient hydraulic head data available for wells in the study area, all observed and simulated hydrographs could not be presented in the main body of this report. Therefore, this appendix was created to show additional hydrographs. The hydrographs included here show observed and simulated water-level (hydraulic head) data for wells identified as being completed in an aquifer or formation. Not all of the transient hydraulic head data available for wells in the study area were plotted as hydrographs and included here. Data for wells with fewer than five measurements were not included. Due to the larger number of wells (more than 6,000), only a subset of the hydrographs are included by limiting the maximum number of hydrographs to 45 per county. All hydrographs presented in the Final Conceptual Model Report (Deeds and Others, 2015) are included in the appendix. Hydrographs are grouped by aquifer and sorted alphabetically by county.

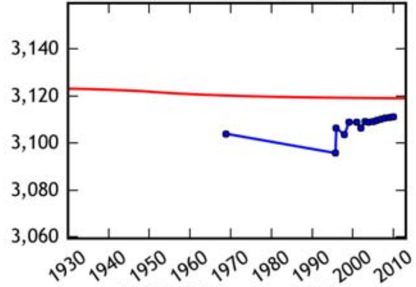
Each hydrograph includes a title that consists of a well identifier, the depth of the well, and the county in which the well is located. For wells with a Texas state well number, the well identifier is the state well number. For wells without a state well number, a well identifier was developed to associate the well with the data source (such as a groundwater conservation district) or with the identification number from an agency (such as the United States Geological Survey or the Oklahoma Water Resources Board). In some cases, an internal identification was given to a well, which can be cross-referenced with the master well database included as part of the electronic delivery with this work.

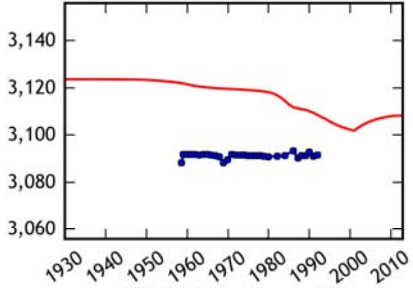
This page intentionally left blank.

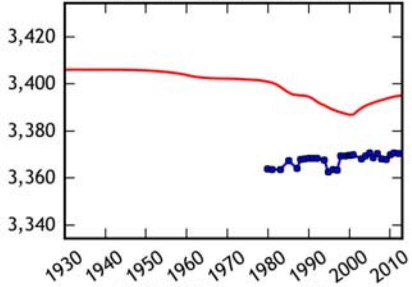
B.1 Ogallala Aquifer Hydrographs

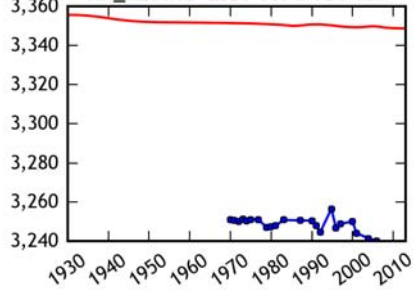
This section contains the observed and simulated hydrographs for the Ogallala Aquifer.

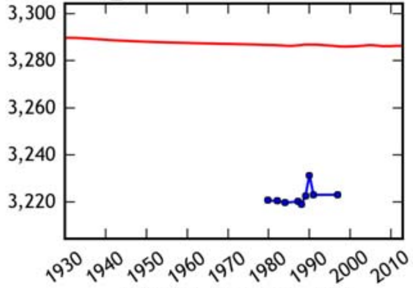
This page intentionally left blank.

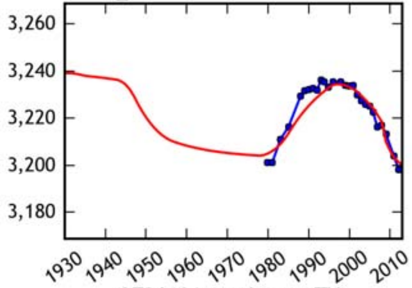

2759311 (Andrews, TX)
HP_000008 LSD: 3171 TD: 134

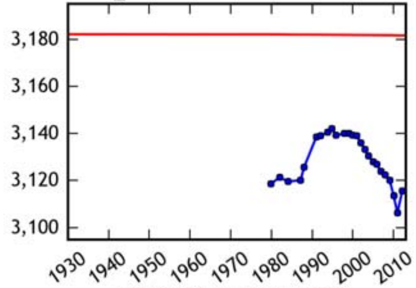

2728901 (Andrews, TX)
HP_020963 LSD: 3141 TD: 61

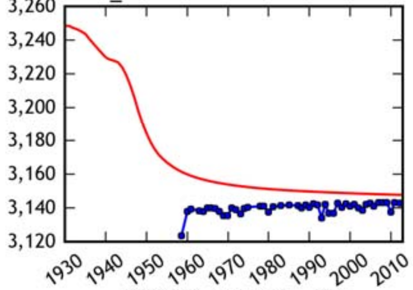

2733201 (Andrews, TX)
HP_021043 LSD: 3430 TD: 70

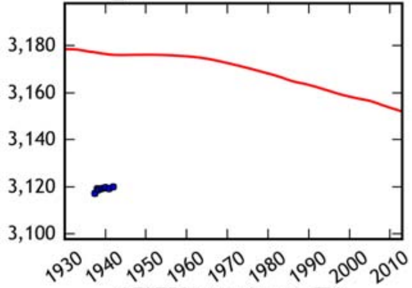

2734101 (Andrews, TX)
HP_021046 LSD: 3375 TD: 139

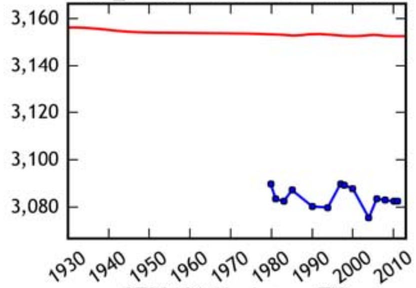

2734301 (Andrews, TX)
HP_021050 LSD: 3303 TD: 140

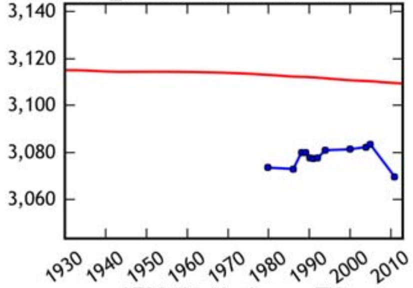

2735201 (Andrews, TX)
HP_021051 LSD: 3256 TD: 89

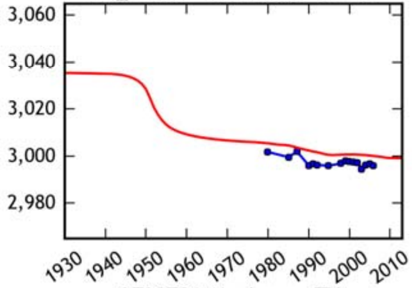

2735302 (Andrews, TX)
HP_021053 LSD: 3198 TD: 110

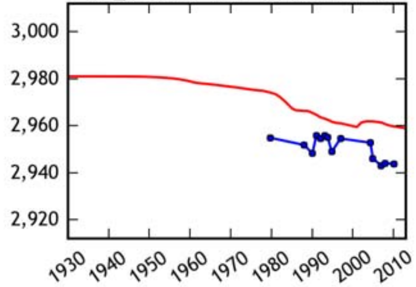

2735701 (Andrews, TX)
HP_021055 LSD: 3235 TD: unk

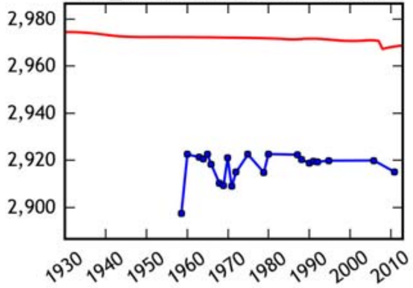

2736101 (Andrews, TX)
HP_021056 LSD: 3197 TD: 111

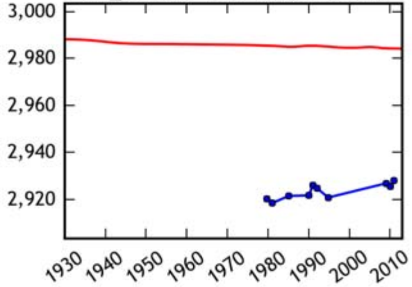

2736401 (Andrews, TX)
HP_021073 LSD: 3191 TD: unk


2736901 (Andrews, TX)
HP_021076 LSD: 3146 TD: unk

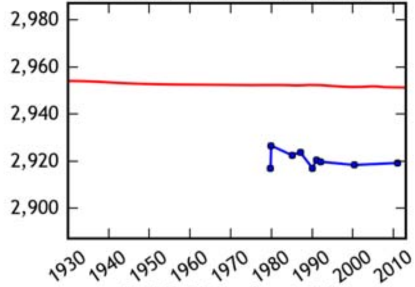

2737501 (Andrews, TX)
HP_021091 LSD: 3040 TD: 55


2738101 (Andrews, TX)
HP_021093 LSD: 3015 TD: 130

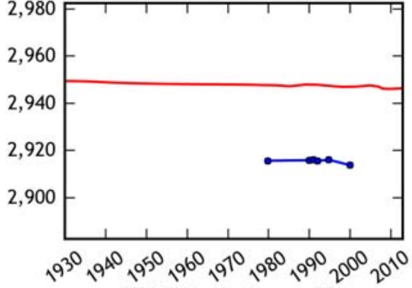

2738401 (Andrews, TX)
HP_021096 LSD: 3006 TD: unk


2738701 (Andrews, TX)
HP_021103 LSD: 3016 TD: unk

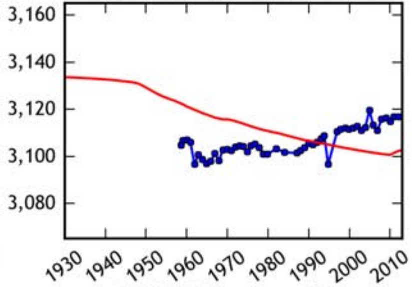
2738801 (Andrews, TX)
HP_021104 LSD: 3000 TD: unk



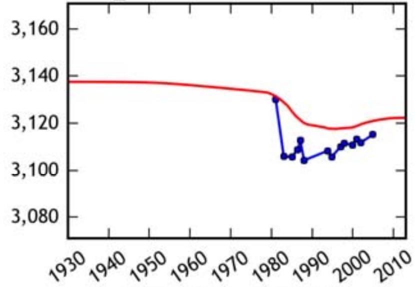
2738802 (Andrews, TX)
HP_021105 LSD: 2995 TD: 95



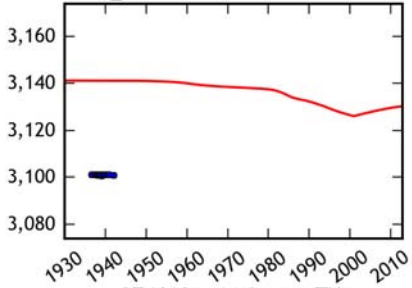
2744201 (Andrews, TX)
HP_021167 LSD: 3161 TD: unk



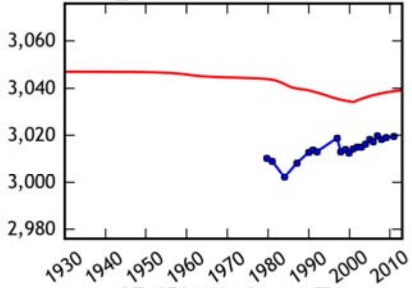
2744215 (Andrews, TX)
HP_021181 LSD: 3180 TD: 120



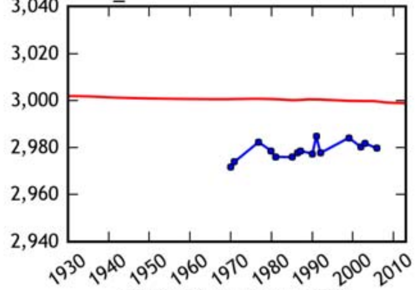
2744503 (Andrews, TX)
HP_021186 LSD: 3213 TD: 127



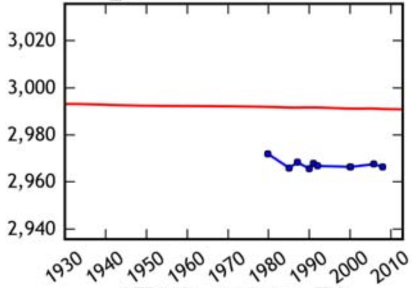
2745201 (Andrews, TX)
HP_021200 LSD: 3070 TD: 72



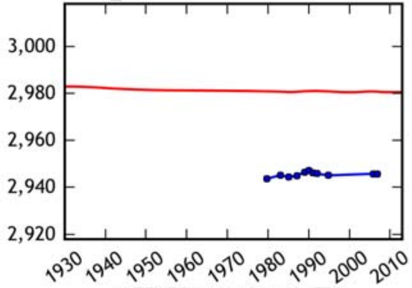
2745901 (Andrews, TX)
HP_021203 LSD: 3033 TD: unk



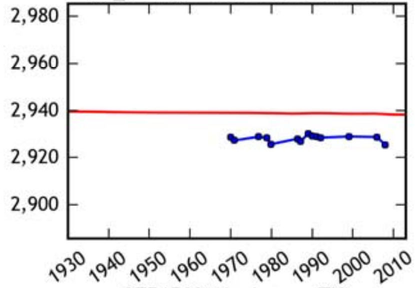
2746101 (Andrews, TX)
HP_021206 LSD: 3032 TD: unk



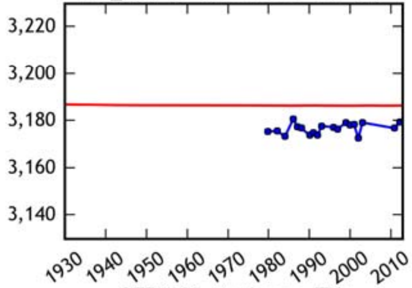
2746501 (Andrews, TX)
HP_021208 LSD: 3002 TD: 107



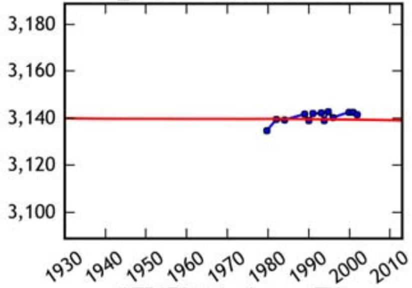
2746601 (Andrews, TX)
HP_021209 LSD: 2984 TD: unk



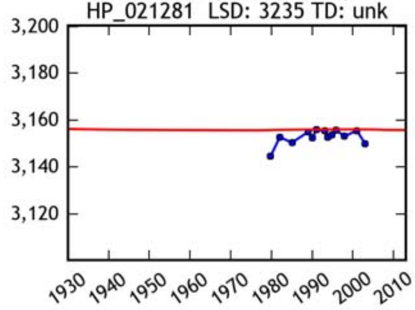
2751401 (Andrews, TX)
HP_021279 LSD: 3271 TD: 129



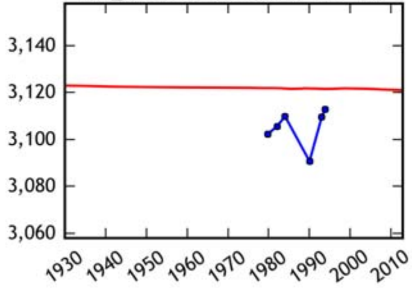
2751501 (Andrews, TX)
HP_021280 LSD: 3210 TD: 91



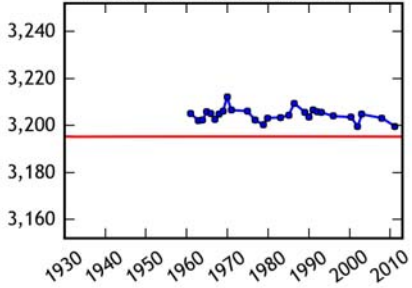
2751502 (Andrews, TX)
HP_021281 LSD: 3235 TD: unk

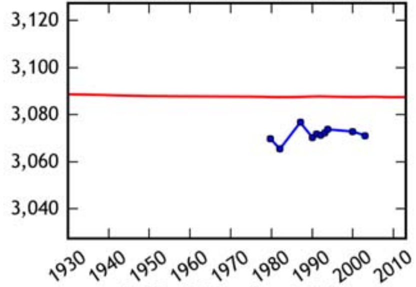


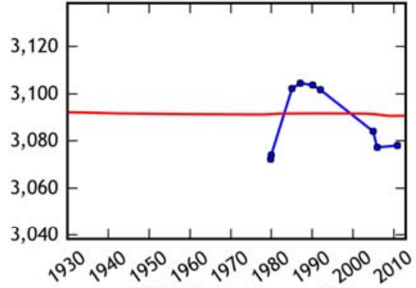
2751601 (Andrews, TX)
HP_021284 LSD: 3192 TD: 115

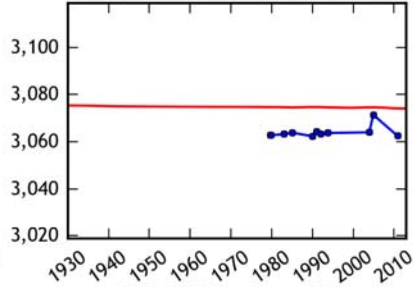


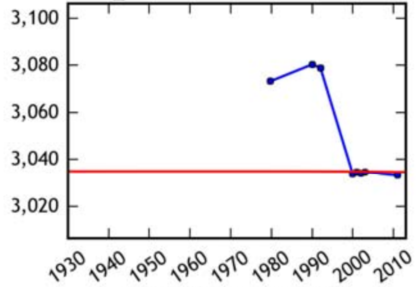
2751701 (Andrews, TX)
HP_021289 LSD: 3275 TD: 119

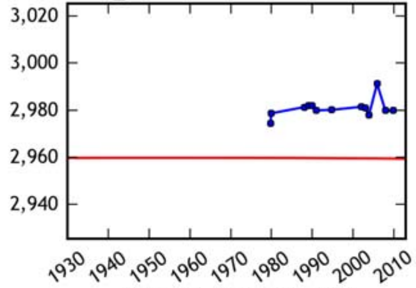


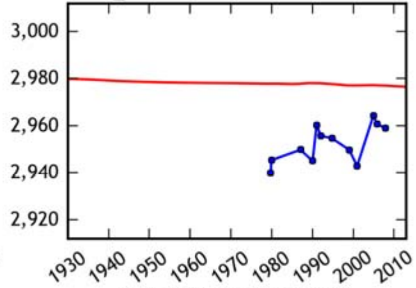

2752301 (Andrews, TX)
HP_021299 LSD: 3154 TD: unk

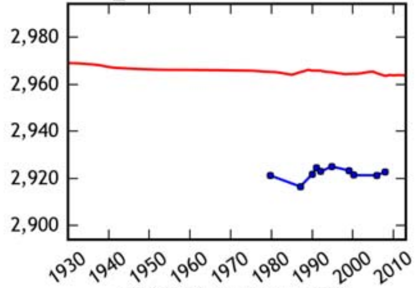

2752402 (Andrews, TX)
HP_021301 LSD: 3160 TD: unk

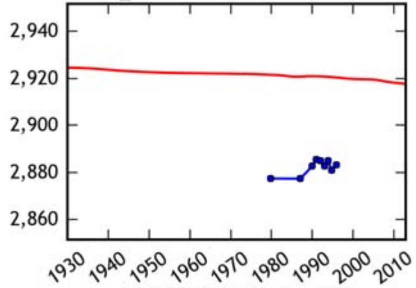

2752501 (Andrews, TX)
HP_021305 LSD: 3134 TD: unk

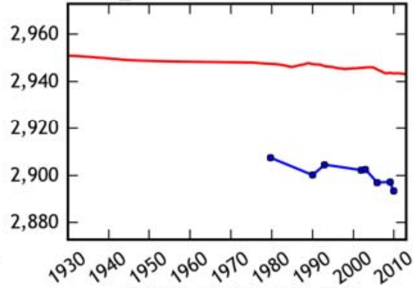

2753402 (Andrews, TX)
HP_021317 LSD: 3124 TD: unk

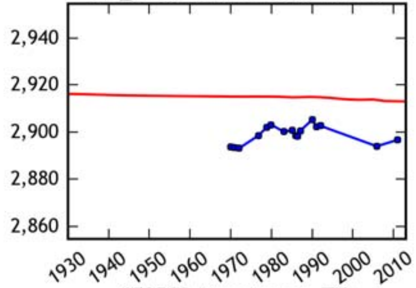

2753903 (Andrews, TX)
HP_021334 LSD: 3046 TD: 108

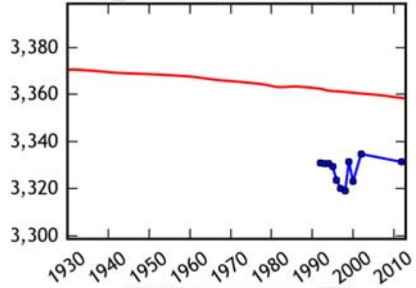

2754101 (Andrews, TX)
HP_021336 LSD: 2998 TD: unk

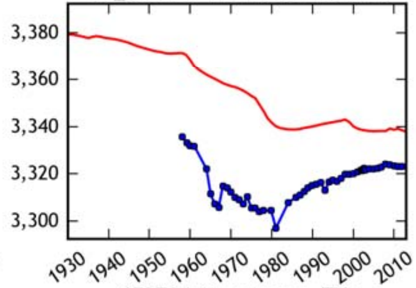

2754201 (Andrews, TX)
HP_021337 LSD: 2950 TD: unk

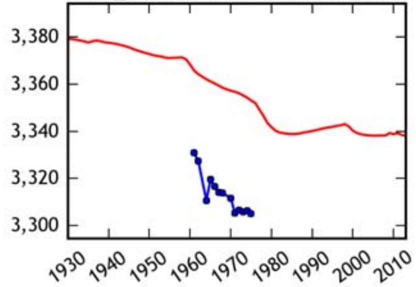

2754301 (Andrews, TX)
HP_021338 LSD: 2914 TD: 50

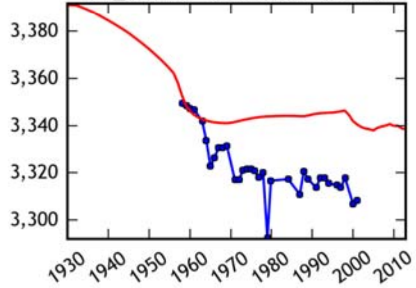

2754502 (Andrews, TX)
HP_021344 LSD: 2922 TD: 47

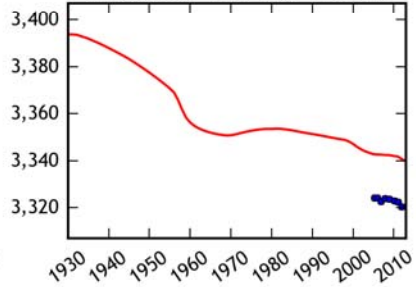

2762201 (Andrews, TX)
HP_021452 LSD: 2930 TD: 75


660202 (Armstrong, TX)
HP_005751 LSD: 3496 TD: 199

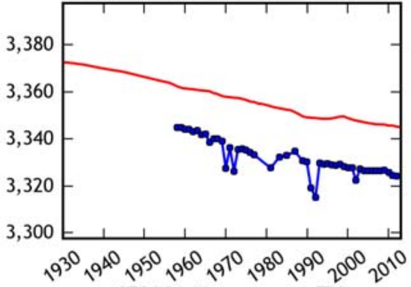

652501 (Armstrong, TX)
HP_005779 LSD: 3524 TD: 263


652503 (Armstrong, TX)
HP_005781 LSD: 3522 TD: 275

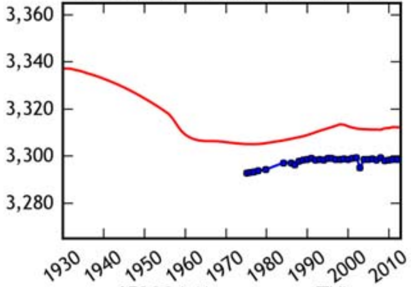

652702 (Armstrong, TX)
HP_005797 LSD: 3531 TD: 260


652704 (Armstrong, TX)
HP_005799 LSD: 3497 TD: unk

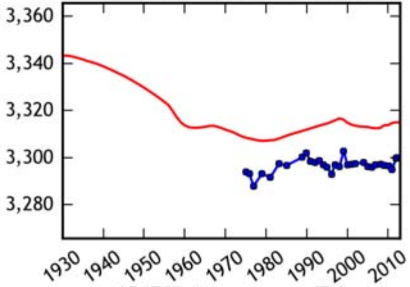
652801 (Armstrong, TX)
HP_005805 LSD: 3498 TD: 250



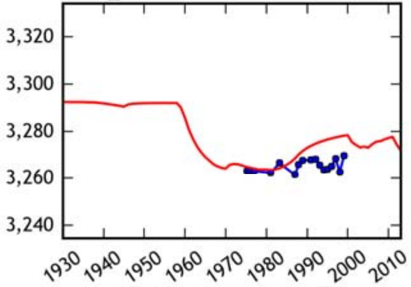
653403 (Armstrong, TX)
HP_005830 LSD: 3482 TD: 223



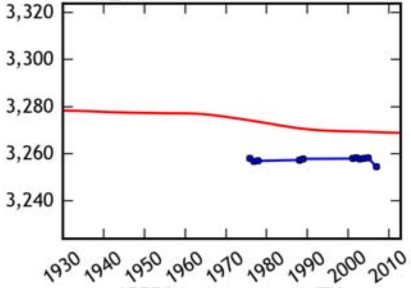
653703 (Armstrong, TX)
HP_005834 LSD: 3486 TD: 230



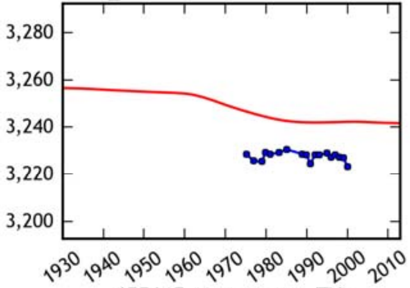
653801 (Armstrong, TX)
HP_005836 LSD: 3433 TD: 244



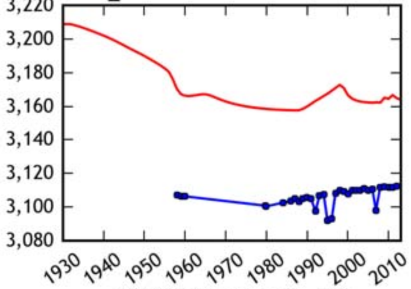
653904 (Armstrong, TX)
HP_005840 LSD: 3448 TD: 200



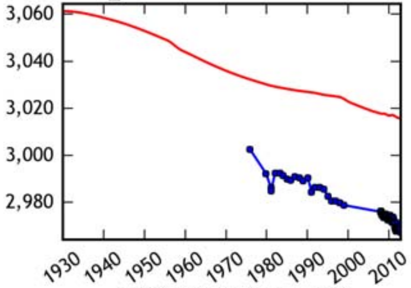
654702 (Armstrong, TX)
HP_005882 LSD: 3415 TD: 210



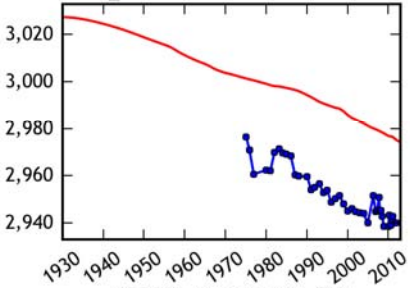
654801 (Armstrong, TX)
HP_005890 LSD: 3407 TD: unk



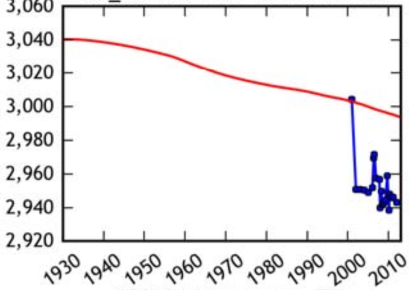
655504 (Armstrong, TX)
HP_005945 LSD: 3330 TD: 500



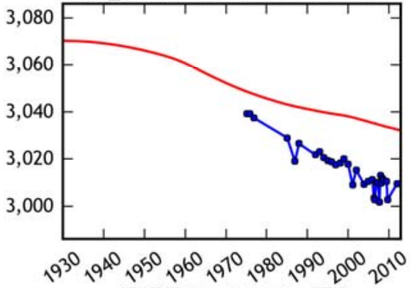
655615 (Armstrong, TX)
HP_005963 LSD: 3298 TD: 448



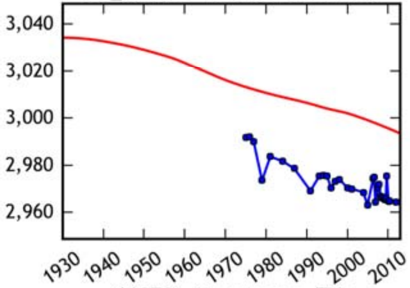
655617 (Armstrong, TX)
HP_005964 LSD: 3315 TD: 422



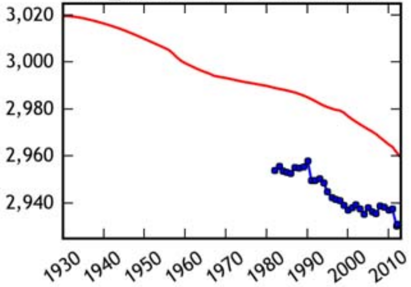
655801 (Armstrong, TX)
HP_005969 LSD: 3149 TD: 147



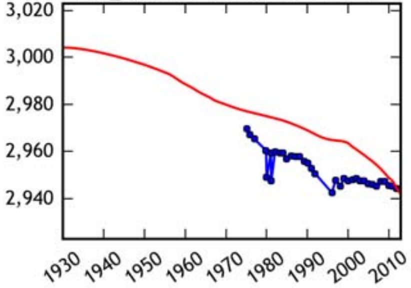
655901 (Armstrong, TX)
HP_005971 LSD: 3220 TD: 341



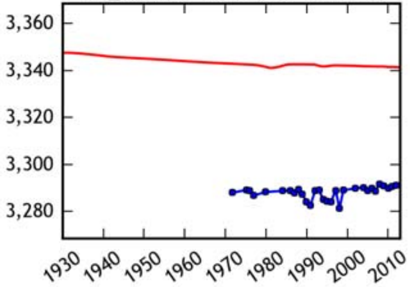
656404 (Armstrong, TX)
HP_005997 LSD: 3282 TD: 520

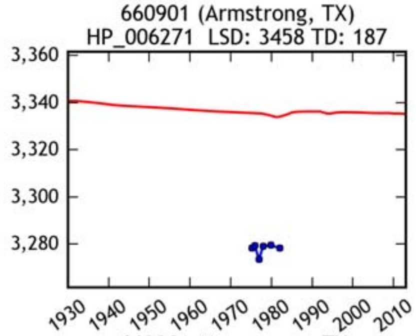


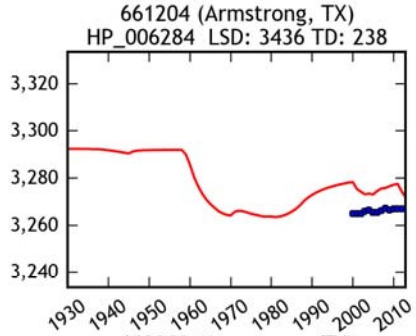
656702 (Armstrong, TX)
HP_006018 LSD: 3282 TD: 502

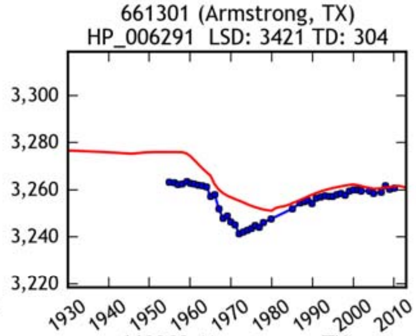


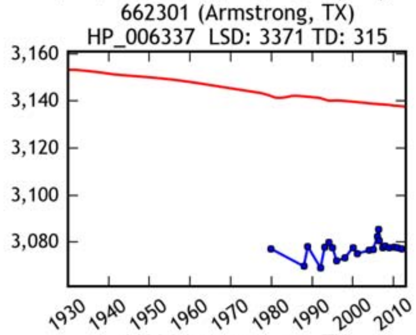
660701 (Armstrong, TX)
HP_006268 LSD: 3477 TD: 316

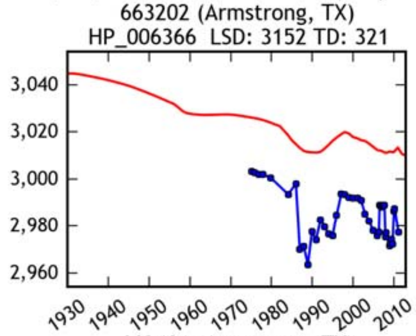


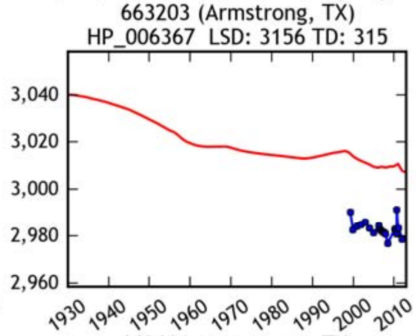

660901 (Armstrong, TX)
HP_006271 LSD: 3458 TD: 187

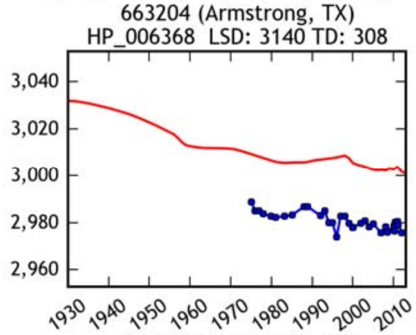

661204 (Armstrong, TX)
HP_006284 LSD: 3436 TD: 238

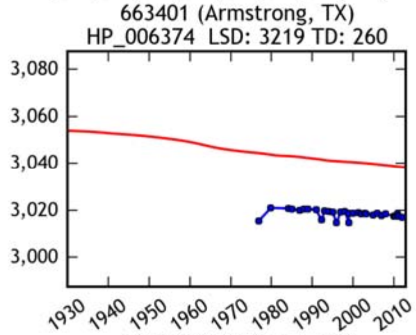

661301 (Armstrong, TX)
HP_006291 LSD: 3421 TD: 304

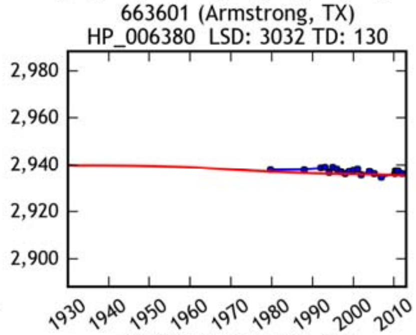

662301 (Armstrong, TX)
HP_006337 LSD: 3371 TD: 315

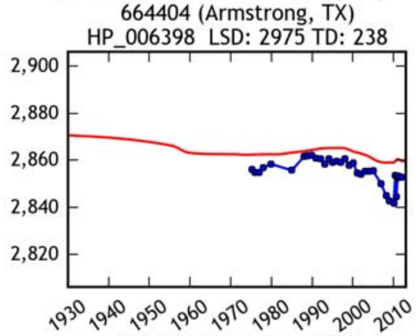

663202 (Armstrong, TX)
HP_006366 LSD: 3152 TD: 321

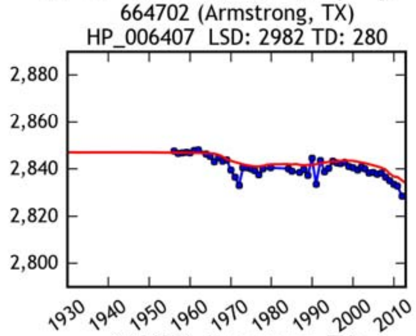

663203 (Armstrong, TX)
HP_006367 LSD: 3156 TD: 315

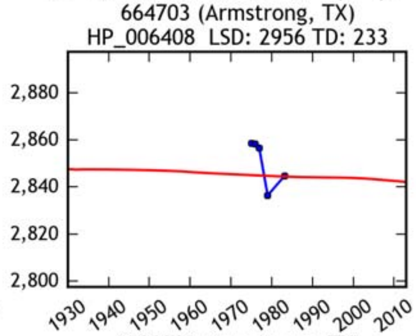

663204 (Armstrong, TX)
HP_006368 LSD: 3140 TD: 308

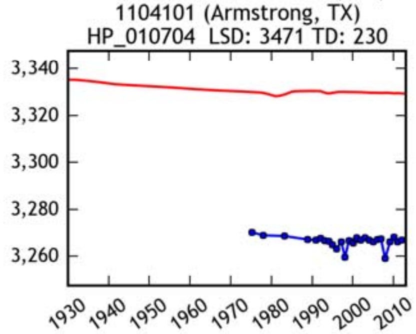

663401 (Armstrong, TX)
HP_006374 LSD: 3219 TD: 260

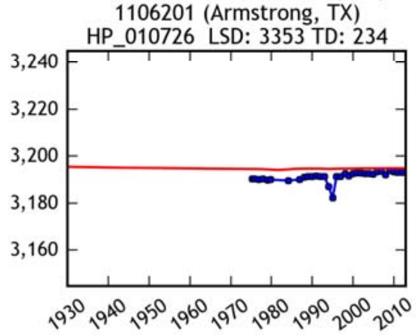

663601 (Armstrong, TX)
HP_006380 LSD: 3032 TD: 130

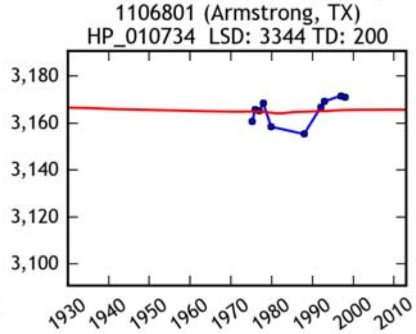

664404 (Armstrong, TX)
HP_006398 LSD: 2975 TD: 238


664702 (Armstrong, TX)
HP_006407 LSD: 2982 TD: 280

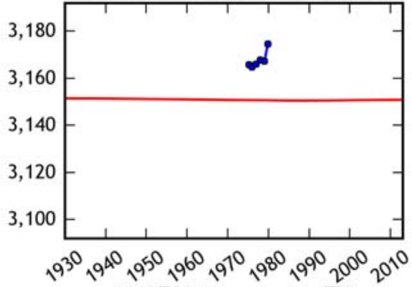

664703 (Armstrong, TX)
HP_006408 LSD: 2956 TD: 233


1104101 (Armstrong, TX)
HP_010704 LSD: 3471 TD: 230

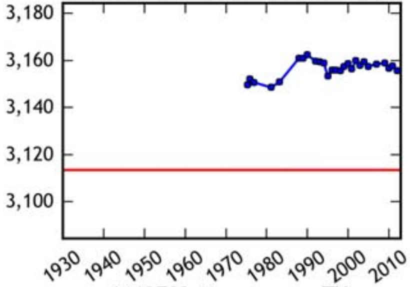

1106201 (Armstrong, TX)
HP_010726 LSD: 3353 TD: 234


1106801 (Armstrong, TX)
HP_010734 LSD: 3344 TD: 200

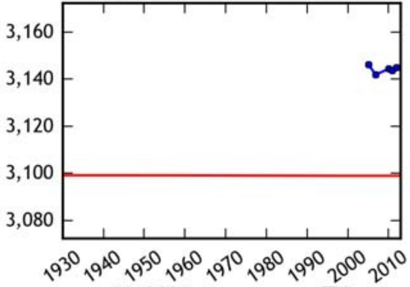
1106902 (Armstrong, TX)
HP_010739 LSD: 3304 TD: 225



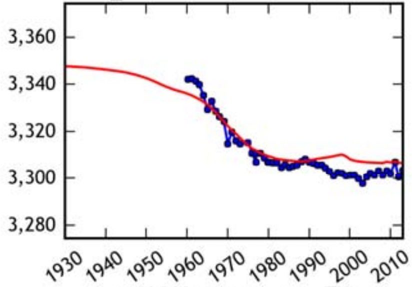
1107401 (Armstrong, TX)
HP_010746 LSD: 3276 TD: 155



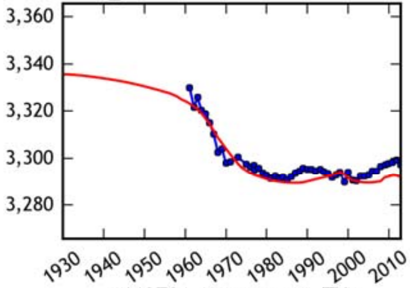
1107750 (Armstrong, TX)
HP_010749 LSD: 3265 TD: unk



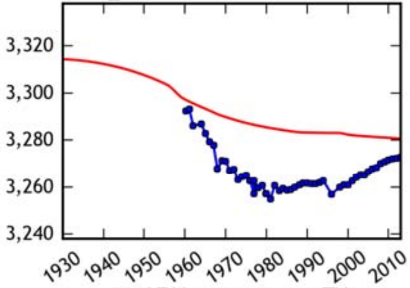
1112701 (Armstrong, TX)
HP_011317 LSD: 3454 TD: 190



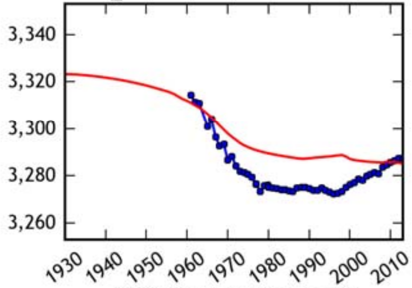
1112702 (Armstrong, TX)
HP_011318 LSD: 3450 TD: 204



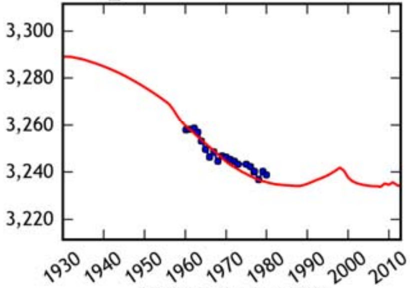
1112801 (Armstrong, TX)
HP_011347 LSD: 3412 TD: 165



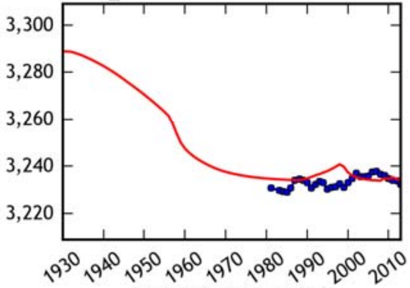
1112802 (Armstrong, TX)
HP_011348 LSD: 3436 TD: 190



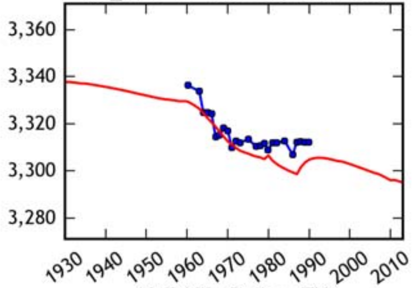
1113701 (Armstrong, TX)
HP_011403 LSD: 3355 TD: 150



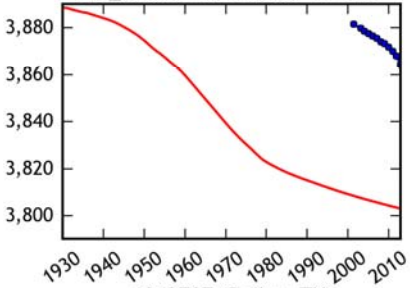
1113702 (Armstrong, TX)
HP_011404 LSD: 3358 TD: 160



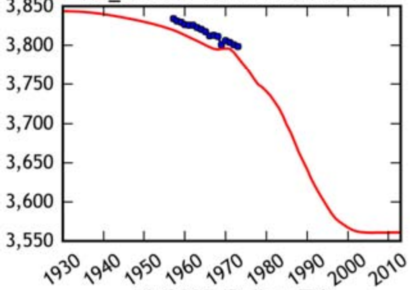
1120101 (Armstrong, TX)
HP_011941 LSD: 3454 TD: unk



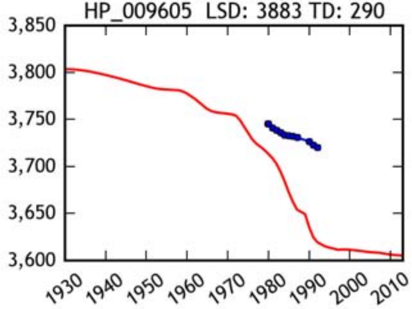
956903 (Bailey, TX)
HP_008084 LSD: 3959 TD: 203



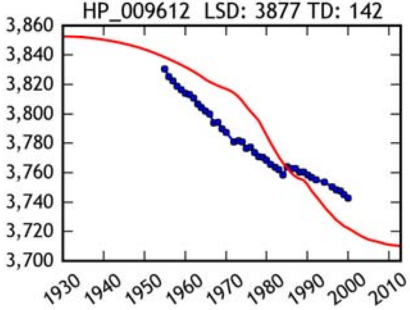
1042503 (Bailey, TX)
HP_009600 LSD: 3920 TD: 170



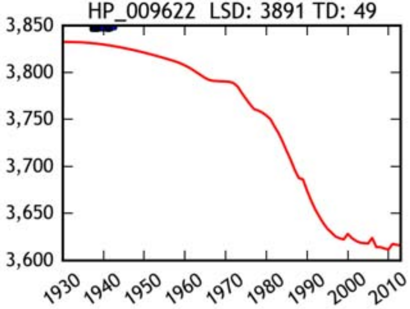
1042602 (Bailey, TX)
HP_009605 LSD: 3883 TD: 290



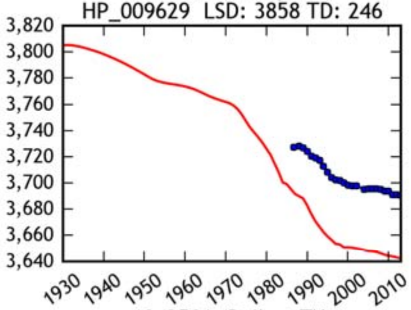
1042707 (Bailey, TX)
HP_009612 LSD: 3877 TD: 142



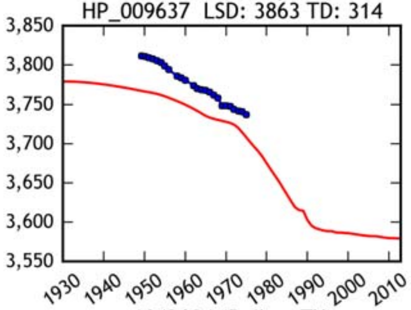
1042809 (Bailey, TX)
HP_009622 LSD: 3891 TD: 49



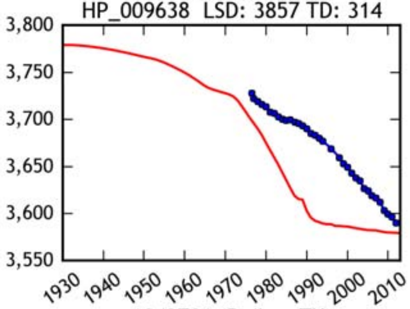
1042905 (Bailey, TX)
HP_009629 LSD: 3858 TD: 246



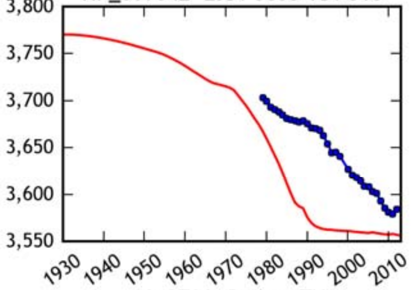
1043401 (Bailey, TX)
HP_009637 LSD: 3863 TD: 314



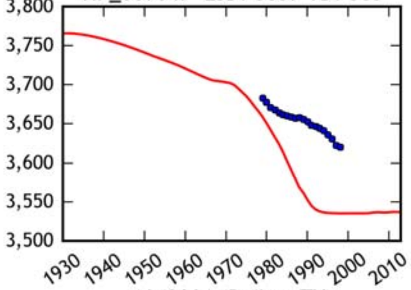
1043402 (Bailey, TX)
HP_009638 LSD: 3857 TD: 314



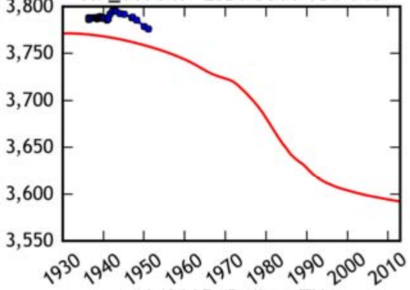
1043501 (Bailey, TX)
HP_009642 LSD: 3833 TD: 318



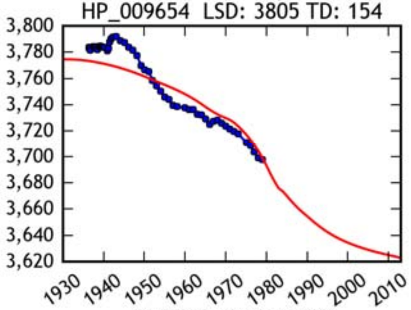
1043604 (Bailey, TX)
HP_009647 LSD: 3837 TD: 365



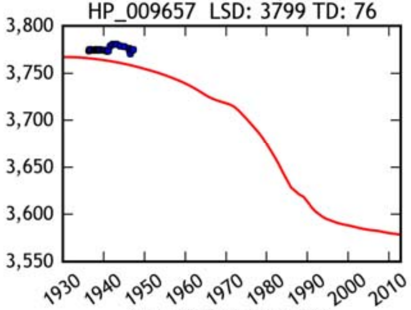
1043701 (Bailey, TX)
HP_009649 LSD: 3811 TD: 140



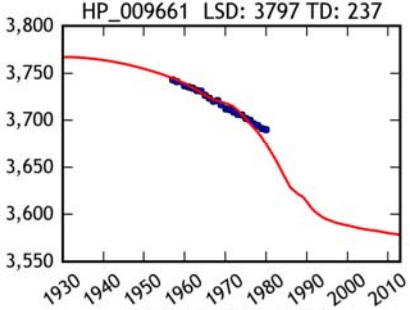
1043706 (Bailey, TX)
HP_009654 LSD: 3805 TD: 154



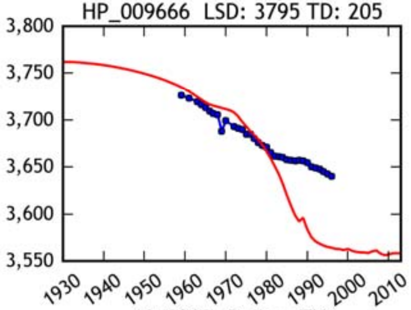
1043801 (Bailey, TX)
HP_009657 LSD: 3799 TD: 76



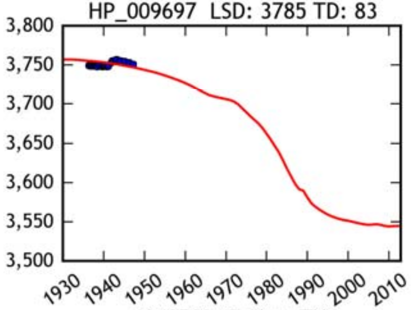
1043805 (Bailey, TX)
HP_009661 LSD: 3797 TD: 237



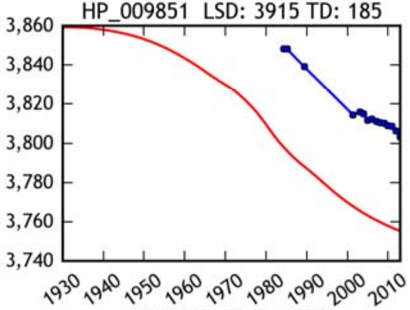
1043903 (Bailey, TX)
HP_009666 LSD: 3795 TD: 205



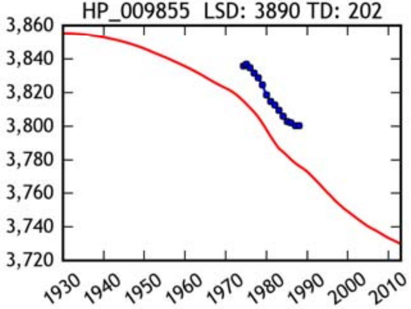
1044707 (Bailey, TX)
HP_009697 LSD: 3785 TD: 83



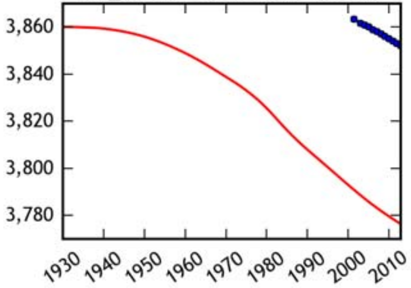
1049209 (Bailey, TX)
HP_009851 LSD: 3915 TD: 185



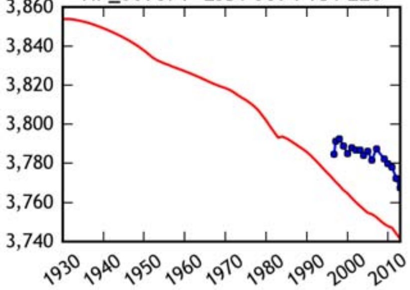
1049303 (Bailey, TX)
HP_009855 LSD: 3890 TD: 202



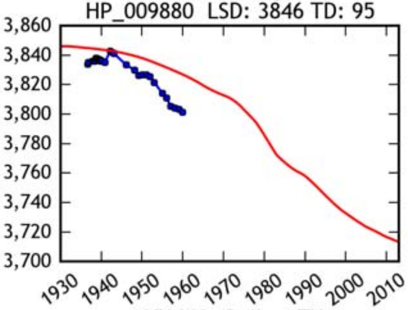
1049502 (Bailey, TX)
HP_009864 LSD: 3925 TD: 207



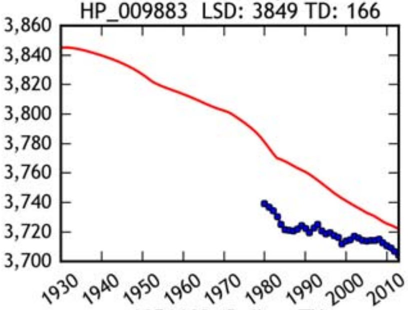
1049607 (Bailey, TX)
HP_009871 LSD: 3894 TD: 226



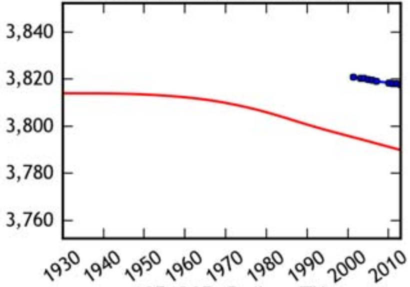
1050101 (Bailey, TX)
HP_009880 LSD: 3846 TD: 95



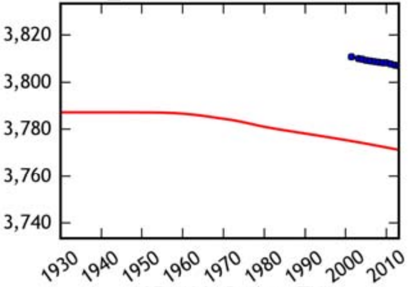
1050104 (Bailey, TX)
HP_009883 LSD: 3849 TD: 166



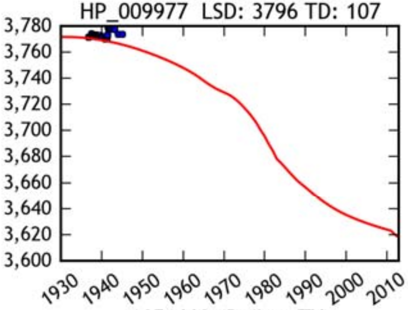
1050804 (Bailey, TX)
HP_009972 LSD: 3892 TD: 138



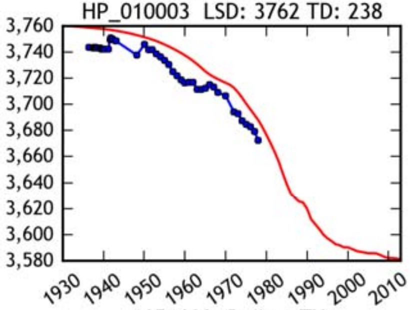
1050902 (Bailey, TX)
HP_009974 LSD: 3886 TD: 161



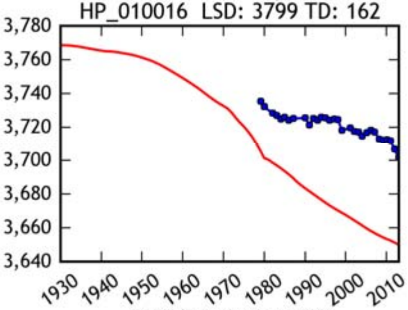
1051103 (Bailey, TX)
HP_009977 LSD: 3796 TD: 107



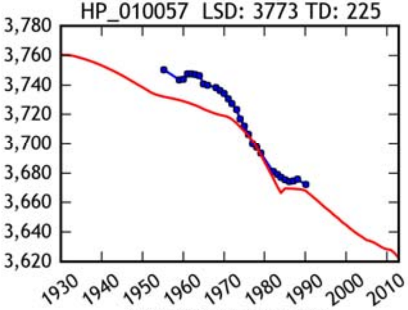
1051305 (Bailey, TX)
HP_010003 LSD: 3762 TD: 238



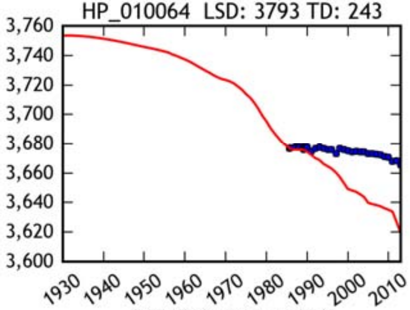
1051406 (Bailey, TX)
HP_010016 LSD: 3799 TD: 162



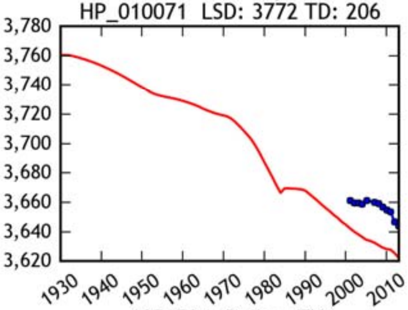
1051602 (Bailey, TX)
HP_010057 LSD: 3773 TD: 225



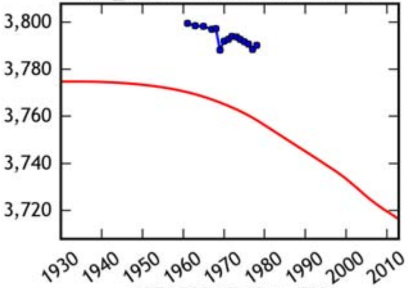
1051609 (Bailey, TX)
HP_010064 LSD: 3793 TD: 243



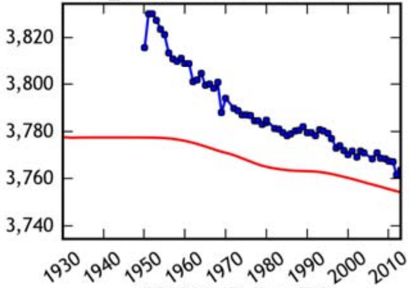
1051616 (Bailey, TX)
HP_010071 LSD: 3772 TD: 206



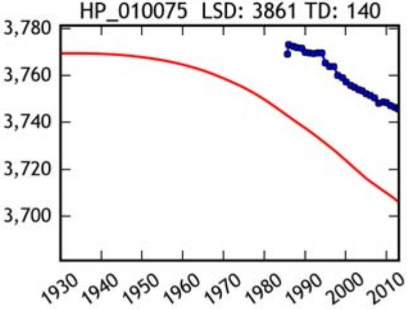
1051701 (Bailey, TX)
HP_010072 LSD: 3861 TD: 75



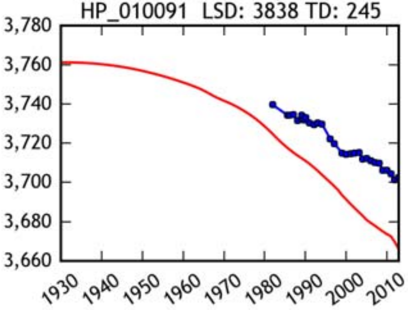
1051703 (Bailey, TX)
HP_010074 LSD: 3878 TD: 160



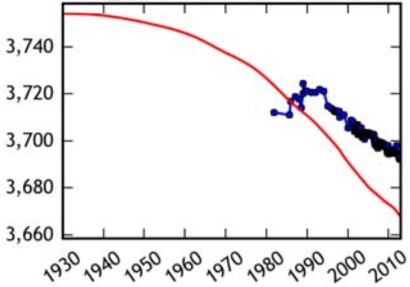
1051704 (Bailey, TX)
HP_010075 LSD: 3861 TD: 140



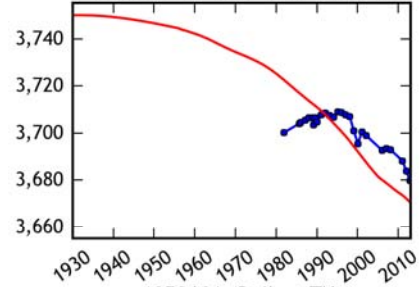
1051808 (Bailey, TX)
HP_010091 LSD: 3838 TD: 245



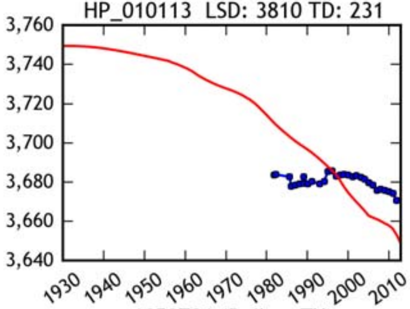
1051909 (Bailey, TX)
HP_010111 LSD: 3841 TD: 243



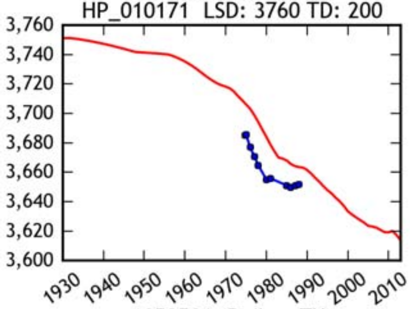
1051910 (Bailey, TX)
HP_010112 LSD: 3825 TD: 232



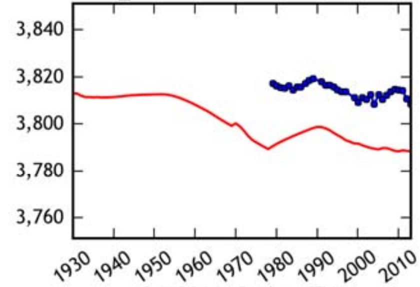
1051911 (Bailey, TX)
HP_010113 LSD: 3810 TD: 231



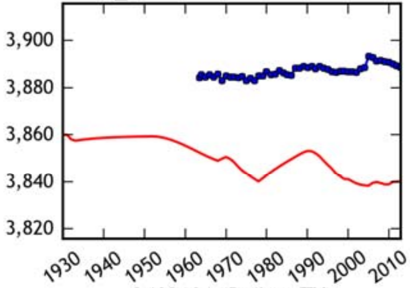
1052408 (Bailey, TX)
HP_010171 LSD: 3760 TD: 200



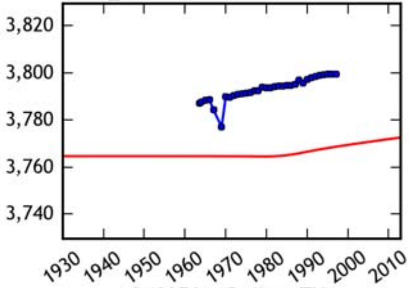
1058601 (Bailey, TX)
HP_010426 LSD: 3888 TD: 133



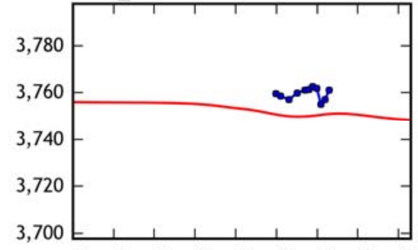
1058701 (Bailey, TX)
HP_010429 LSD: 3939 TD: 73



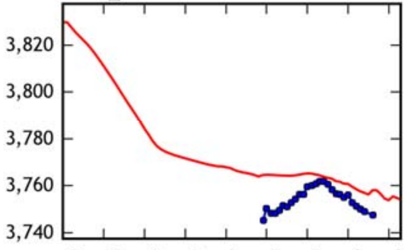
1059501 (Bailey, TX)
HP_010448 LSD: 3890 TD: 176



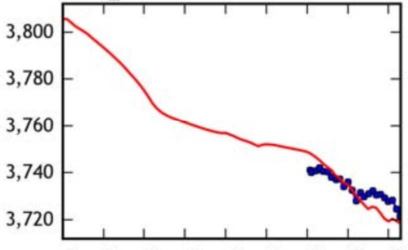
2402801 (Bailey, TX)
HP_017329 LSD: 3847 TD: 144



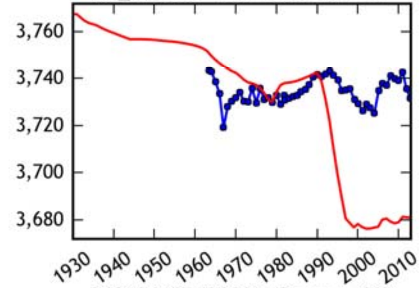
2409101 (Bailey, TX)
HP_017478 LSD: 3917 TD: 214



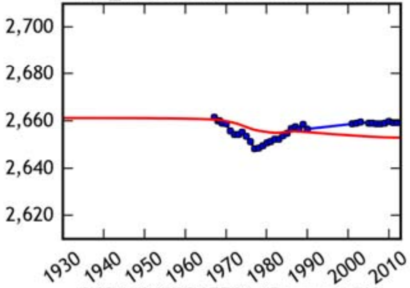
2409501 (Bailey, TX)
HP_017491 LSD: 3889 TD: 207



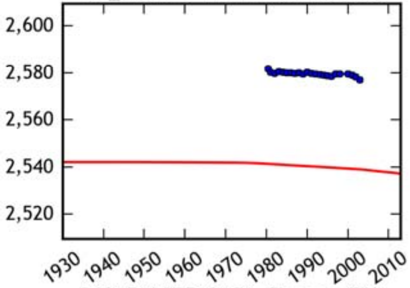
2410201 (Bailey, TX)
HP_017503 LSD: 3845 TD: 207



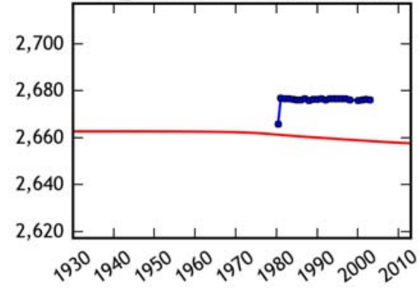
363006100404201 (Beaver, OK)
HP_115362 LSD: 2896 TD: 343



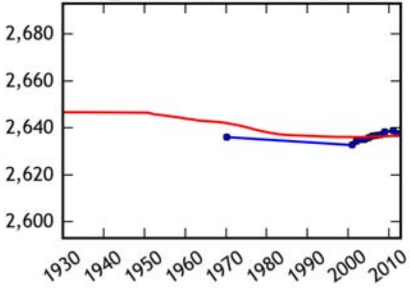
363017100250501 (Beaver, OK)
HP_115398 LSD: 2651 TD: 250



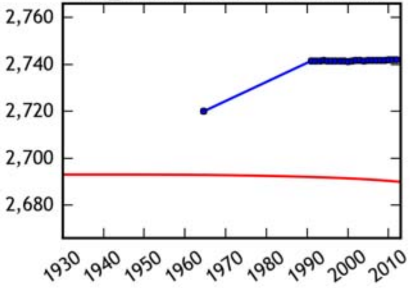
363136100430001 (Beaver, OK)
HP_115621 LSD: 2889 TD: 245



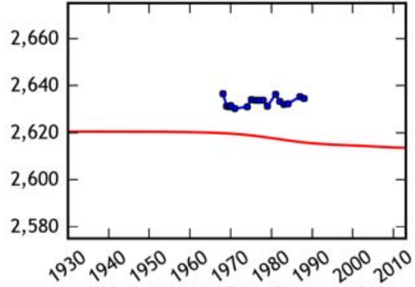
363140100365501 (Beaver, OK)
HP_115634 LSD: 2864 TD: 480



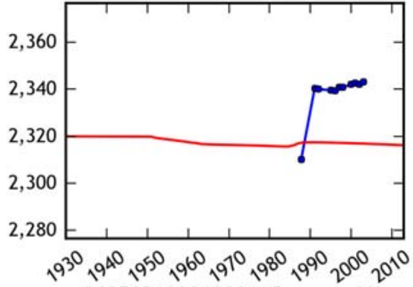
363151100512101 (Beaver, OK)
HP_115686 LSD: 2942 TD: 330



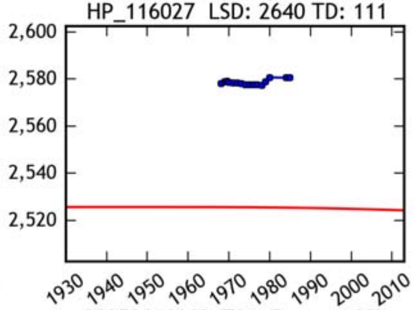
363233100324001 (Beaver, OK)
HP_115804 LSD: 2814 TD: 176



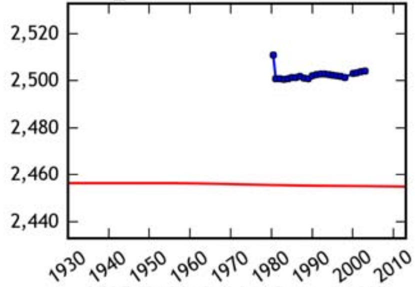
363259100015901 (Beaver, OK)
HP_115876 LSD: 2369 TD: 200



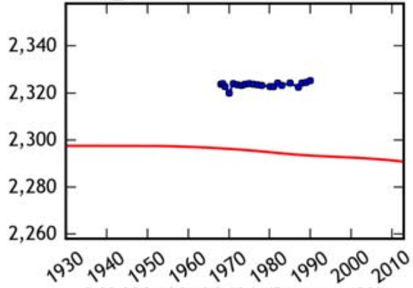
363356100241801 (Beaver, OK)
HP_116027 LSD: 2640 TD: 111



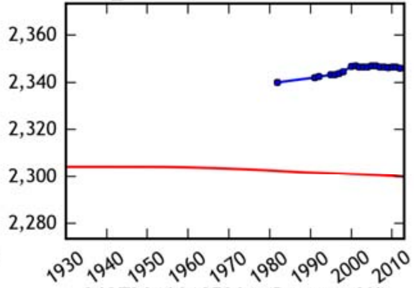
363424100192501 (Beaver, OK)
HP_116121 LSD: 2640 TD: 240



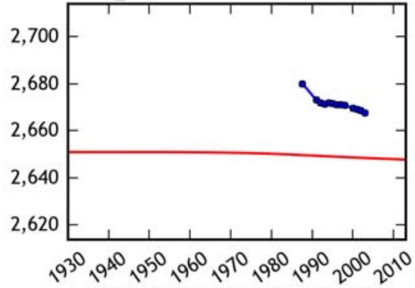
363503100010001 (Beaver, OK)
HP_116250 LSD: 2477 TD: 256



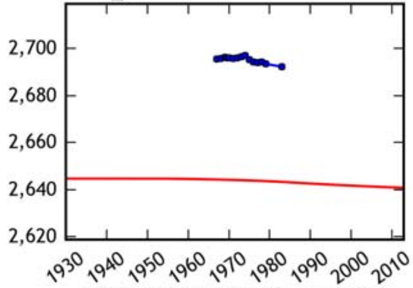
363536100024701 (Beaver, OK)
HP_116359 LSD: 2512 TD: 260



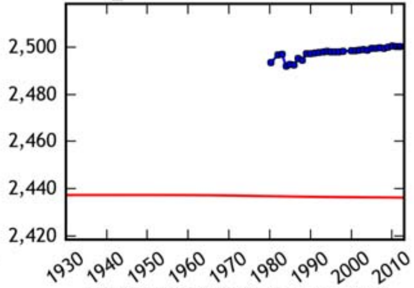
363549100421201 (Beaver, OK)
HP_116395 LSD: 2859 TD: 220



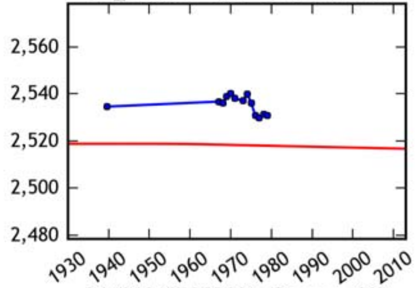
363622100400401 (Beaver, OK)
HP_116485 LSD: 2797 TD: 144



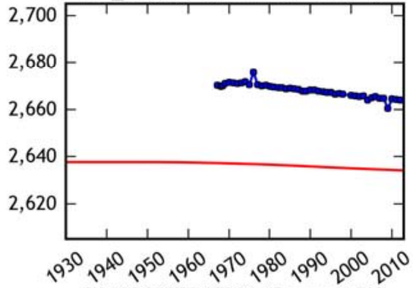
363720100185301 (Beaver, OK)
HP_116657 LSD: 2640 TD: 245



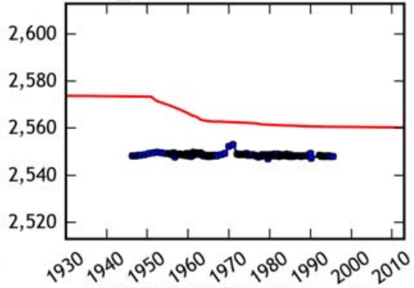
363721100255801 (Beaver, OK)
HP_116662 LSD: 2723 TD: 228



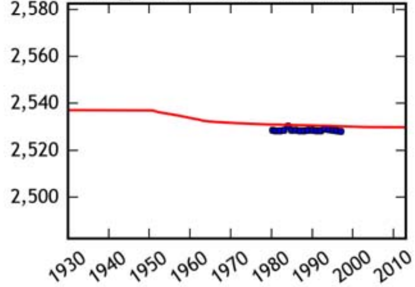
363759100391901 (Beaver, OK)
HP_116775 LSD: 2767 TD: 379



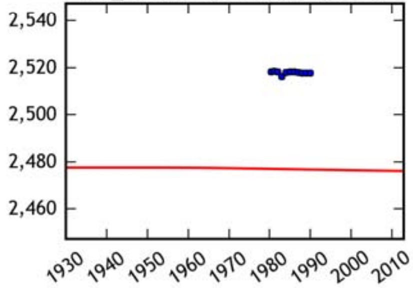
363853100311001 (Beaver, OK)
HP_116942 LSD: 2644 TD: 95



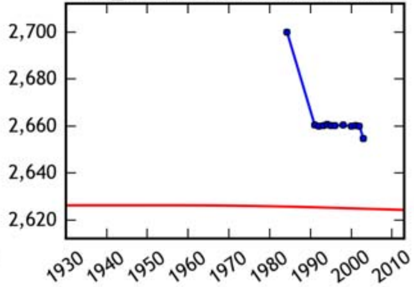
364018100283001 (Beaver, OK)
HP_117159 LSD: 2540 TD: 40



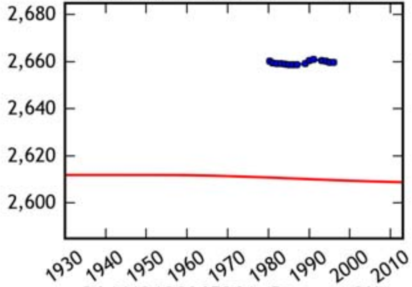
364036100240301 (Beaver, OK)
HP_117218 LSD: 2705 TD: 234



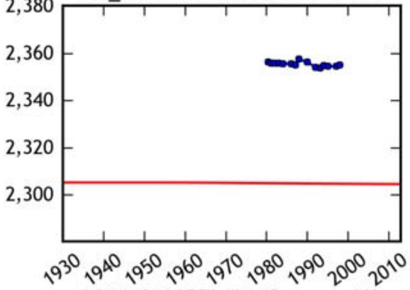
364037100402701 (Beaver, OK)
HP_117221 LSD: 2840 TD: 260



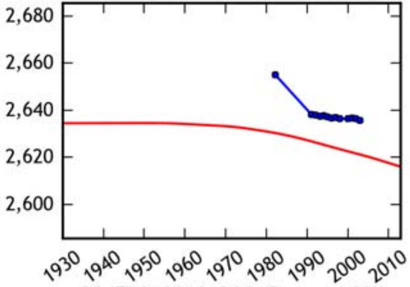
364110100374501 (Beaver, OK)
HP_117294 LSD: 2742 TD: 280



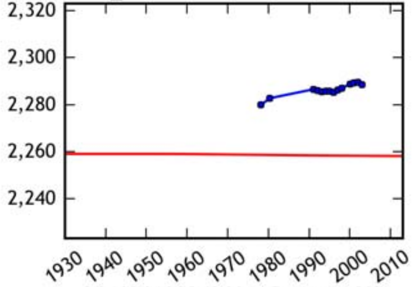
364226100085901 (Beaver, OK)
HP_117463 LSD: 2448 TD: 138



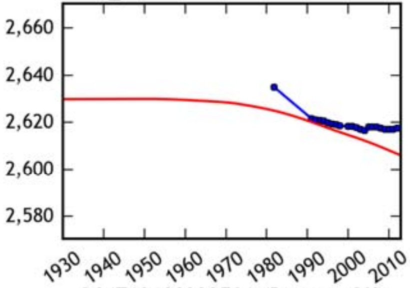
364340100564401 (Beaver, OK)
HP_117651 LSD: 2732 TD: 160



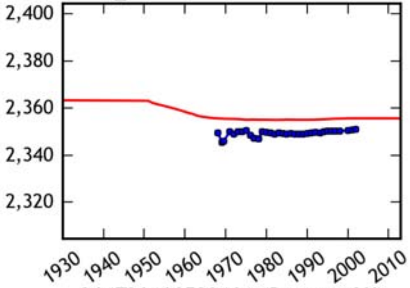
364412100065201 (Beaver, OK)
HP_117735 LSD: 2362 TD: 110



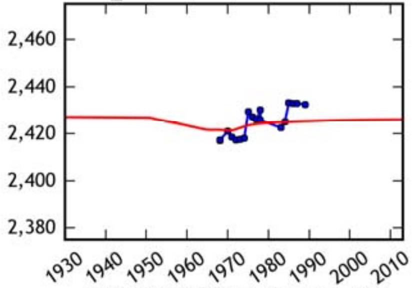
364446100552401 (Beaver, OK)
HP_117812 LSD: 2729 TD: 240



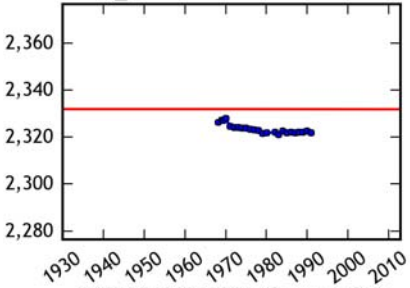
364500100181201 (Beaver, OK)
HP_117861 LSD: 2422 TD: 96



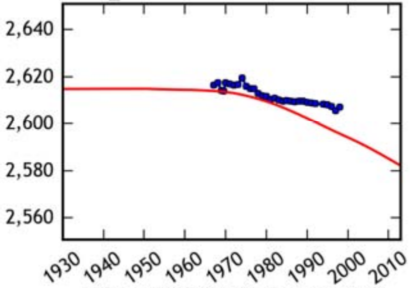
364626100242601 (Beaver, OK)
HP_118050 LSD: 2501 TD: 132



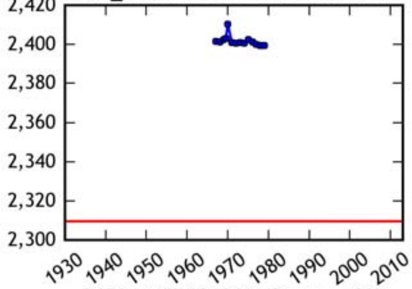
364719100223501 (Beaver, OK)
HP_118185 LSD: 2339 TD: 63



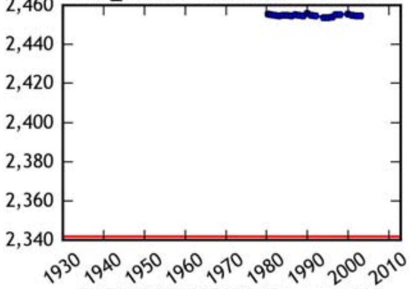
364728100533101 (Beaver, OK)
HP_118218 LSD: 2733 TD: 330



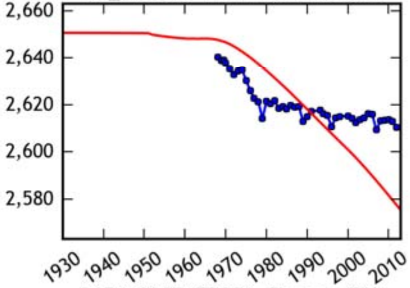
365010100170601 (Beaver, OK)
HP_118617 LSD: 2537 TD: 168



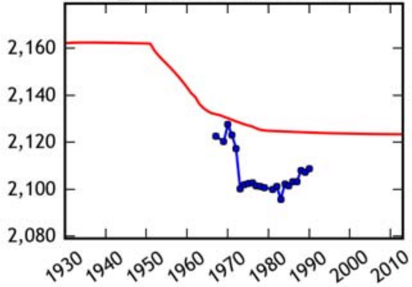
365138100203201 (Beaver, OK)
HP_118798 LSD: 2528 TD: 191



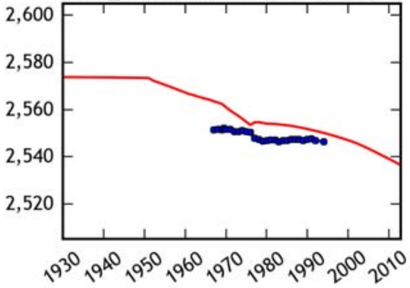
365141100542101 (Beaver, OK)
HP_118816 LSD: 2762 TD: 503



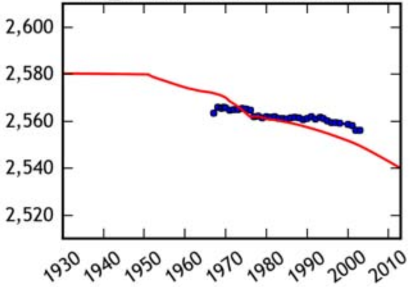
365214100021201 (Beaver, OK)
HP_118906 LSD: 2167 TD: 91



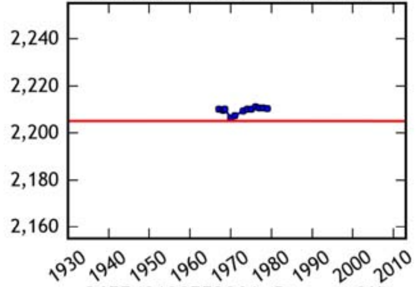
365418100465001 (Beaver, OK)
HP_119153 LSD: 2726 TD: 560



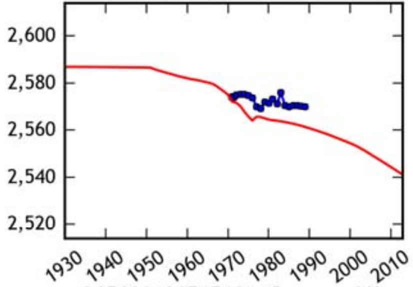
365419100472001 (Beaver, OK)
HP_119157 LSD: 2726 TD: 525



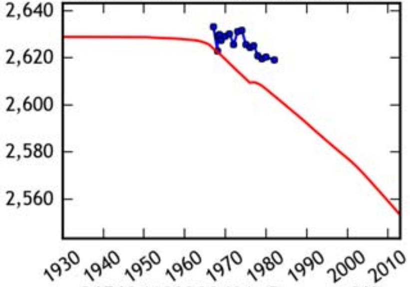
365446100080701 (Beaver, OK)
HP_119236 LSD: 2270 TD: 100



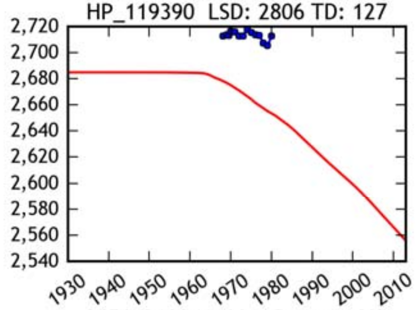
365450100475501 (Beaver, OK)
HP_119248 LSD: 2737 TD: 438



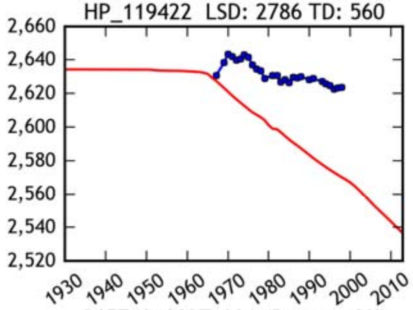
365508100514801 (Beaver, OK)
HP_119289 LSD: 2768 TD: 171



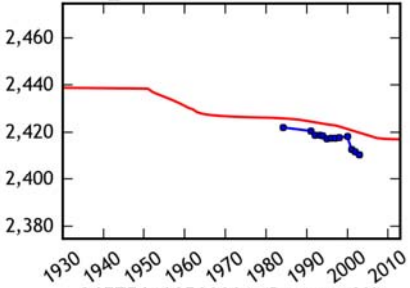
365548100553001 (Beaver, OK)
HP_119390 LSD: 2806 TD: 127



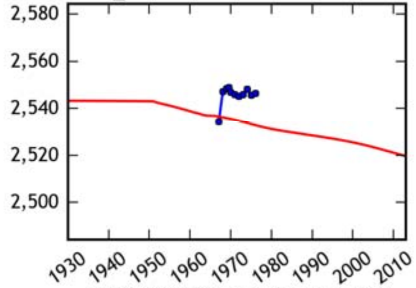
365600100515101 (Beaver, OK)
HP_119422 LSD: 2786 TD: 560



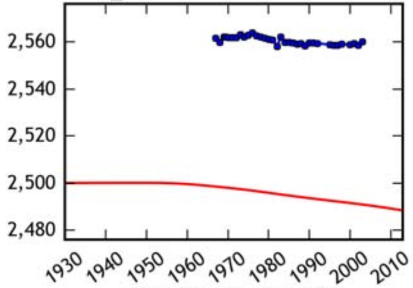
365634100300401 (Beaver, OK)
HP_119508 LSD: 2500 TD: 120



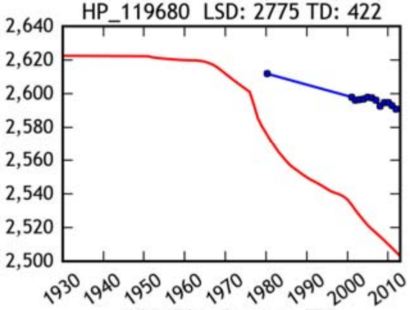
365643100414001 (Beaver, OK)
HP_119523 LSD: 2711 TD: 204



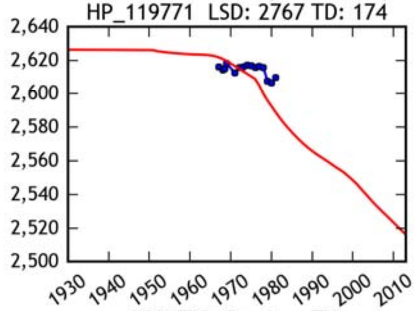
365748100371901 (Beaver, OK)
HP_119650 LSD: 2664 TD: 128



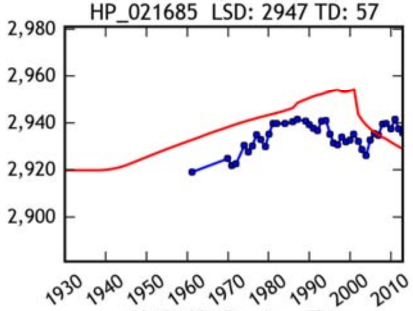
365756100500901 (Beaver, OK)
HP_119680 LSD: 2775 TD: 422



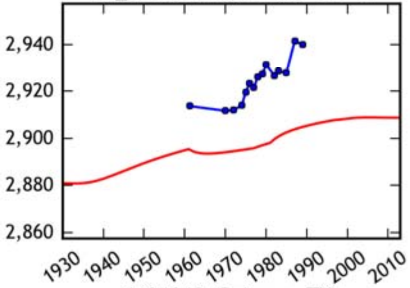
365841100500801 (Beaver, OK)
HP_119771 LSD: 2767 TD: 174



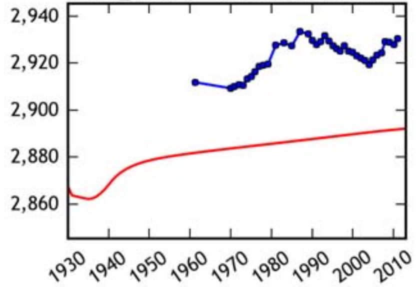
2803601 (Borden, TX)
HP_021685 LSD: 2947 TD: 57



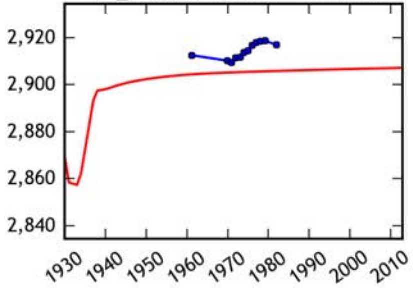
2804701 (Borden, TX)
HP_021698 LSD: 2947 TD: 61



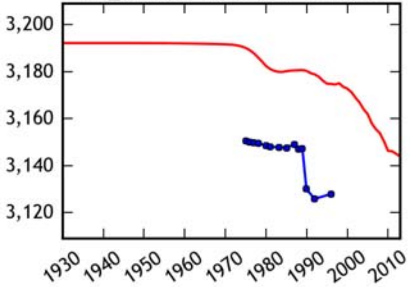
2804702 (Borden, TX)
HP_021699 LSD: 2941 TD: 60

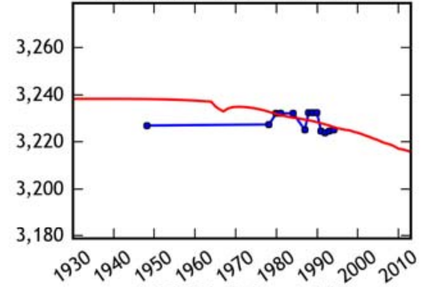


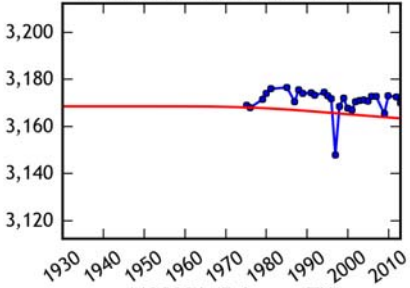
2812102 (Borden, TX)
HP_022015 LSD: 2941 TD: 35

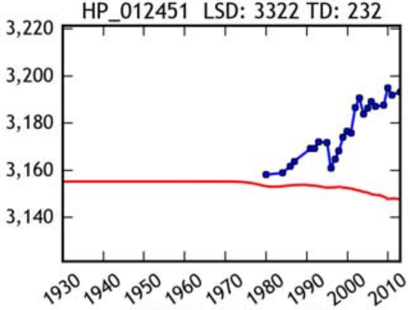


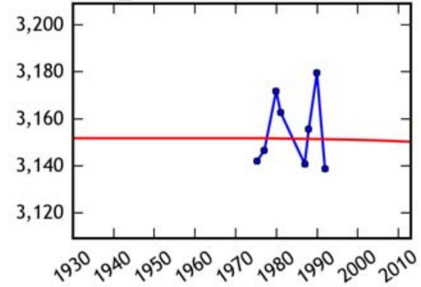
1121313 (Briscoe, TX)
HP_012071 LSD: 3327 TD: 210

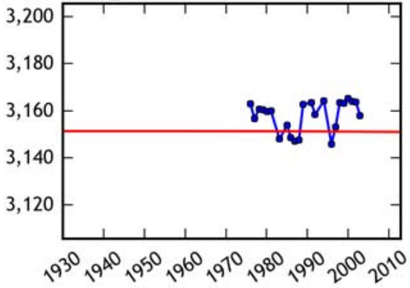


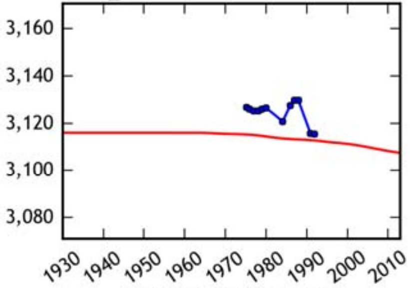

1129201 (Briscoe, TX)
HP_012431 LSD: 3317 TD: 135

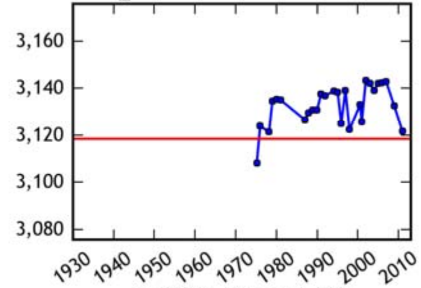

1129703 (Briscoe, TX)
HP_012449 LSD: 3266 TD: 130

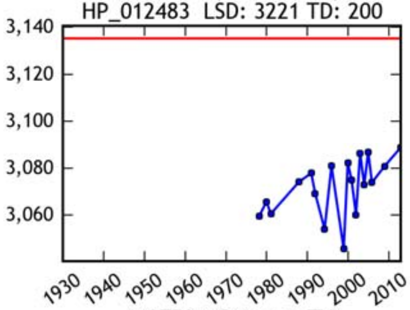

1129901 (Briscoe, TX)
HP_012451 LSD: 3322 TD: 232

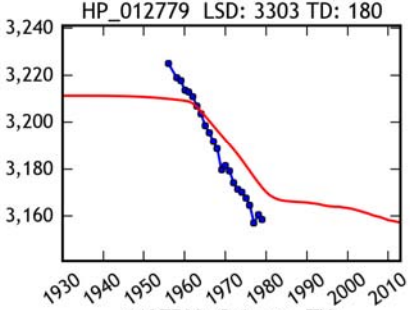

1130701 (Briscoe, TX)
HP_012460 LSD: 3306 TD: 180

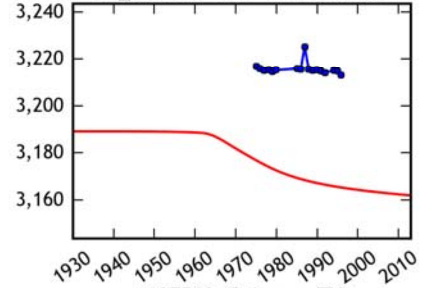

1130801 (Briscoe, TX)
HP_012461 LSD: 3308 TD: 180

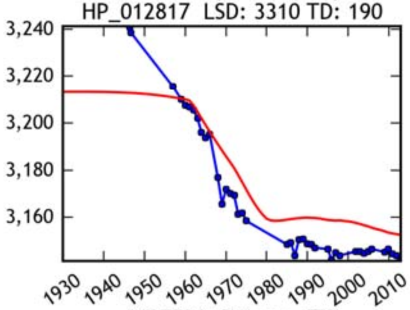

1130902 (Briscoe, TX)
HP_012463 LSD: 3286 TD: 230

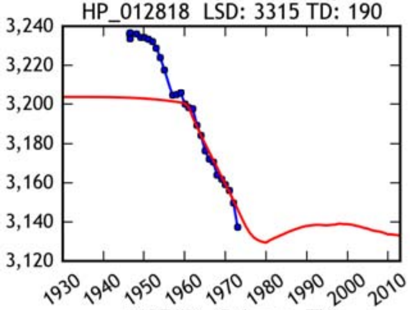

1131402 (Briscoe, TX)
HP_012480 LSD: 3267 TD: 200

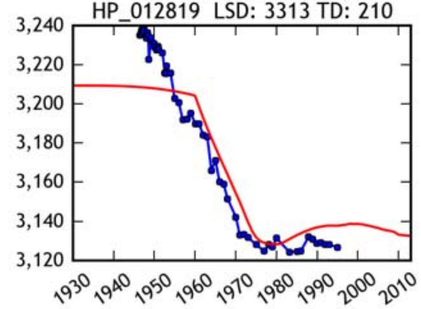

1131801 (Briscoe, TX)
HP_012483 LSD: 3221 TD: 200

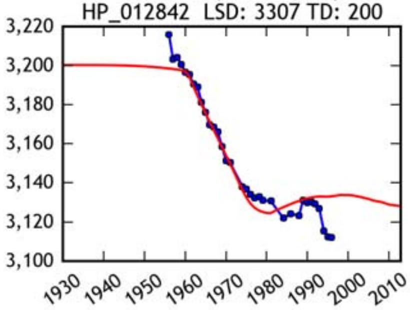

1137201 (Briscoe, TX)
HP_012779 LSD: 3303 TD: 180

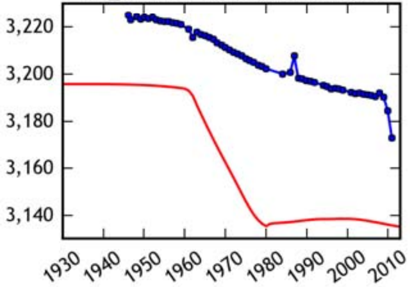

1137306 (Briscoe, TX)
HP_012795 LSD: 3325 TD: 150


1137501 (Briscoe, TX)
HP_012817 LSD: 3310 TD: 190

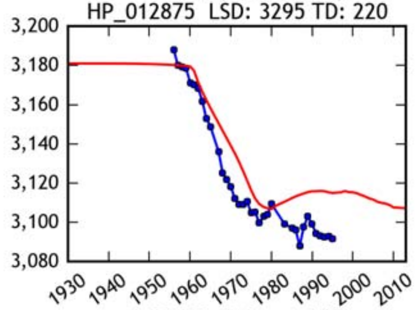

1137502 (Briscoe, TX)
HP_012818 LSD: 3315 TD: 190


1137503 (Briscoe, TX)
HP_012819 LSD: 3313 TD: 210

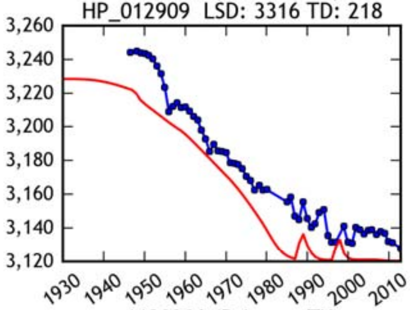

1137526 (Briscoe, TX)
HP_012842 LSD: 3307 TD: 200


1137601 (Briscoe, TX)
HP_012874 LSD: 3312 TD: 200

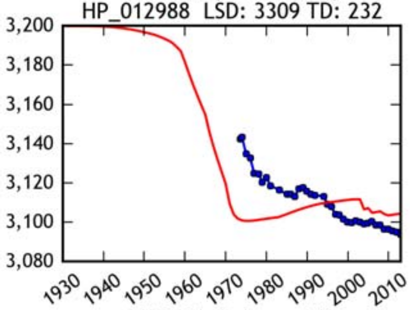
1137603 (Briscoe, TX)
HP_012875 LSD: 3295 TD: 220



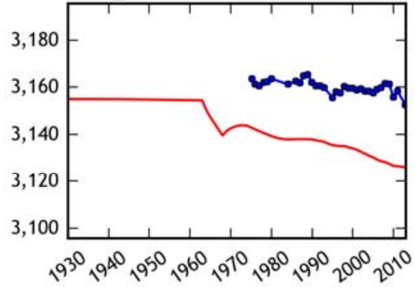
1137701 (Briscoe, TX)
HP_012909 LSD: 3316 TD: 218



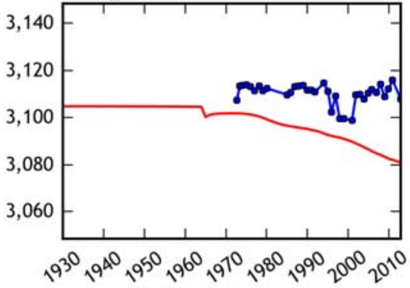
1137914 (Briscoe, TX)
HP_012988 LSD: 3309 TD: 232



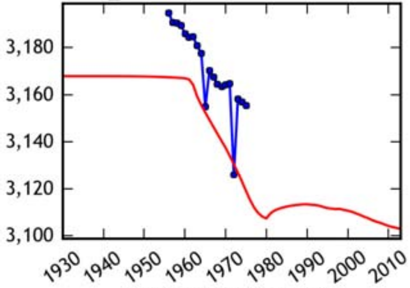
1138109 (Briscoe, TX)
HP_013025 LSD: 3292 TD: 205



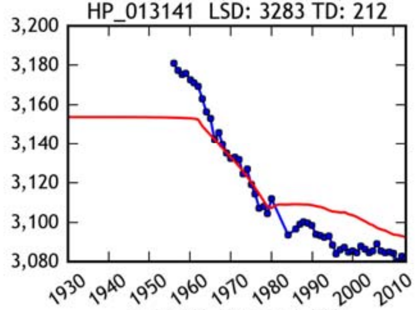
1138306 (Briscoe, TX)
HP_013106 LSD: 3271 TD: 232



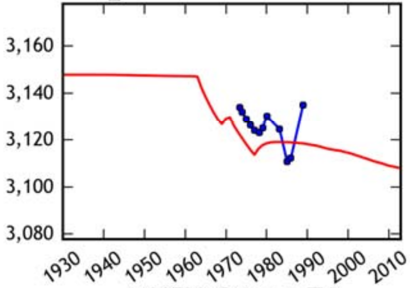
1138401 (Briscoe, TX)
HP_013140 LSD: 3290 TD: 185



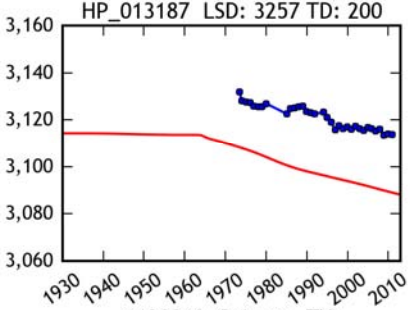
1138402 (Briscoe, TX)
HP_013141 LSD: 3283 TD: 212



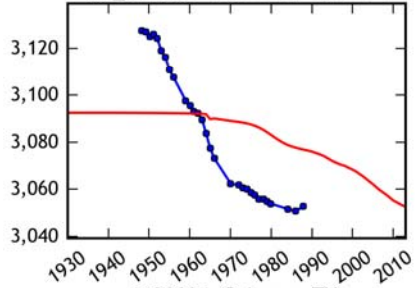
1138418 (Briscoe, TX)
HP_013157 LSD: 3262 TD: 186



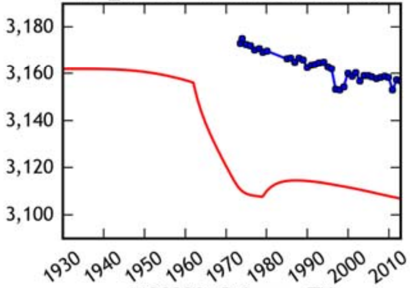
1138509 (Briscoe, TX)
HP_013187 LSD: 3257 TD: 200



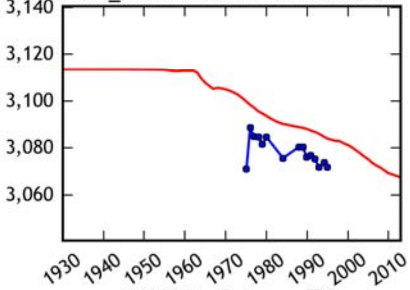
1138601 (Briscoe, TX)
HP_013200 LSD: 3241 TD: 214



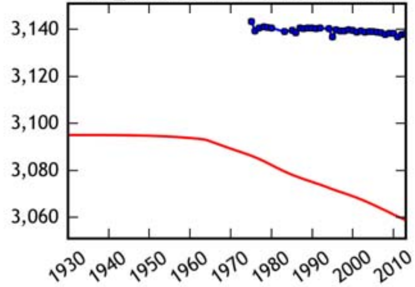
1138728 (Briscoe, TX)
HP_013259 LSD: 3276 TD: 180



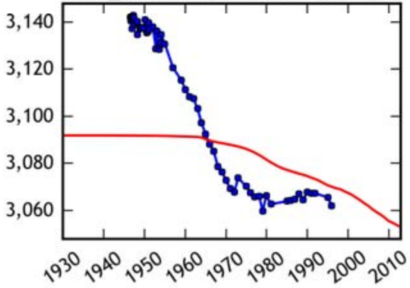
1138818 (Briscoe, TX)
HP_013291 LSD: 3265 TD: 226



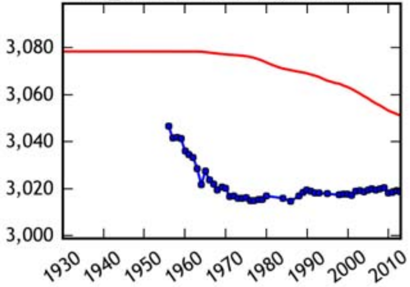
1138921 (Briscoe, TX)
HP_013330 LSD: 3238 TD: 148



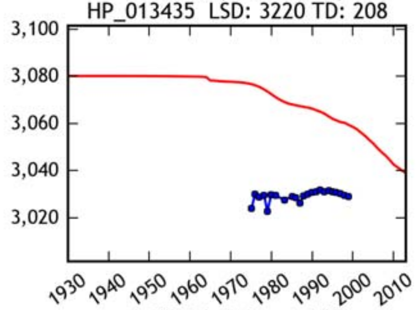
1138922 (Briscoe, TX)
HP_013331 LSD: 3246 TD: 210



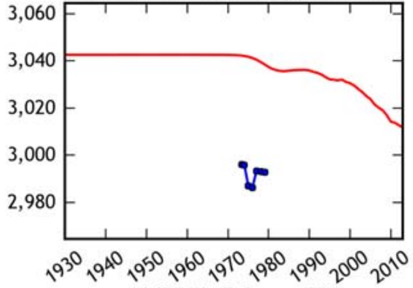
1139201 (Briscoe, TX)
HP_013348 LSD: 3222 TD: 217



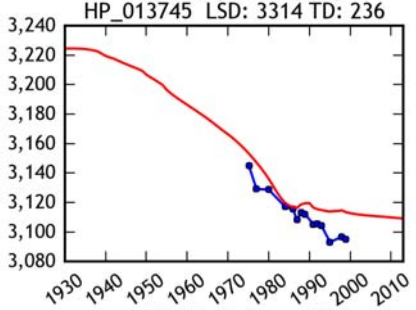
1139533 (Briscoe, TX)
HP_013435 LSD: 3220 TD: 208



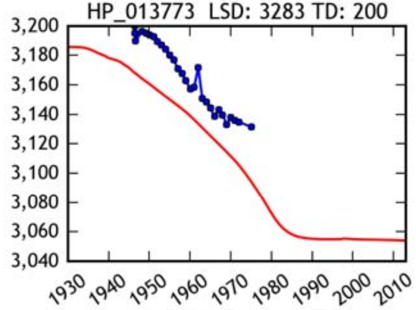
1139602 (Briscoe, TX)
HP_013437 LSD: 3202 TD: unk



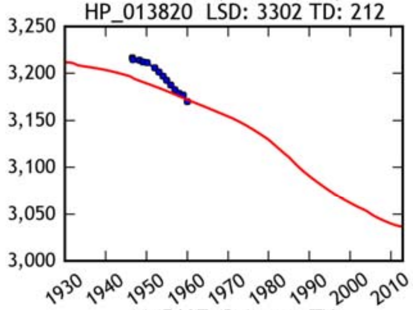
1145102 (Briscoe, TX)
HP_013745 LSD: 3314 TD: 236



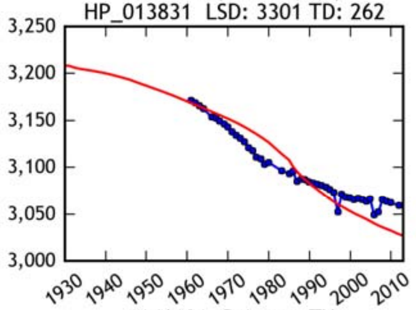
1145301 (Briscoe, TX)
HP_013773 LSD: 3283 TD: 200



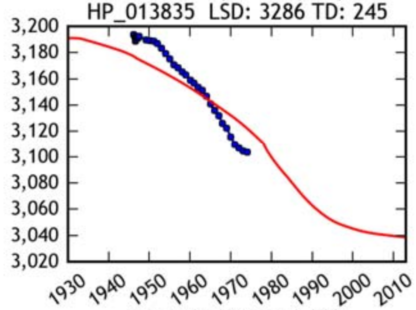
1145501 (Briscoe, TX)
HP_013820 LSD: 3302 TD: 212



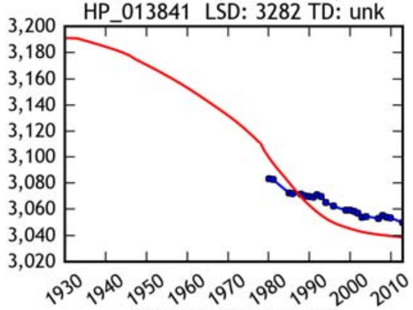
1145512 (Briscoe, TX)
HP_013831 LSD: 3301 TD: 262



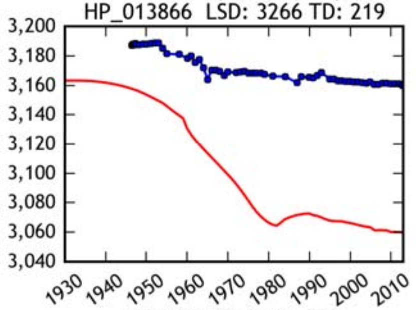
1145601 (Briscoe, TX)
HP_013835 LSD: 3286 TD: 245



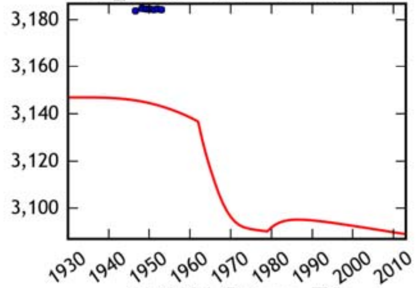
1145607 (Briscoe, TX)
HP_013841 LSD: 3282 TD: unk



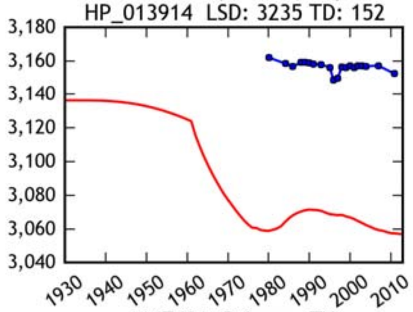
1146101 (Briscoe, TX)
HP_013866 LSD: 3266 TD: 219



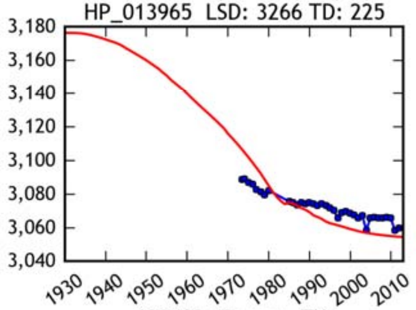
1146202 (Briscoe, TX)
HP_013902 LSD: 3259 TD: 202



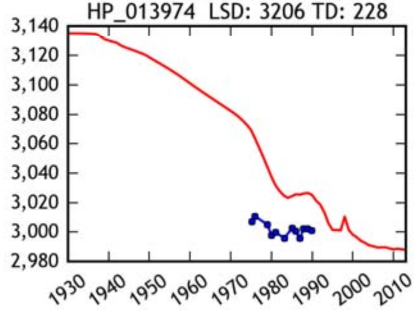
1146214 (Briscoe, TX)
HP_013914 LSD: 3235 TD: 152



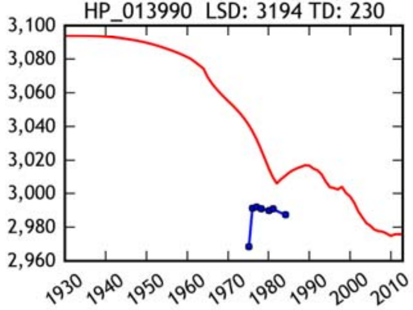
1146409 (Briscoe, TX)
HP_013965 LSD: 3266 TD: 225



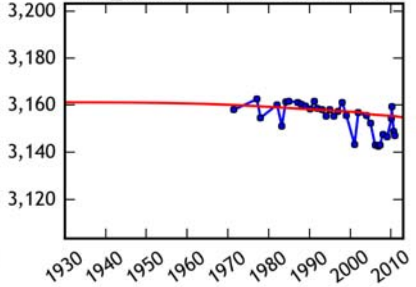
1146604 (Briscoe, TX)
HP_013974 LSD: 3206 TD: 228

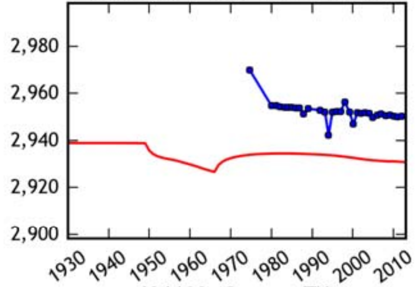


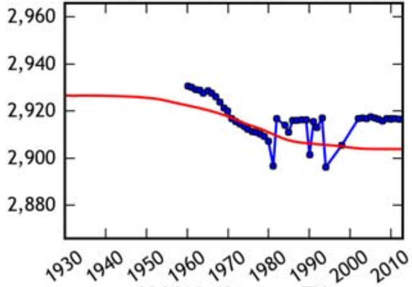
1147401 (Briscoe, TX)
HP_013990 LSD: 3194 TD: 230

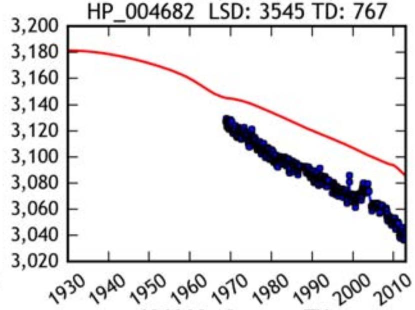


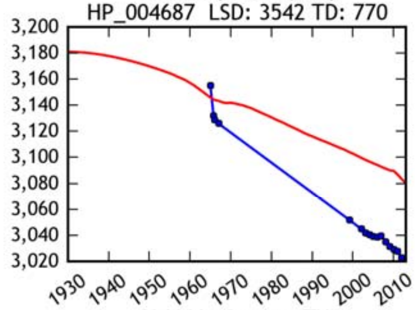
628402 (Carson, TX)
HP_004537 LSD: 3348 TD: 286

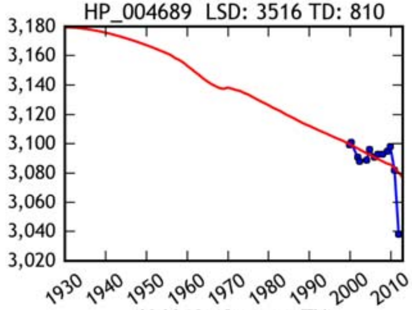


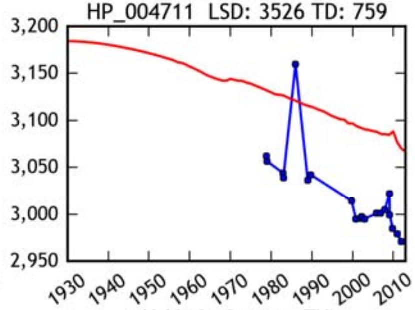

631203 (Carson, TX)
HP_004567 LSD: 3252 TD: 416

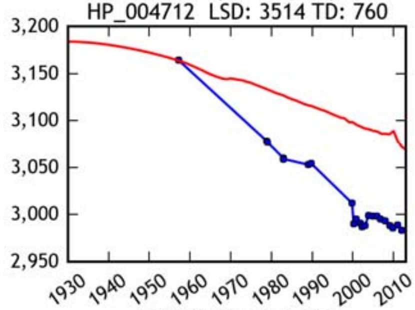

632701 (Carson, TX)
HP_004610 LSD: 3308 TD: 488

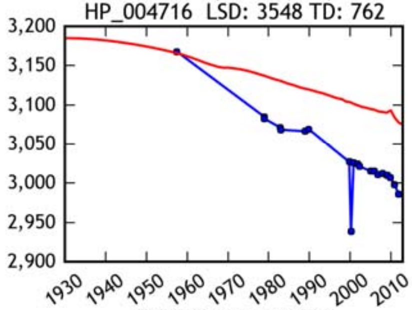

636602 (Carson, TX)
HP_004682 LSD: 3545 TD: 767

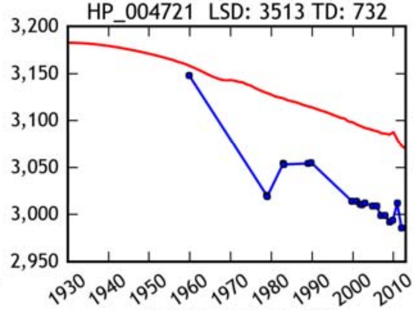

636608 (Carson, TX)
HP_004687 LSD: 3542 TD: 770

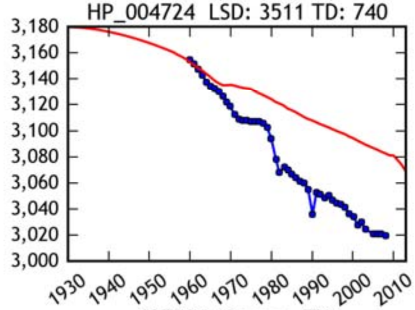

636610 (Carson, TX)
HP_004689 LSD: 3516 TD: 810

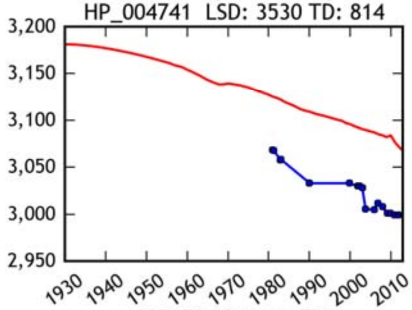

636808 (Carson, TX)
HP_004711 LSD: 3526 TD: 759

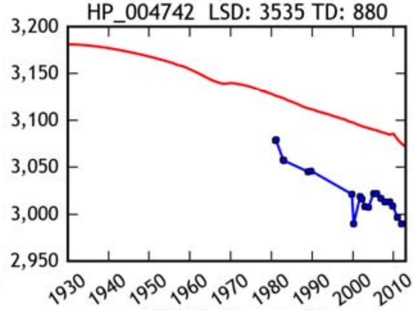

636809 (Carson, TX)
HP_004712 LSD: 3514 TD: 760

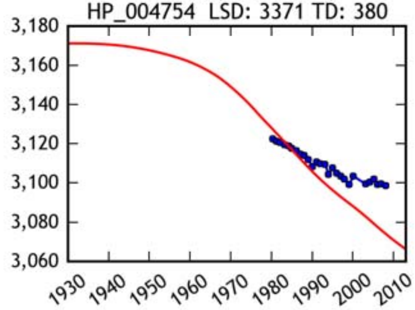

636813 (Carson, TX)
HP_004716 LSD: 3548 TD: 762

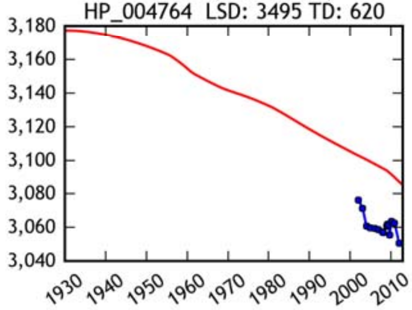

636818 (Carson, TX)
HP_004721 LSD: 3513 TD: 732

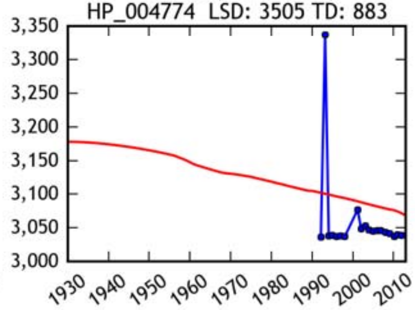

636901 (Carson, TX)
HP_004724 LSD: 3511 TD: 740


636920 (Carson, TX)
HP_004741 LSD: 3530 TD: 814

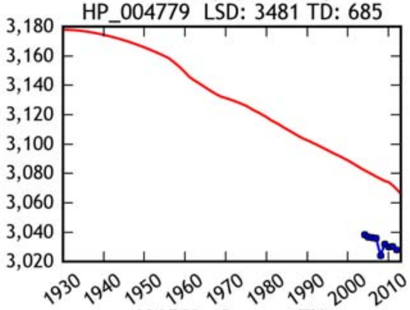

636921 (Carson, TX)
HP_004742 LSD: 3535 TD: 880


637301 (Carson, TX)
HP_004754 LSD: 3371 TD: 380

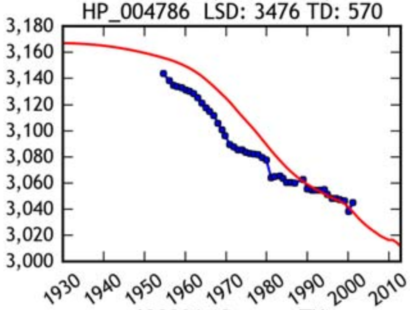

637458 (Carson, TX)
HP_004764 LSD: 3495 TD: 620


637705 (Carson, TX)
HP_004774 LSD: 3505 TD: 883

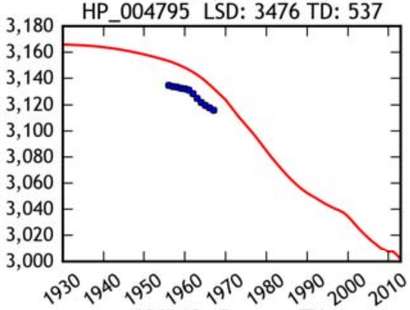
637710 (Carson, TX)
HP_004779 LSD: 3481 TD: 685



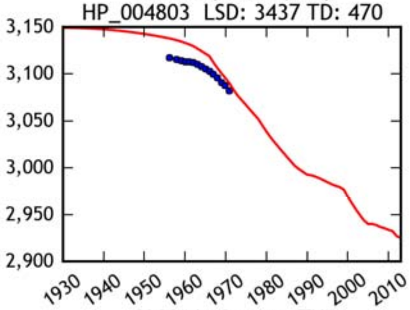
637901 (Carson, TX)
HP_004786 LSD: 3476 TD: 570



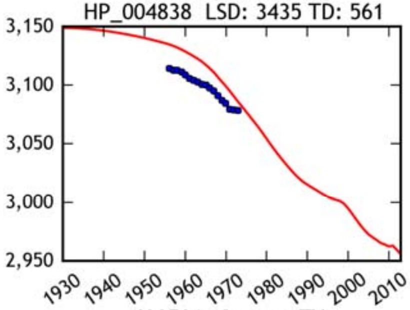
637910 (Carson, TX)
HP_004795 LSD: 3476 TD: 537



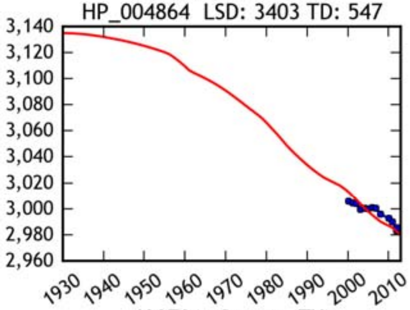
638502 (Carson, TX)
HP_004803 LSD: 3437 TD: 470



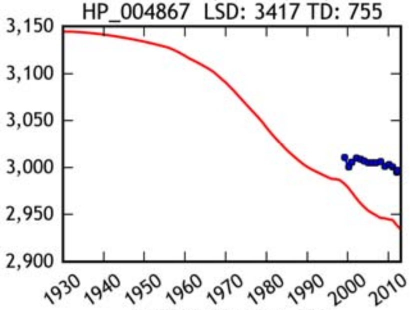
638801 (Carson, TX)
HP_004838 LSD: 3435 TD: 561



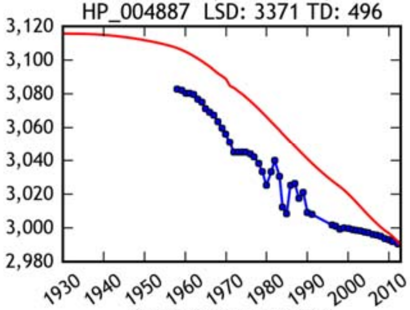
638913 (Carson, TX)
HP_004864 LSD: 3403 TD: 547



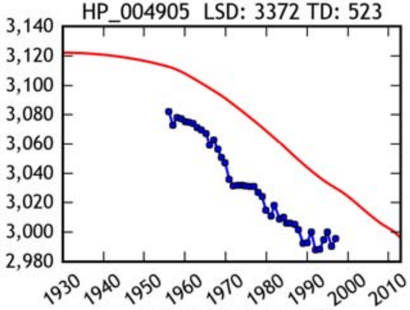
638916 (Carson, TX)
HP_004867 LSD: 3417 TD: 755



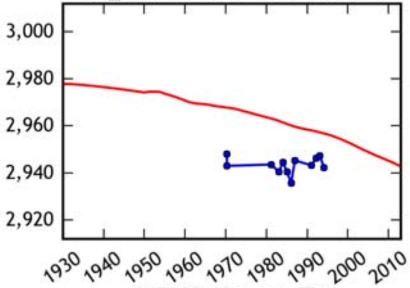
639501 (Carson, TX)
HP_004887 LSD: 3371 TD: 496



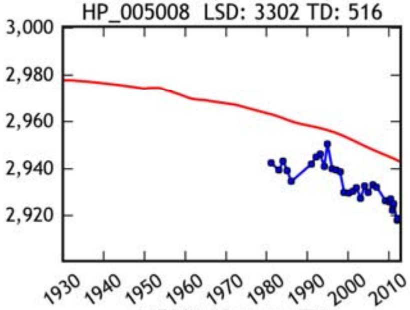
639701 (Carson, TX)
HP_004905 LSD: 3372 TD: 523



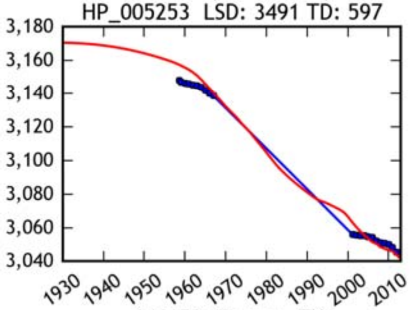
640711 (Carson, TX)
HP_005004 LSD: 3301 TD: 516



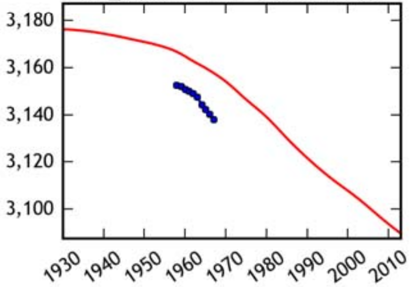
640716 (Carson, TX)
HP_005008 LSD: 3302 TD: 516



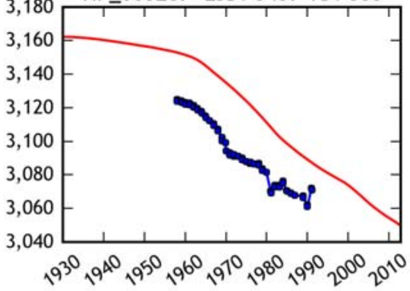
645513 (Carson, TX)
HP_005253 LSD: 3491 TD: 597



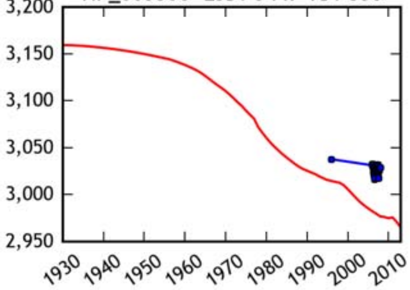
645802 (Carson, TX)
HP_005282 LSD: 3493 TD: 468

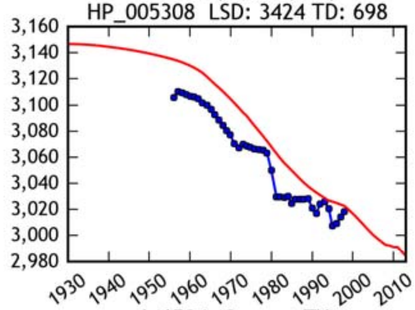


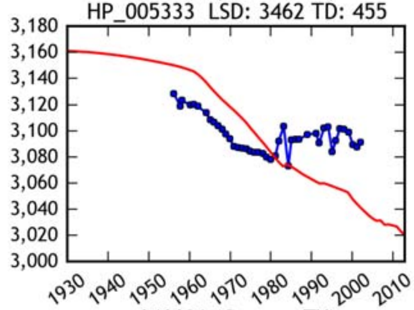
645901 (Carson, TX)
HP_005287 LSD: 3457 TD: 535

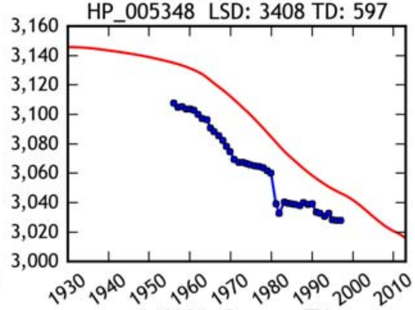


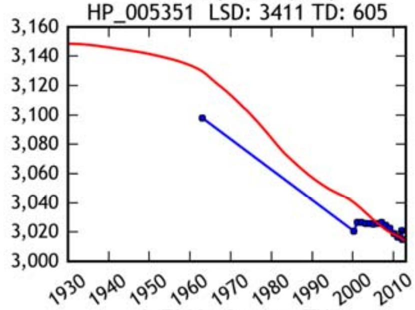
646159 (Carson, TX)
HP_005306 LSD: 3447 TD: 830

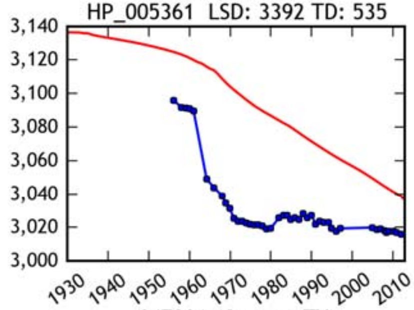


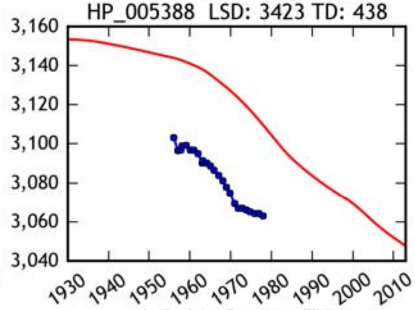

646201 (Carson, TX)
HP_005308 LSD: 3424 TD: 698

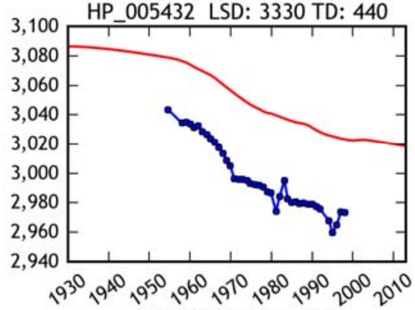

646401 (Carson, TX)
HP_005333 LSD: 3462 TD: 455

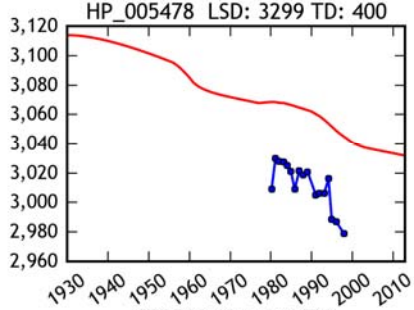

646501 (Carson, TX)
HP_005348 LSD: 3408 TD: 597

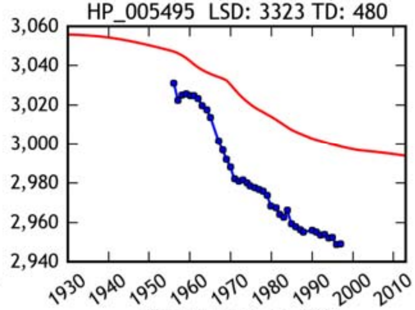

646504 (Carson, TX)
HP_005351 LSD: 3411 TD: 605

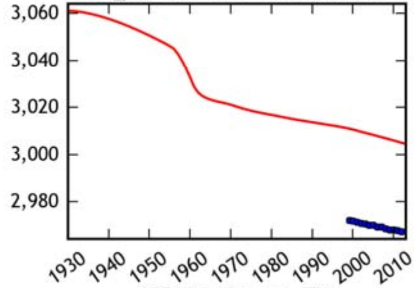

646601 (Carson, TX)
HP_005361 LSD: 3392 TD: 535

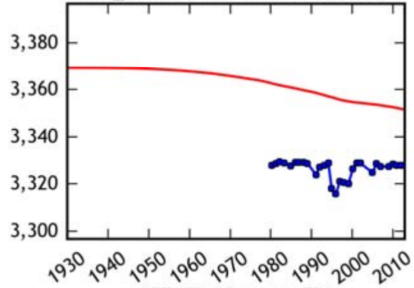

646801 (Carson, TX)
HP_005388 LSD: 3423 TD: 438

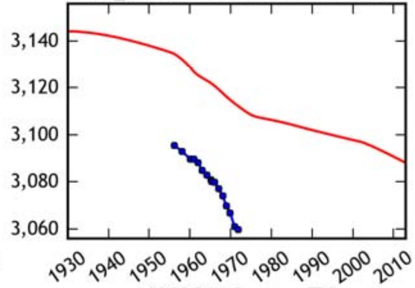

647302 (Carson, TX)
HP_005432 LSD: 3330 TD: 440

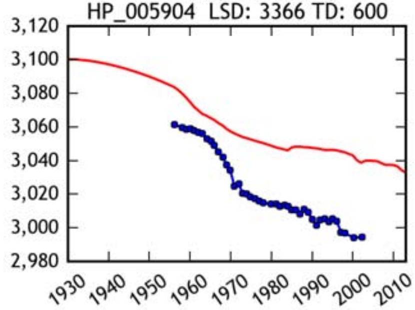

647801 (Carson, TX)
HP_005478 LSD: 3299 TD: 400

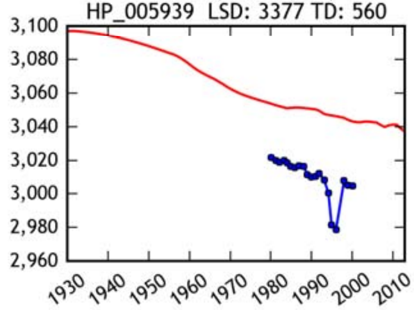

648101 (Carson, TX)
HP_005495 LSD: 3323 TD: 480

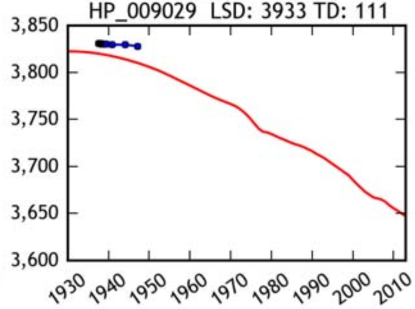

648102 (Carson, TX)
HP_005496 LSD: 3323 TD: 423


652508 (Carson, TX)
HP_005786 LSD: 3532 TD: 218

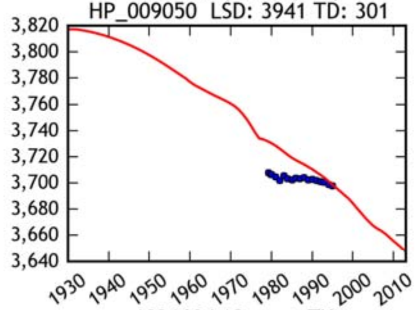

654201 (Carson, TX)
HP_005847 LSD: 3417 TD: 430


655101 (Carson, TX)
HP_005904 LSD: 3366 TD: 600

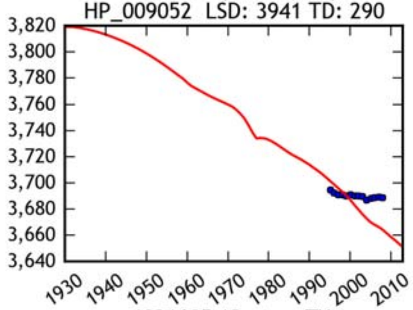

655402 (Carson, TX)
HP_005939 LSD: 3377 TD: 560


1020301 (Castro, TX)
HP_009029 LSD: 3933 TD: 111

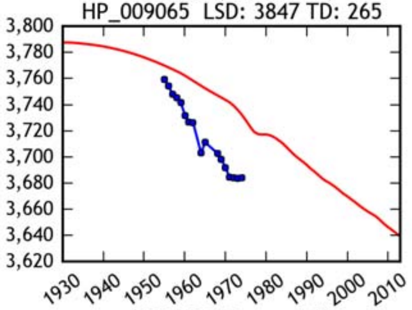
1021102 (Castro, TX)
HP_009050 LSD: 3941 TD: 301



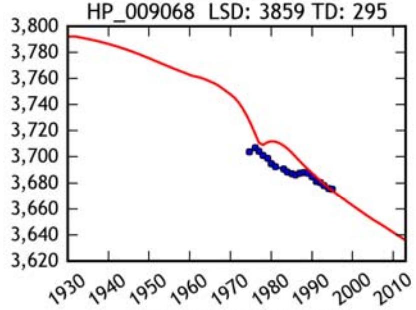
1021104 (Castro, TX)
HP_009052 LSD: 3941 TD: 290



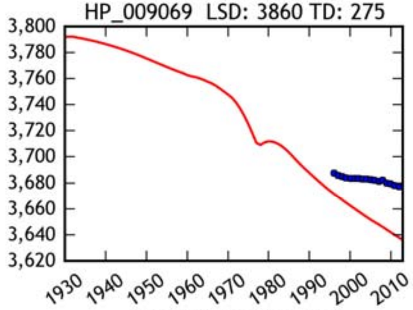
1021601 (Castro, TX)
HP_009065 LSD: 3847 TD: 265



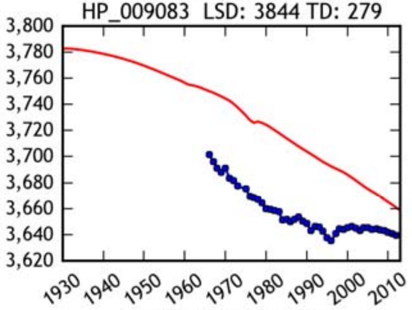
1021604 (Castro, TX)
HP_009068 LSD: 3859 TD: 295



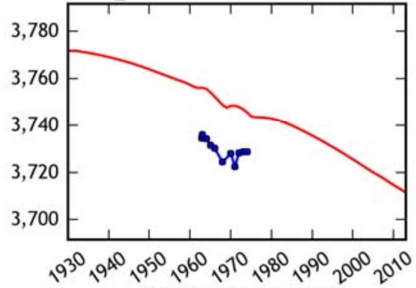
1021605 (Castro, TX)
HP_009069 LSD: 3860 TD: 275



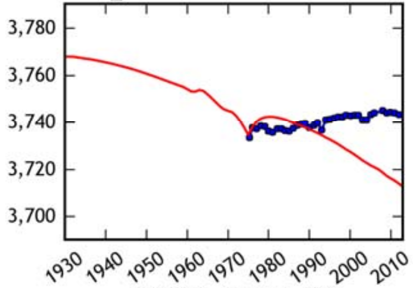
1022203 (Castro, TX)
HP_009083 LSD: 3844 TD: 279



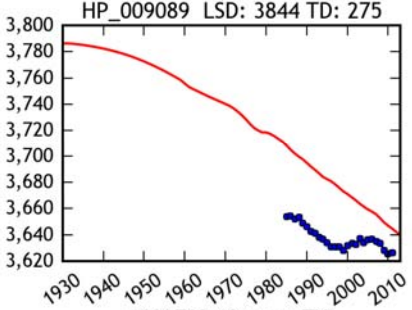
1022301 (Castro, TX)
HP_009084 LSD: 3844 TD: 140



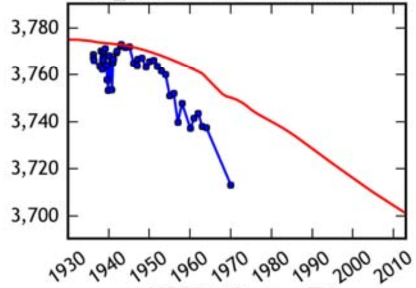
1022302 (Castro, TX)
HP_009085 LSD: 3846 TD: 158



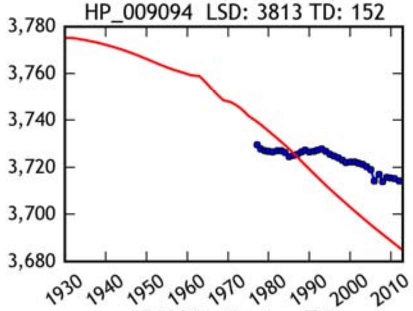
1022404 (Castro, TX)
HP_009089 LSD: 3844 TD: 275



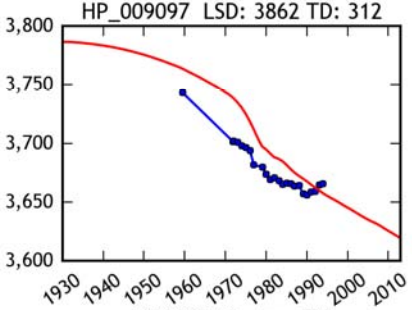
1022601 (Castro, TX)
HP_009093 LSD: 3831 TD: 162



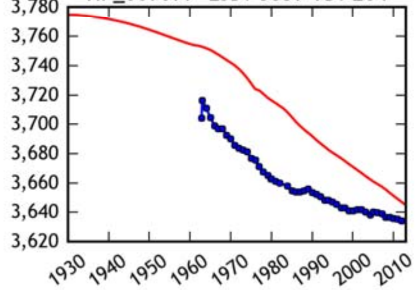
1022602 (Castro, TX)
HP_009094 LSD: 3813 TD: 152



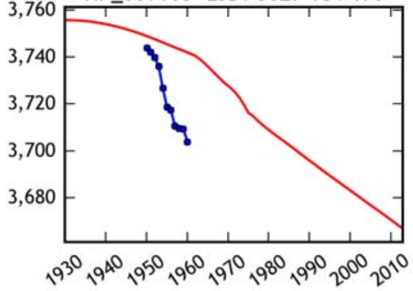
1022702 (Castro, TX)
HP_009097 LSD: 3862 TD: 312



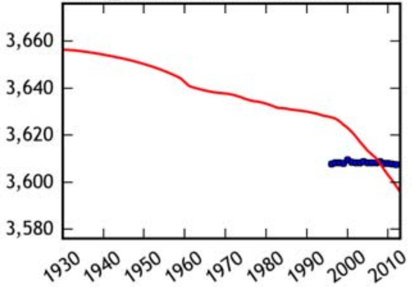
1022801 (Castro, TX)
HP_009099 LSD: 3839 TD: 264

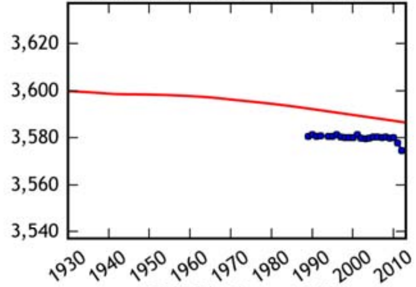


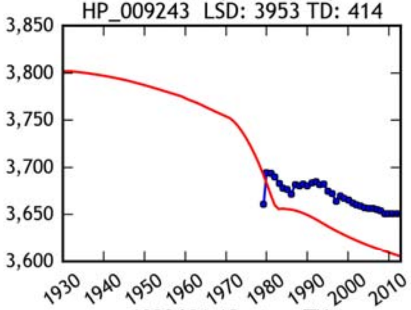
1022901 (Castro, TX)
HP_009103 LSD: 3827 TD: 175

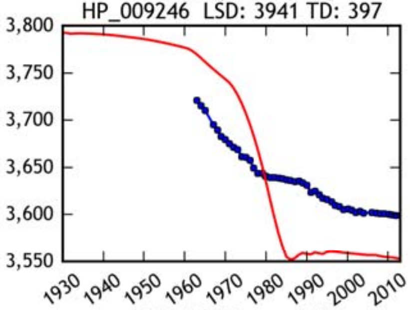


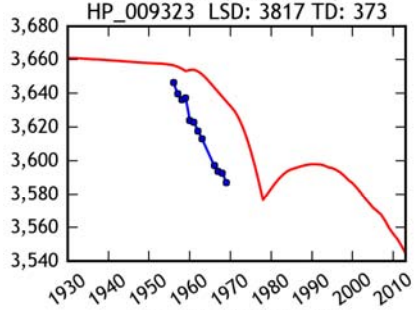
1023902 (Castro, TX)
HP_009119 LSD: 3809 TD: 227

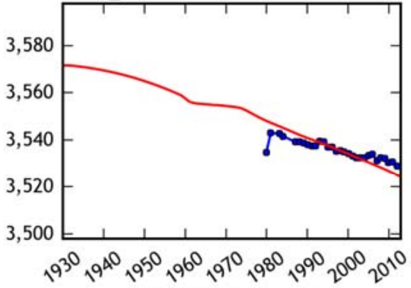


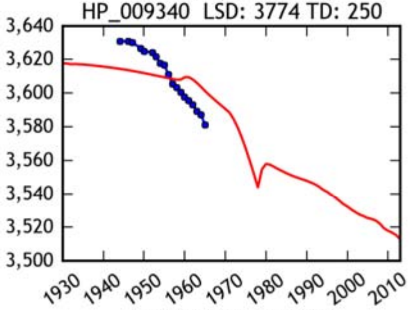

1024203 (Castro, TX)
HP_009123 LSD: 3759 TD: 200

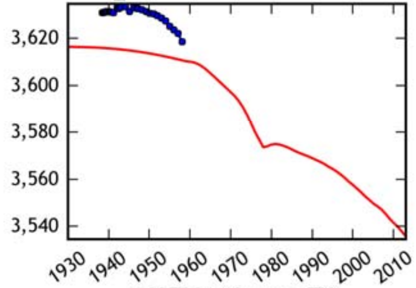

1029201 (Castro, TX)
HP_009243 LSD: 3953 TD: 414

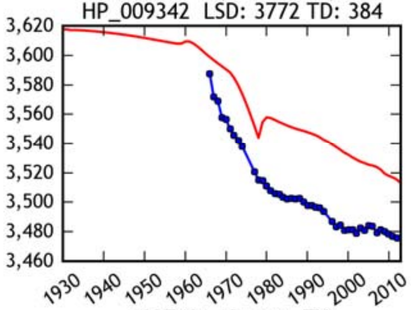

1029302 (Castro, TX)
HP_009246 LSD: 3941 TD: 397

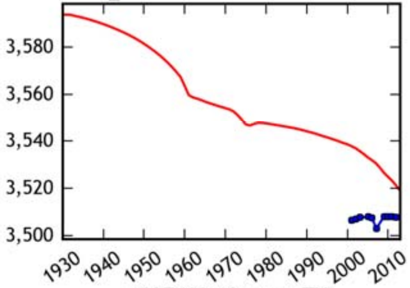

1031801 (Castro, TX)
HP_009323 LSD: 3817 TD: 373

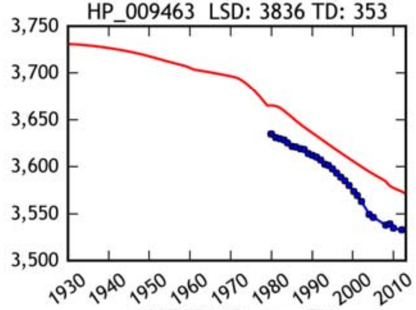

1032601 (Castro, TX)
HP_009337 LSD: 3673 TD: 189

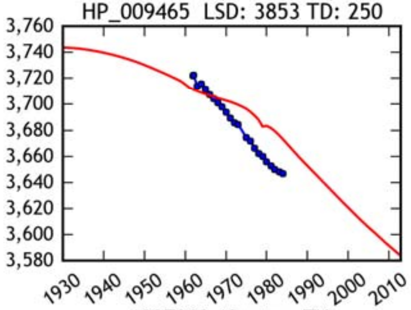

1032701 (Castro, TX)
HP_009340 LSD: 3774 TD: 250

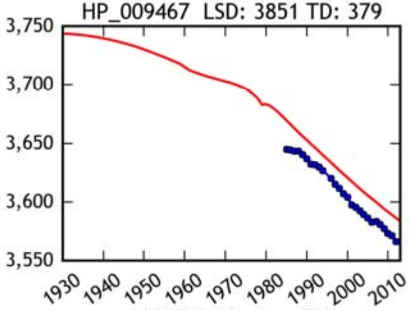

1032702 (Castro, TX)
HP_009341 LSD: 3733 TD: 126

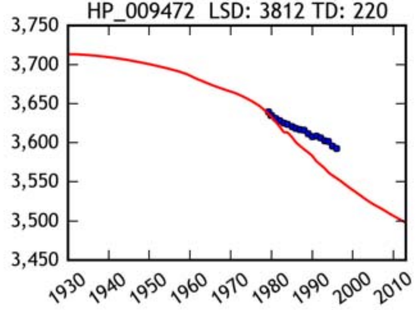

1032703 (Castro, TX)
HP_009342 LSD: 3772 TD: 384

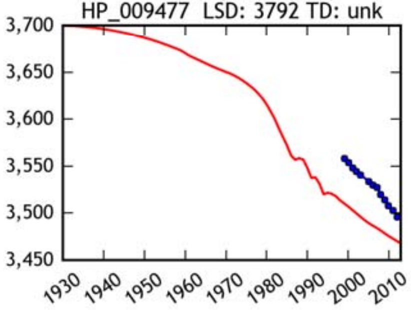

1032803 (Castro, TX)
HP_009347 LSD: 3726 TD: 295

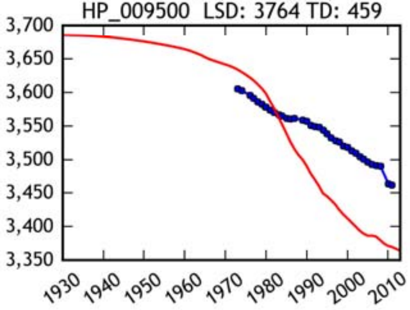

1037301 (Castro, TX)
HP_009463 LSD: 3836 TD: 353


1037401 (Castro, TX)
HP_009465 LSD: 3853 TD: 250

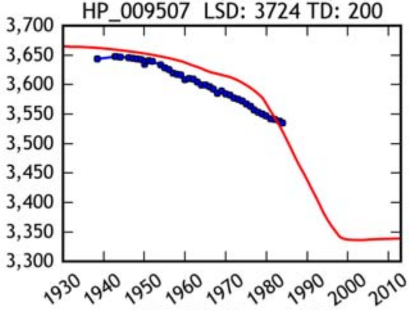

1037403 (Castro, TX)
HP_009467 LSD: 3851 TD: 379


1037801 (Castro, TX)
HP_009472 LSD: 3812 TD: 220

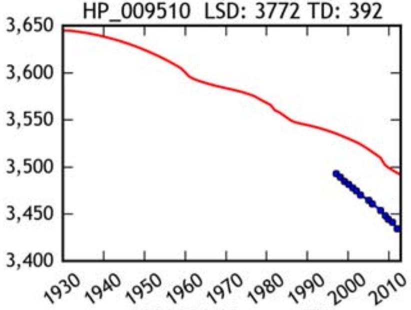

1037903 (Castro, TX)
HP_009477 LSD: 3792 TD: unk


1038703 (Castro, TX)
HP_009500 LSD: 3764 TD: 459

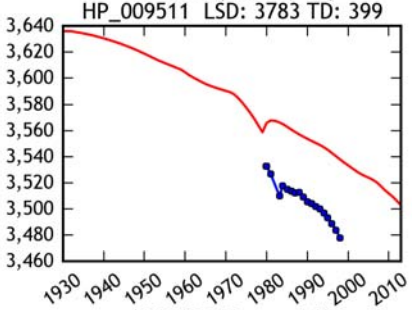
1038901 (Castro, TX)
HP_009507 LSD: 3724 TD: 200



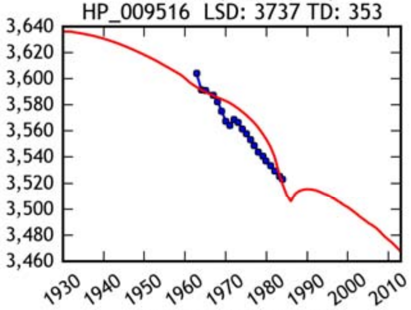
1039102 (Castro, TX)
HP_009510 LSD: 3772 TD: 392



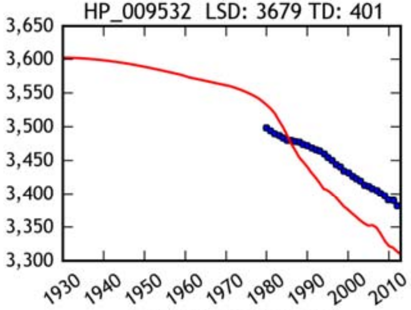
1039201 (Castro, TX)
HP_009511 LSD: 3783 TD: 399



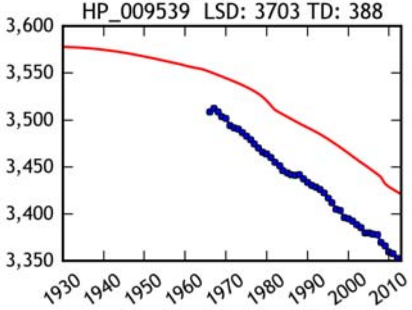
1039401 (Castro, TX)
HP_009516 LSD: 3737 TD: 353



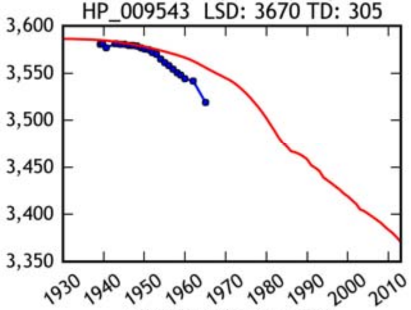
1039901 (Castro, TX)
HP_009532 LSD: 3679 TD: 401



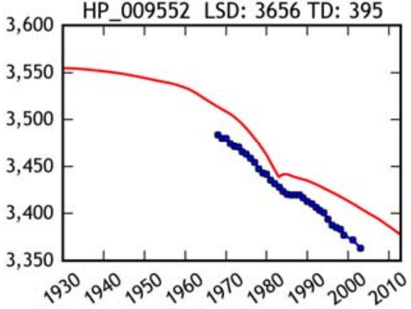
1040502 (Castro, TX)
HP_009539 LSD: 3703 TD: 388



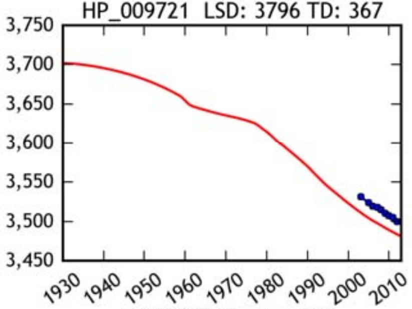
1040702 (Castro, TX)
HP_009543 LSD: 3670 TD: 305



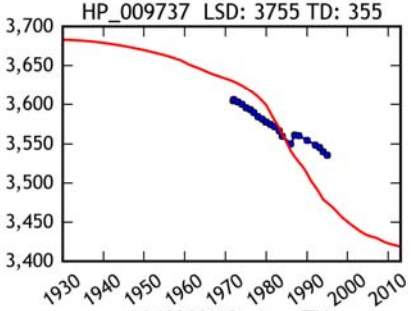
1040803 (Castro, TX)
HP_009552 LSD: 3656 TD: 395



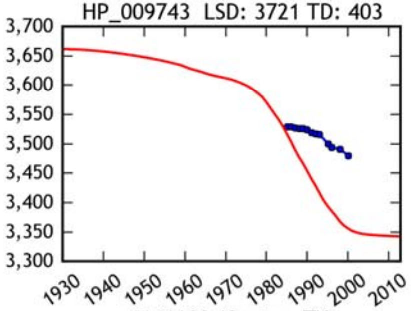
1045202 (Castro, TX)
HP_009721 LSD: 3796 TD: 367



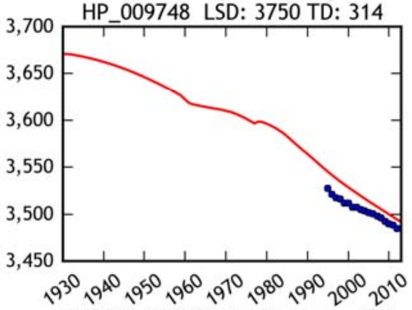
1046101 (Castro, TX)
HP_009737 LSD: 3755 TD: 355



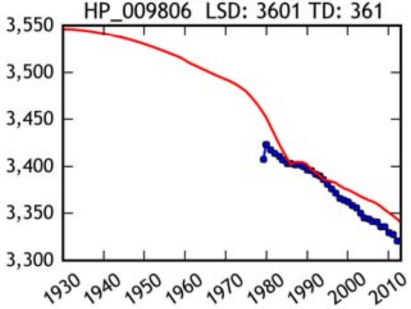
1046303 (Castro, TX)
HP_009743 LSD: 3721 TD: 403



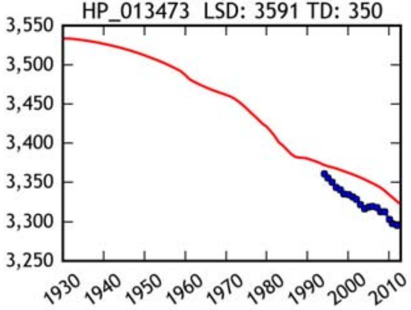
1046407 (Castro, TX)
HP_009748 LSD: 3750 TD: 314



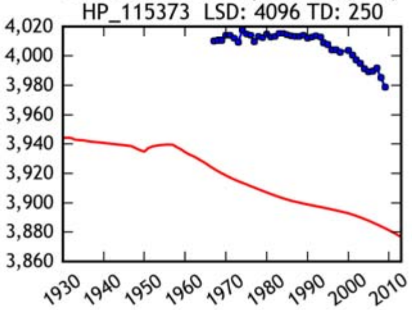
1048302 (Castro, TX)
HP_009806 LSD: 3601 TD: 361

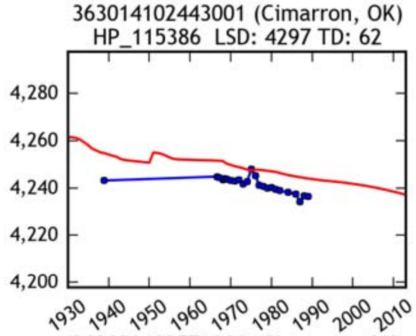


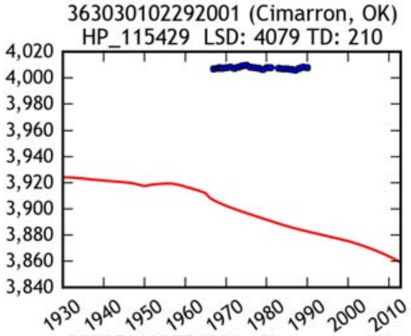
1141108 (Castro, TX)
HP_013473 LSD: 3591 TD: 350

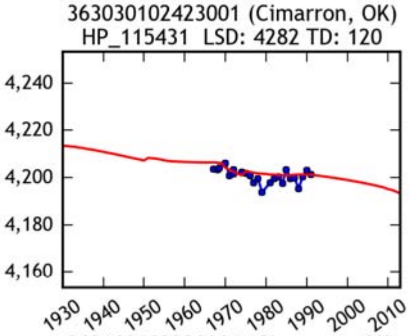


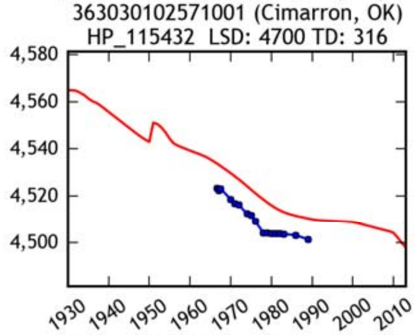
363010102303001 (Cimarron, OK)
HP_115373 LSD: 4096 TD: 250

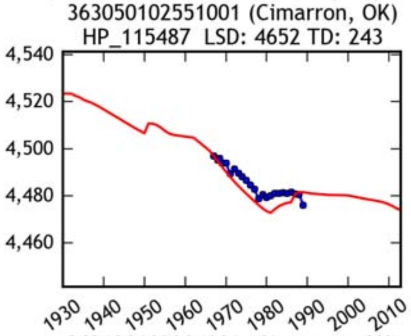


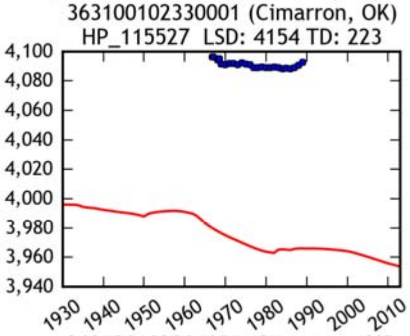

363014102443001 (Cimarron, OK)
HP_115386 LSD: 4297 TD: 62

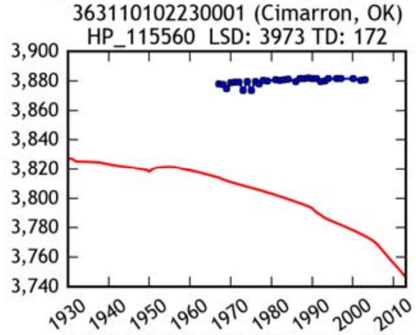

363030102292001 (Cimarron, OK)
HP_115429 LSD: 4079 TD: 210

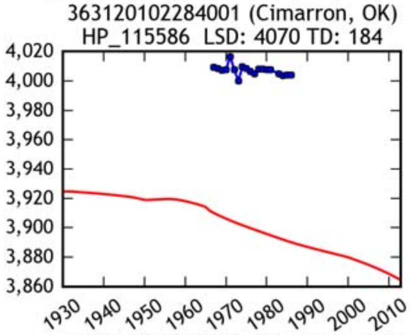

363030102423001 (Cimarron, OK)
HP_115431 LSD: 4282 TD: 120

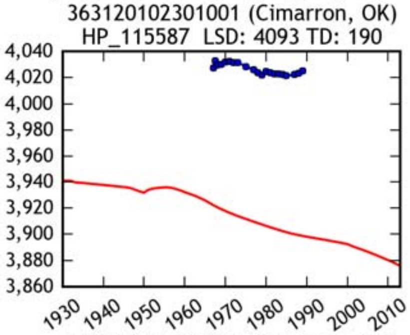

363030102571001 (Cimarron, OK)
HP_115432 LSD: 4700 TD: 316

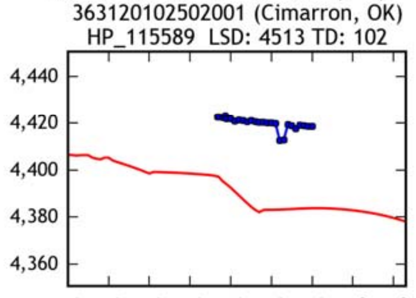

363050102551001 (Cimarron, OK)
HP_115487 LSD: 4652 TD: 243

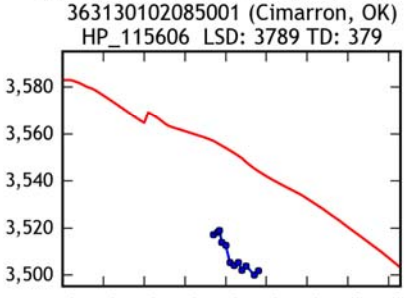

363100102330001 (Cimarron, OK)
HP_115527 LSD: 4154 TD: 223

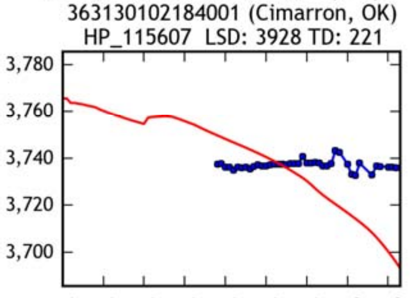

363110102230001 (Cimarron, OK)
HP_115560 LSD: 3973 TD: 172

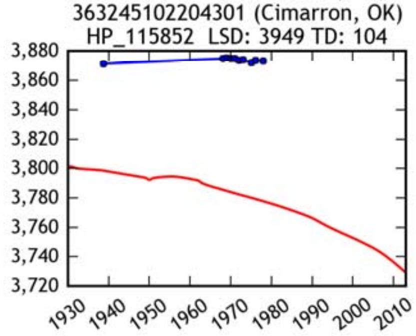

363120102284001 (Cimarron, OK)
HP_115586 LSD: 4070 TD: 184

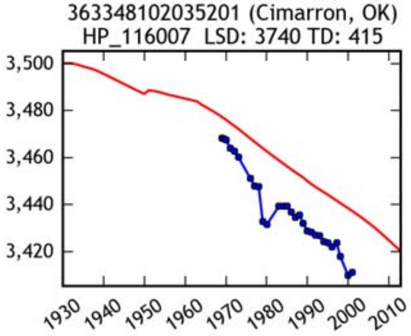

363120102301001 (Cimarron, OK)
HP_115587 LSD: 4093 TD: 190

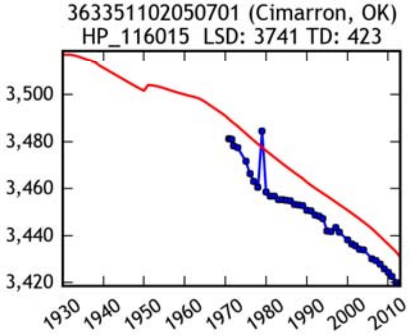

363120102502001 (Cimarron, OK)
HP_115589 LSD: 4513 TD: 102

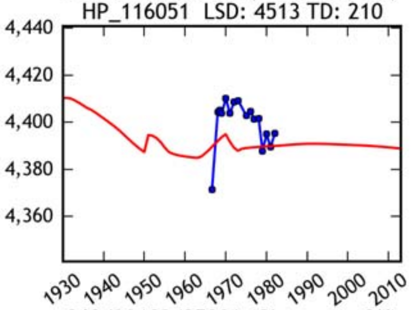

363130102085001 (Cimarron, OK)
HP_115606 LSD: 3789 TD: 379

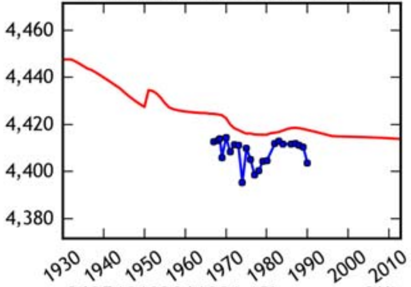

363130102184001 (Cimarron, OK)
HP_115607 LSD: 3928 TD: 221

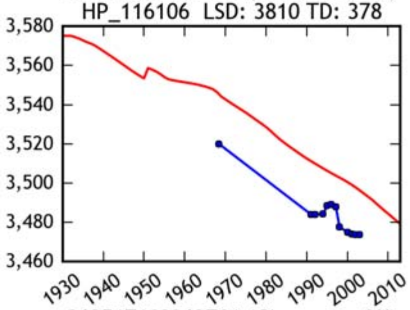

363245102204301 (Cimarron, OK)
HP_115852 LSD: 3949 TD: 104

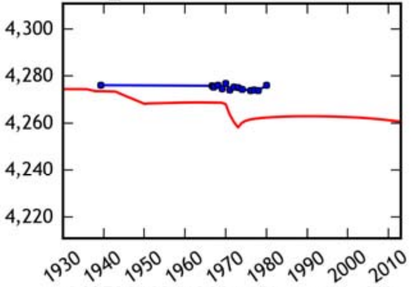

363348102035201 (Cimarron, OK)
HP_116007 LSD: 3740 TD: 415

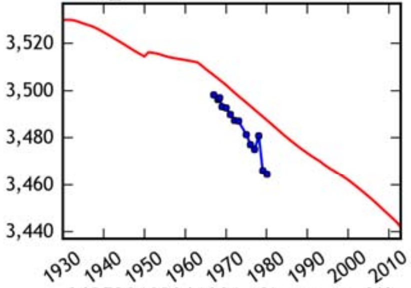

363351102050701 (Cimarron, OK)
HP_116015 LSD: 3741 TD: 423

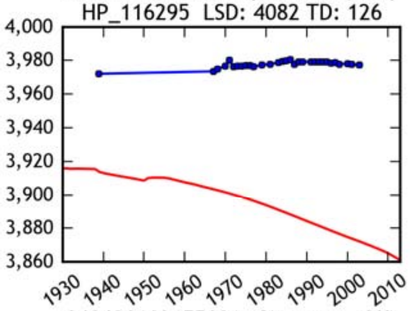

363400102500001 (Cimarron, OK)
HP_116051 LSD: 4513 TD: 210

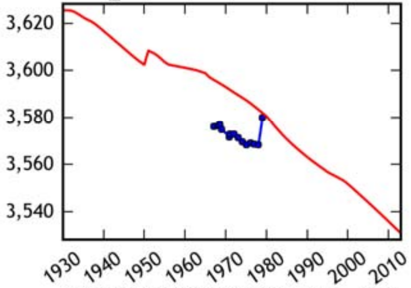

363410102513001 (Cimarron, OK)
HP_116081 LSD: 4547 TD: 170

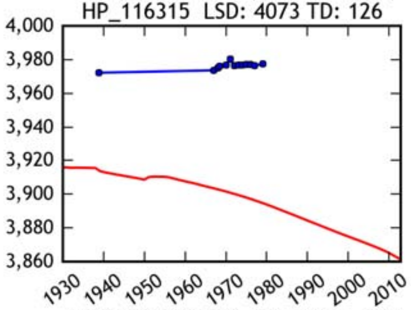

363418102082201 (Cimarron, OK)
HP_116106 LSD: 3810 TD: 378

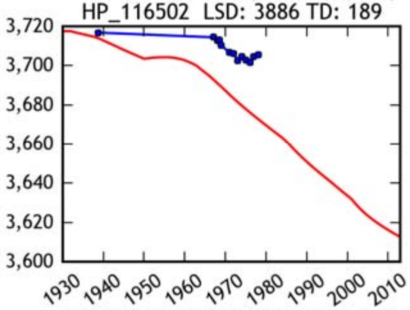

363429102435901 (Cimarron, OK)
HP_116155 LSD: 4381 TD: 129

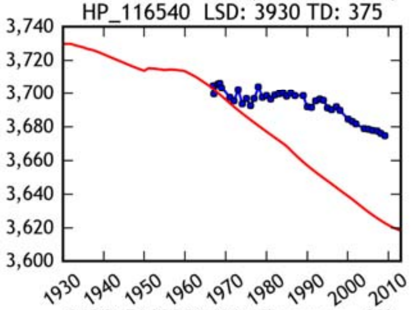

363510102061001 (Cimarron, OK)
HP_116269 LSD: 3778 TD: 405

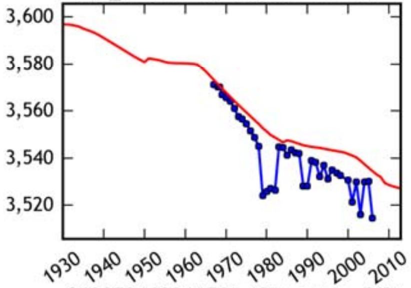

363517102262701 (Cimarron, OK)
HP_116295 LSD: 4082 TD: 126

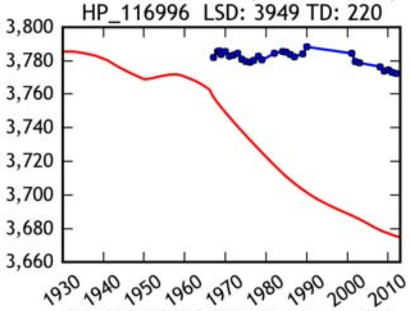

363520102113001 (Cimarron, OK)
HP_116313 LSD: 3871 TD: 412

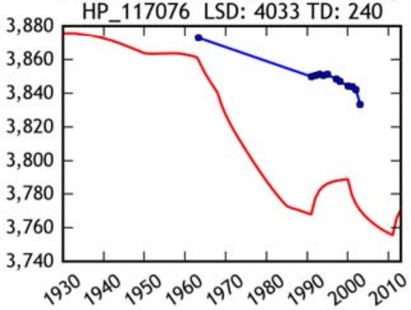

363520102261001 (Cimarron, OK)
HP_116315 LSD: 4073 TD: 126

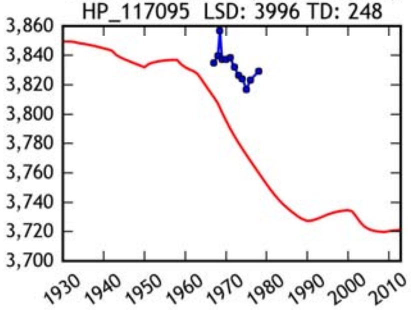

363630102155001 (Cimarron, OK)
HP_116502 LSD: 3886 TD: 189

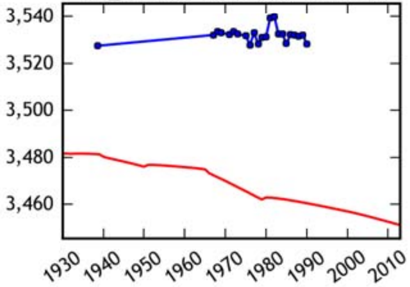

363650102161001 (Cimarron, OK)
HP_116540 LSD: 3930 TD: 375


363700102100001 (Cimarron, OK)
HP_116581 LSD: 3863 TD: 373

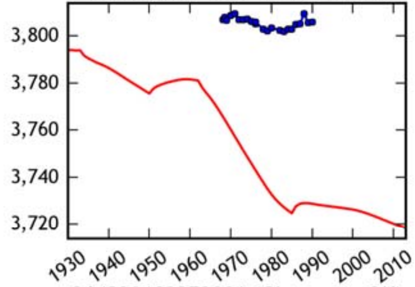

363920102184001 (Cimarron, OK)
HP_116996 LSD: 3949 TD: 220


363945102221401 (Cimarron, OK)
HP_117076 LSD: 4033 TD: 240

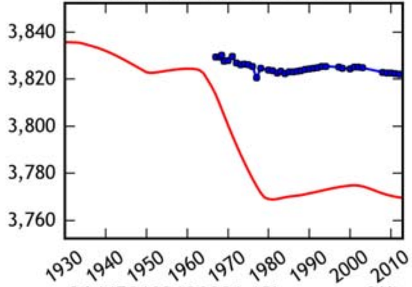

363953102211501 (Cimarron, OK)
HP_117095 LSD: 3996 TD: 248


364008102032601 (Cimarron, OK)
HP_117135 LSD: 3637 TD: 135

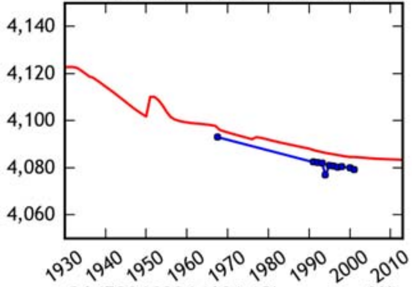
364040102182001 (Cimarron, OK)
HP_117227 LSD: 3943 TD: 190



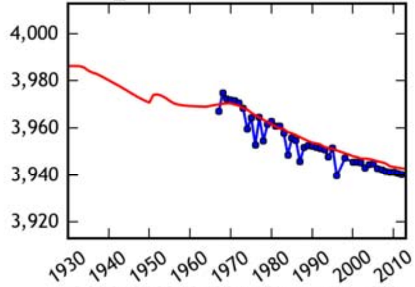
364130102195001 (Cimarron, OK)
HP_117342 LSD: 3971 TD: 189



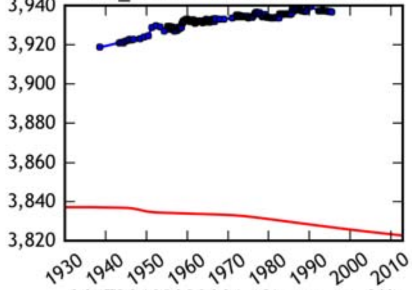
364149102330001 (Cimarron, OK)
HP_117375 LSD: 4198 TD: 176



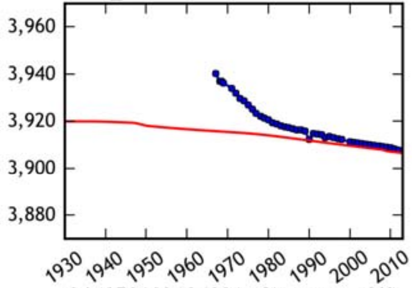
364330102253001 (Cimarron, OK)
HP_117627 LSD: 4081 TD: 216



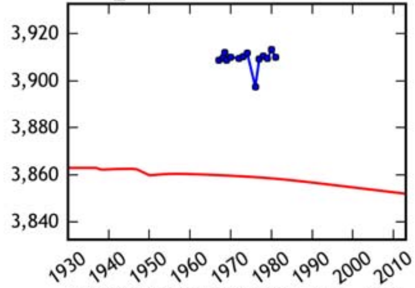
364450102190001 (Cimarron, OK)
HP_117826 LSD: 3972 TD: 61



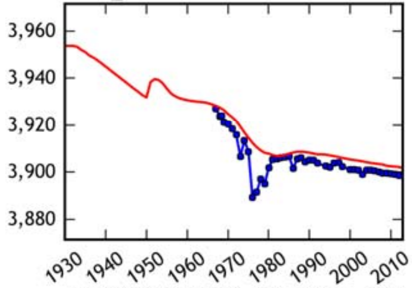
364539102214601 (Cimarron, OK)
HP_117940 LSD: 4031 TD: 152



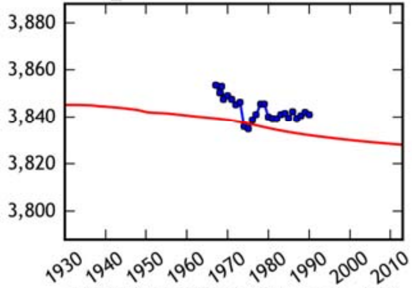
364610102194001 (Cimarron, OK)
HP_118013 LSD: 3994 TD: 156



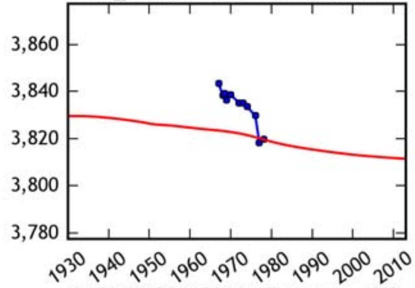
364720102222001 (Cimarron, OK)
HP_118190 LSD: 4039 TD: 193



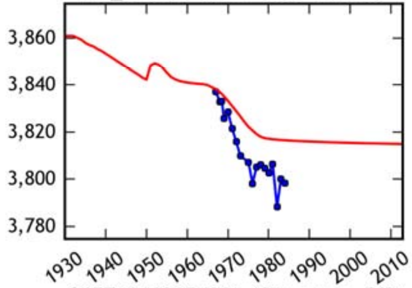
364850102184001 (Cimarron, OK)
HP_118417 LSD: 3986 TD: 204



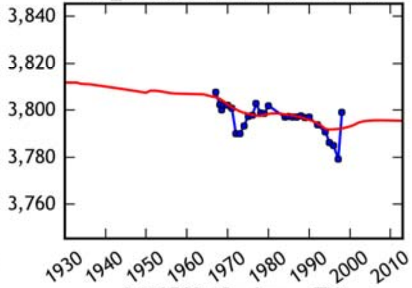
364910102180001 (Cimarron, OK)
HP_118461 LSD: 3983 TD: 248



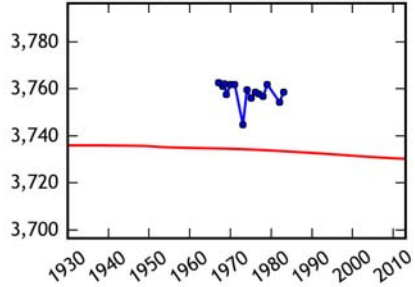
364940102190001 (Cimarron, OK)
HP_118535 LSD: 4014 TD: 238



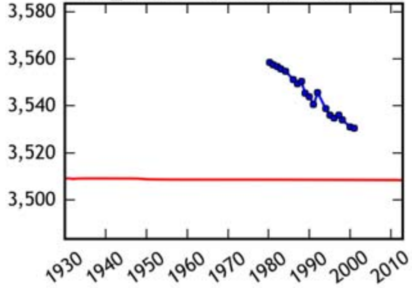
365030102175001 (Cimarron, OK)
HP_118660 LSD: 3989 TD: 265



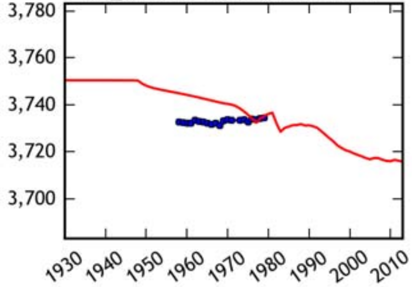
365040102145001 (Cimarron, OK)
HP_118680 LSD: 3952 TD: 271

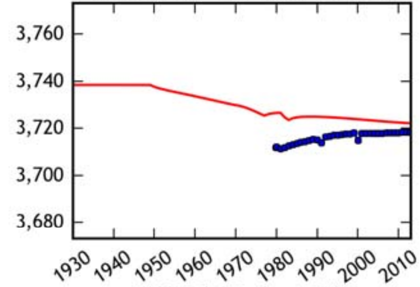


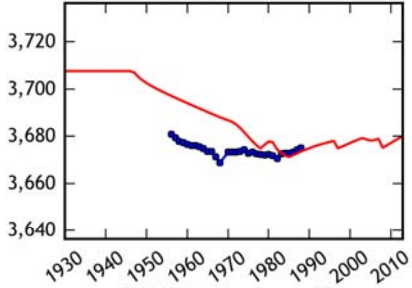
365740102054901 (Cimarron, OK)
HP_119641 LSD: 3704 TD: 300

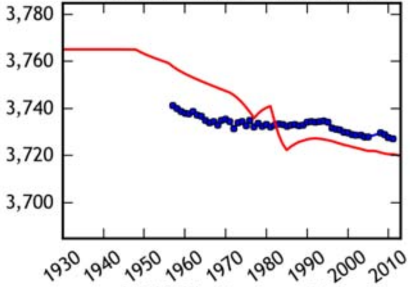


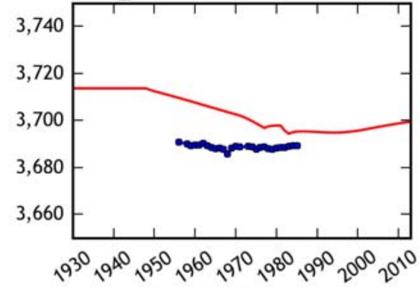
2410502 (Cochran, TX)
HP_017511 LSD: 3820 TD: 117

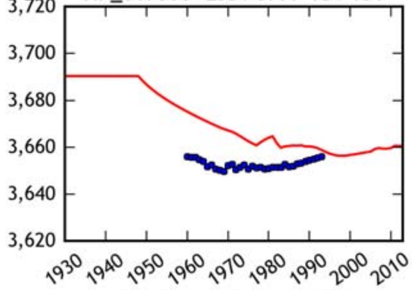


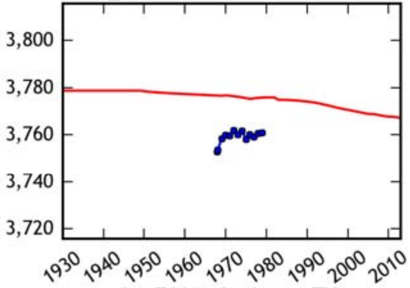

2410503 (Cochran, TX)
HP_017512 LSD: 3817 TD: 134

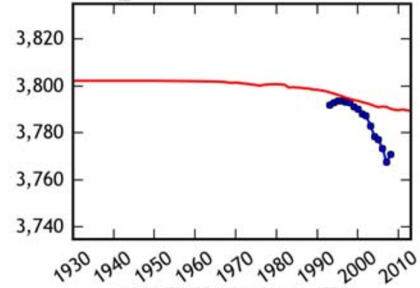

2410601 (Cochran, TX)
HP_017514 LSD: 3766 TD: 111

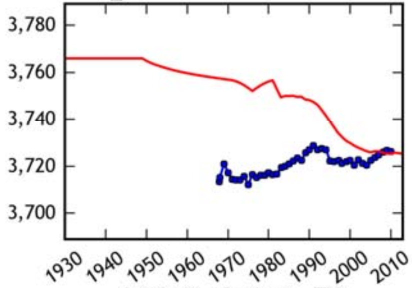

2410702 (Cochran, TX)
HP_017519 LSD: 3844 TD: 147

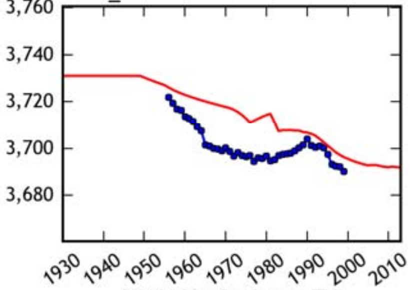

2410901 (Cochran, TX)
HP_017520 LSD: 3790 TD: 125

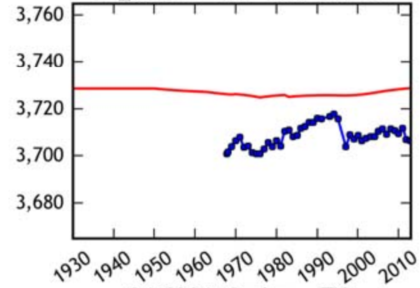

2411701 (Cochran, TX)
HP_017533 LSD: 3777 TD: 156

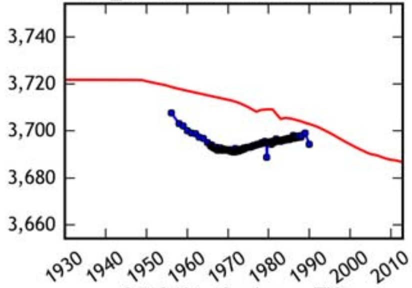

2417201 (Cochran, TX)
HP_017698 LSD: 3905 TD: 182

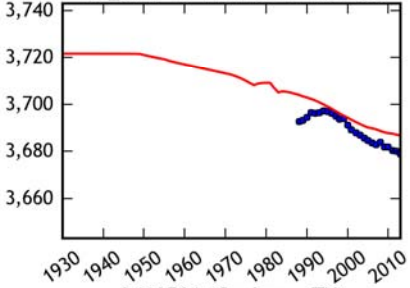

2417401 (Cochran, TX)
HP_017704 LSD: 3916 TD: 198

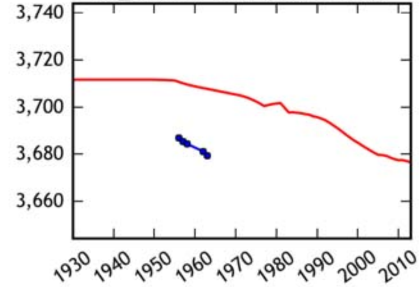

2417502 (Cochran, TX)
HP_017705 LSD: 3877 TD: 190

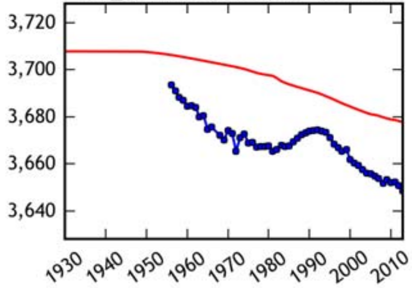

2417601 (Cochran, TX)
HP_017707 LSD: 3847 TD: 190

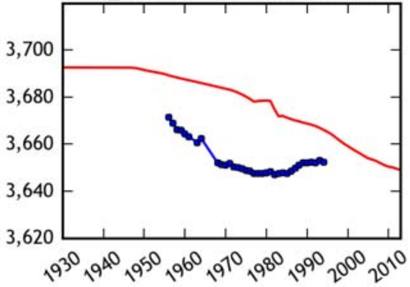

2417801 (Cochran, TX)
HP_017713 LSD: 3859 TD: 203


2418101 (Cochran, TX)
HP_017717 LSD: 3843 TD: 184

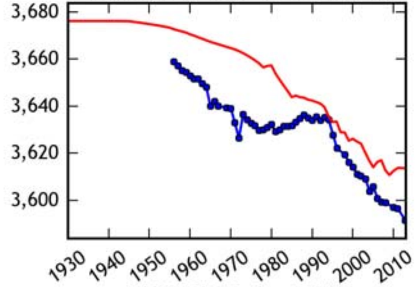

2418103 (Cochran, TX)
HP_017719 LSD: 3843 TD: 190


2418204 (Cochran, TX)
HP_017724 LSD: 3809 TD: 197

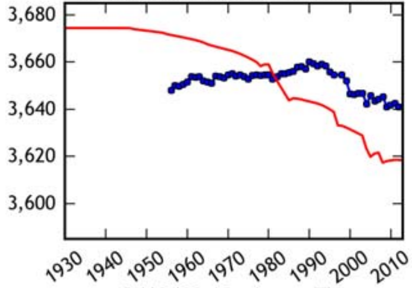

2418401 (Cochran, TX)
HP_017740 LSD: 3823 TD: 194


2418501 (Cochran, TX)
HP_017741 LSD: 3847 TD: 237

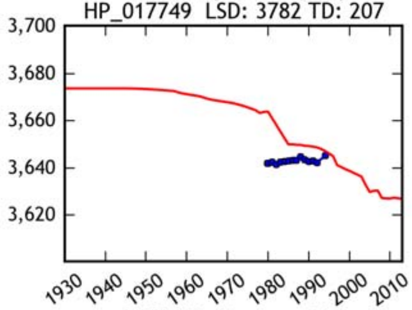
2418601 (Cochran, TX)
HP_017743 LSD: 3802 TD: 238



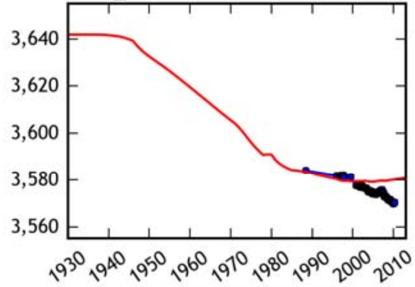
2418901 (Cochran, TX)
HP_017748 LSD: 3772 TD: 189



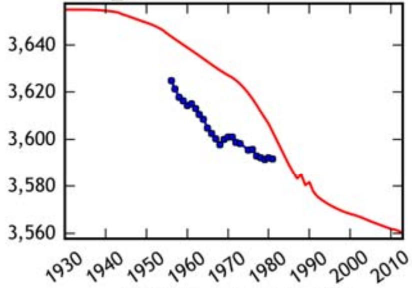
2418902 (Cochran, TX)
HP_017749 LSD: 3782 TD: 207



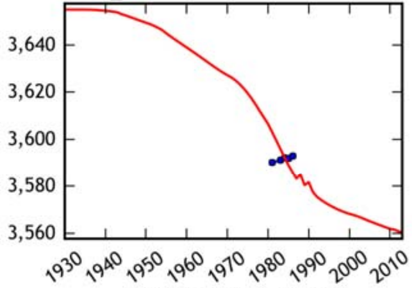
2419204 (Cochran, TX)
HP_017760 LSD: 3724 TD: 168



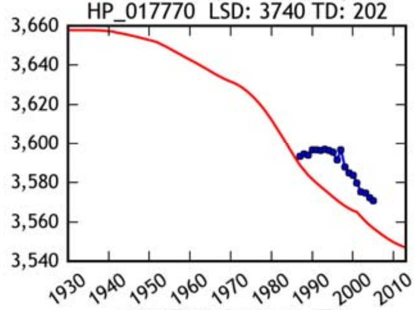
2419402 (Cochran, TX)
HP_017768 LSD: 3747 TD: 183



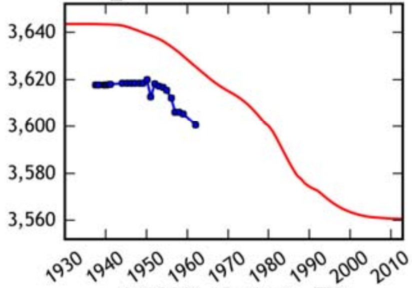
2419403 (Cochran, TX)
HP_017769 LSD: 3747 TD: 184



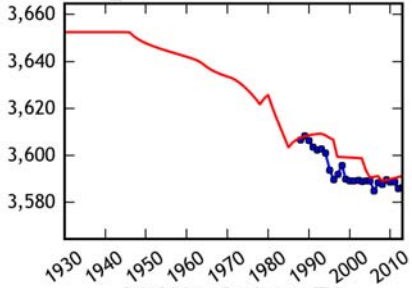
2419404 (Cochran, TX)
HP_017770 LSD: 3740 TD: 202



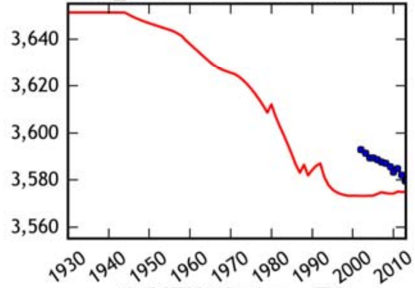
2419501 (Cochran, TX)
HP_017773 LSD: 3745 TD: 146



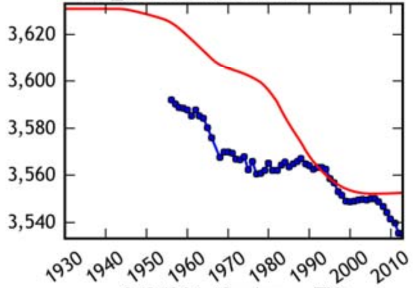
2419702 (Cochran, TX)
HP_017780 LSD: 3749 TD: 198



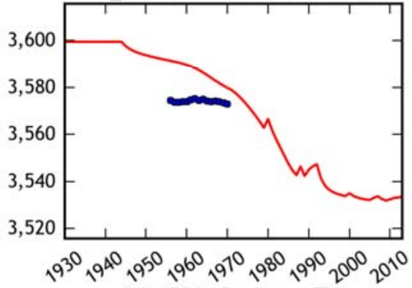
2419703 (Cochran, TX)
HP_017781 LSD: 3734 TD: 195



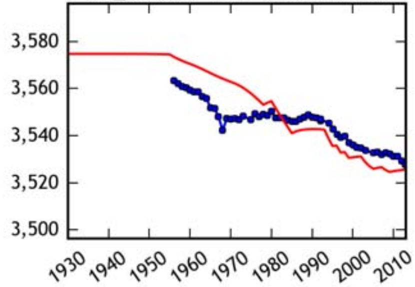
2419801 (Cochran, TX)
HP_017782 LSD: 3729 TD: 205



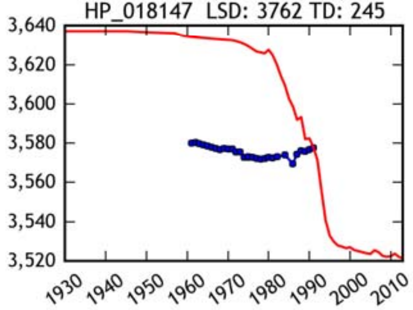
2419901 (Cochran, TX)
HP_017785 LSD: 3700 TD: 195



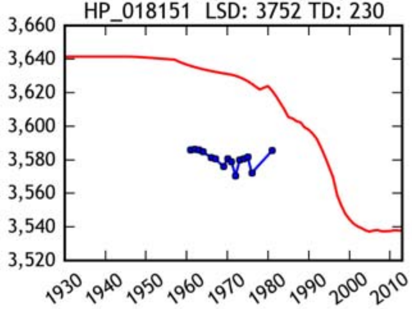
2420702 (Cochran, TX)
HP_017806 LSD: 3706 TD: 196

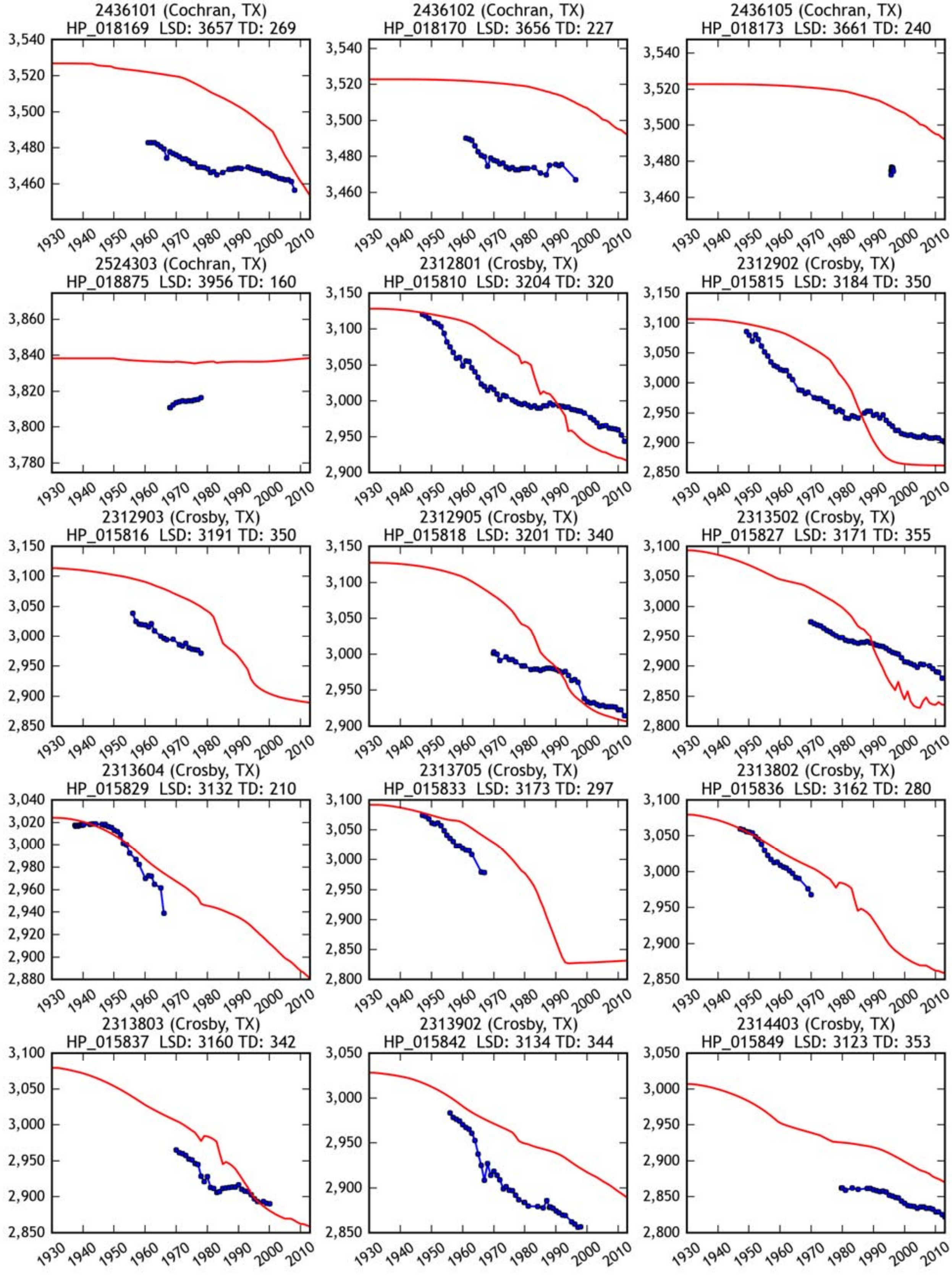


2434301 (Cochran, TX)
HP_018147 LSD: 3762 TD: 245

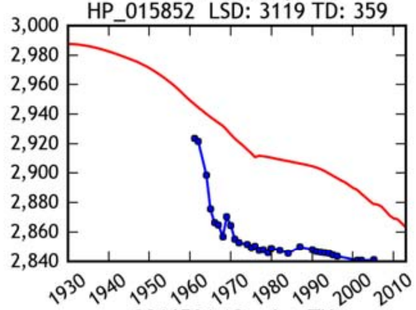


2434501 (Cochran, TX)
HP_018151 LSD: 3752 TD: 230

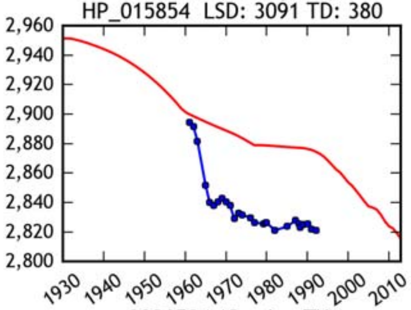



2436101 (Cochran, TX)
HP_018169 LSD: 3657 TD: 269
2436102 (Cochran, TX)
HP_018170 LSD: 3656 TD: 227
2436105 (Cochran, TX)
HP_018173 LSD: 3661 TD: 240
2524303 (Cochran, TX)
HP_018875 LSD: 3956 TD: 160
2312801 (Crosby, TX)
HP_015810 LSD: 3204 TD: 320
2312902 (Crosby, TX)
HP_015815 LSD: 3184 TD: 350
2312903 (Crosby, TX)
HP_015816 LSD: 3191 TD: 350
2312905 (Crosby, TX)
HP_015818 LSD: 3201 TD: 340
2313502 (Crosby, TX)
HP_015827 LSD: 3171 TD: 355
2313604 (Crosby, TX)
HP_015829 LSD: 3132 TD: 210
2313705 (Crosby, TX)
HP_015833 LSD: 3173 TD: 297
2313802 (Crosby, TX)
HP_015836 LSD: 3162 TD: 280
2313803 (Crosby, TX)
HP_015837 LSD: 3160 TD: 342
2313902 (Crosby, TX)
HP_015842 LSD: 3134 TD: 344
2314403 (Crosby, TX)
HP_015849 LSD: 3123 TD: 353
1930
1940
1950
1960
1970
1980
1990
2000
2010

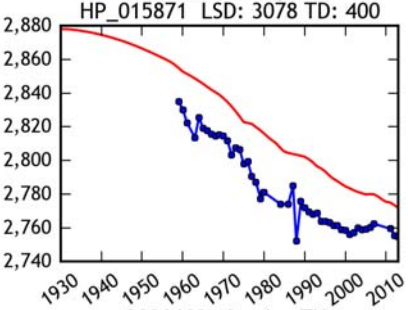
2314501 (Crosby, TX)
HP_015852 LSD: 3119 TD: 359



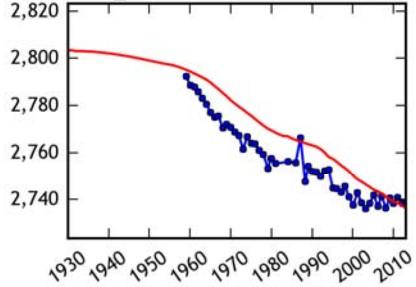
2314802 (Crosby, TX)
HP_015854 LSD: 3091 TD: 380



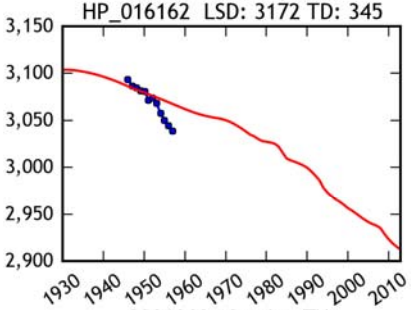
2315501 (Crosby, TX)
HP_015871 LSD: 3078 TD: 400



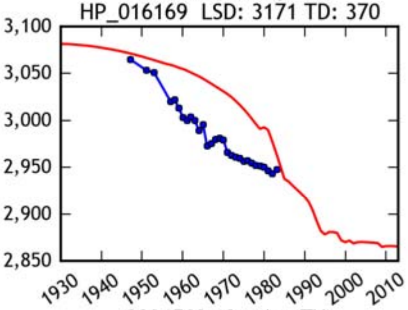
2316501 (Crosby, TX)
HP_015893 LSD: 3040 TD: 408



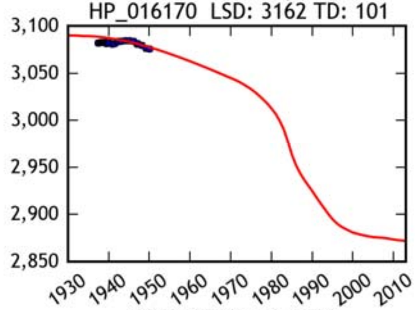
2320504 (Crosby, TX)
HP_016162 LSD: 3172 TD: 345



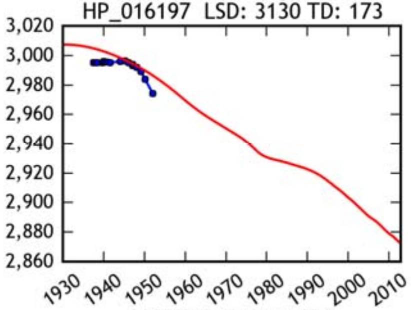
2320602 (Crosby, TX)
HP_016169 LSD: 3171 TD: 370



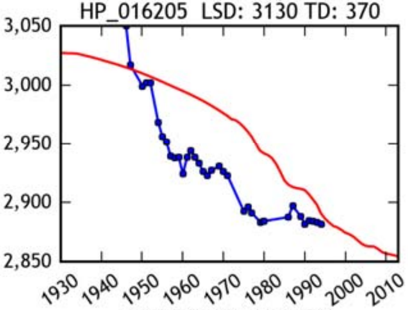
2320607 (Crosby, TX)
HP_016170 LSD: 3162 TD: 101



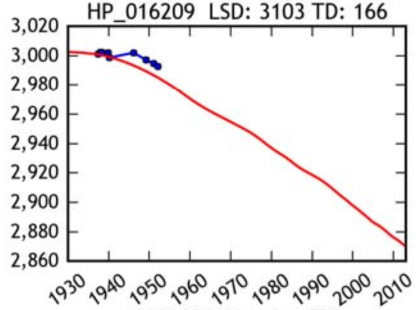
2321302 (Crosby, TX)
HP_016197 LSD: 3130 TD: 173



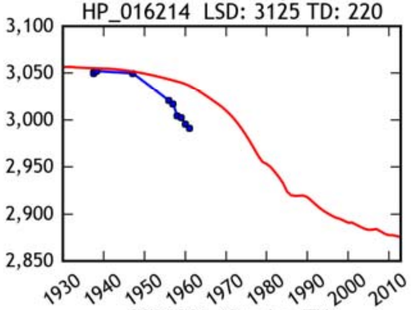
2321502 (Crosby, TX)
HP_016205 LSD: 3130 TD: 370



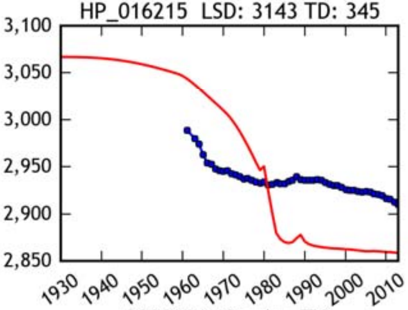
2321607 (Crosby, TX)
HP_016209 LSD: 3103 TD: 166



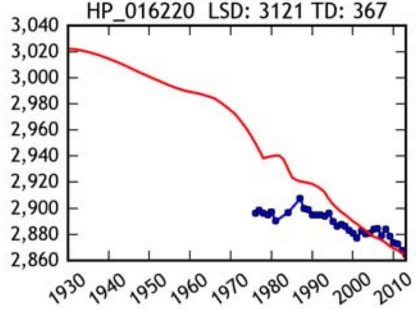
2321705 (Crosby, TX)
HP_016214 LSD: 3125 TD: 220



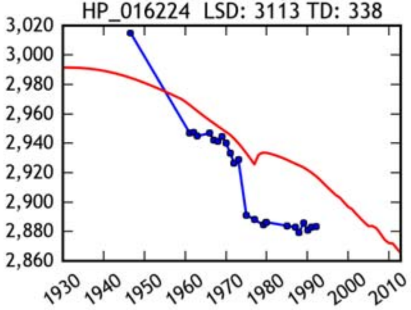
2321706 (Crosby, TX)
HP_016215 LSD: 3143 TD: 345



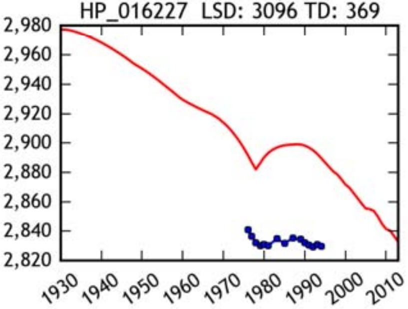
2321801 (Crosby, TX)
HP_016220 LSD: 3121 TD: 367



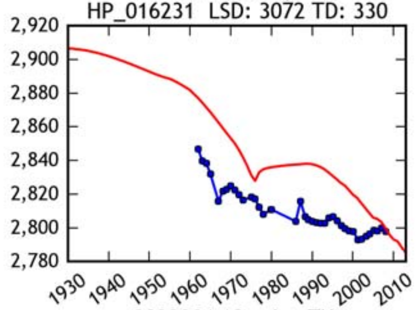
2321901 (Crosby, TX)
HP_016224 LSD: 3113 TD: 338



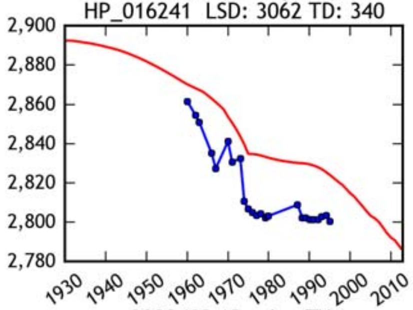
2322101 (Crosby, TX)
HP_016227 LSD: 3096 TD: 369



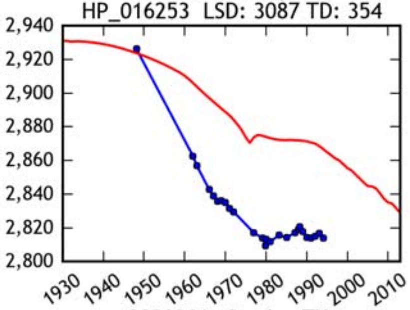
2322204 (Crosby, TX)
HP_016231 LSD: 3072 TD: 330



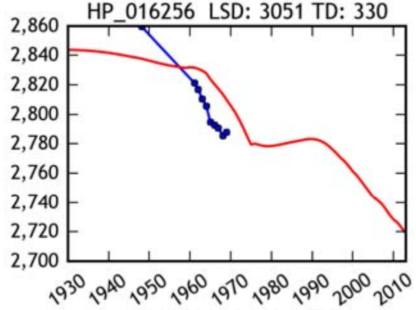
2322501 (Crosby, TX)
HP_016241 LSD: 3062 TD: 340



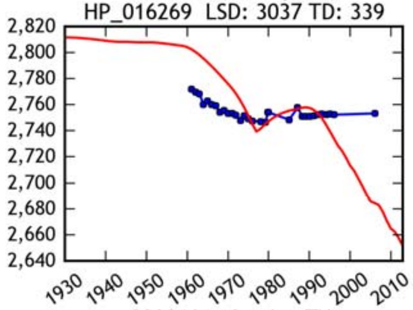
2322702 (Crosby, TX)
HP_016253 LSD: 3087 TD: 354



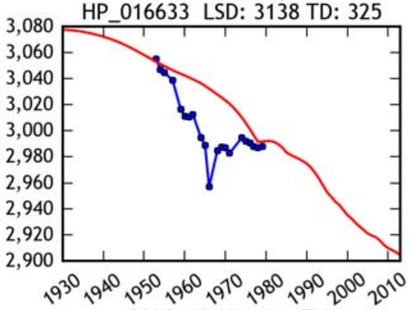
2322901 (Crosby, TX)
HP_016256 LSD: 3051 TD: 330



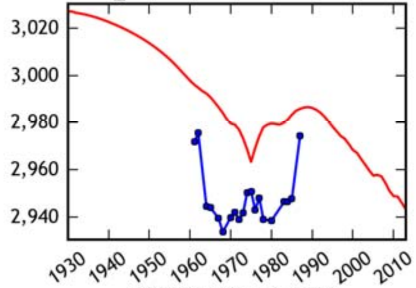
2323402 (Crosby, TX)
HP_016269 LSD: 3037 TD: 339



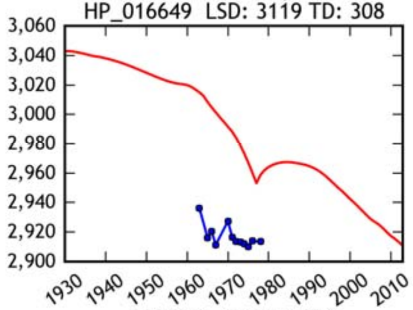
2328301 (Crosby, TX)
HP_016633 LSD: 3138 TD: 325



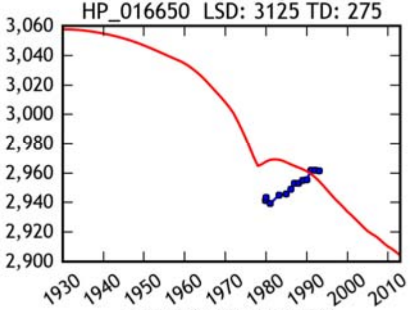
2328601 (Crosby, TX)
HP_016644 LSD: 3092 TD: 240



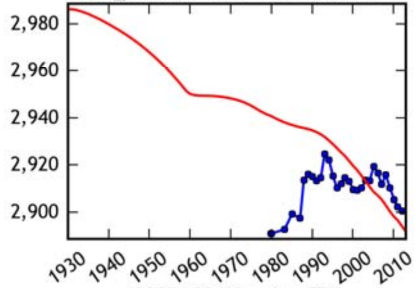
2329101 (Crosby, TX)
HP_016649 LSD: 3119 TD: 308



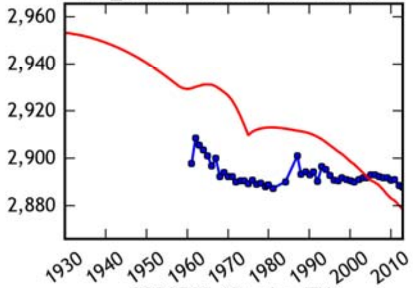
2329102 (Crosby, TX)
HP_016650 LSD: 3125 TD: 275



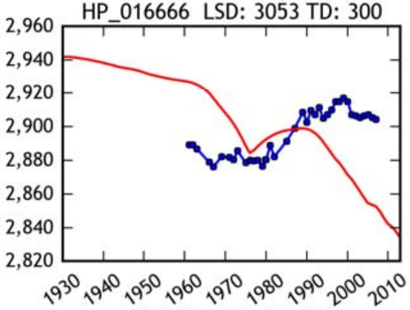
2329201 (Crosby, TX)
HP_016654 LSD: 3093 TD: 260



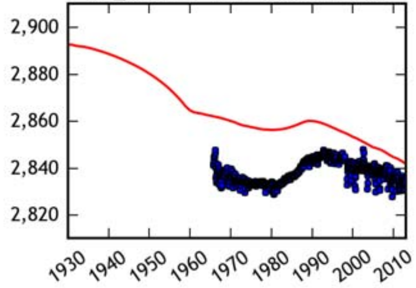
2329302 (Crosby, TX)
HP_016657 LSD: 3076 TD: 306



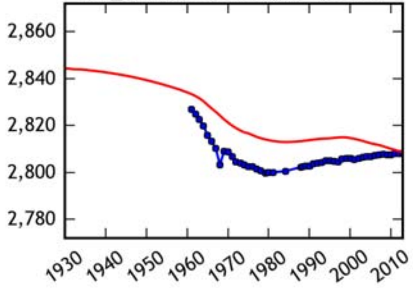
2329801 (Crosby, TX)
HP_016666 LSD: 3053 TD: 300



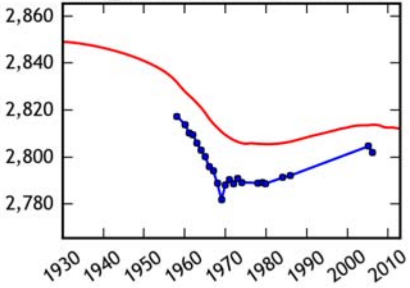
2330103 (Crosby, TX)
HP_016671 LSD: 3052 TD: 300

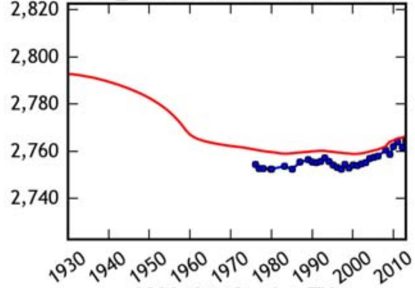


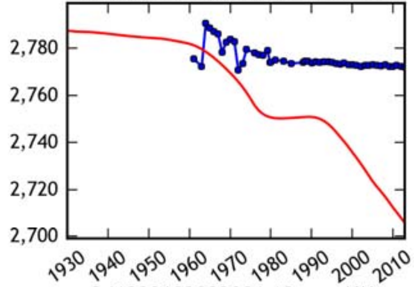
2330502 (Crosby, TX)
HP_016678 LSD: 3025 TD: 294

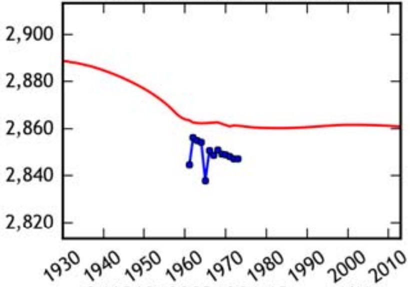


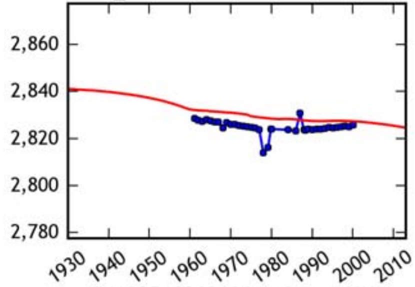
2330804 (Crosby, TX)
HP_016681 LSD: 3021 TD: 280

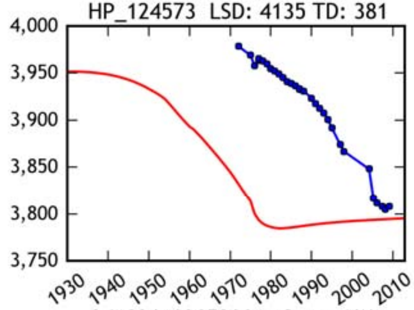


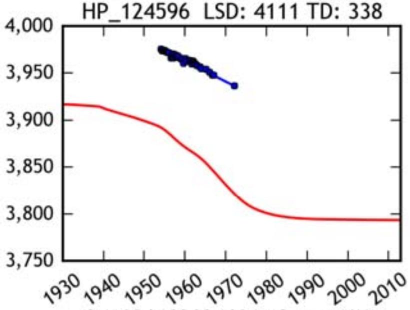

2330901 (Crosby, TX)
HP_016683 LSD: 3006 TD: 311

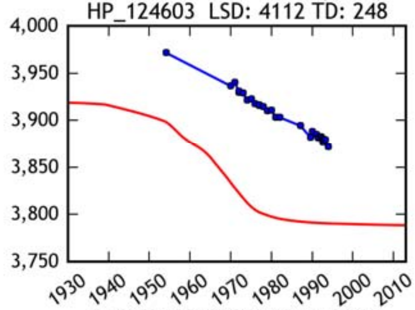

2331101 (Crosby, TX)
HP_016684 LSD: 3005 TD: 300

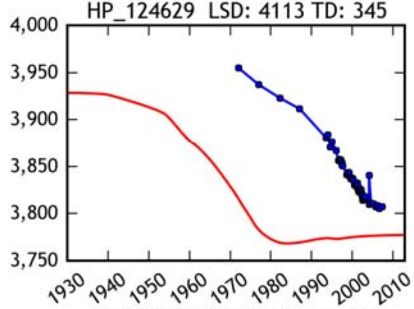

2337201 (Crosby, TX)
HP_016834 LSD: 3037 TD: 254

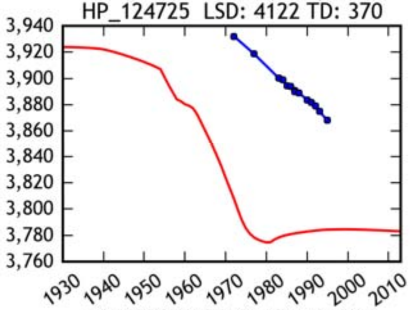

2338101 (Crosby, TX)
HP_016838 LSD: 3020 TD: 265

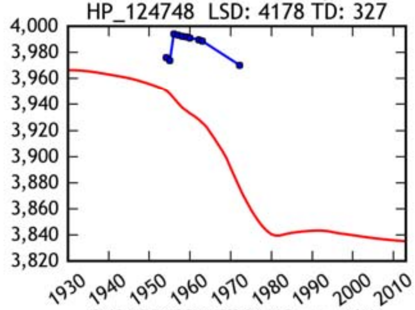

341808103082901 (Curry, NM)
HP_124573 LSD: 4135 TD: 381

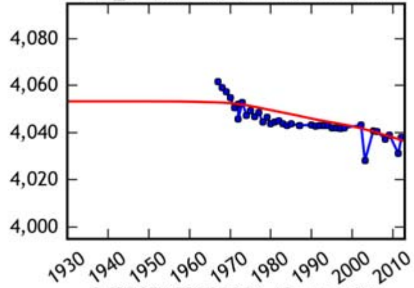

341819103031901 (Curry, NM)
HP_124596 LSD: 4111 TD: 338

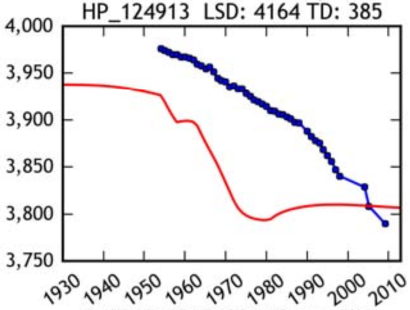

341825103031301 (Curry, NM)
HP_124603 LSD: 4112 TD: 248

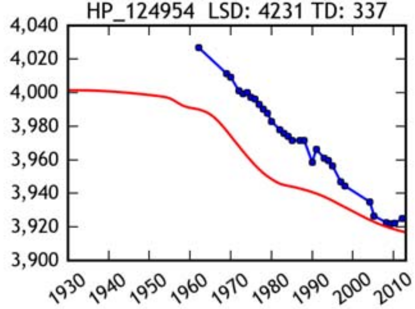

341836103052001 (Curry, NM)
HP_124629 LSD: 4113 TD: 345

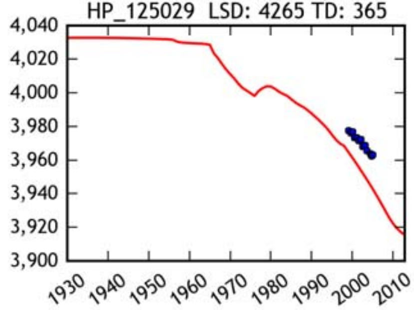

341936103034601 (Curry, NM)
HP_124725 LSD: 4122 TD: 370

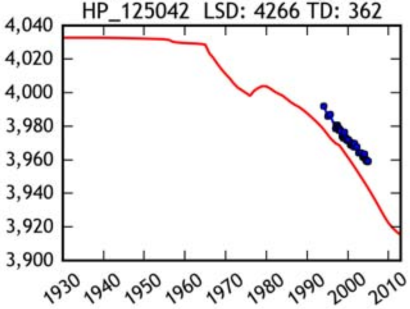

341953103100901 (Curry, NM)
HP_124748 LSD: 4178 TD: 327

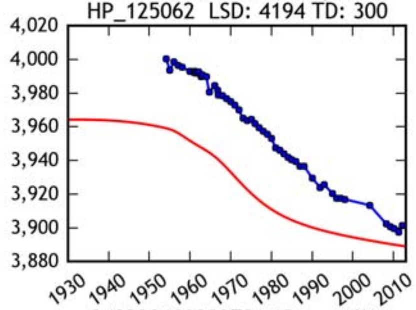

342036103220001 (Curry, NM)
HP_124849 LSD: 4239 TD: 235

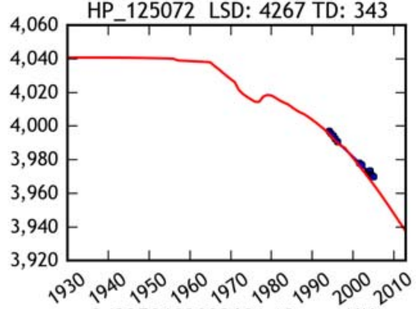

342059103052201 (Curry, NM)
HP_124913 LSD: 4164 TD: 385

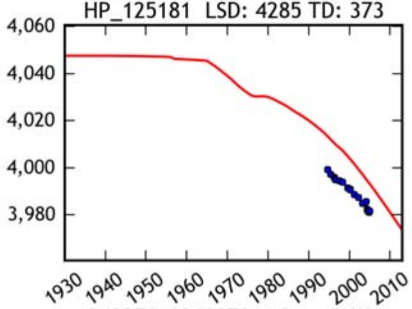

342121103142301 (Curry, NM)
HP_124954 LSD: 4231 TD: 337

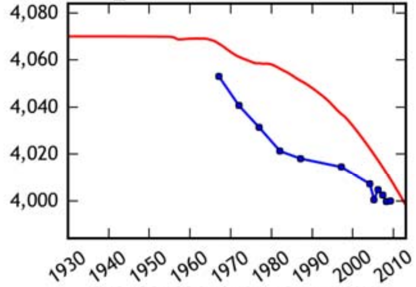

342200103180901 (Curry, NM)
HP_125029 LSD: 4265 TD: 365

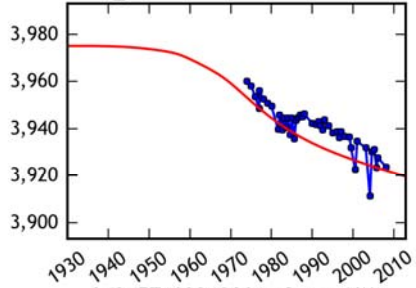

342203103181001 (Curry, NM)
HP_125042 LSD: 4266 TD: 362

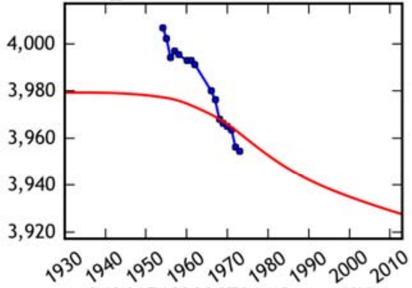

342214103091301 (Curry, NM)
HP_125062 LSD: 4194 TD: 300

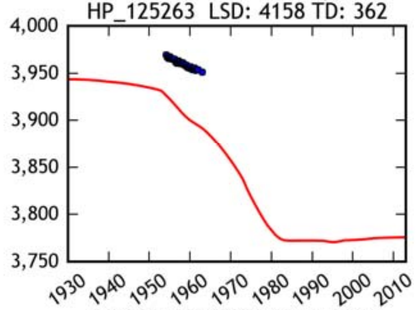

342218103182601 (Curry, NM)
HP_125072 LSD: 4267 TD: 343

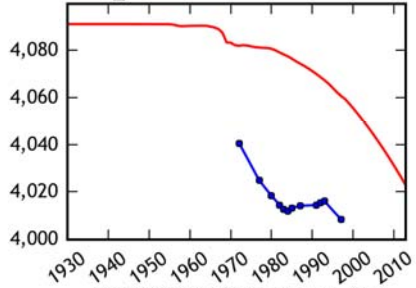

342328103182401 (Curry, NM)
HP_125181 LSD: 4285 TD: 373

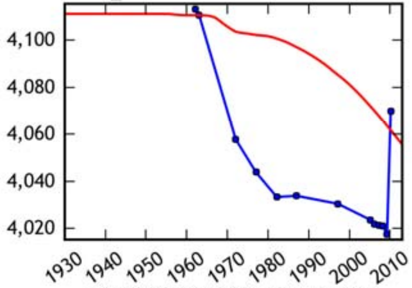

342338103203701 (Curry, NM)
HP_125190 LSD: 4334 TD: 365

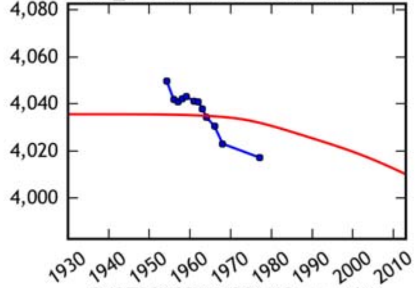

342358103093601 (Curry, NM)
HP_125214 LSD: 4230 TD: 370

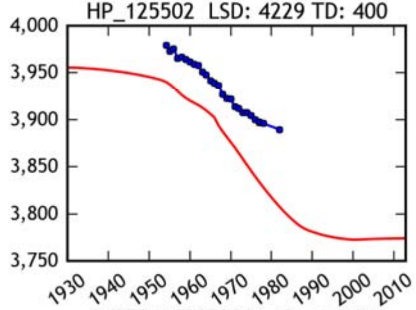

342359103100701 (Curry, NM)
HP_125216 LSD: 4241 TD: 350

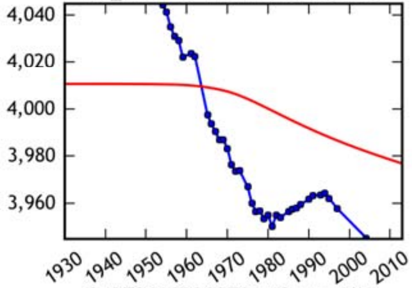

342422103040401 (Curry, NM)
HP_125263 LSD: 4158 TD: 362

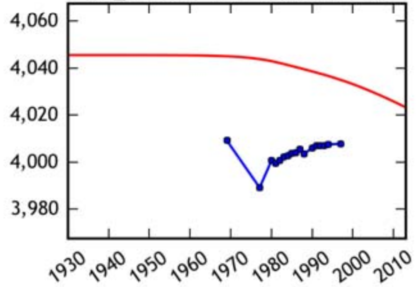

342457103213901 (Curry, NM)
HP_125317 LSD: 4375 TD: 430

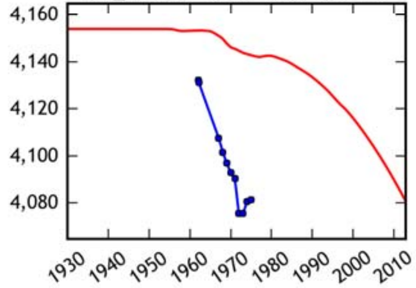

342615103220701 (Curry, NM)
HP_125436 LSD: 4422 TD: 406

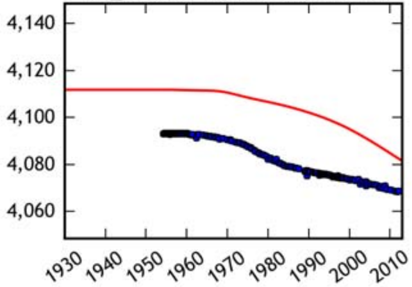

342630103145201 (Curry, NM)
HP_125448 LSD: 4346 TD: 387


342726103030601 (Curry, NM)
HP_125502 LSD: 4229 TD: 400

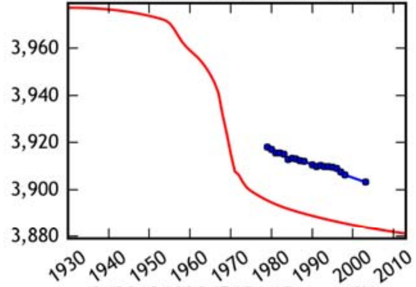

342729103103801 (Curry, NM)
HP_125510 LSD: 4342 TD: 424


342729103141901 (Curry, NM)
HP_125511 LSD: 4396 TD: 430

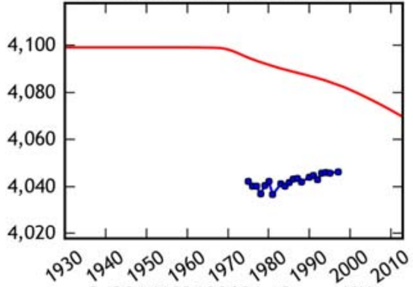

342734103252301 (Curry, NM)
HP_125519 LSD: 4487 TD: 476


342736103203701 (Curry, NM)
HP_125522 LSD: 4438 TD: 418

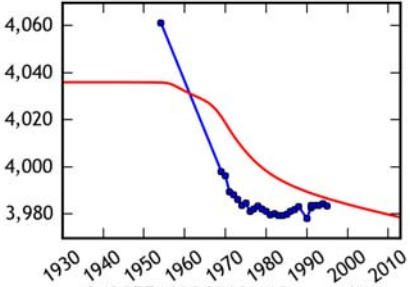
342744103055701 (Curry, NM)
HP_125539 LSD: 4266 TD: 390



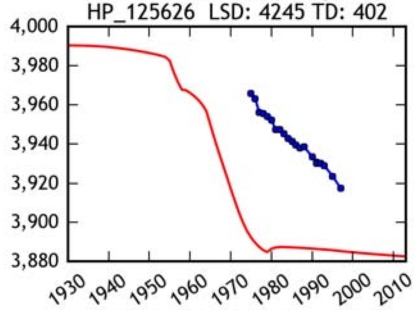
342908103155201 (Curry, NM)
HP_125620 LSD: 4437 TD: 435



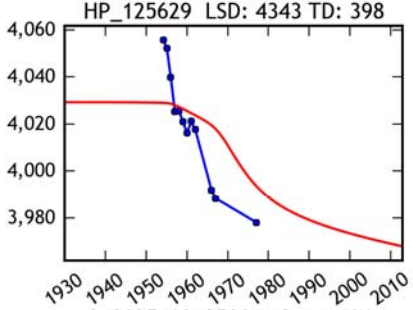
342912103103801 (Curry, NM)
HP_125623 LSD: 4350 TD: 395



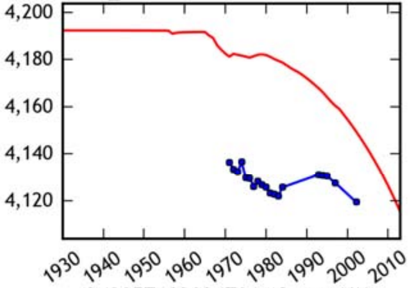
342913103045101 (Curry, NM)
HP_125626 LSD: 4245 TD: 402



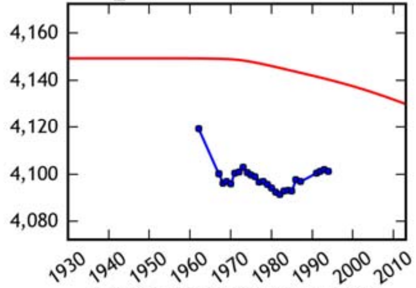
342914103100601 (Curry, NM)
HP_125629 LSD: 4343 TD: 398



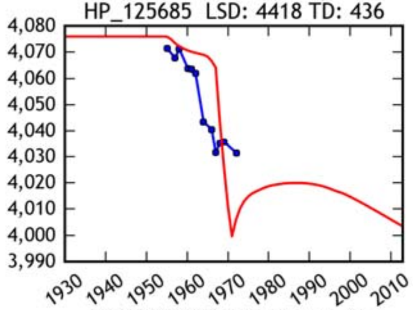
342955103262101 (Curry, NM)
HP_125662 LSD: 4512 TD: 410



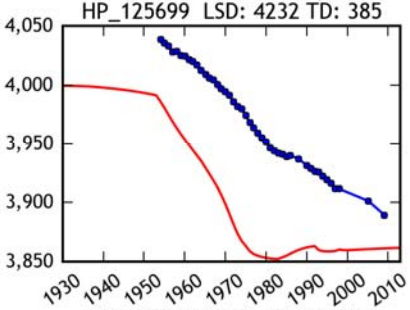
343010103210001 (Curry, NM)
HP_125670 LSD: 4504 TD: 450



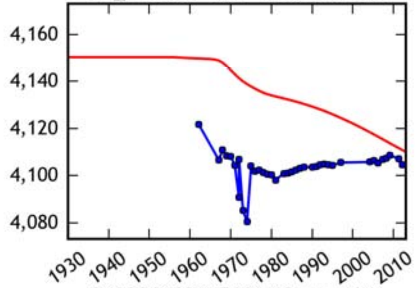
343025103135001 (Curry, NM)
HP_125685 LSD: 4418 TD: 436



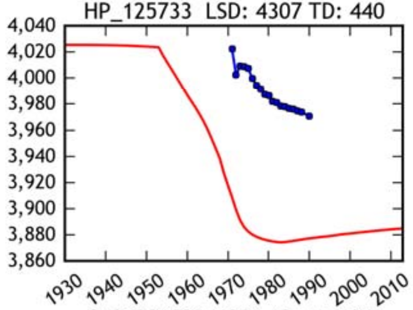
343057103034701 (Curry, NM)
HP_125699 LSD: 4232 TD: 385



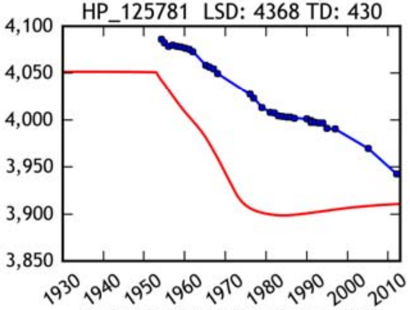
343100103190201 (Curry, NM)
HP_125704 LSD: 4489 TD: 416



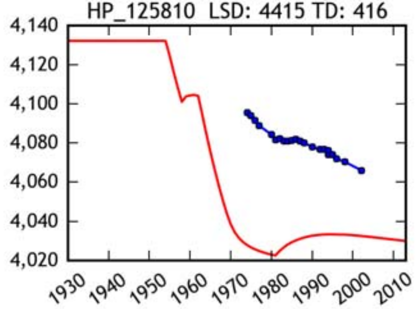
343150103071901 (Curry, NM)
HP_125733 LSD: 4307 TD: 440



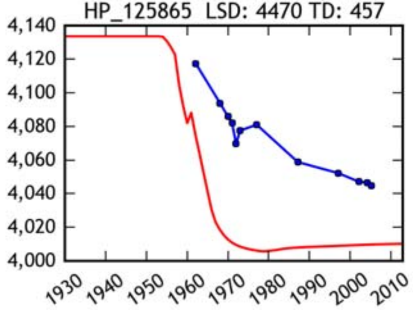
343255103093401 (Curry, NM)
HP_125781 LSD: 4368 TD: 430



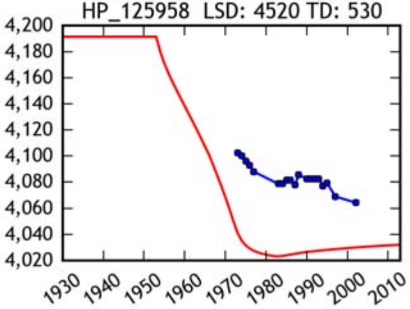
343336103145001 (Curry, NM)
HP_125810 LSD: 4415 TD: 416



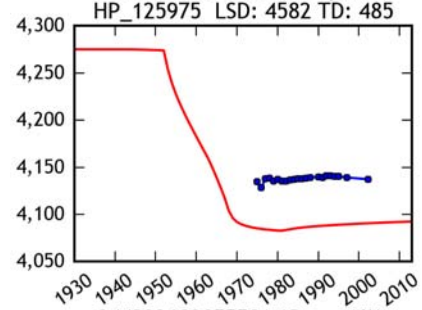
343428103141201 (Curry, NM)
HP_125865 LSD: 4470 TD: 457



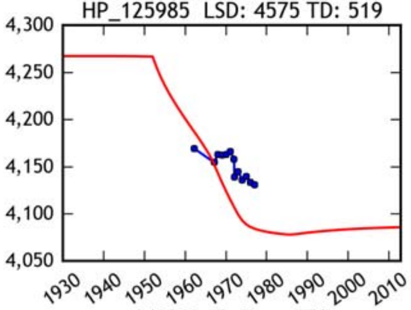
343613103144401 (Curry, NM)
HP_125958 LSD: 4520 TD: 530



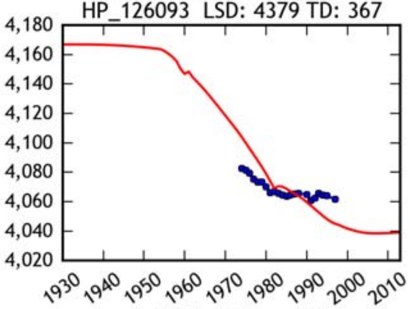
343637103180001 (Curry, NM)
HP_125975 LSD: 4582 TD: 485



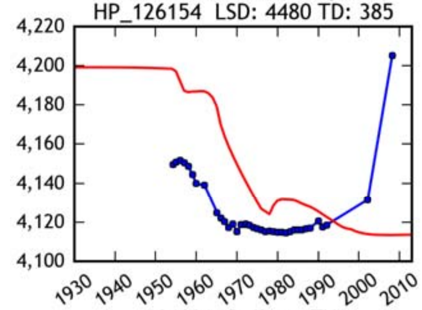
343650103172601 (Curry, NM)
HP_125985 LSD: 4575 TD: 519



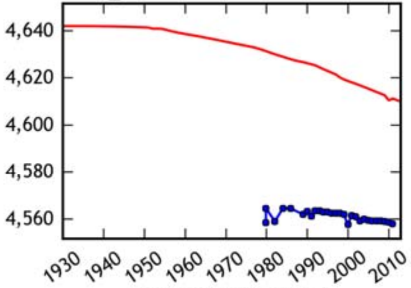
344019103031501 (Curry, NM)
HP_126093 LSD: 4379 TD: 367



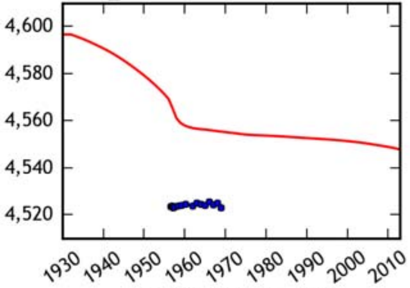
344322103055501 (Curry, NM)
HP_126154 LSD: 4480 TD: 385



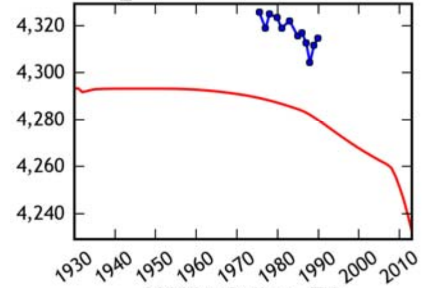
140902 (Dallam, TX)
HP_000154 LSD: 4695 TD: 160



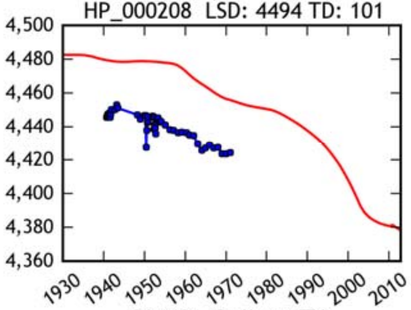
148301 (Dallam, TX)
HP_000160 LSD: 4608 TD: 132



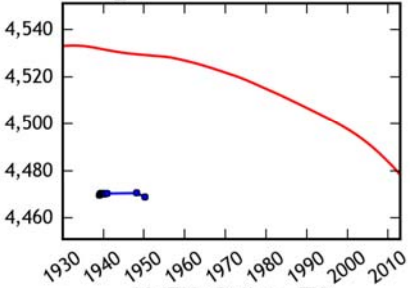
164601 (Dallam, TX)
HP_000192 LSD: 4425 TD: 280



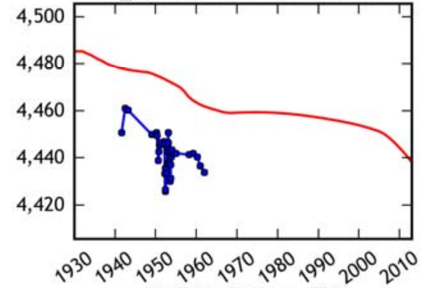
233803 (Dallam, TX)
HP_000208 LSD: 4494 TD: 101



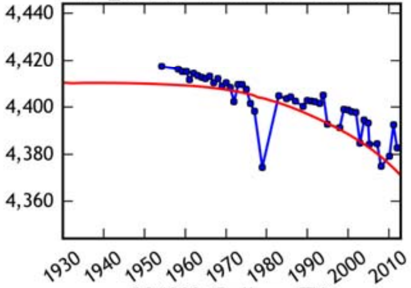
233807 (Dallam, TX)
HP_000212 LSD: 4533 TD: 99



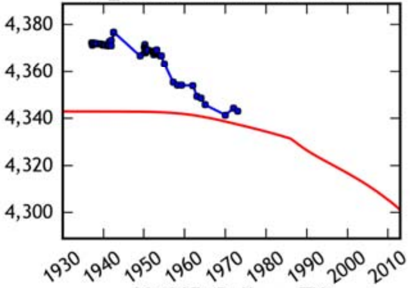
233901 (Dallam, TX)
HP_000215 LSD: 4482 TD: 150



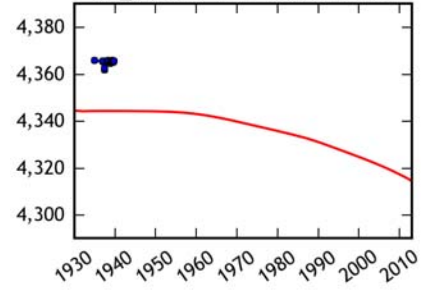
234401 (Dallam, TX)
HP_000235 LSD: 4492 TD: 160



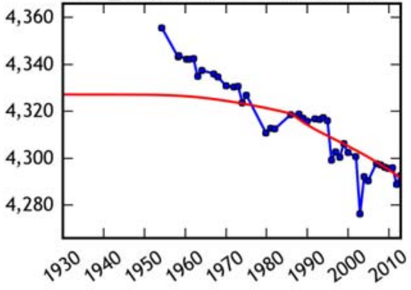
234702 (Dallam, TX)
HP_000244 LSD: 4388 TD: 117



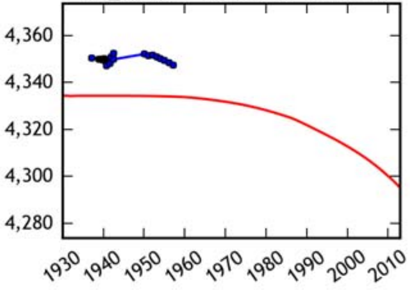
234706 (Dallam, TX)
HP_000248 LSD: 4390 TD: 118



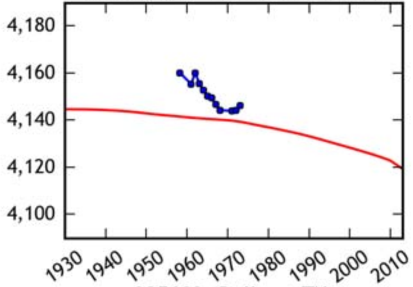
234803 (Dallam, TX)
HP_000257 LSD: 4383 TD: 140



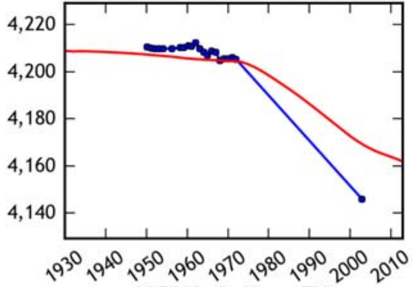
234805 (Dallam, TX)
HP_000259 LSD: 4417 TD: 113



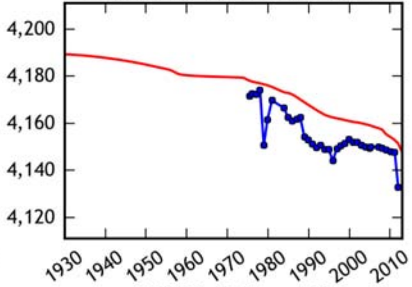
235202 (Dallam, TX)
HP_000267 LSD: 4219 TD: 177



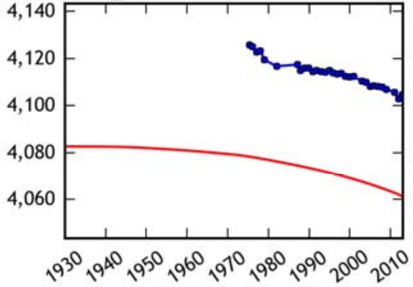
235401 (Dallam, TX)
HP_000271 LSD: 4236 TD: 120



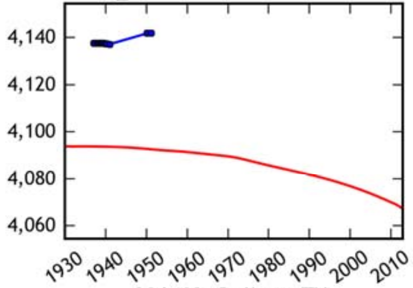
235502 (Dallam, TX)
HP_000276 LSD: 4236 TD: 135



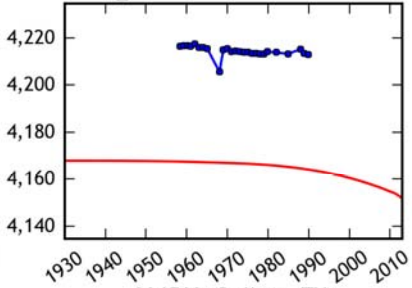
235602 (Dallam, TX)
HP_000278 LSD: 4161 TD: 130



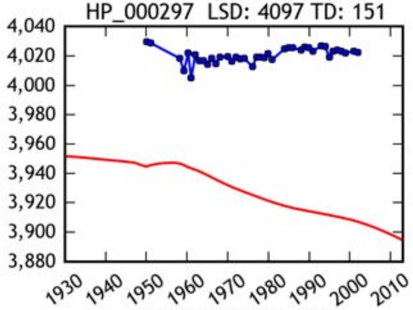
235603 (Dallam, TX)
HP_000279 LSD: 4183 TD: 48



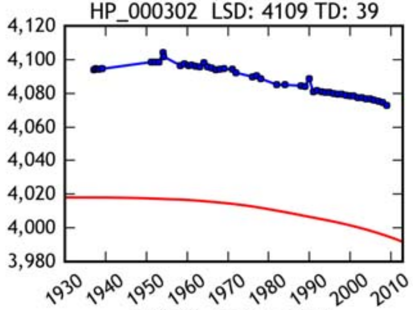
235702 (Dallam, TX)
HP_000281 LSD: 4229 TD: 80



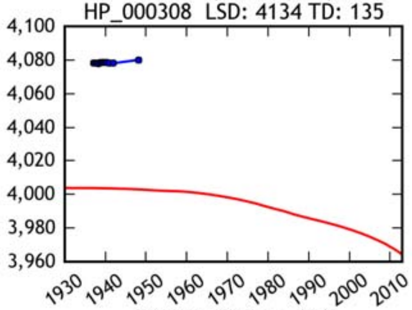
236301 (Dallam, TX)
HP_000297 LSD: 4097 TD: 151



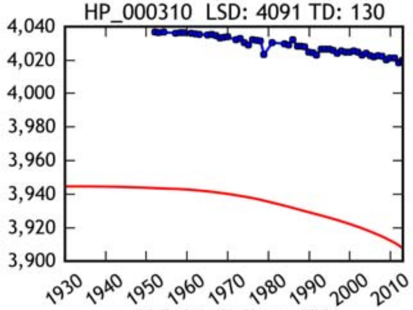
236402 (Dallam, TX)
HP_000302 LSD: 4109 TD: 39



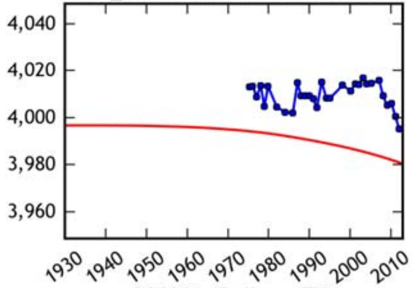
236503 (Dallam, TX)
HP_000308 LSD: 4134 TD: 135



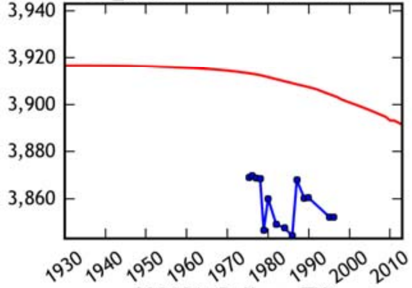
236601 (Dallam, TX)
HP_000310 LSD: 4091 TD: 130



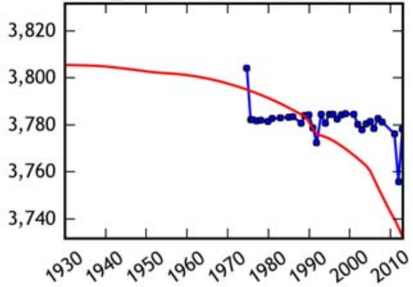
236701 (Dallam, TX)
HP_000312 LSD: 4151 TD: 207



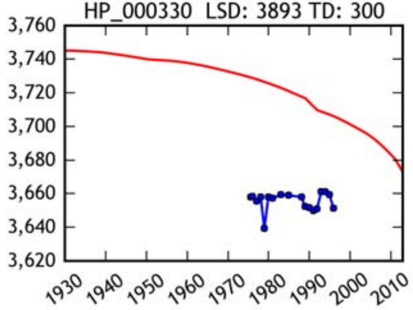
236902 (Dallam, TX)
HP_000318 LSD: 4093 TD: 271



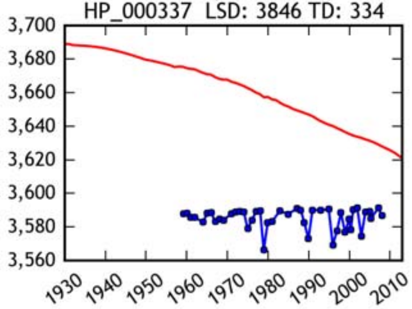
237601 (Dallam, TX)
HP_000323 LSD: 4004 TD: 313

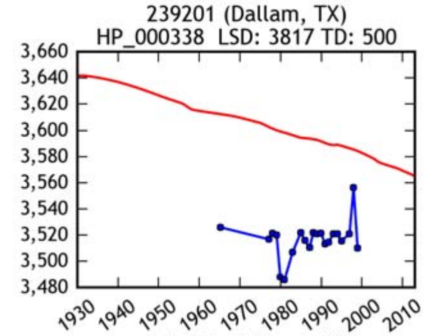


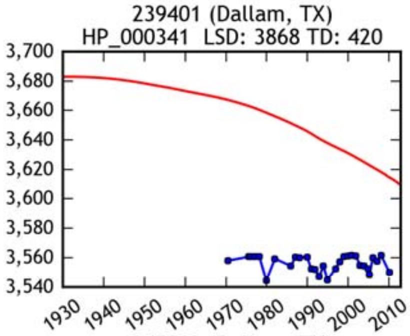
238201 (Dallam, TX)
HP_000330 LSD: 3893 TD: 300

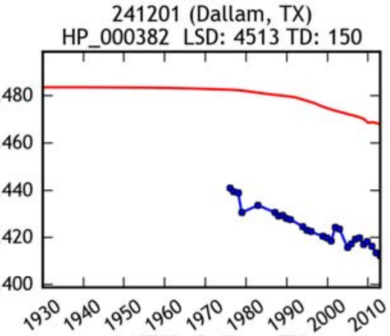


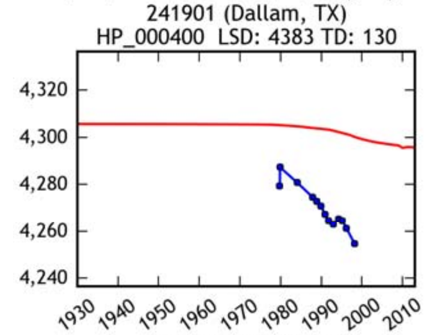
239101 (Dallam, TX)
HP_000337 LSD: 3846 TD: 334

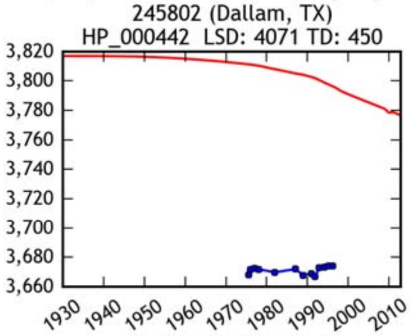


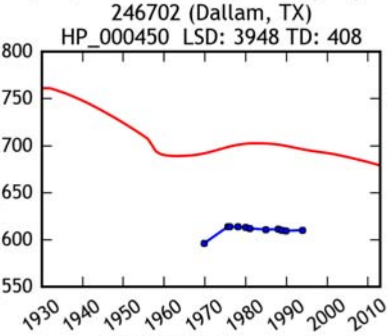

239201 (Dallam, TX)
HP_000338 LSD: 3817 TD: 500

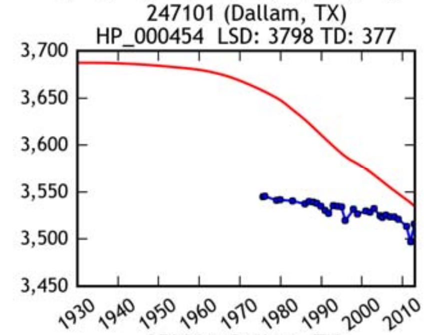

239401 (Dallam, TX)
HP_000341 LSD: 3868 TD: 420

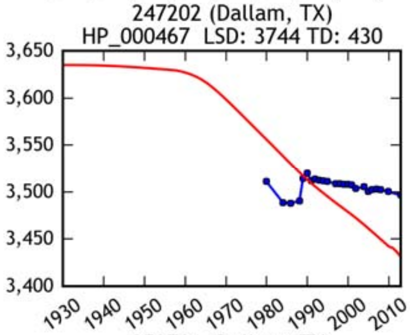

241201 (Dallam, TX)
HP_000382 LSD: 4513 TD: 150

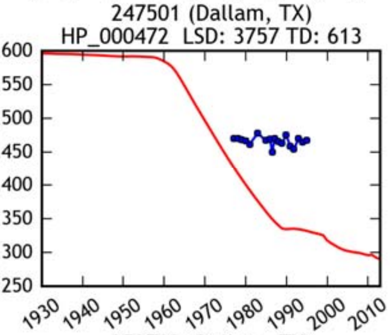

241901 (Dallam, TX)
HP_000400 LSD: 4383 TD: 130

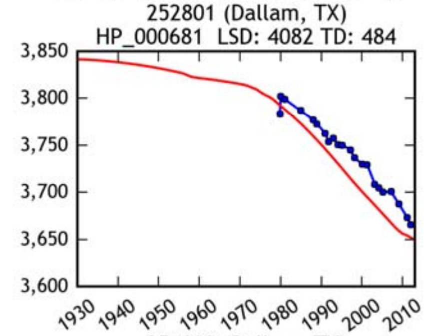

245802 (Dallam, TX)
HP_000442 LSD: 4071 TD: 450

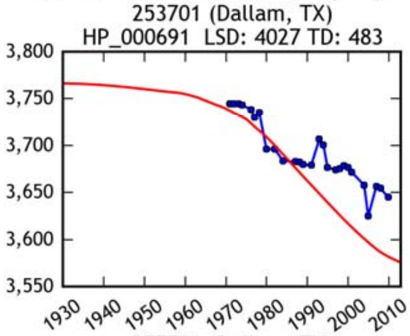

246702 (Dallam, TX)
HP_000450 LSD: 3948 TD: 408

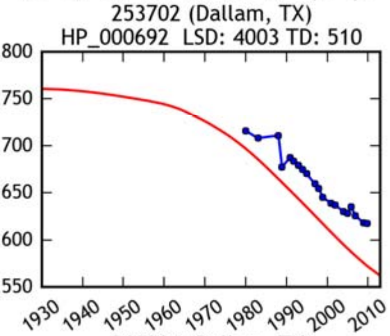

247101 (Dallam, TX)
HP_000454 LSD: 3798 TD: 377

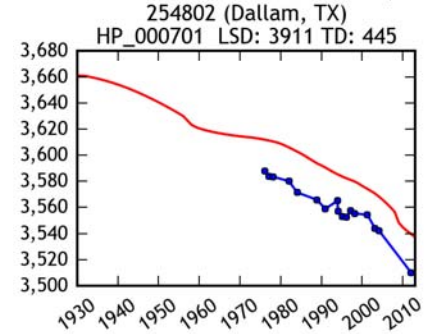

247202 (Dallam, TX)
HP_000467 LSD: 3744 TD: 430

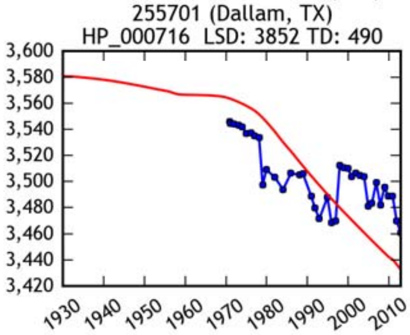

247501 (Dallam, TX)
HP_000472 LSD: 3757 TD: 613

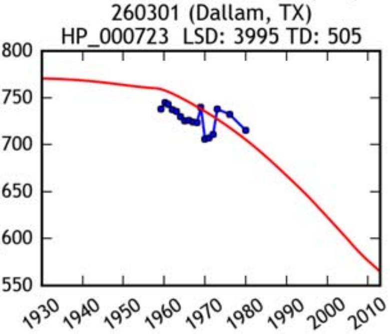

252801 (Dallam, TX)
HP_000681 LSD: 4082 TD: 484

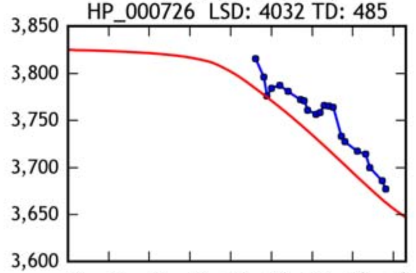

253701 (Dallam, TX)
HP_000691 LSD: 4027 TD: 483

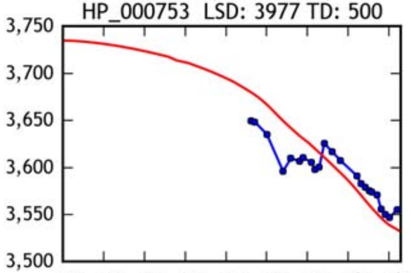

253702 (Dallam, TX)
HP_000692 LSD: 4003 TD: 510

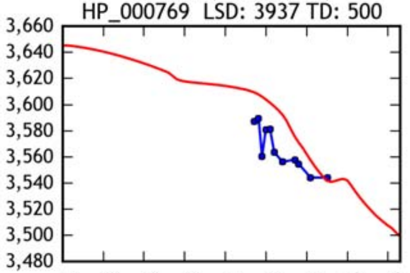

254802 (Dallam, TX)
HP_000701 LSD: 3911 TD: 445

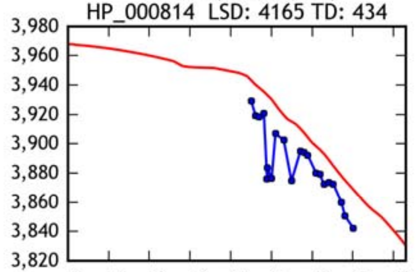

255701 (Dallam, TX)
HP_000716 LSD: 3852 TD: 490

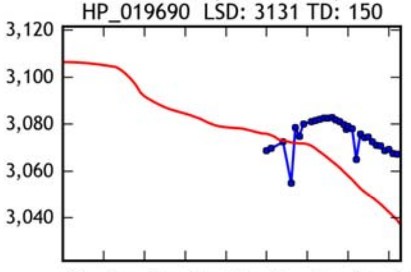

260301 (Dallam, TX)
HP_000723 LSD: 3995 TD: 505

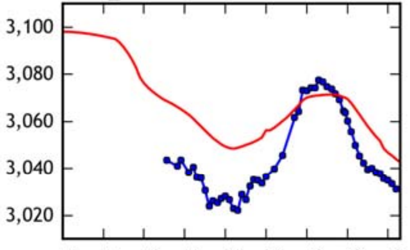

260401 (Dallam, TX)
HP_000726 LSD: 4032 TD: 485

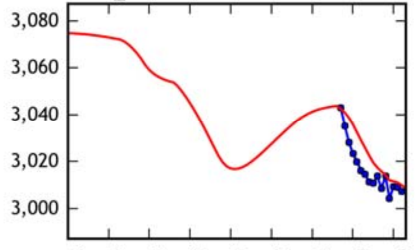

261501 (Dallam, TX)
HP_000753 LSD: 3977 TD: 500

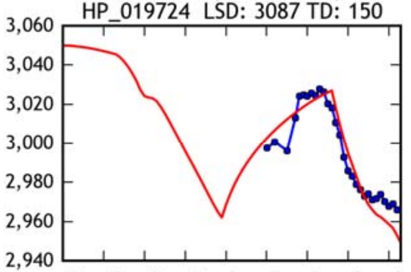

262402 (Dallam, TX)
HP_000769 LSD: 3937 TD: 500

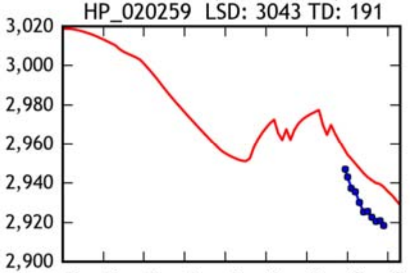

259402 (Dallam, TX)
HP_000814 LSD: 4165 TD: 434

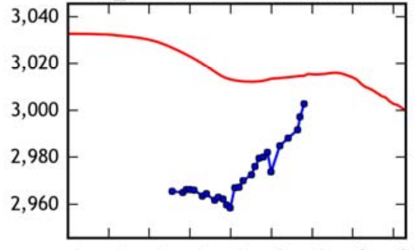

2707801 (Dawson, TX)
HP_019690 LSD: 3131 TD: 150

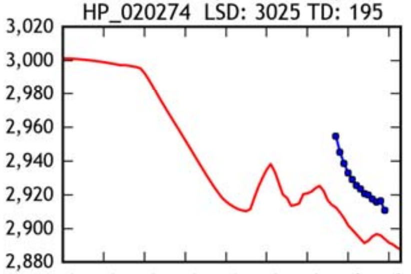

2707901 (Dawson, TX)
HP_019693 LSD: 3114 TD: 148

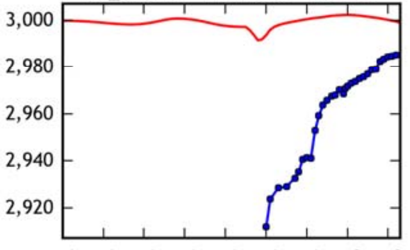

2708505 (Dawson, TX)
HP_019714 LSD: 3094 TD: 110

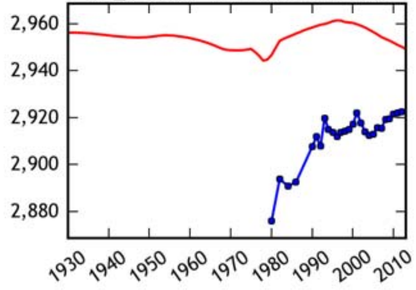

2708801 (Dawson, TX)
HP_019724 LSD: 3087 TD: 150

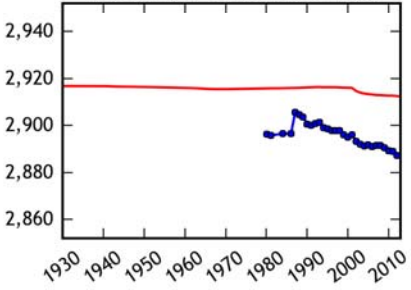

2716301 (Dawson, TX)
HP_020259 LSD: 3043 TD: 191

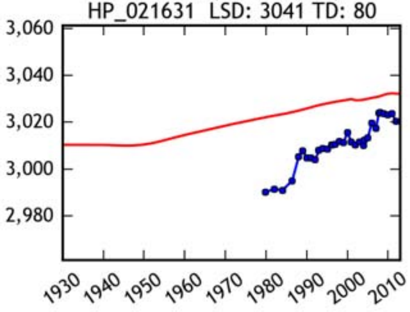

2716401 (Dawson, TX)
HP_020260 LSD: 3068 TD: 160


2716607 (Dawson, TX)
HP_020274 LSD: 3025 TD: 195

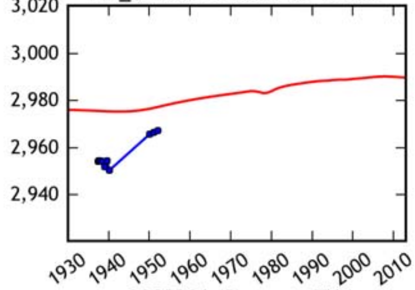

2724202 (Dawson, TX)
HP_020777 LSD: 3007 TD: 117


2724902 (Dawson, TX)
HP_020806 LSD: 2951 TD: 150

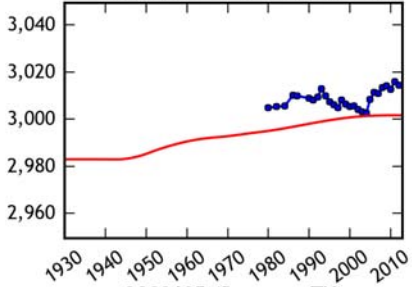

2731602 (Dawson, TX)
HP_021011 LSD: 2913 TD: 85


2801801 (Dawson, TX)
HP_021631 LSD: 3041 TD: 80

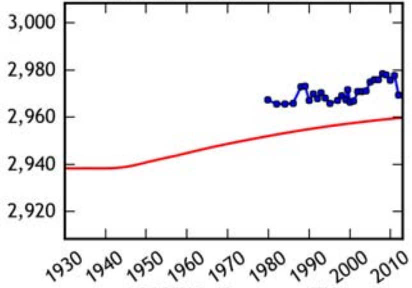
2801904 (Dawson, TX)
HP_021636 LSD: 3003 TD: 60



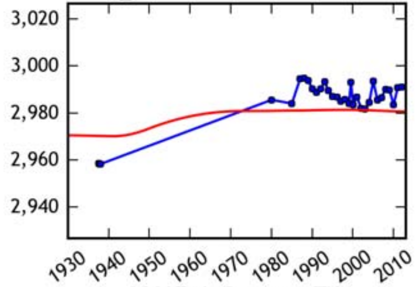
2802501 (Dawson, TX)
HP_021657 LSD: 3034 TD: 68



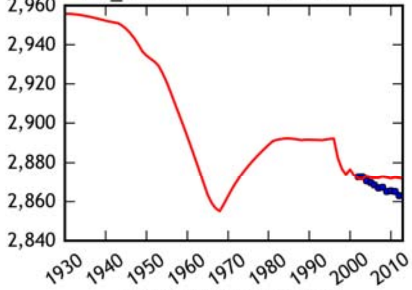
2802901 (Dawson, TX)
HP_021667 LSD: 2991 TD: 60



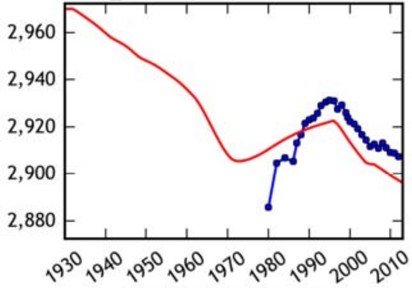
2809301 (Dawson, TX)
HP_021722 LSD: 3004 TD: 52



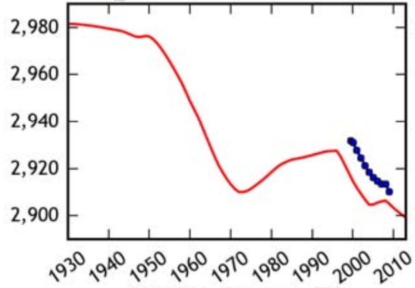
2809605 (Dawson, TX)
HP_021733 LSD: 2998 TD: 168



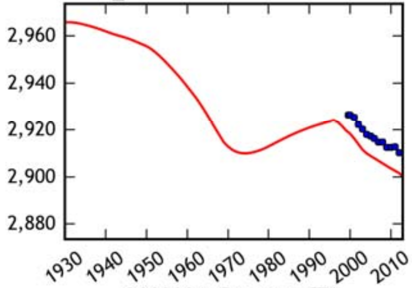
2809710 (Dawson, TX)
HP_021744 LSD: 2985 TD: 200



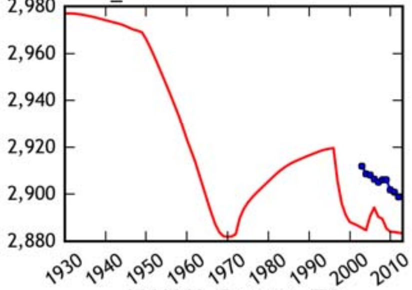
2809716 (Dawson, TX)
HP_021750 LSD: 3001 TD: 202



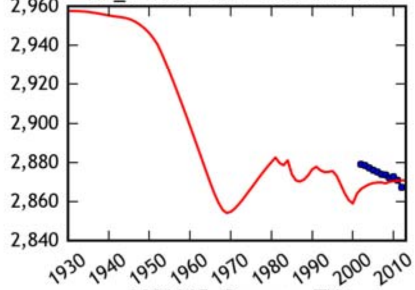
2809717 (Dawson, TX)
HP_021751 LSD: 2996 TD: 201



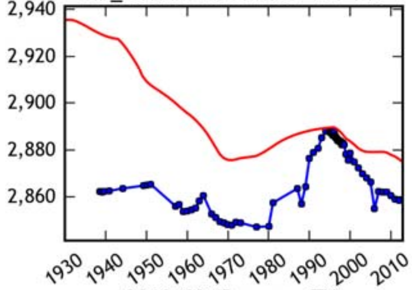
2809719 (Dawson, TX)
HP_021753 LSD: 3006 TD: 208



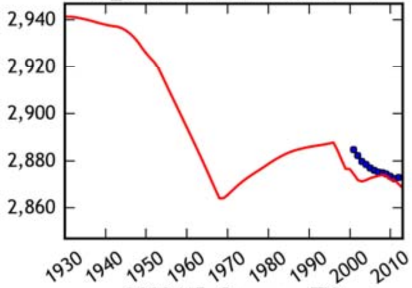
2809809 (Dawson, TX)
HP_021765 LSD: 3009 TD: 168



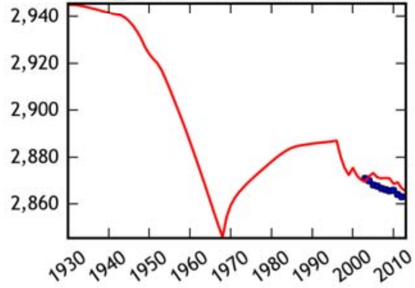
2809901 (Dawson, TX)
HP_021774 LSD: 2986 TD: 140



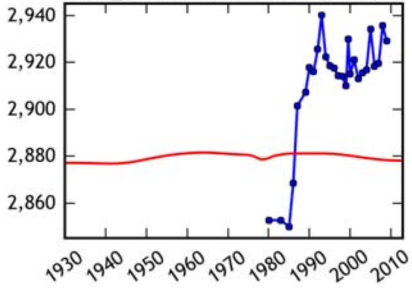
2809903 (Dawson, TX)
HP_021776 LSD: 2986 TD: 147



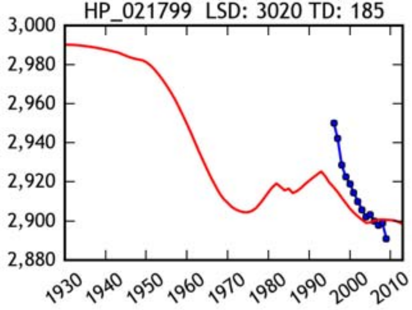
2809905 (Dawson, TX)
HP_021778 LSD: 2992 TD: 156



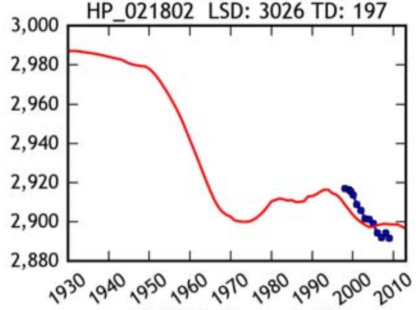
2810403 (Dawson, TX)
HP_021791 LSD: 2950 TD: 140



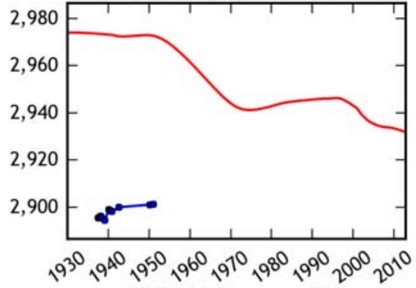
2809415 (Dawson, TX)
HP_021799 LSD: 3020 TD: 185



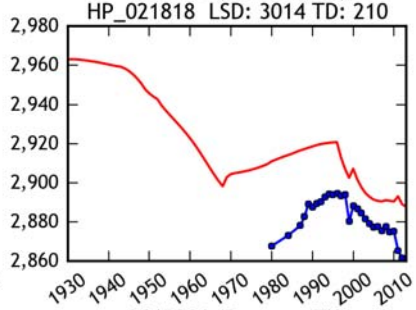
2809418 (Dawson, TX)
HP_021802 LSD: 3026 TD: 197



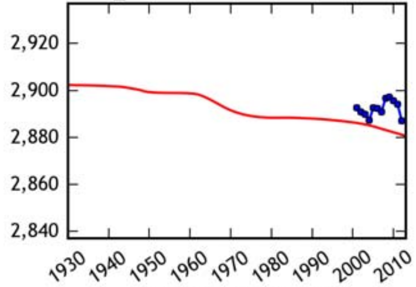
2809502 (Dawson, TX)
HP_021810 LSD: 2997 TD: 113



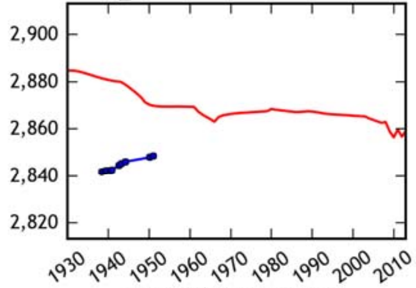
2809602 (Dawson, TX)
HP_021818 LSD: 3014 TD: 210



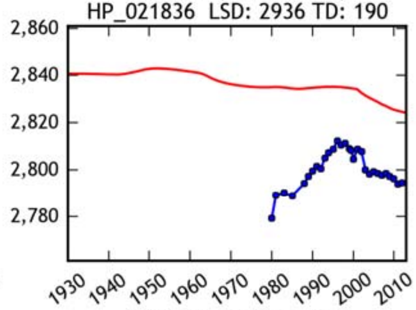
2817705 (Dawson, TX)
HP_021819 LSD: 2923 TD: 153



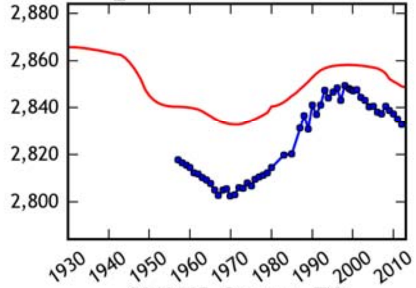
2817901 (Dawson, TX)
HP_021828 LSD: 2924 TD: 86



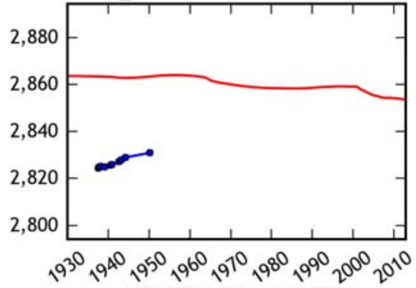
2818201 (Dawson, TX)
HP_021836 LSD: 2936 TD: 190



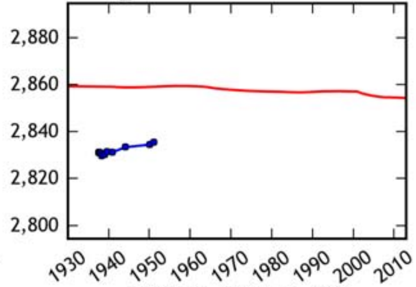
2818501 (Dawson, TX)
HP_021848 LSD: 2915 TD: 160



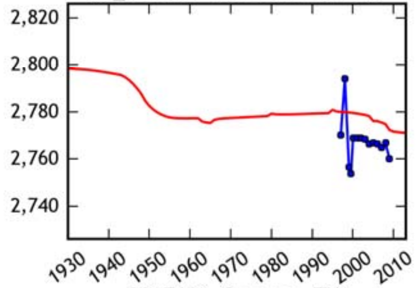
2818701 (Dawson, TX)
HP_021861 LSD: 2910 TD: 88



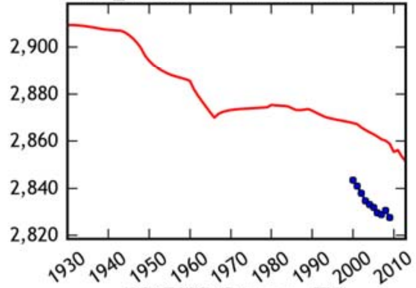
2818703 (Dawson, TX)
HP_021863 LSD: 2884 TD: 65



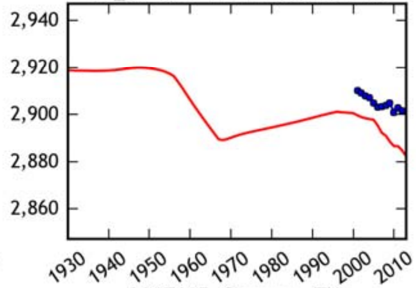
2819105 (Dawson, TX)
HP_021880 LSD: 2922 TD: 197



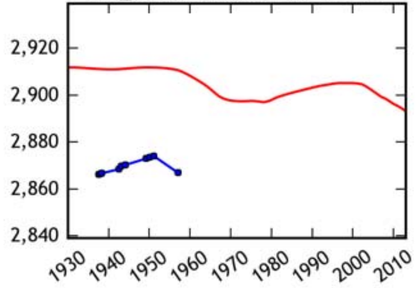
2810704 (Dawson, TX)
HP_021996 LSD: 2988 TD: 200



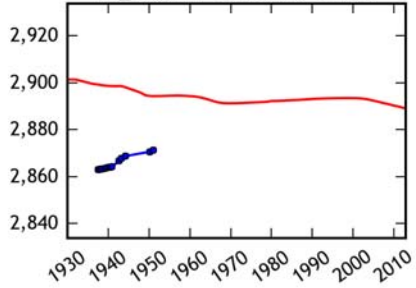
2817306 (Dawson, TX)
HP_022075 LSD: 2966 TD: 188



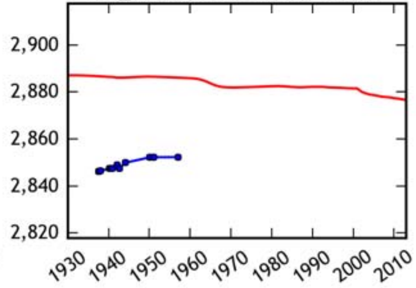
2817601 (Dawson, TX)
HP_022094 LSD: 2936 TD: 92



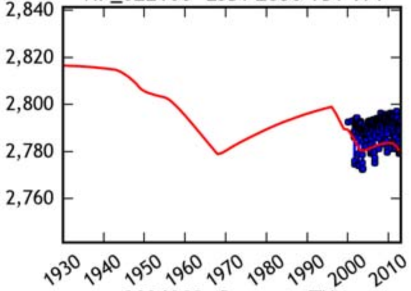
2817603 (Dawson, TX)
HP_022096 LSD: 2937 TD: 77



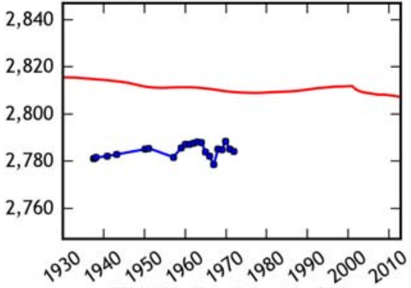
2817605 (Dawson, TX)
HP_022098 LSD: 2925 TD: 84



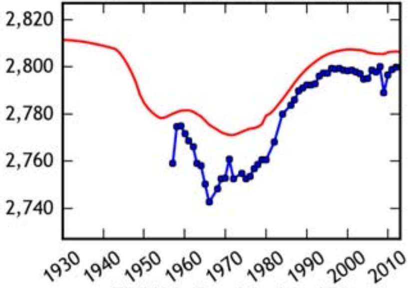
2825604 (Dawson, TX)
HP_022108 LSD: 2856 TD: 191



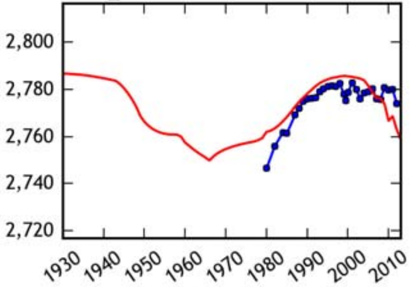
2826203 (Dawson, TX)
HP_022125 LSD: 2878 TD: 118



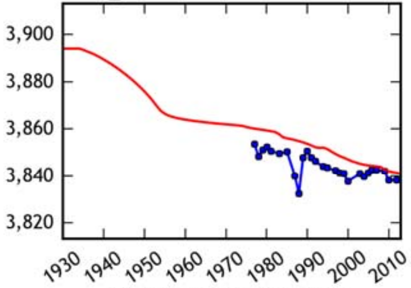
2826206 (Dawson, TX)
HP_022128 LSD: 2871 TD: 170



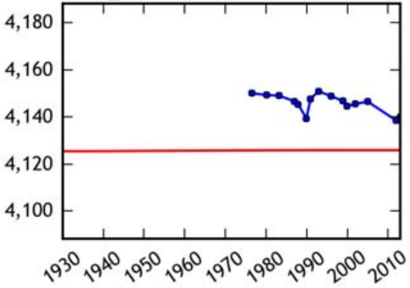
2826302 (Dawson, TX)
HP_022133 LSD: 2866 TD: 187



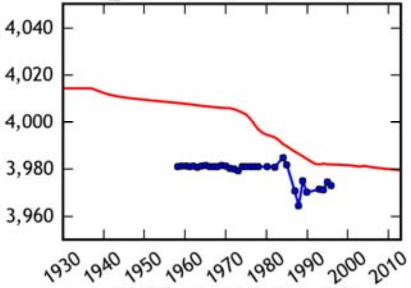
751902 (Deaf Smith, TX)
HP_006998 LSD: 4148 TD: 394



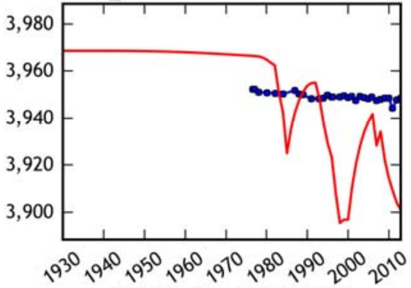
757401 (Deaf Smith, TX)
HP_007492 LSD: 4327 TD: 215



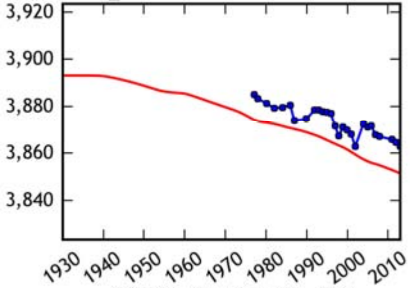
758801 (Deaf Smith, TX)
HP_007506 LSD: 4229 TD: 265



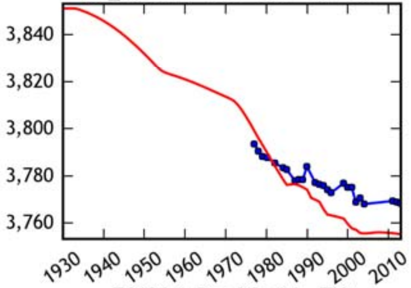
758901 (Deaf Smith, TX)
HP_007507 LSD: 4171 TD: 275



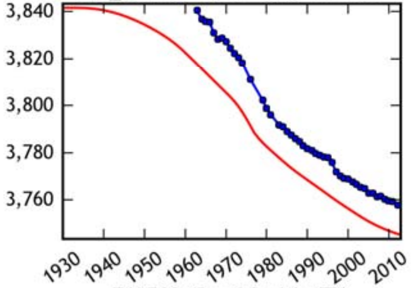
759802 (Deaf Smith, TX)
HP_007517 LSD: 4130 TD: 340



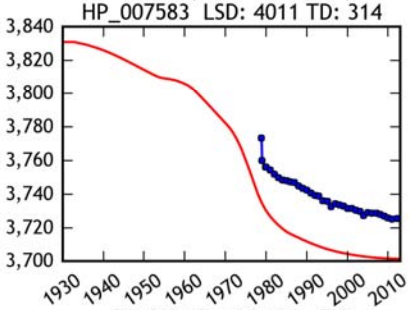
760302 (Deaf Smith, TX)
HP_007524 LSD: 4067 TD: 367



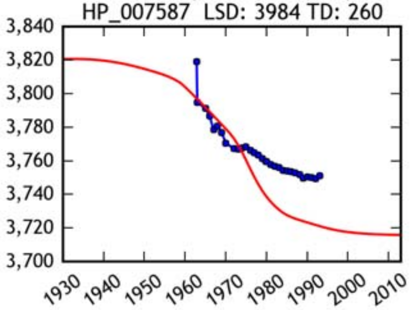
760901 (Deaf Smith, TX)
HP_007539 LSD: 4035 TD: 302



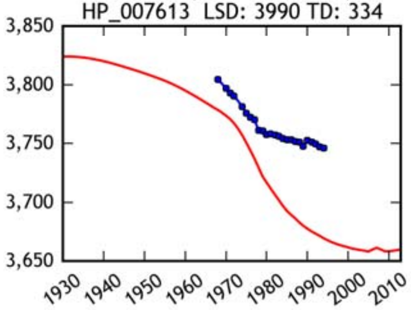
761224 (Deaf Smith, TX)
HP_007583 LSD: 4011 TD: 314



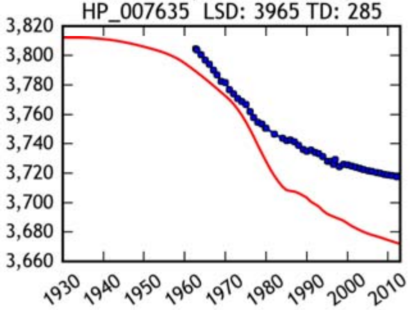
761301 (Deaf Smith, TX)
HP_007587 LSD: 3984 TD: 260

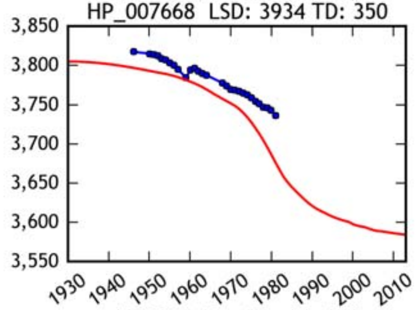


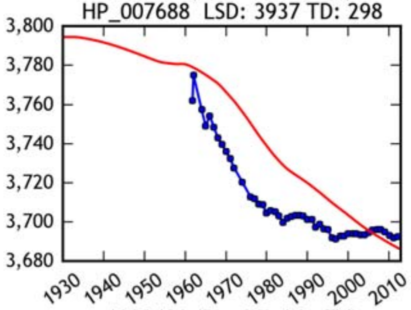
761502 (Deaf Smith, TX)
HP_007613 LSD: 3990 TD: 334

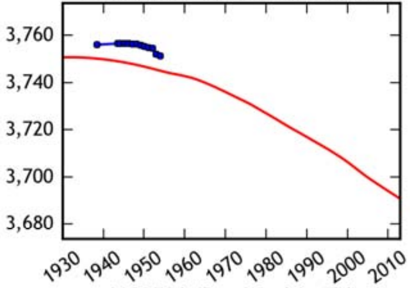


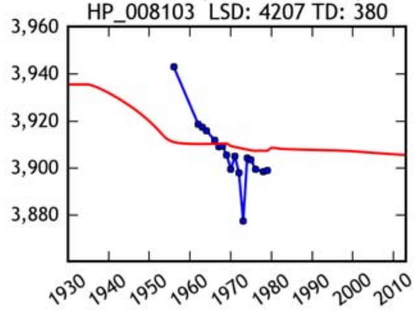
761601 (Deaf Smith, TX)
HP_007635 LSD: 3965 TD: 285

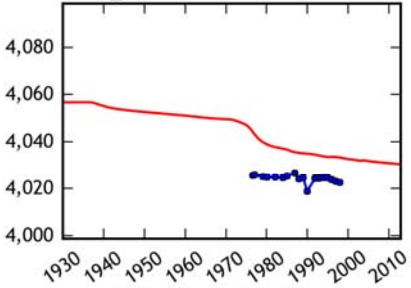


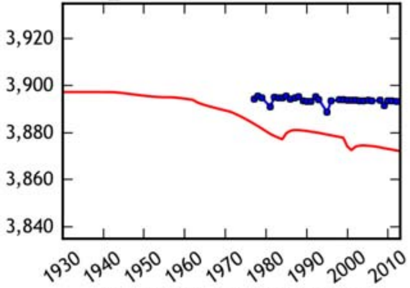

761901 (Deaf Smith, TX)
HP_007668 LSD: 3934 TD: 350

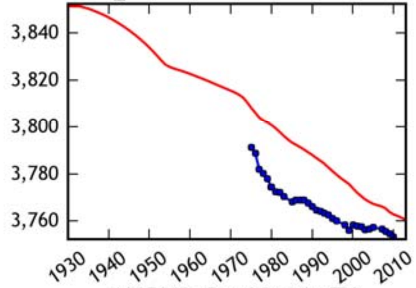

762101 (Deaf Smith, TX)
HP_007688 LSD: 3937 TD: 298

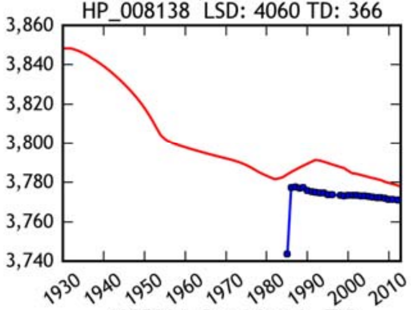

762302 (Deaf Smith, TX)
HP_007694 LSD: 3890 TD: 140

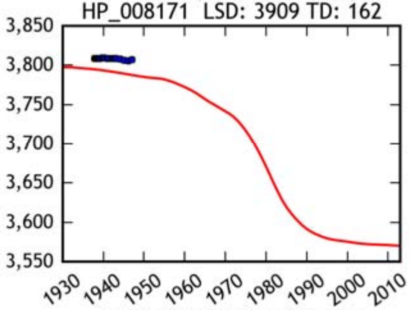

1002302 (Deaf Smith, TX)
HP_008103 LSD: 4207 TD: 380

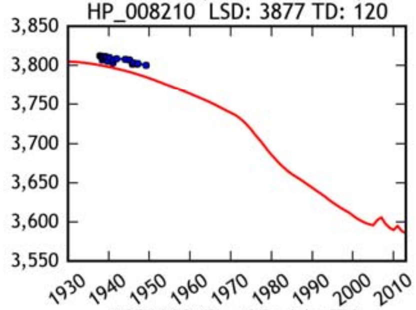

1002401 (Deaf Smith, TX)
HP_008104 LSD: 4232 TD: 221

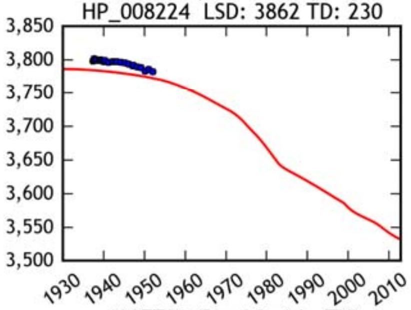

1003501 (Deaf Smith, TX)
HP_008118 LSD: 4154 TD: 302

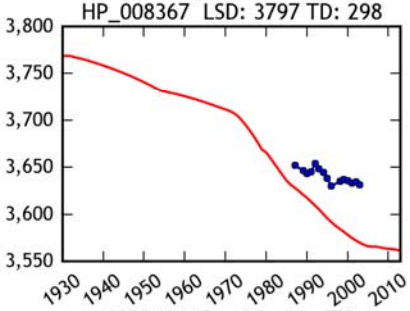

1004202 (Deaf Smith, TX)
HP_008132 LSD: 4077 TD: 373

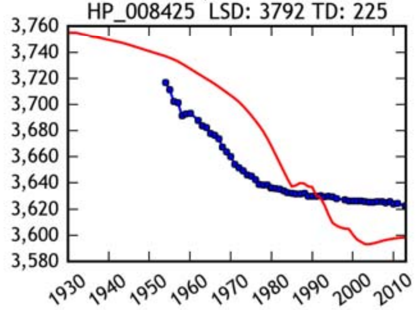

1004504 (Deaf Smith, TX)
HP_008138 LSD: 4060 TD: 366

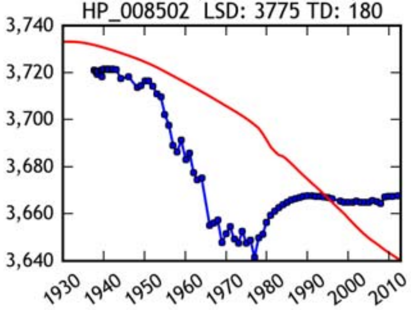

1005303 (Deaf Smith, TX)
HP_008171 LSD: 3909 TD: 162

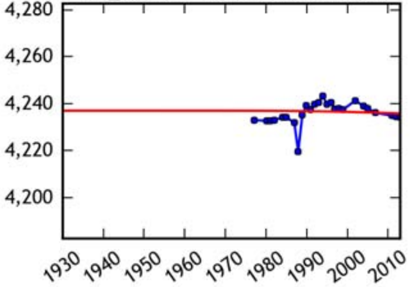

1005803 (Deaf Smith, TX)
HP_008210 LSD: 3877 TD: 120


1005904 (Deaf Smith, TX)
HP_008224 LSD: 3862 TD: 230

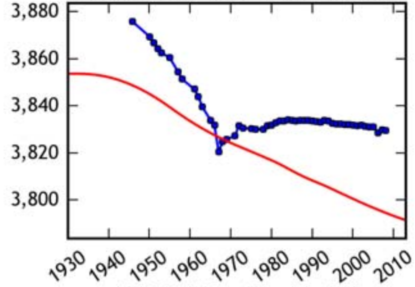

1006805 (Deaf Smith, TX)
HP_008367 LSD: 3797 TD: 298


1006909 (Deaf Smith, TX)
HP_008425 LSD: 3792 TD: 225

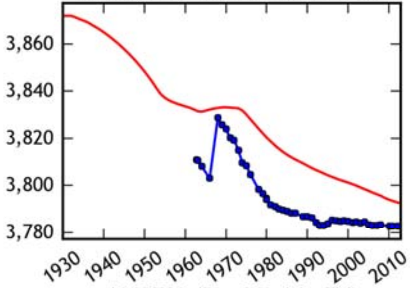

1007701 (Deaf Smith, TX)
HP_008502 LSD: 3775 TD: 180


1009401 (Deaf Smith, TX)
HP_008609 LSD: 4333 TD: 125

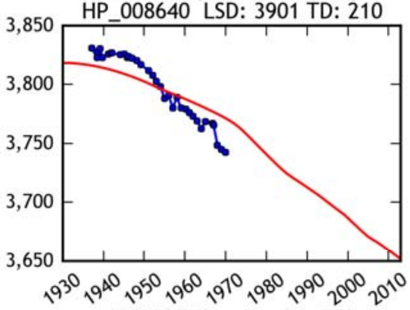
1011601 (Deaf Smith, TX)
HP_008624 LSD: 3996 TD: 185



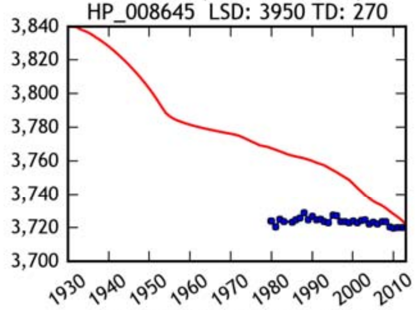
1011901 (Deaf Smith, TX)
HP_008629 LSD: 3990 TD: 240



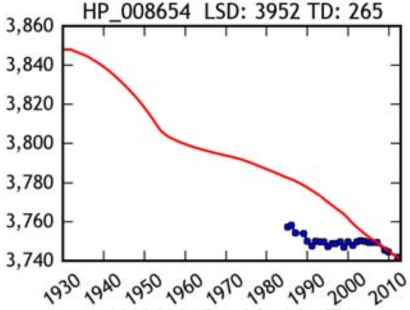
1012301 (Deaf Smith, TX)
HP_008640 LSD: 3901 TD: 210



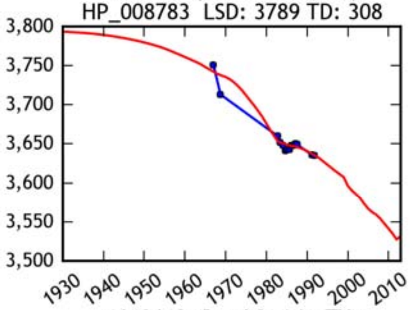
1012404 (Deaf Smith, TX)
HP_008645 LSD: 3950 TD: 270



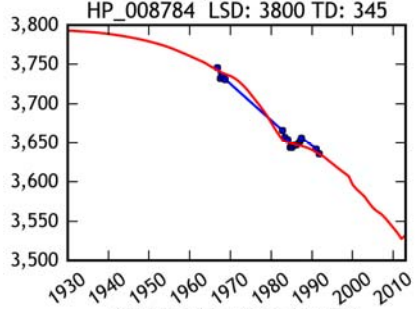
1012703 (Deaf Smith, TX)
HP_008654 LSD: 3952 TD: 265



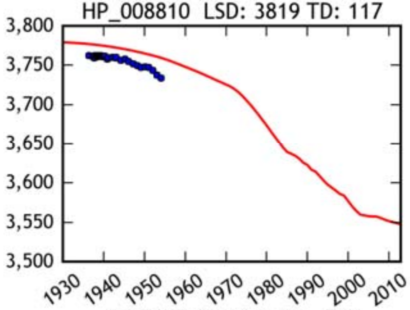
1013537 (Deaf Smith, TX)
HP_008783 LSD: 3789 TD: 308



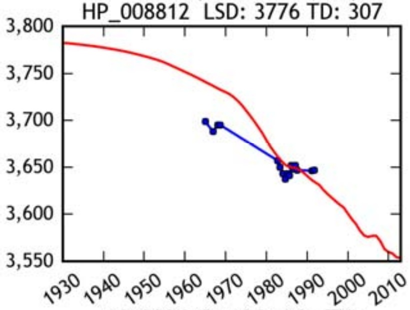
1013538 (Deaf Smith, TX)
HP_008784 LSD: 3800 TD: 345



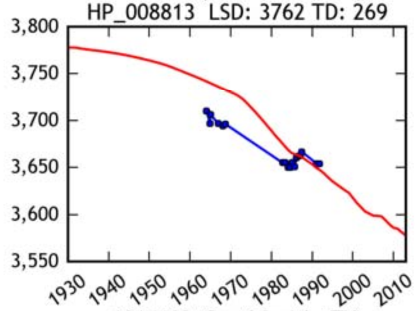
1013610 (Deaf Smith, TX)
HP_008810 LSD: 3819 TD: 117



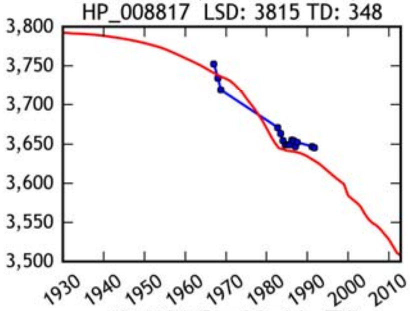
1013612 (Deaf Smith, TX)
HP_008812 LSD: 3776 TD: 307



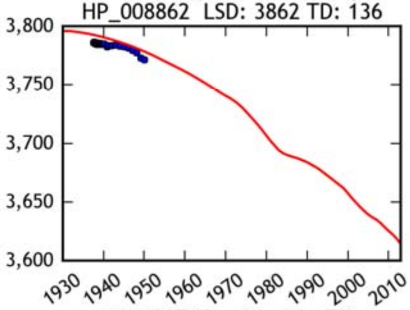
1013613 (Deaf Smith, TX)
HP_008813 LSD: 3762 TD: 269



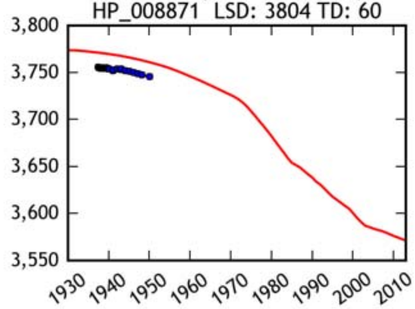
1013617 (Deaf Smith, TX)
HP_008817 LSD: 3815 TD: 348



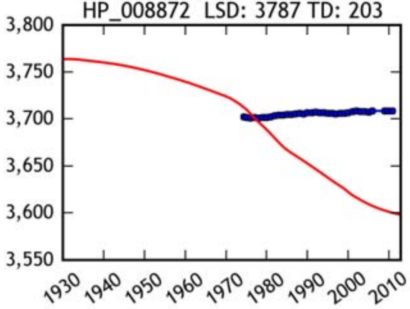
1013904 (Deaf Smith, TX)
HP_008862 LSD: 3862 TD: 136



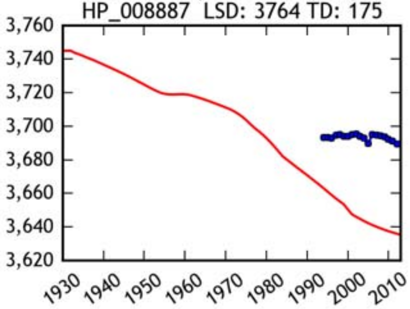
1014103 (Deaf Smith, TX)
HP_008871 LSD: 3804 TD: 60

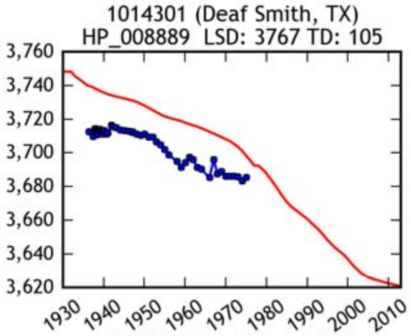


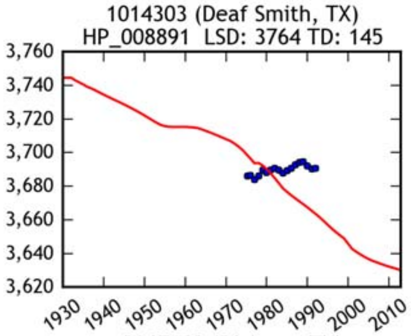
1014104 (Deaf Smith, TX)
HP_008872 LSD: 3787 TD: 203

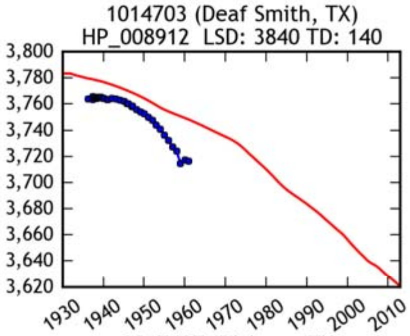


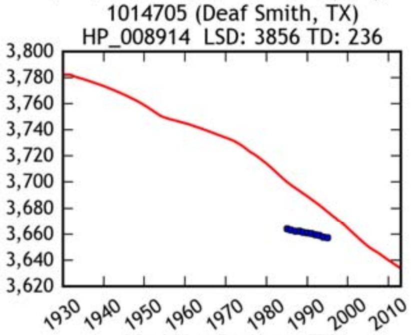
1014207 (Deaf Smith, TX)
HP_008887 LSD: 3764 TD: 175

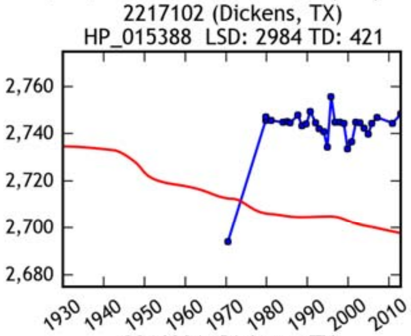


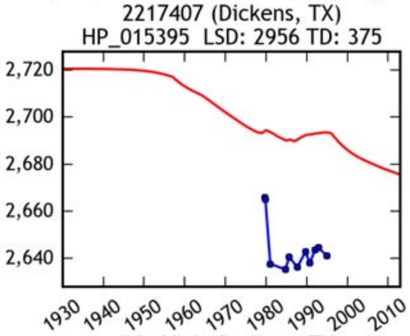

1014301 (Deaf Smith, TX)
HP_008889 LSD: 3767 TD: 105

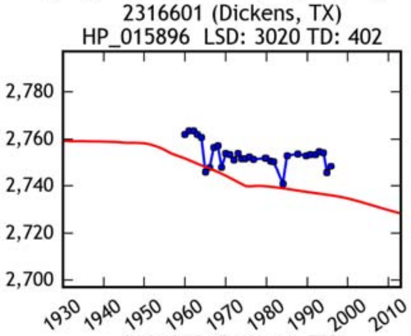

1014303 (Deaf Smith, TX)
HP_008891 LSD: 3764 TD: 145

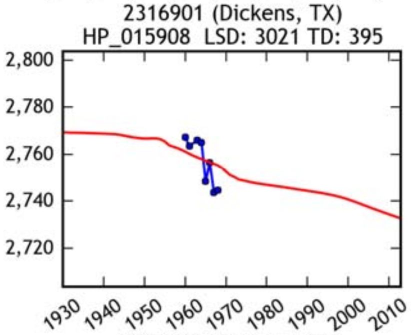

1014703 (Deaf Smith, TX)
HP_008912 LSD: 3840 TD: 140

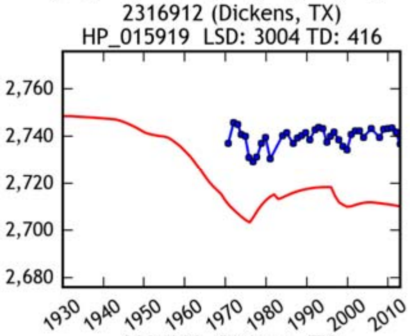

1014705 (Deaf Smith, TX)
HP_008914 LSD: 3856 TD: 236

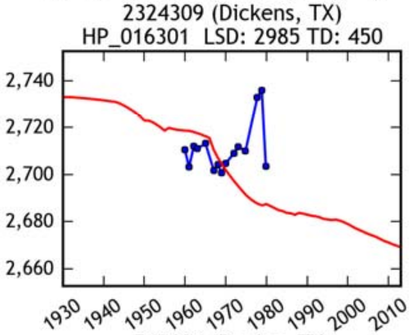

2217102 (Dickens, TX)
HP_015388 LSD: 2984 TD: 421

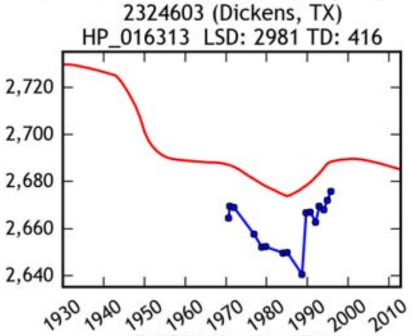

2217407 (Dickens, TX)
HP_015395 LSD: 2956 TD: 375

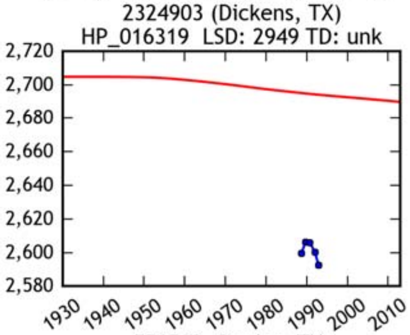

2316601 (Dickens, TX)
HP_015896 LSD: 3020 TD: 402

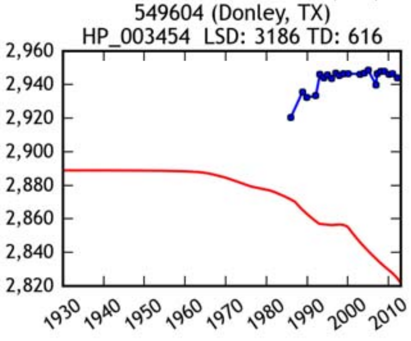

2316901 (Dickens, TX)
HP_015908 LSD: 3021 TD: 395

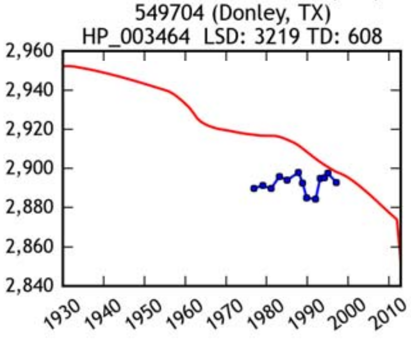

2316912 (Dickens, TX)
HP_015919 LSD: 3004 TD: 416

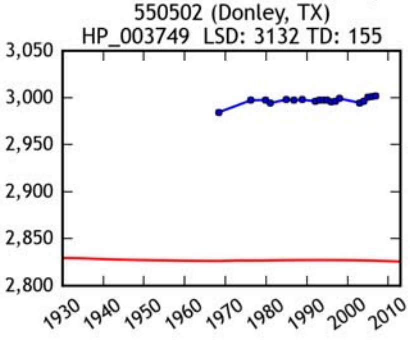

2324309 (Dickens, TX)
HP_016301 LSD: 2985 TD: 450


2324603 (Dickens, TX)
HP_016313 LSD: 2981 TD: 416

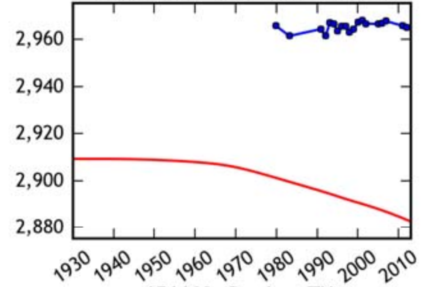

2324903 (Dickens, TX)
HP_016319 LSD: 2949 TD: unk


549604 (Donley, TX)
HP_003454 LSD: 3186 TD: 616

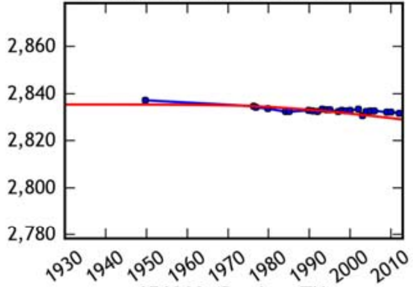

549704 (Donley, TX)
HP_003464 LSD: 3219 TD: 608


550502 (Donley, TX)
HP_003749 LSD: 3132 TD: 155

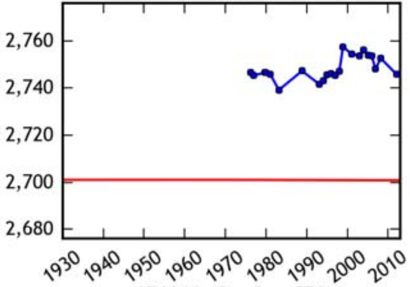
557101 (Donley, TX)
HP_003858 LSD: 3081 TD: 250



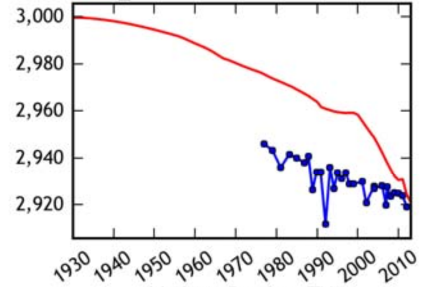
557502 (Donley, TX)
HP_003867 LSD: 2932 TD: 136



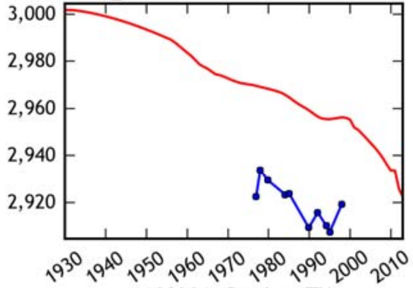
558303 (Donley, TX)
HP_003913 LSD: 2791 TD: 90



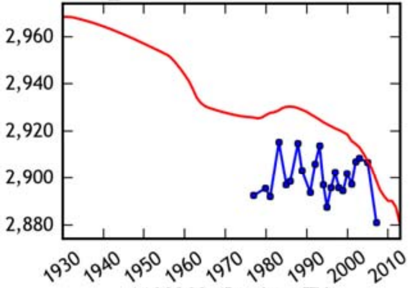
656603 (Donley, TX)
HP_006016 LSD: 3234 TD: 525



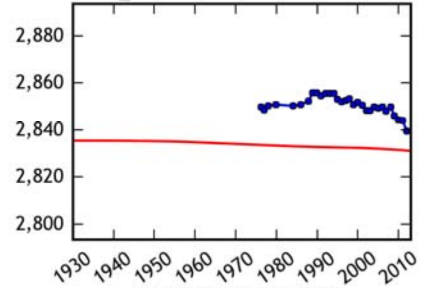
656802 (Donley, TX)
HP_006021 LSD: 3271 TD: 480



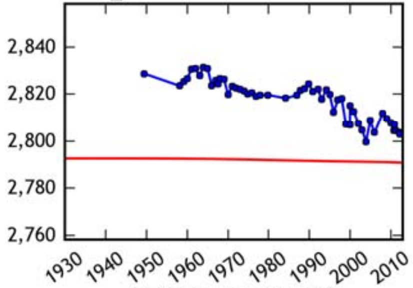
656903 (Donley, TX)
HP_006027 LSD: 3230 TD: 660



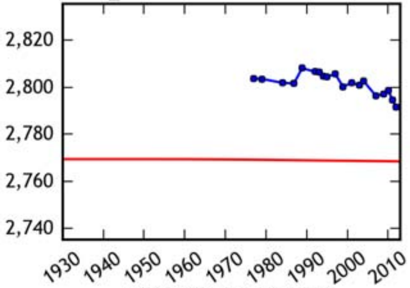
664811 (Donley, TX)
HP_006427 LSD: 2951 TD: 203



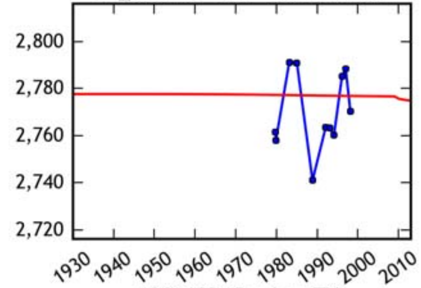
1108201 (Donley, TX)
HP_010752 LSD: 2929 TD: 207



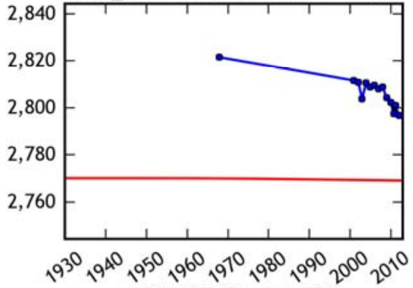
1108203 (Donley, TX)
HP_010754 LSD: 2837 TD: 157



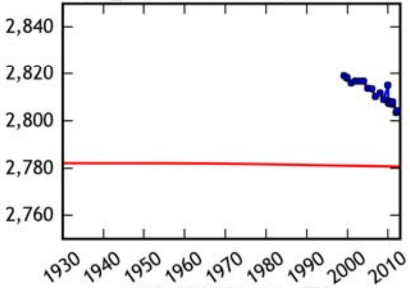
1108204 (Donley, TX)
HP_010755 LSD: 2864 TD: 150



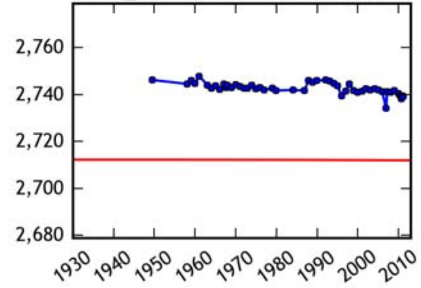
1108309 (Donley, TX)
HP_010765 LSD: 2882 TD: 155



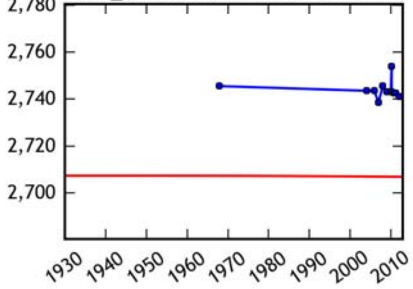
1108312 (Donley, TX)
HP_010768 LSD: 2886 TD: 171



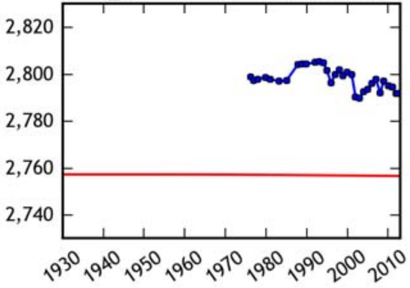
1201102 (Donley, TX)
HP_014670 LSD: 2771 TD: 88

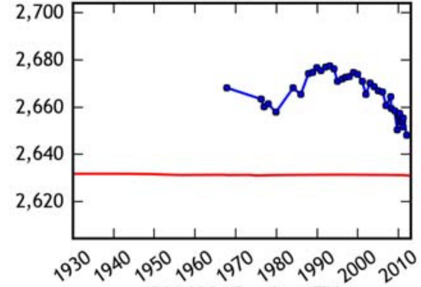


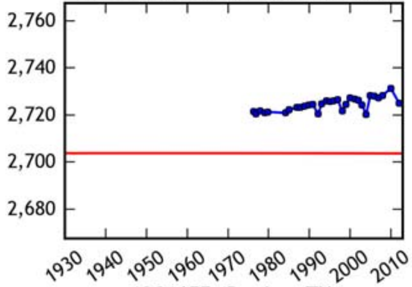
1201107 (Donley, TX)
HP_014675 LSD: 2790 TD: 118

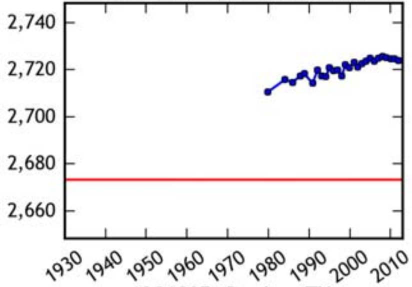


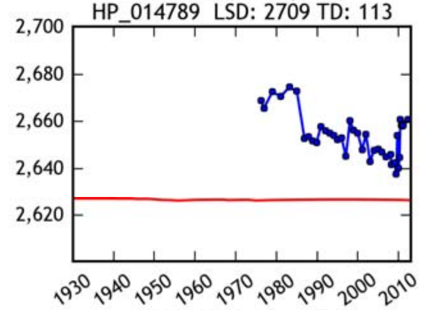
1201131 (Donley, TX)
HP_014699 LSD: 2851 TD: 116

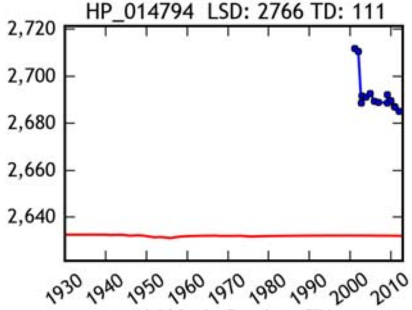


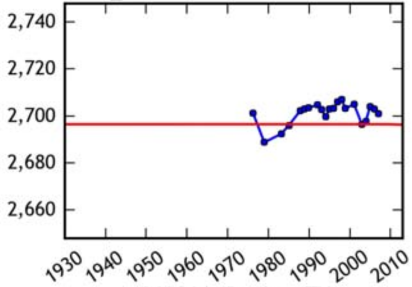

1201306 (Donley, TX)
HP_014725 LSD: 2717 TD: 152

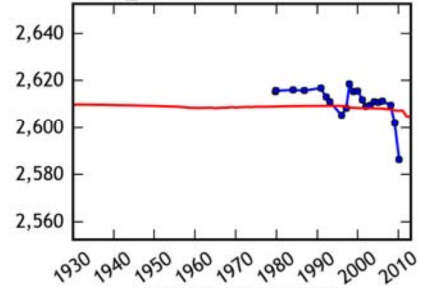

1201502 (Donley, TX)
HP_014752 LSD: 2861 TD: 205

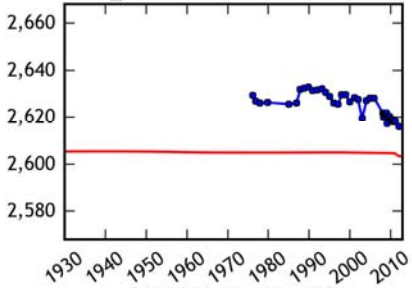

1201617 (Donley, TX)
HP_014783 LSD: 2843 TD: 177

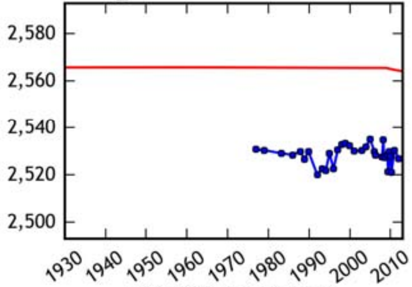

1201623 (Donley, TX)
HP_014789 LSD: 2709 TD: 113

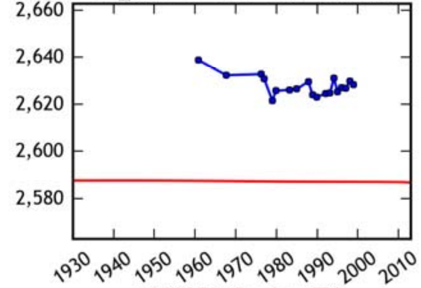

1201655 (Donley, TX)
HP_014794 LSD: 2766 TD: 111

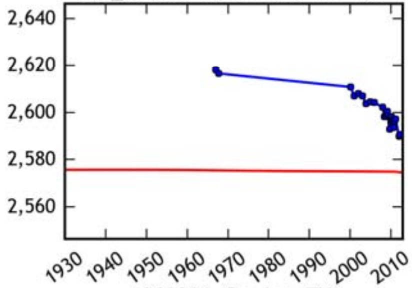

1201805 (Donley, TX)
HP_014801 LSD: 2900 TD: 216

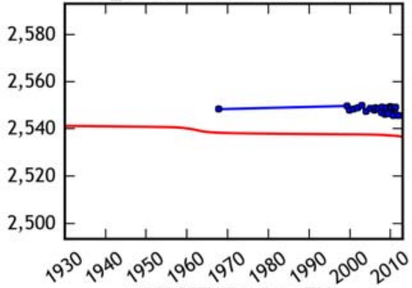

1202103 (Donley, TX)
HP_014815 LSD: 2622 TD: 81

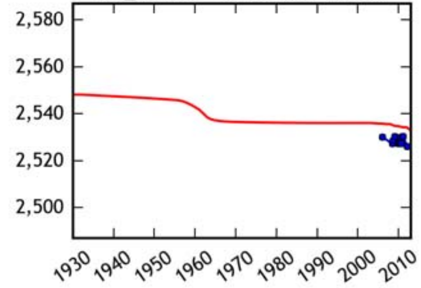

1202210 (Donley, TX)
HP_014830 LSD: 2690 TD: 190

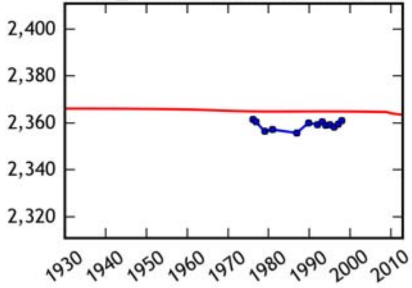

1202306 (Donley, TX)
HP_014835 LSD: 2591 TD: 80

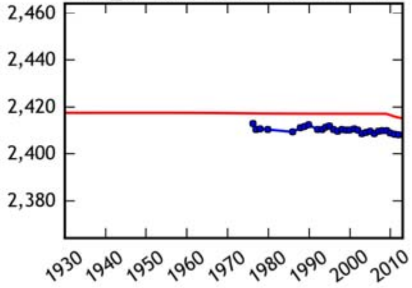

1202501 (Donley, TX)
HP_014848 LSD: 2697 TD: 266


1202604 (Donley, TX)
HP_014869 LSD: 2665 TD: 192

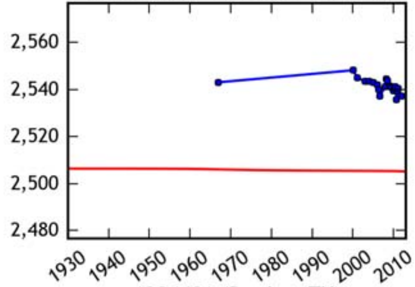

1202907 (Donley, TX)
HP_014909 LSD: 2561 TD: 116


1202958 (Donley, TX)
HP_014937 LSD: 2558 TD: 80

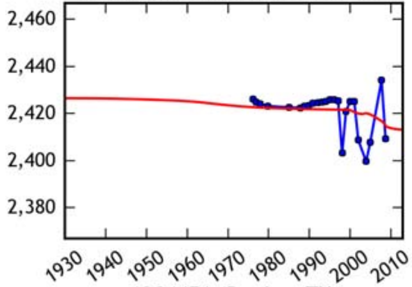

1203206 (Donley, TX)
HP_014949 LSD: 2397 TD: 80


1203207 (Donley, TX)
HP_014950 LSD: 2489 TD: 119

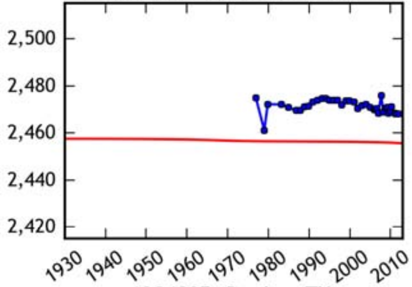
1203405 (Donley, TX)
HP_014958 LSD: 2611 TD: 144



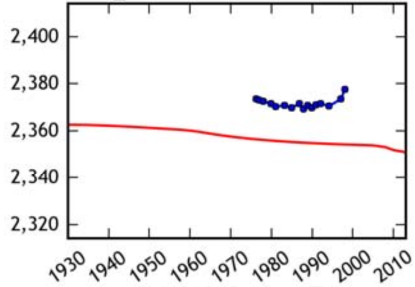
1203606 (Donley, TX)
HP_014984 LSD: 2519 TD: 160



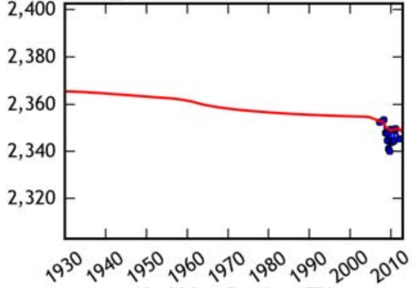
1203806 (Donley, TX)
HP_015015 LSD: 2591 TD: 150



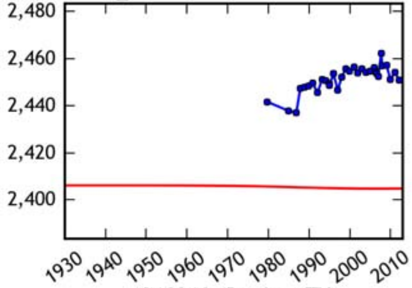
1204401 (Donley, TX)
HP_015039 LSD: 2451 TD: 160



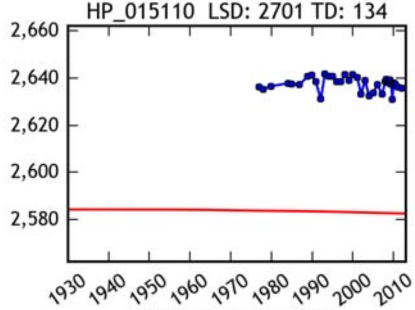
1204451 (Donley, TX)
HP_015043 LSD: 2478 TD: 230



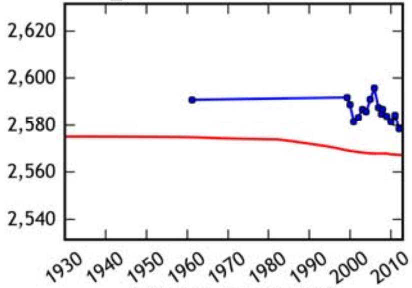
1204805 (Donley, TX)
HP_015069 LSD: 2485 TD: 59



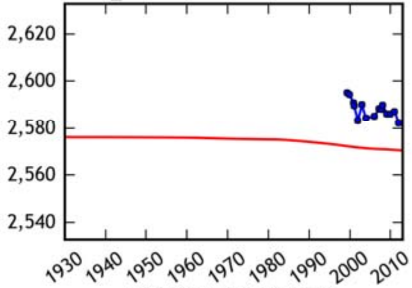
1210218 (Donley, TX)
HP_015110 LSD: 2701 TD: 134



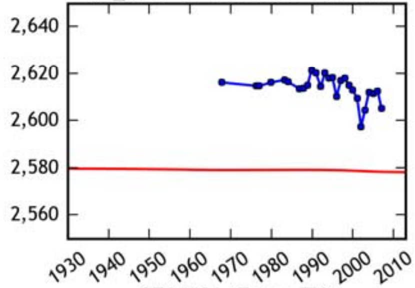
1210301 (Donley, TX)
HP_015114 LSD: 2600 TD: 128



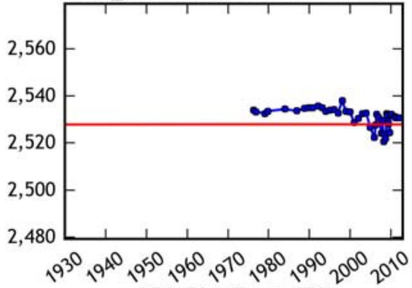
1210310 (Donley, TX)
HP_015123 LSD: 2615 TD: 130



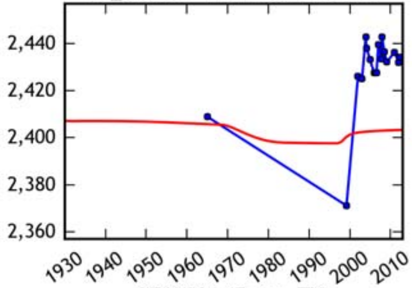
1210504 (Donley, TX)
HP_015146 LSD: 2699 TD: 144



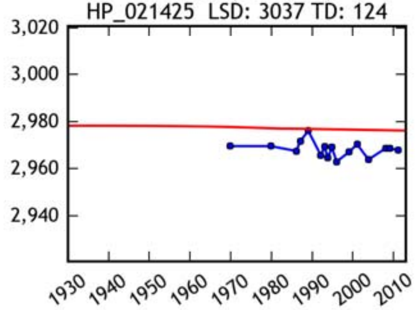
1211508 (Donley, TX)
HP_015220 LSD: 2697 TD: 205



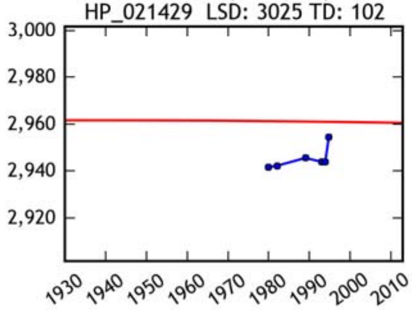
1212104 (Donley, TX)
HP_015231 LSD: 2562 TD: 217



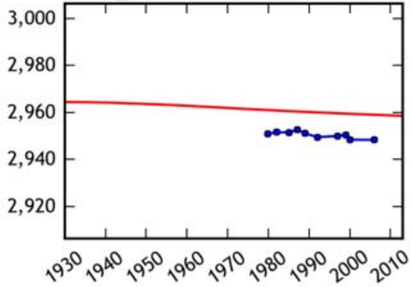
2761401 (Ector, TX)
HP_021425 LSD: 3037 TD: 124

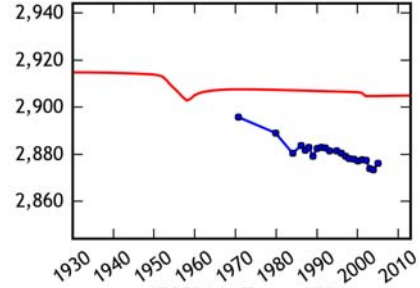


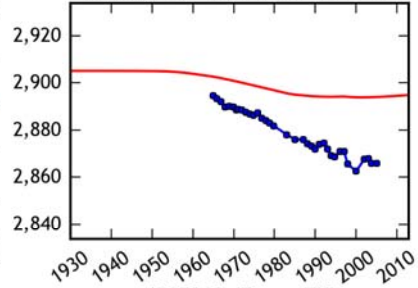
2761501 (Ector, TX)
HP_021429 LSD: 3025 TD: 102

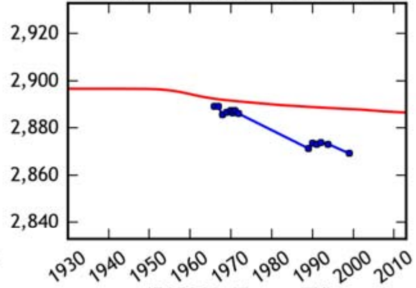


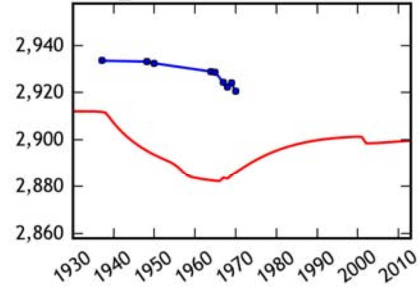
2761801 (Ector, TX)
HP_021441 LSD: 3007 TD: 66

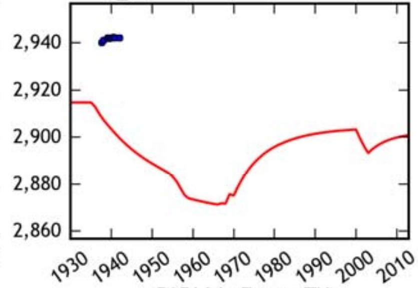


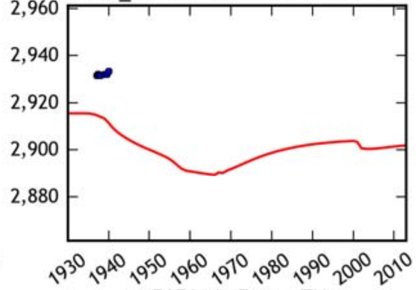

2761903 (Ector, TX)
HP_021447 LSD: 2962 TD: 91

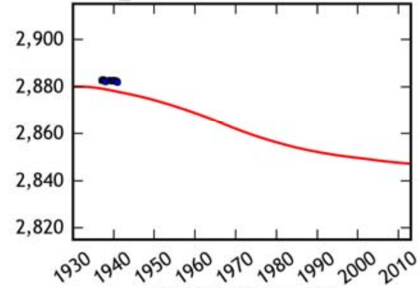

2762703 (Ector, TX)
HP_021481 LSD: 2956 TD: 120

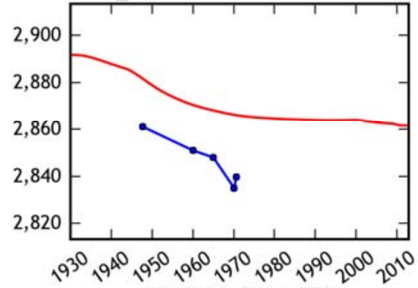

2762705 (Ector, TX)
HP_021483 LSD: 2930 TD: 75

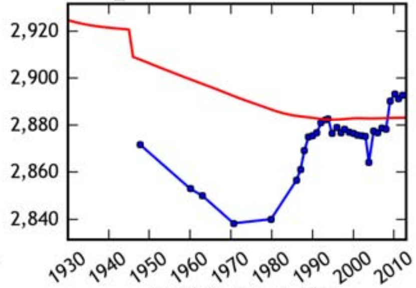

4505301 (Ector, TX)
HP_029035 LSD: 3004 TD: 110

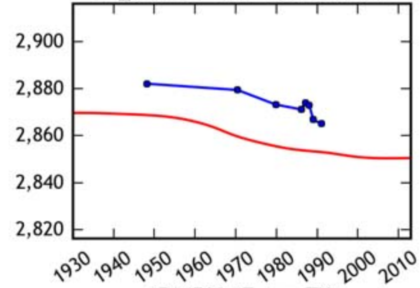

4505302 (Ector, TX)
HP_029036 LSD: 3014 TD: 128

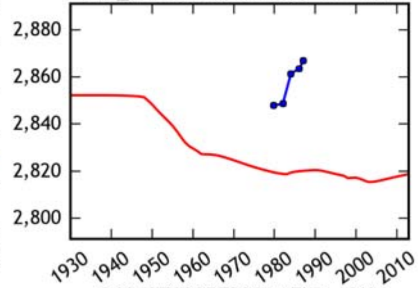

4505303 (Ector, TX)
HP_029037 LSD: 3013 TD: 87

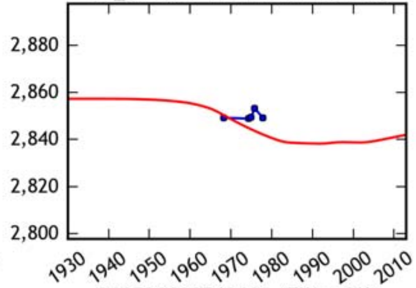

4505902 (Ector, TX)
HP_029153 LSD: 2943 TD: 118

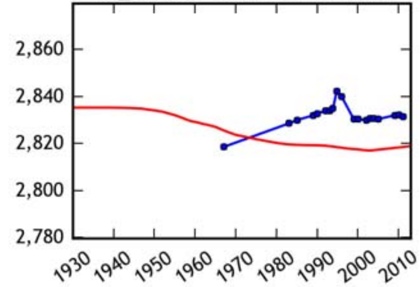

4505906 (Ector, TX)
HP_029157 LSD: 2938 TD: 150

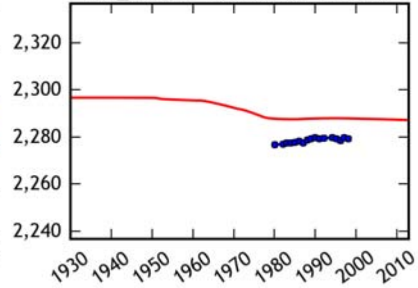

4505916 (Ector, TX)
HP_029167 LSD: 2951 TD: 155

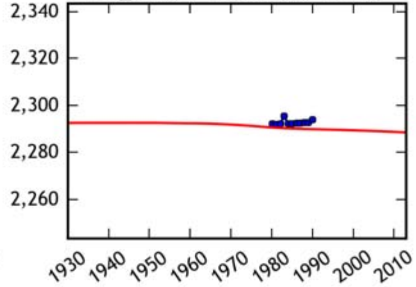

4506503 (Ector, TX)
HP_029254 LSD: 2975 TD: 113

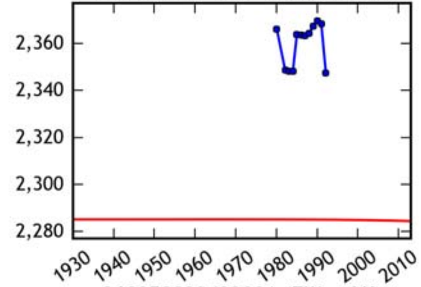

4514204 (Ector, TX)
HP_029550 LSD: 2905 TD: 115

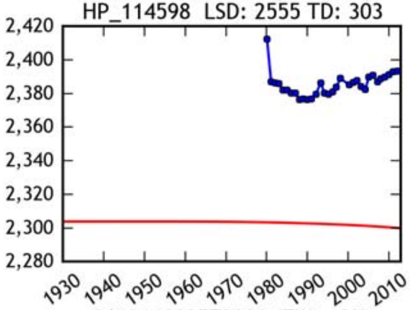

4514406 (Ector, TX)
HP_029575 LSD: 2871 TD: 100

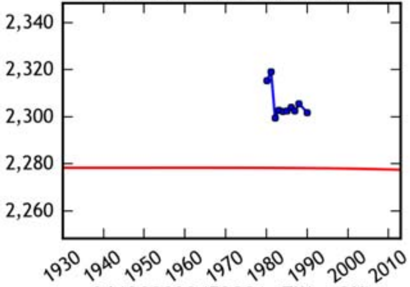

4514502 (Ector, TX)
HP_029582 LSD: 2862 TD: 104

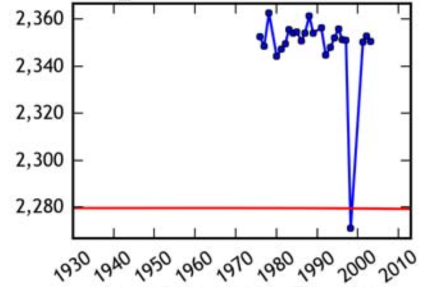

360427099572801 (Ellis, OK)
HP_114541 LSD: 2404 TD: 215

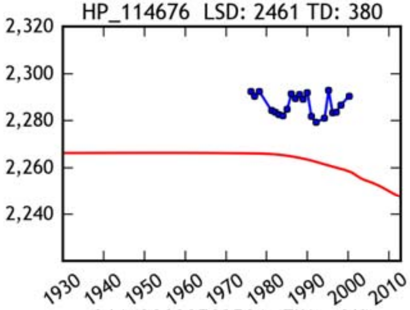

360520099562601 (Ellis, OK)
HP_114547 LSD: 2300 TD: 65

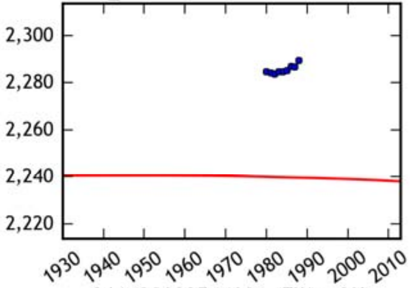

360804099475001 (Ellis, OK)
HP_114587 LSD: 2430 TD: 170

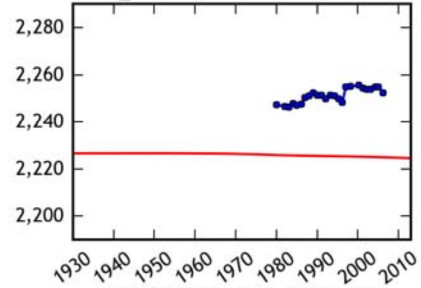

360825099582701 (Ellis, OK)
HP_114598 LSD: 2555 TD: 303

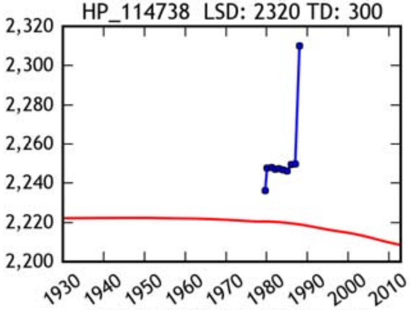

360929099455901 (Ellis, OK)
HP_114617 LSD: 2460 TD: 273

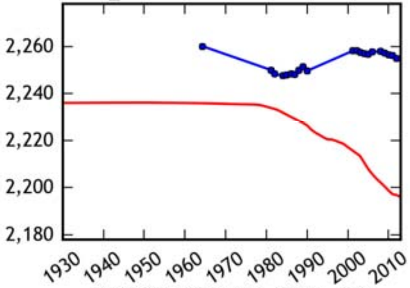

360958099432901 (Ellis, OK)
HP_114623 LSD: 2470 TD: 283

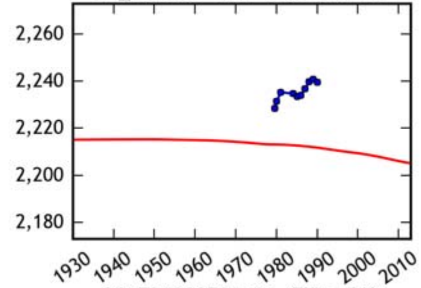

361211099573801 (Ellis, OK)
HP_114676 LSD: 2461 TD: 380

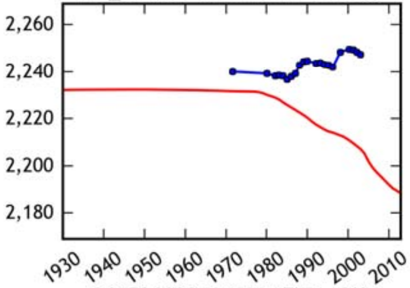

361300099453801 (Ellis, OK)
HP_114702 LSD: 2406 TD: unk

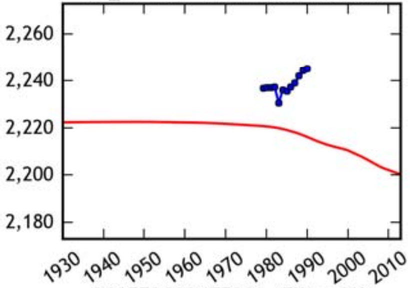

361405099443301 (Ellis, OK)
HP_114727 LSD: 2256 TD: 180

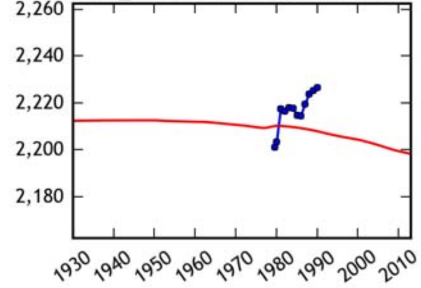

361429099503501 (Ellis, OK)
HP_114738 LSD: 2320 TD: 300

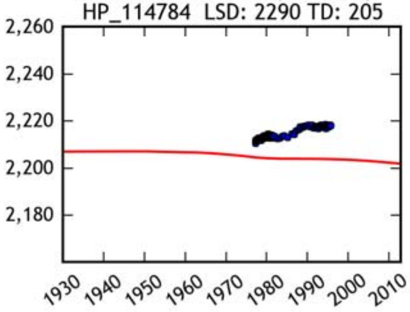

361429099544001 (Ellis, OK)
HP_114739 LSD: 2334 TD: 232

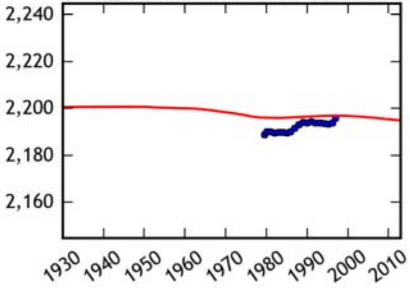

361455099490201 (Ellis, OK)
HP_114763 LSD: 2271 TD: 230


361456099542401 (Ellis, OK)
HP_114765 LSD: 2312 TD: 200

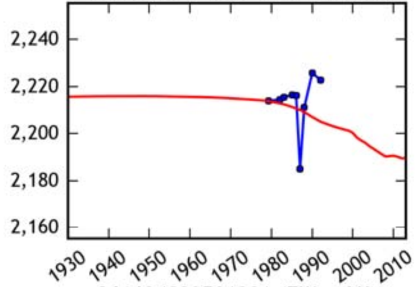

361501099521201 (Ellis, OK)
HP_114767 LSD: 2302 TD: 238


361534099501401 (Ellis, OK)
HP_114782 LSD: 2299 TD: 105

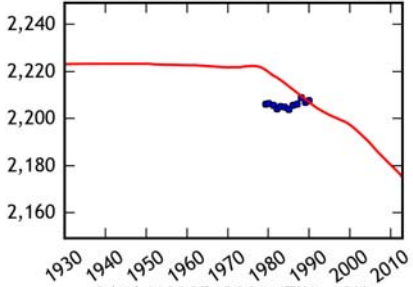

361536099464601 (Ellis, OK)
HP_114784 LSD: 2290 TD: 205


361552099475201 (Ellis, OK)
HP_114803 LSD: 2259 TD: 210

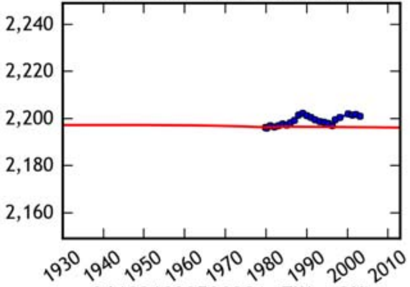
361558099524101 (Ellis, OK)
HP_114807 LSD: 2312 TD: 318



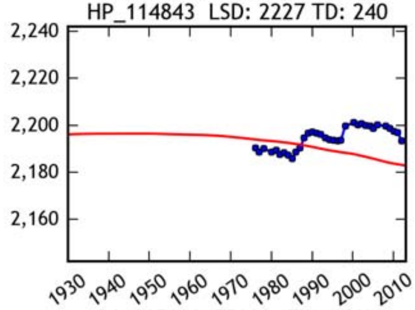
361622099552601 (Ellis, OK)
HP_114830 LSD: 2254 TD: 297



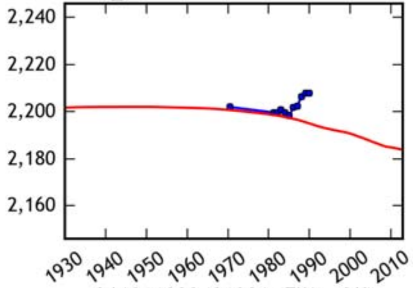
361629099424301 (Ellis, OK)
HP_114833 LSD: 2248 TD: 170



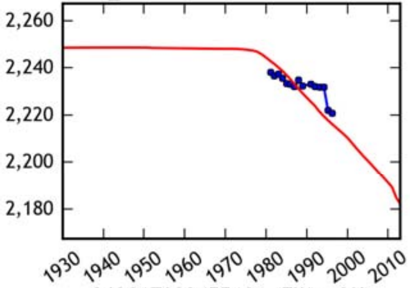
361634099501301 (Ellis, OK)
HP_114843 LSD: 2227 TD: 240



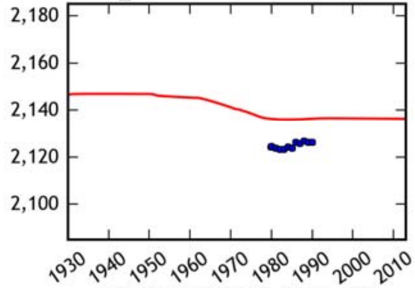
361641099513801 (Ellis, OK)
HP_114852 LSD: 2216 TD: 215



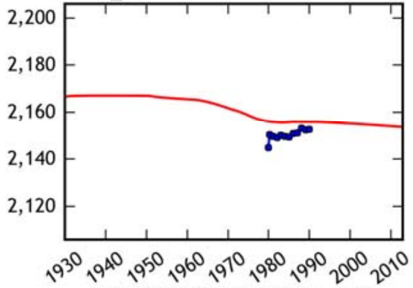
361831099590901 (Ellis, OK)
HP_114935 LSD: 2321 TD: 380



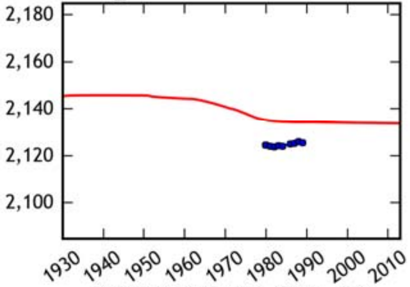
361905099455801 (Ellis, OK)
HP_114953 LSD: 2134 TD: 60



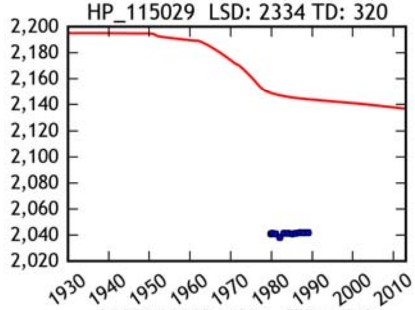
361911099481901 (Ellis, OK)
HP_114960 LSD: 2160 TD: 167



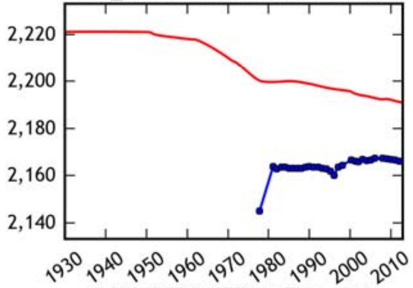
362017099455101 (Ellis, OK)
HP_115017 LSD: 2166 TD: 78



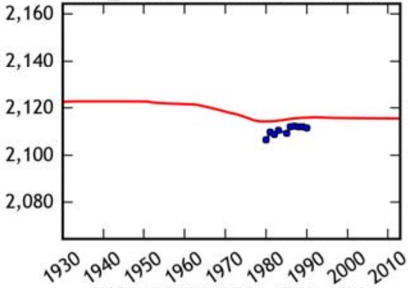
362042099495901 (Ellis, OK)
HP_115029 LSD: 2334 TD: 320



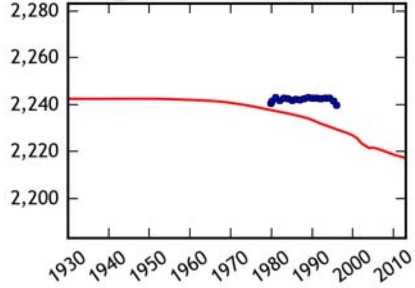
362049099524601 (Ellis, OK)
HP_115032 LSD: 2423 TD: 500



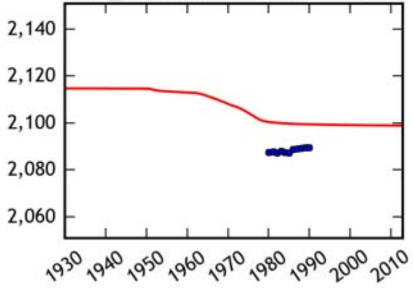
362129099424901 (Ellis, OK)
HP_115072 LSD: 2131 TD: unk



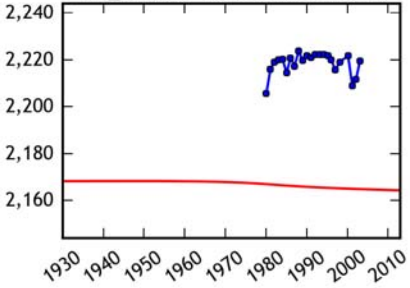
362226099544201 (Ellis, OK)
HP_115108 LSD: 2448 TD: 470



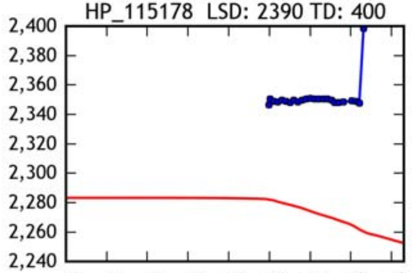
362249099405701 (Ellis, OK)
HP_115130 LSD: 2104 TD: unk



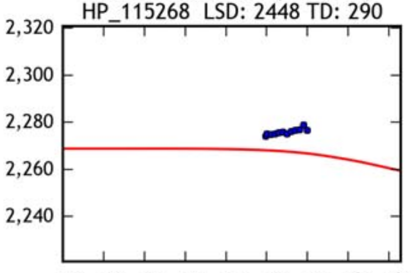
362349099443501 (Ellis, OK)
HP_115168 LSD: 2339 TD: 295



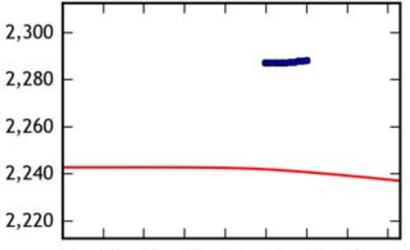
362410099594601 (Ellis, OK)
HP_115178 LSD: 2390 TD: 400



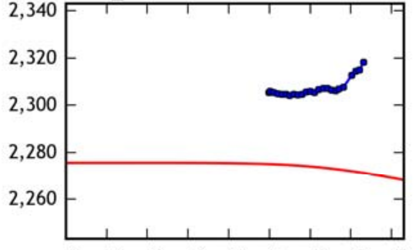
362647099554901 (Ellis, OK)
HP_115268 LSD: 2448 TD: 290



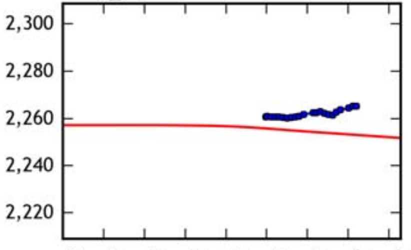
362736099510801 (Ellis, OK)
HP_115285 LSD: 2402 TD: 335



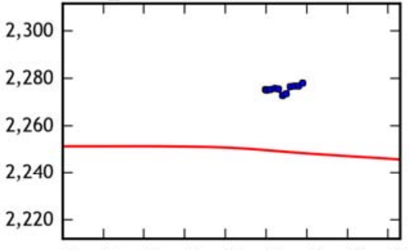
362740099563001 (Ellis, OK)
HP_115286 LSD: 2450 TD: 280



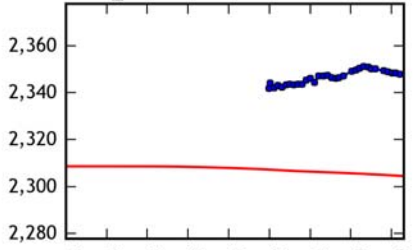
362939099525401 (Ellis, OK)
HP_115330 LSD: 2443 TD: 345



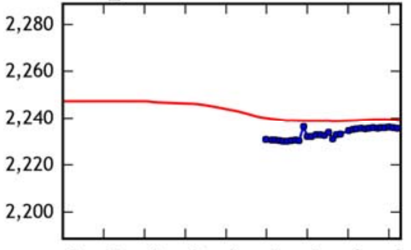
362957099514501 (Ellis, OK)
HP_115343 LSD: 2383 TD: 320



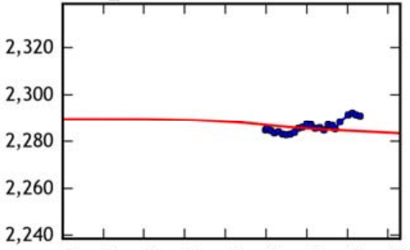
363118099595701 (Ellis, OK)
HP_115578 LSD: 2462 TD: 240



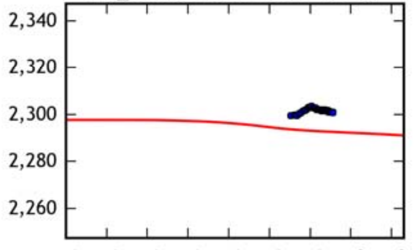
363145099515201 (Ellis, OK)
HP_115658 LSD: 2416 TD: 260



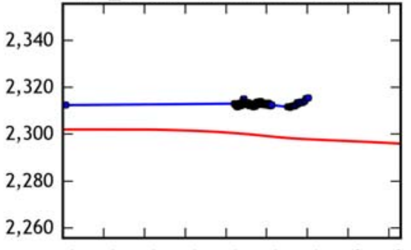
363211099580201 (Ellis, OK)
HP_115751 LSD: 2360 TD: 160



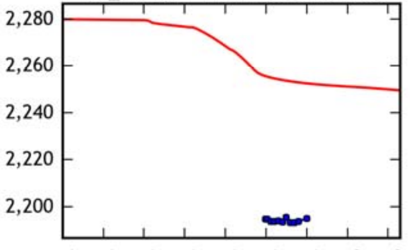
363224099584601 (Ellis, OK)
HP_115788 LSD: 2340 TD: 94



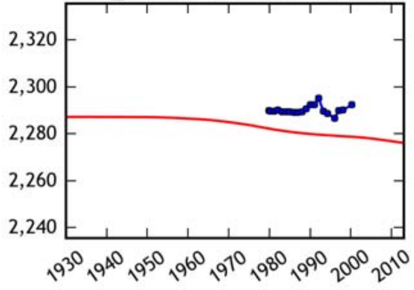
363235099592801 (Ellis, OK)
HP_115809 LSD: 2343 TD: 120



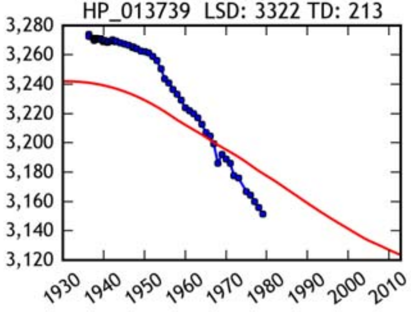
363407099580101 (Ellis, OK)
HP_116072 LSD: 2388 TD: 200



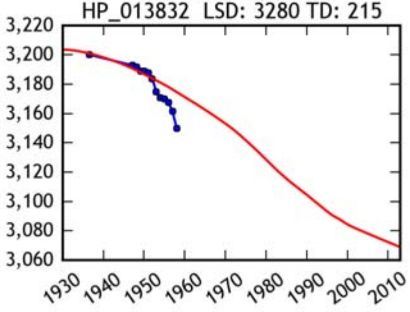
363501099594201 (Ellis, OK)
HP_116247 LSD: 2397 TD: 180

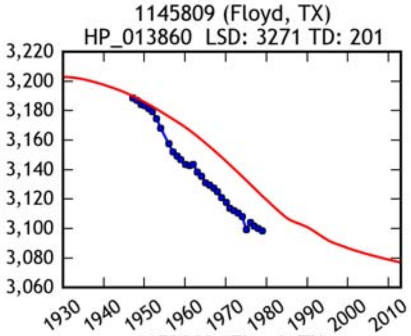


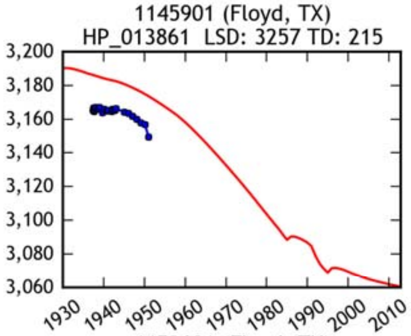
1144901 (Floyd, TX)
HP_013739 LSD: 3322 TD: 213

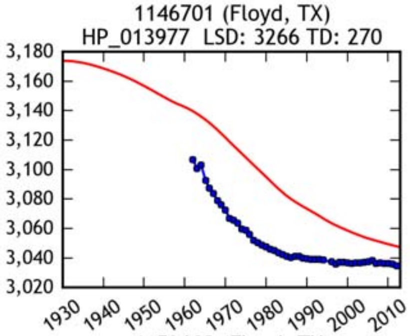


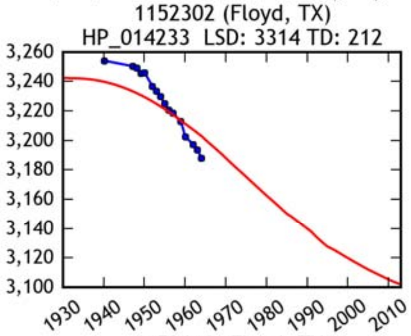
1145513 (Floyd, TX)
HP_013832 LSD: 3280 TD: 215

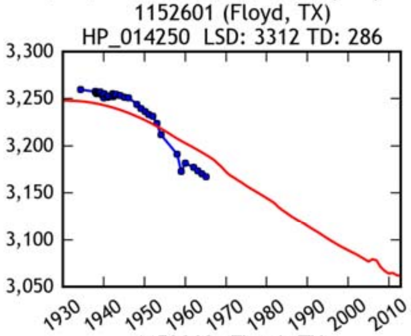


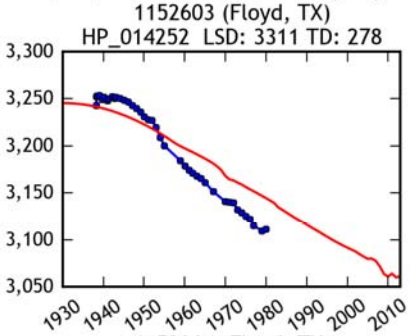

1145809 (Floyd, TX)
HP_013860 LSD: 3271 TD: 201

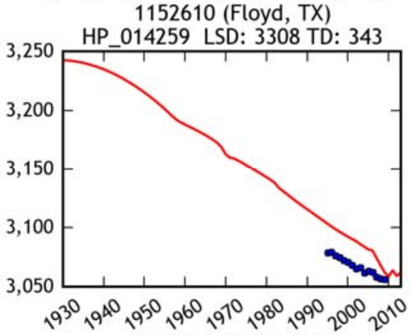

1145901 (Floyd, TX)
HP_013861 LSD: 3257 TD: 215

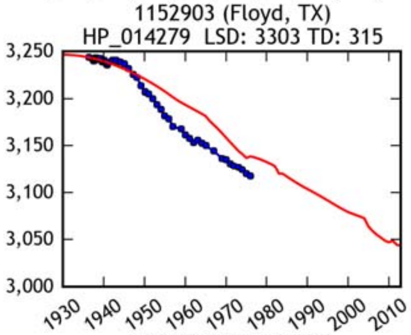

1146701 (Floyd, TX)
HP_013977 LSD: 3266 TD: 270

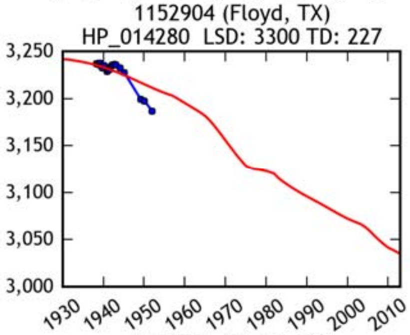

1152302 (Floyd, TX)
HP_014233 LSD: 3314 TD: 212

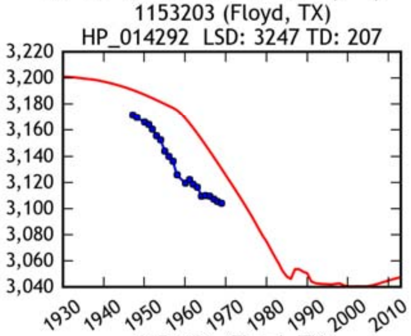

1152601 (Floyd, TX)
HP_014250 LSD: 3312 TD: 286

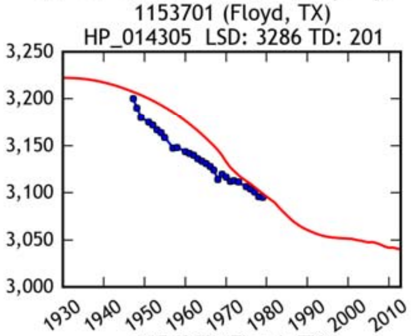

1152603 (Floyd, TX)
HP_014252 LSD: 3311 TD: 278

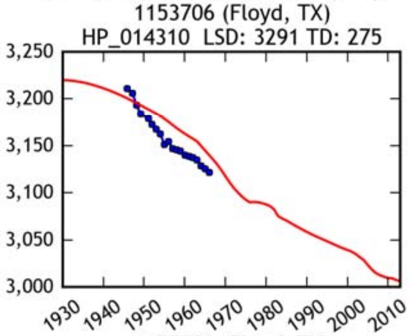

1152610 (Floyd, TX)
HP_014259 LSD: 3308 TD: 343

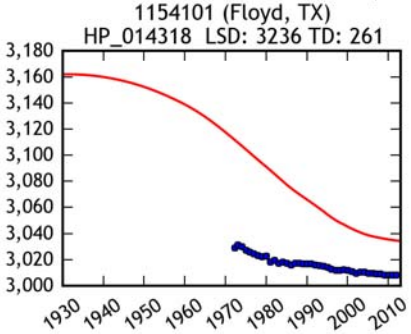

1152903 (Floyd, TX)
HP_014279 LSD: 3303 TD: 315

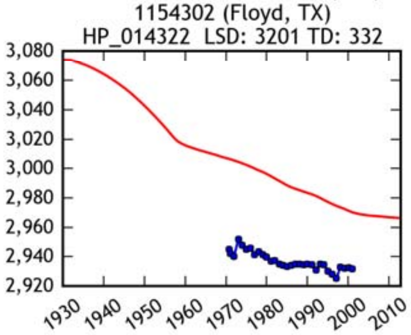

1152904 (Floyd, TX)
HP_014280 LSD: 3300 TD: 227

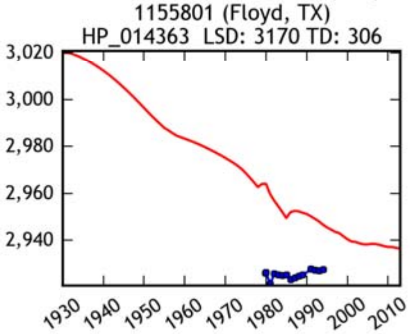

1153203 (Floyd, TX)
HP_014292 LSD: 3247 TD: 207

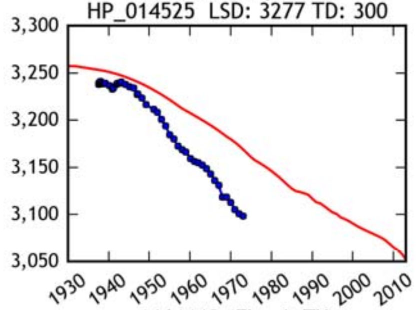

1153701 (Floyd, TX)
HP_014305 LSD: 3286 TD: 201

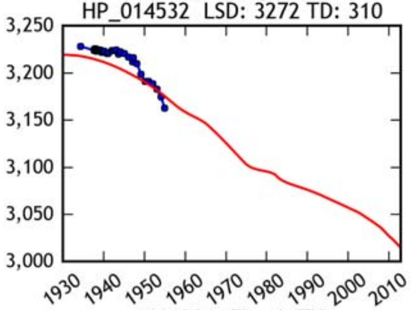

1153706 (Floyd, TX)
HP_014310 LSD: 3291 TD: 275

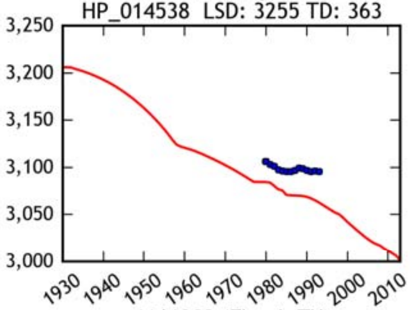

1154101 (Floyd, TX)
HP_014318 LSD: 3236 TD: 261

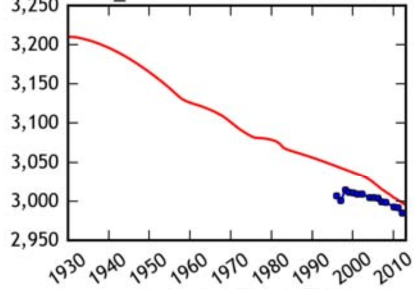

1154302 (Floyd, TX)
HP_014322 LSD: 3201 TD: 332

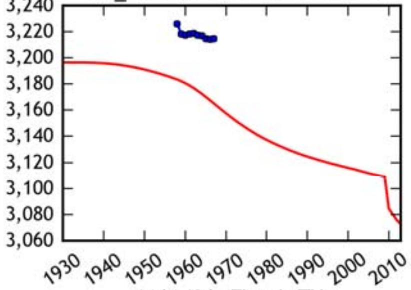

1155801 (Floyd, TX)
HP_014363 LSD: 3170 TD: 306

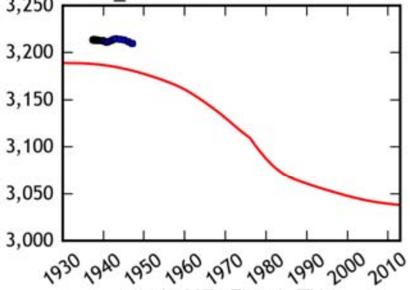

1160501 (Floyd, TX)
HP_014525 LSD: 3277 TD: 300

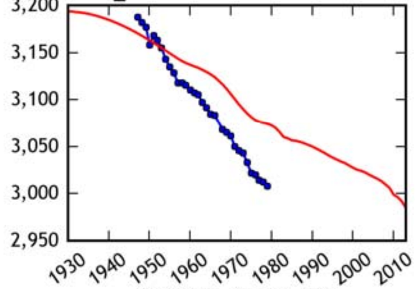

1160606 (Floyd, TX)
HP_014532 LSD: 3272 TD: 310

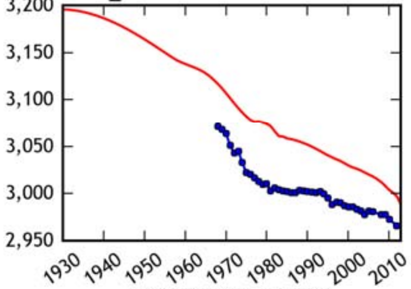

1160801 (Floyd, TX)
HP_014538 LSD: 3255 TD: 363

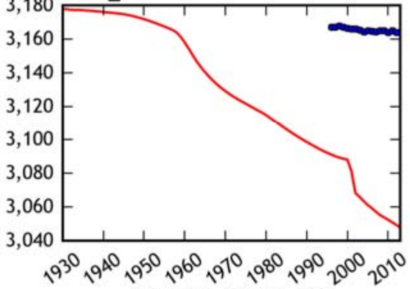

1161113 (Floyd, TX)
HP_014553 LSD: 3262 TD: 393

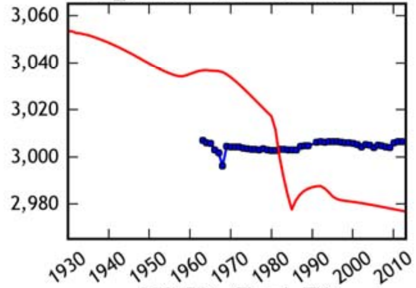

1161301 (Floyd, TX)
HP_014569 LSD: 3257 TD: 44

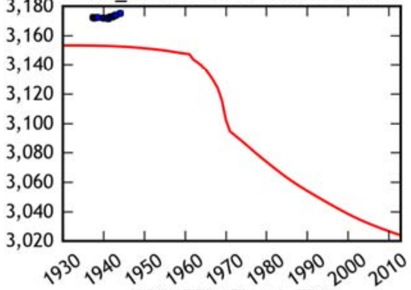

1161303 (Floyd, TX)
HP_014571 LSD: 3256 TD: 47

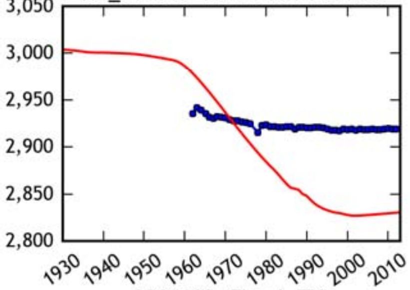

1161401 (Floyd, TX)
HP_014574 LSD: 3252 TD: 280

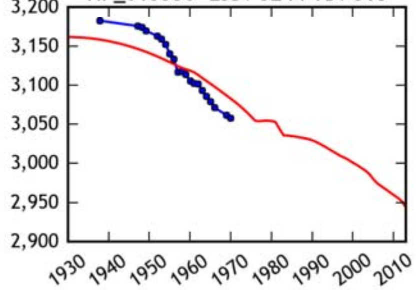

1161406 (Floyd, TX)
HP_014578 LSD: 3249 TD: 405

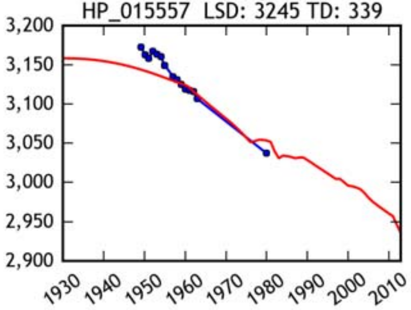

1161605 (Floyd, TX)
HP_014588 LSD: 3251 TD: 159

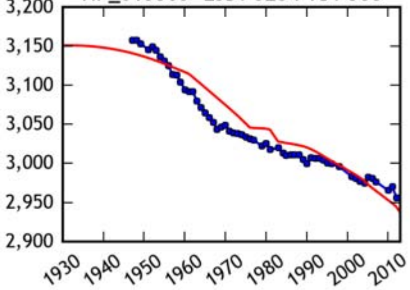

1162601 (Floyd, TX)
HP_014601 LSD: 3154 TD: 243

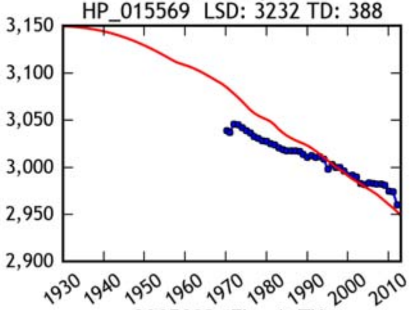

1162703 (Floyd, TX)
HP_014605 LSD: 3225 TD: 73

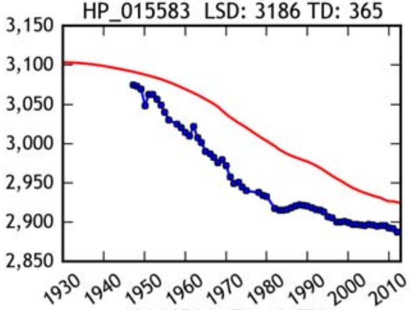

1163801 (Floyd, TX)
HP_014619 LSD: 3134 TD: 270

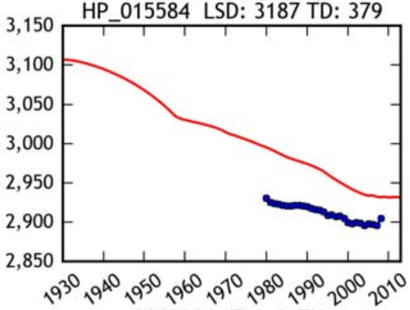

2304501 (Floyd, TX)
HP_015556 LSD: 3244 TD: 365

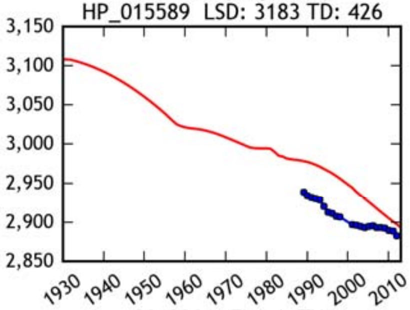

2304502 (Floyd, TX)
HP_015557 LSD: 3245 TD: 339

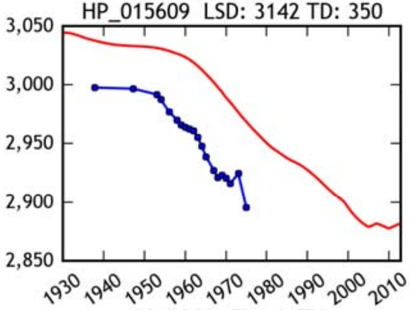

2304603 (Floyd, TX)
HP_015563 LSD: 3234 TD: 388

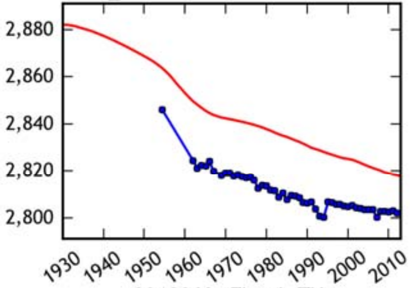

2304802 (Floyd, TX)
HP_015569 LSD: 3232 TD: 388

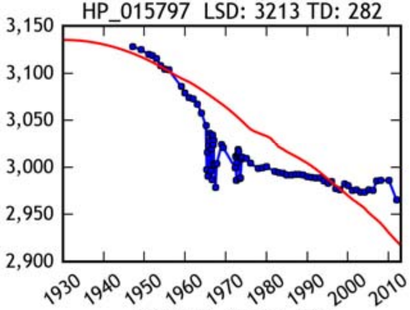

2305602 (Floyd, TX)
HP_015583 LSD: 3186 TD: 365

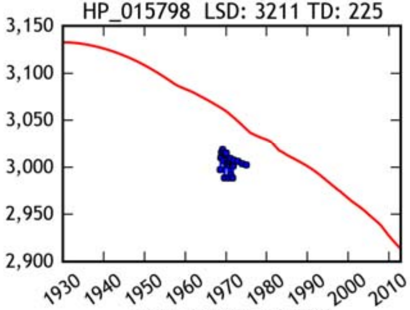

2305603 (Floyd, TX)
HP_015584 LSD: 3187 TD: 379

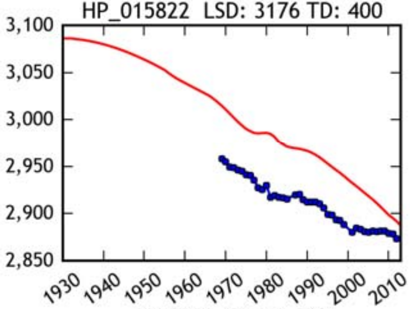

2305803 (Floyd, TX)
HP_015589 LSD: 3183 TD: 426

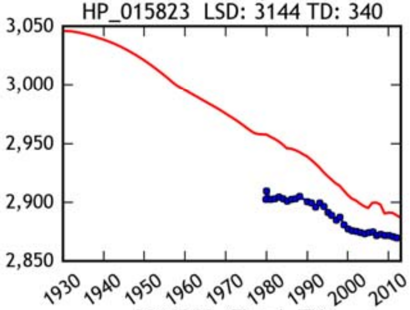

2306501 (Floyd, TX)
HP_015609 LSD: 3142 TD: 350

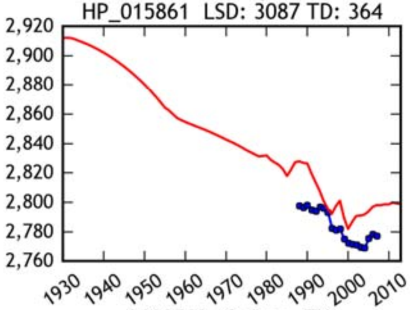

2308201 (Floyd, TX)
HP_015653 LSD: 3086 TD: 355

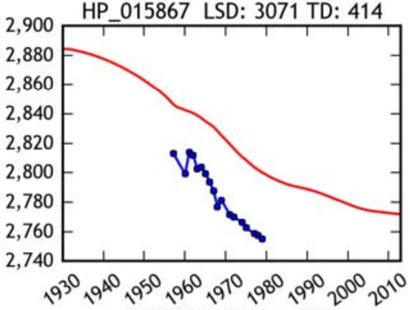

2312301 (Floyd, TX)
HP_015797 LSD: 3213 TD: 282

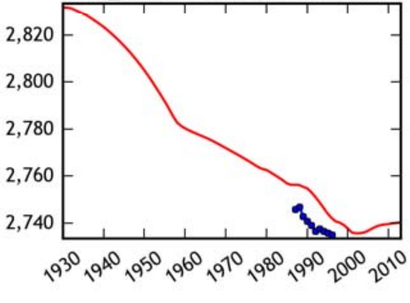

2312302 (Floyd, TX)
HP_015798 LSD: 3211 TD: 225

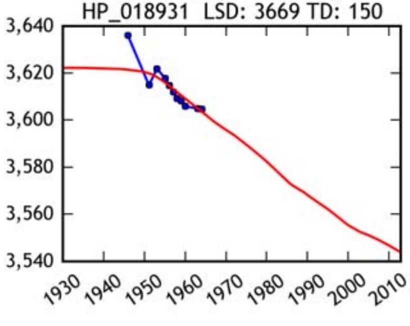

2313302 (Floyd, TX)
HP_015822 LSD: 3176 TD: 400

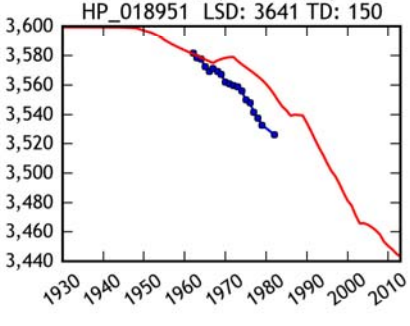

2313303 (Floyd, TX)
HP_015823 LSD: 3144 TD: 340

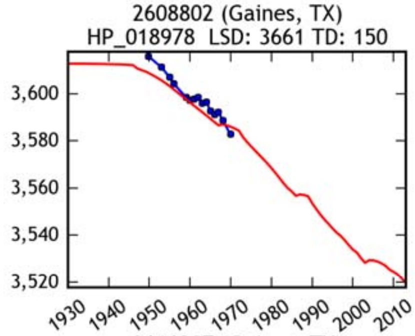

2315101 (Floyd, TX)
HP_015861 LSD: 3087 TD: 364

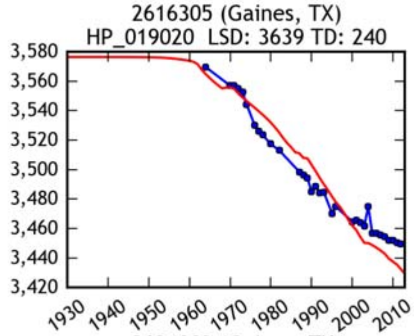

2315301 (Floyd, TX)
HP_015867 LSD: 3071 TD: 414

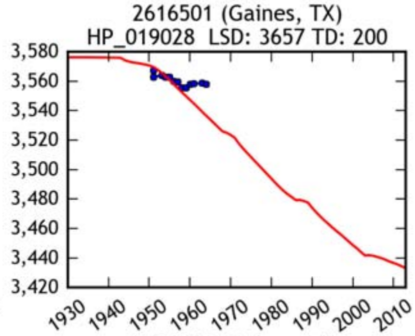

2316202 (Floyd, TX)
HP_015887 LSD: 3052 TD: 394

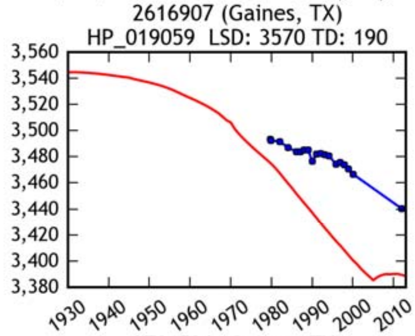

2608502 (Gaines, TX)
HP_018931 LSD: 3669 TD: 150

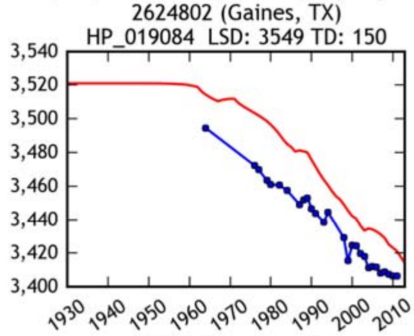

2608601 (Gaines, TX)
HP_018951 LSD: 3641 TD: 150

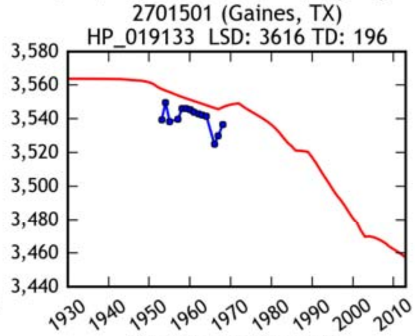

2608802 (Gaines, TX)
HP_018978 LSD: 3661 TD: 150

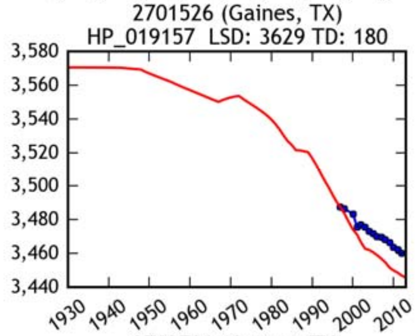

2616305 (Gaines, TX)
HP_019020 LSD: 3639 TD: 240

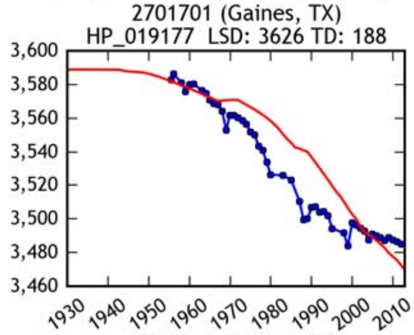

2616501 (Gaines, TX)
HP_019028 LSD: 3657 TD: 200

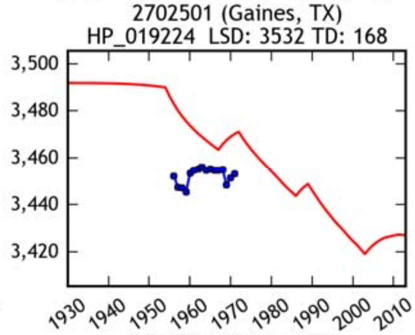

2616907 (Gaines, TX)
HP_019059 LSD: 3570 TD: 190

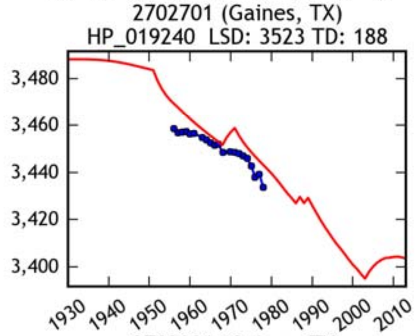

2624802 (Gaines, TX)
HP_019084 LSD: 3549 TD: 150

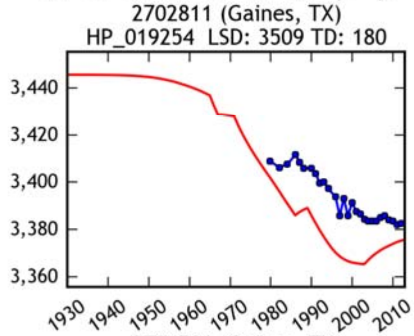

2701501 (Gaines, TX)
HP_019133 LSD: 3616 TD: 196

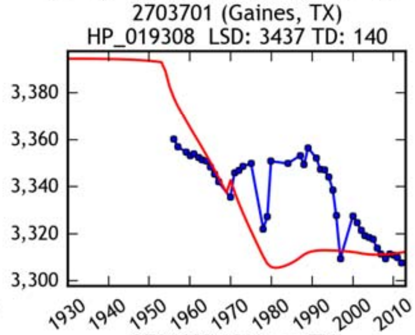

2701526 (Gaines, TX)
HP_019157 LSD: 3629 TD: 180

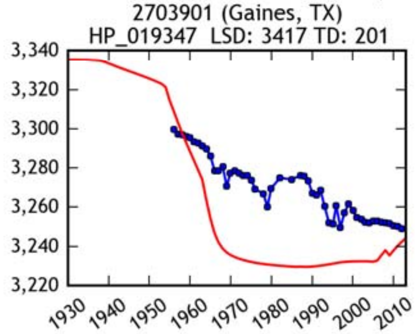

2701701 (Gaines, TX)
HP_019177 LSD: 3626 TD: 188

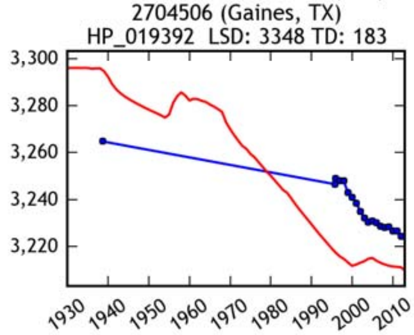

2702501 (Gaines, TX)
HP_019224 LSD: 3532 TD: 168

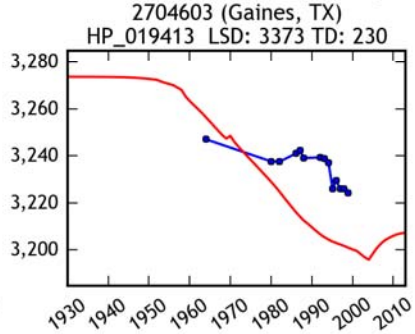

2702701 (Gaines, TX)
HP_019240 LSD: 3523 TD: 188


2702811 (Gaines, TX)
HP_019254 LSD: 3509 TD: 180

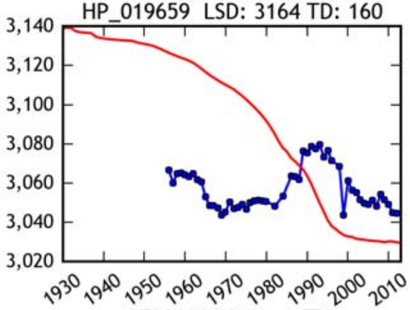

2703701 (Gaines, TX)
HP_019308 LSD: 3437 TD: 140


2703901 (Gaines, TX)
HP_019347 LSD: 3417 TD: 201

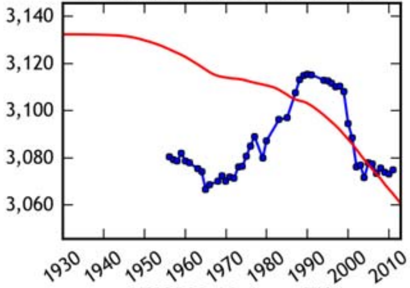

2704506 (Gaines, TX)
HP_019392 LSD: 3348 TD: 183


2704603 (Gaines, TX)
HP_019413 LSD: 3373 TD: 230

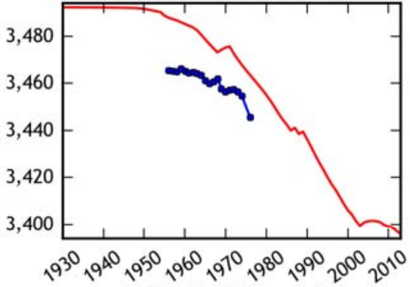
2706901 (Gaines, TX)
HP_019659 LSD: 3164 TD: 160



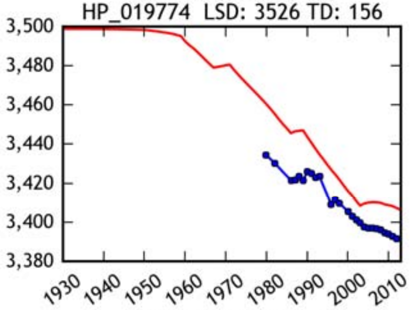
2707401 (Gaines, TX)
HP_019670 LSD: 3133 TD: 110



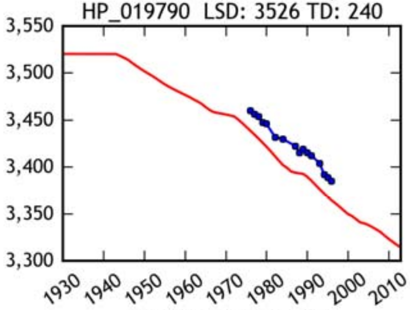
2709301 (Gaines, TX)
HP_019747 LSD: 3525 TD: 135



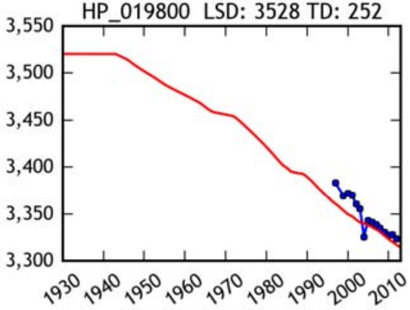
2709601 (Gaines, TX)
HP_019774 LSD: 3526 TD: 156



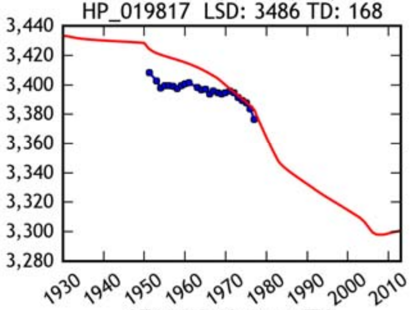
2709803 (Gaines, TX)
HP_019790 LSD: 3526 TD: 240



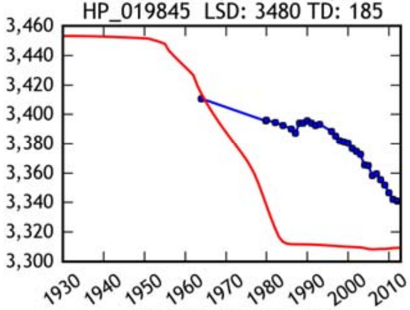
2709813 (Gaines, TX)
HP_019800 LSD: 3528 TD: 252



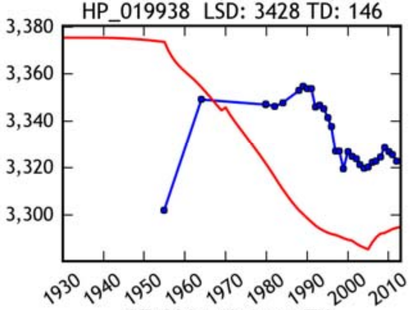
2710201 (Gaines, TX)
HP_019817 LSD: 3486 TD: 168



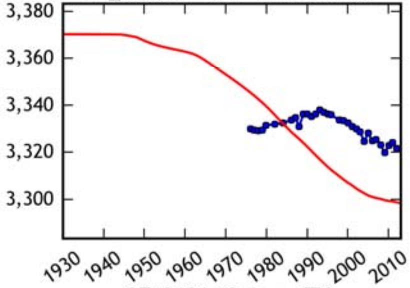
2710407 (Gaines, TX)
HP_019845 LSD: 3480 TD: 185



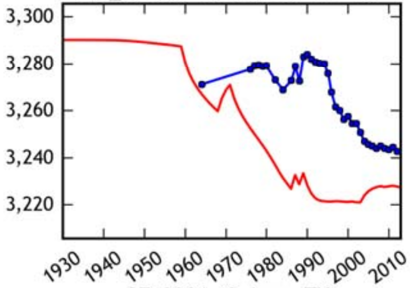
2711109 (Gaines, TX)
HP_019938 LSD: 3428 TD: 146



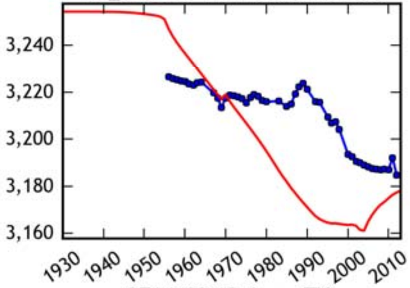
2711413 (Gaines, TX)
HP_019990 LSD: 3415 TD: 130



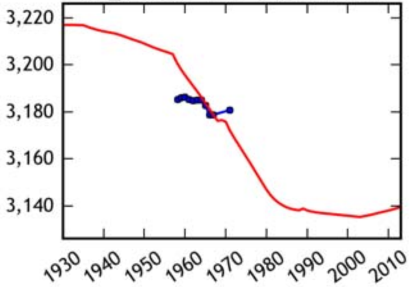
2711602 (Gaines, TX)
HP_019999 LSD: 3360 TD: 153



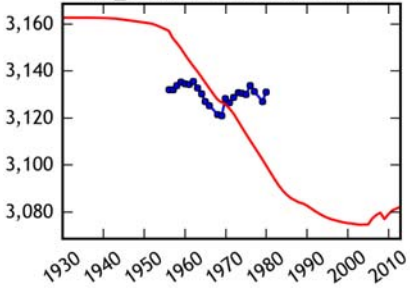
2712201 (Gaines, TX)
HP_020046 LSD: 3306 TD: 150



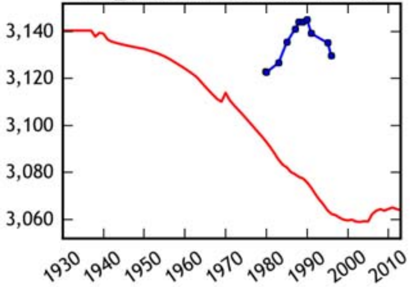
2713101 (Gaines, TX)
HP_020109 LSD: 3261 TD: 125



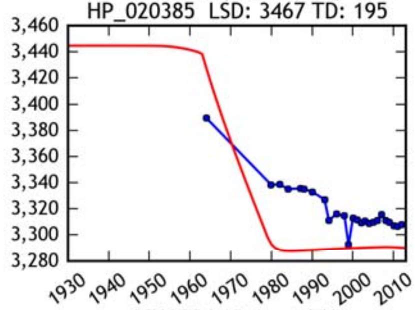
2713301 (Gaines, TX)
HP_020141 LSD: 3162 TD: 99



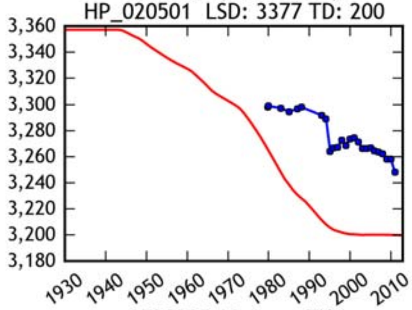
2714403 (Gaines, TX)
HP_020208 LSD: 3150 TD: 70



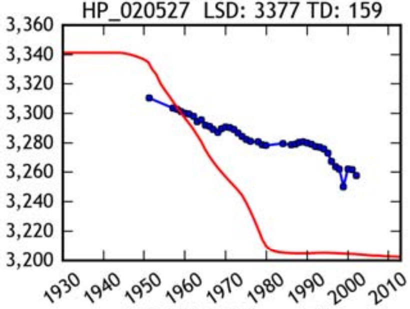
2717901 (Gaines, TX)
HP_020385 LSD: 3467 TD: 195



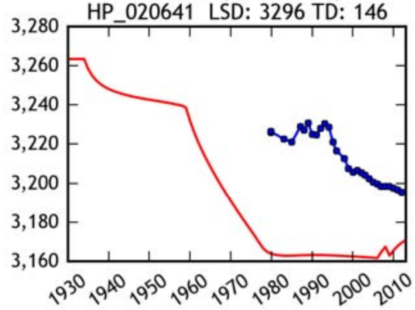
2718611 (Gaines, TX)
HP_020501 LSD: 3377 TD: 200



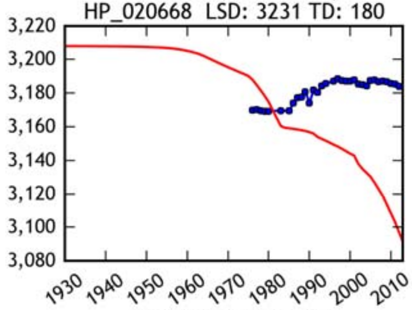
2719101 (Gaines, TX)
HP_020527 LSD: 3377 TD: 159



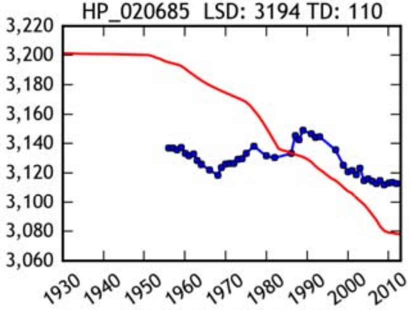
2719804 (Gaines, TX)
HP_020641 LSD: 3296 TD: 146



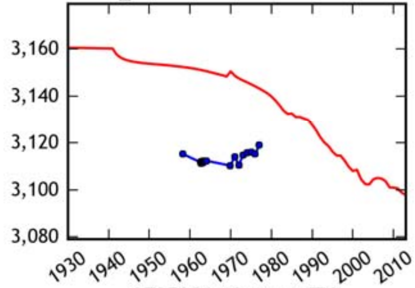
2720305 (Gaines, TX)
HP_020668 LSD: 3231 TD: 180



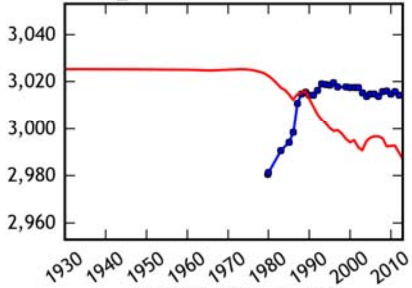
2721101 (Gaines, TX)
HP_020685 LSD: 3194 TD: 110



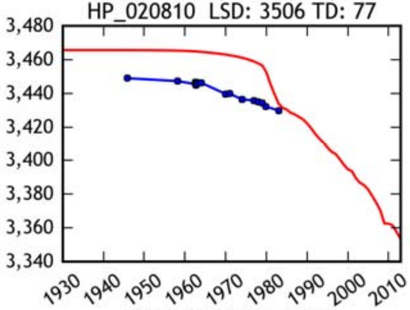
2721201 (Gaines, TX)
HP_020712 LSD: 3176 TD: 94



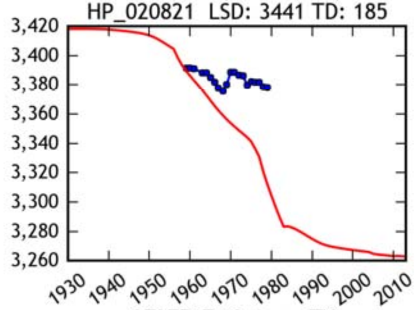
2723402 (Gaines, TX)
HP_020760 LSD: 3036 TD: 67



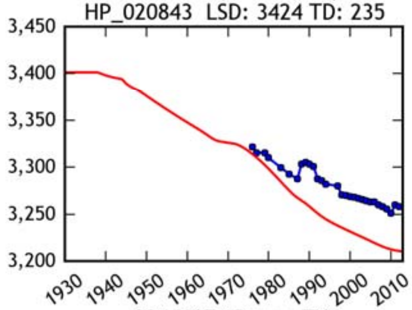
2725101 (Gaines, TX)
HP_020810 LSD: 3506 TD: 77



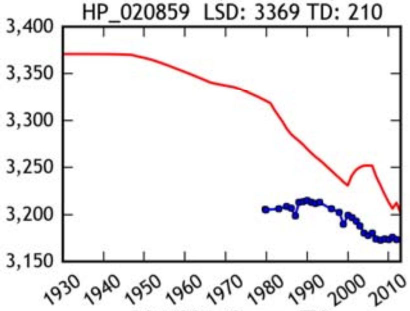
2725301 (Gaines, TX)
HP_020821 LSD: 3441 TD: 185



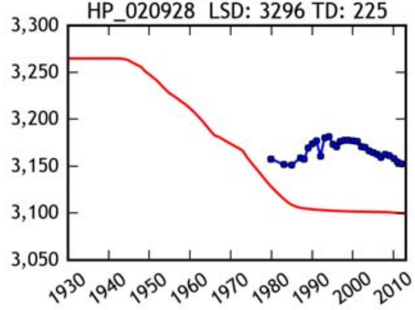
2725603 (Gaines, TX)
HP_020843 LSD: 3424 TD: 235



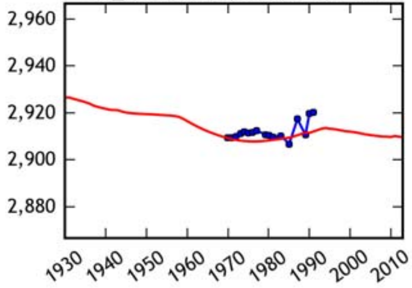
2726403 (Gaines, TX)
HP_020859 LSD: 3369 TD: 210



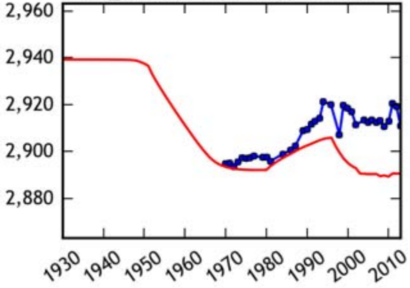
2727517 (Gaines, TX)
HP_020928 LSD: 3296 TD: 225



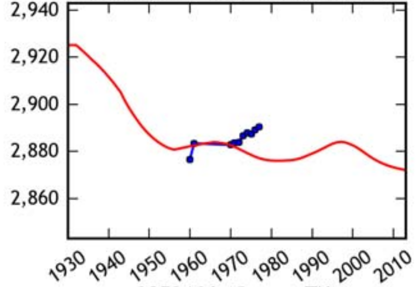
2344607 (Garza, TX)
HP_016982 LSD: 2991 TD: 111



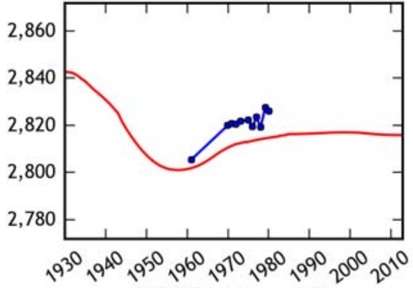
2344904 (Garza, TX)
HP_017003 LSD: 2967 TD: 127



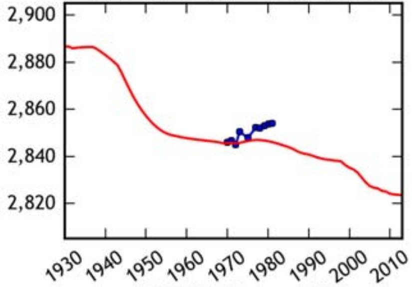
2352601 (Garza, TX)
HP_017139 LSD: 2930 TD: 110



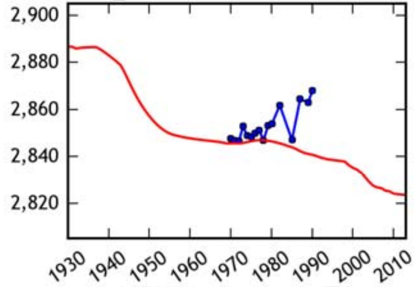
2352904 (Garza, TX)
HP_017157 LSD: 2889 TD: 123



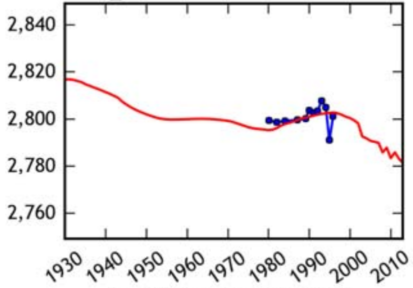
2353105 (Garza, TX)
HP_017162 LSD: 2932 TD: unk



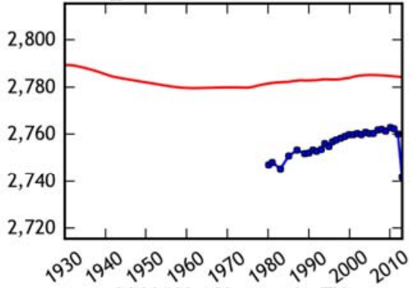
2353106 (Garza, TX)
HP_017163 LSD: 2933 TD: unk



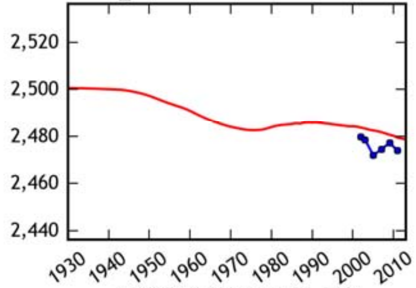
2353801 (Garza, TX)
HP_017176 LSD: 2883 TD: unk



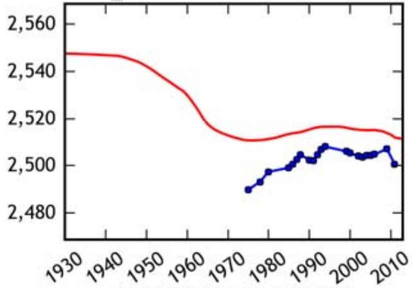
2353901 (Garza, TX)
HP_017177 LSD: 2872 TD: 180



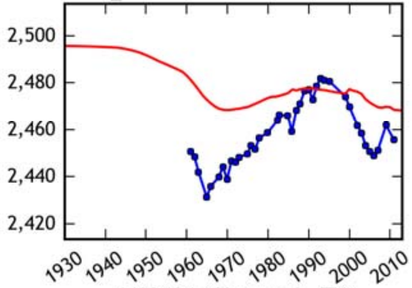
2859306 (Glasscock, TX)
HP_023316 LSD: 2527 TD: 87



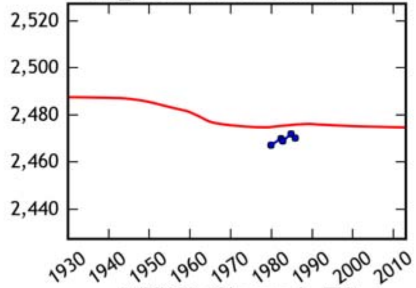
2859801 (Glasscock, TX)
HP_023330 LSD: 2601 TD: 145



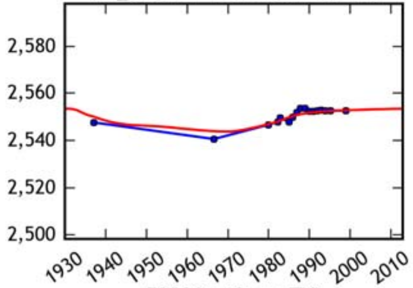
2860402 (Glasscock, TX)
HP_023342 LSD: 2525 TD: 140



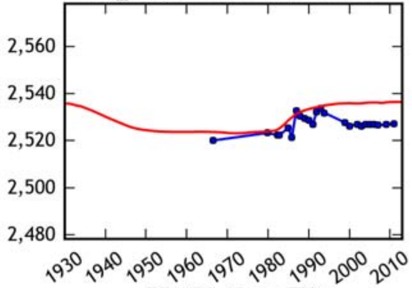
2860501 (Glasscock, TX)
HP_023346 LSD: 2533 TD: 77



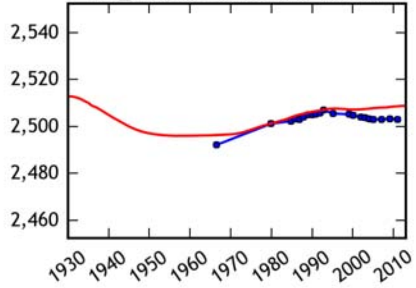
4402601 (Glasscock, TX)
HP_025312 LSD: 2581 TD: 44



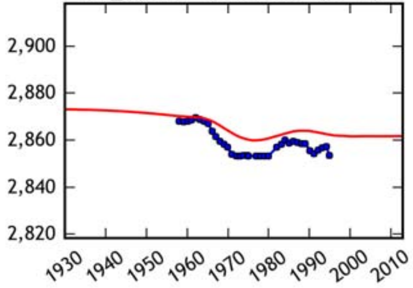
4403404 (Glasscock, TX)
HP_025331 LSD: 2549 TD: 35



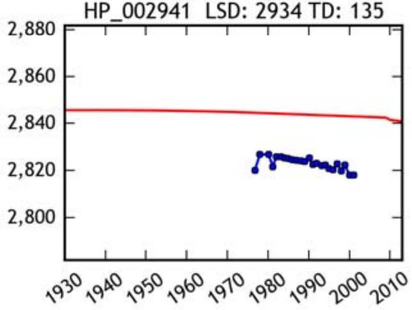
4403601 (Glasscock, TX)
HP_025335 LSD: 2552 TD: 60



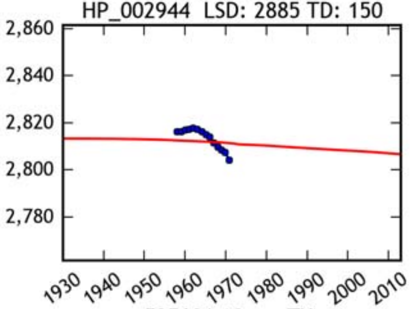
533301 (Gray, TX)
HP_002911 LSD: 2933 TD: 140



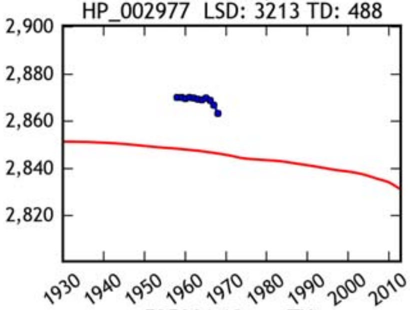
534403 (Gray, TX)
HP_002941 LSD: 2934 TD: 135



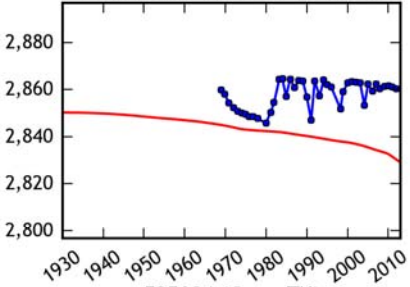
534501 (Gray, TX)
HP_002944 LSD: 2885 TD: 150



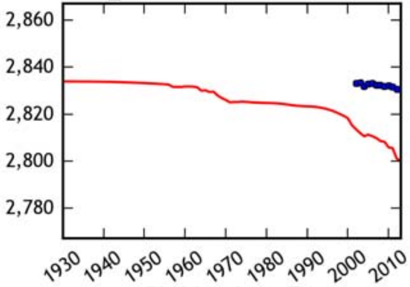
525501 (Gray, TX)
HP_002977 LSD: 3213 TD: 488



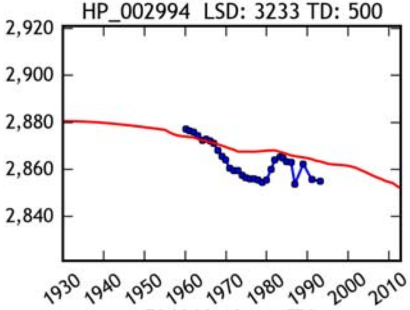
525502 (Gray, TX)
HP_002978 LSD: 3213 TD: 630



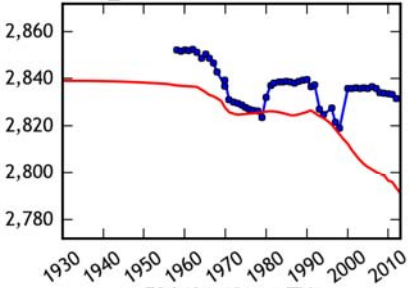
525601 (Gray, TX)
HP_002982 LSD: 3202 TD: 620



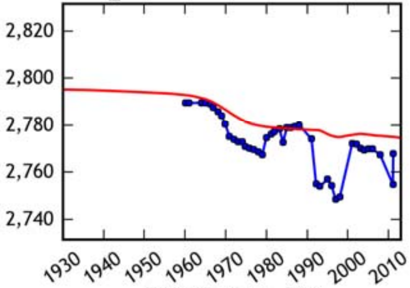
525801 (Gray, TX)
HP_002994 LSD: 3233 TD: 500



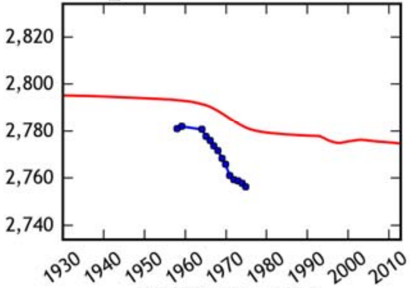
525904 (Gray, TX)
HP_003012 LSD: 3200 TD: 440



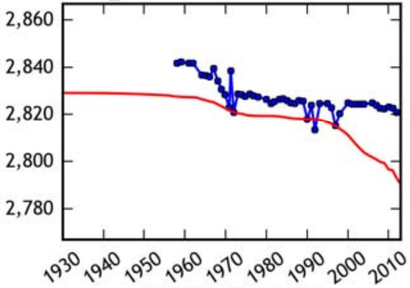
526301 (Gray, TX)
HP_003025 LSD: 3131 TD: 576



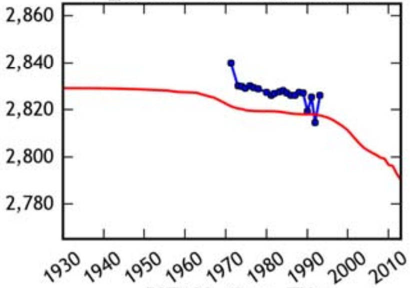
526302 (Gray, TX)
HP_003026 LSD: 3127 TD: 519



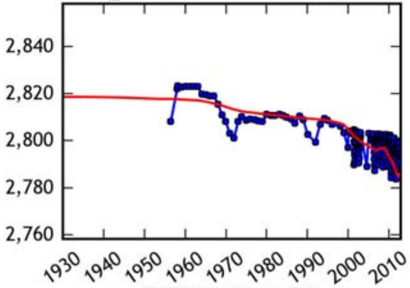
526401 (Gray, TX)
HP_003033 LSD: 3195 TD: 540



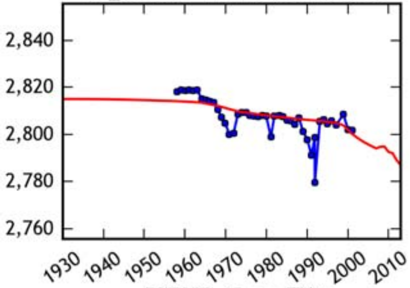
526407 (Gray, TX)
HP_003039 LSD: 3195 TD: 690



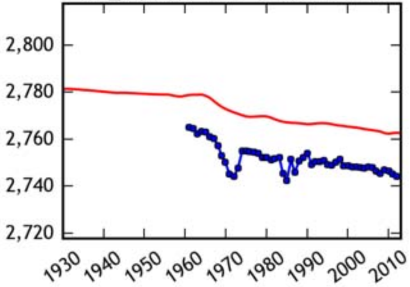
526501 (Gray, TX)
HP_003043 LSD: 3168 TD: 537



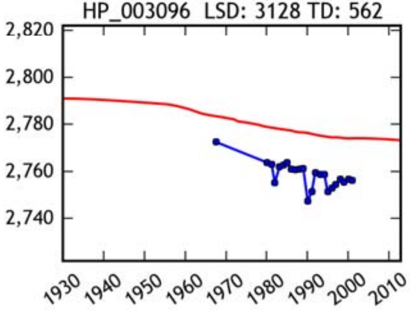
526502 (Gray, TX)
HP_003044 LSD: 3160 TD: 528



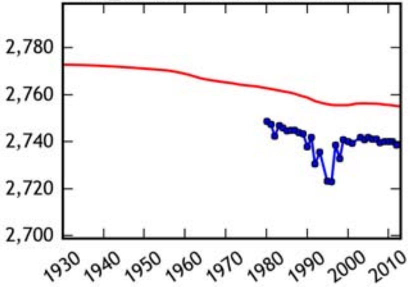
527102 (Gray, TX)
HP_003068 LSD: 3106 TD: 550

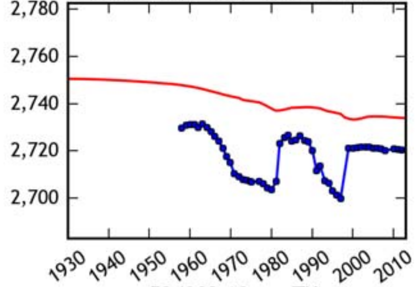


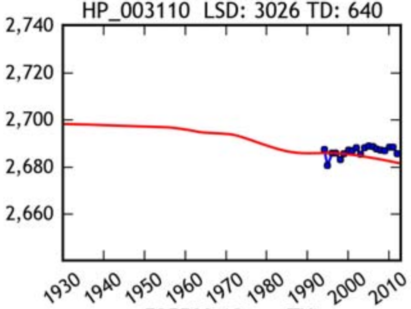
527703 (Gray, TX)
HP_003096 LSD: 3128 TD: 562

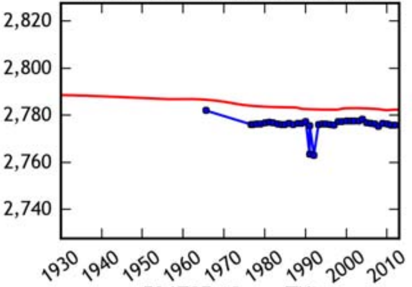


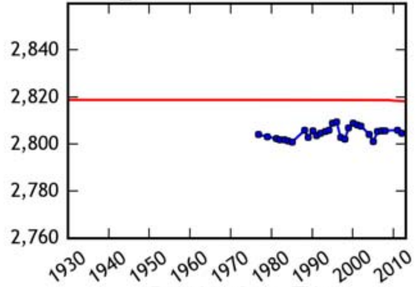
527802 (Gray, TX)
HP_003103 LSD: 3082 TD: 599

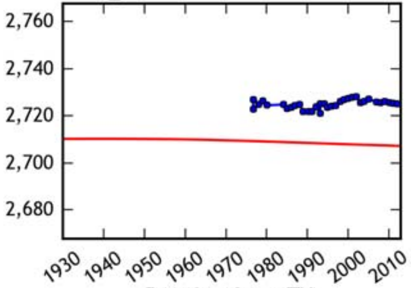


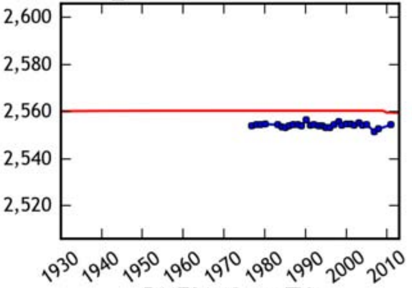

527901 (Gray, TX)
HP_003106 LSD: 3061 TD: 550

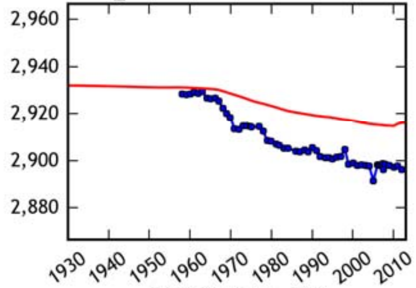

528203 (Gray, TX)
HP_003110 LSD: 3026 TD: 640

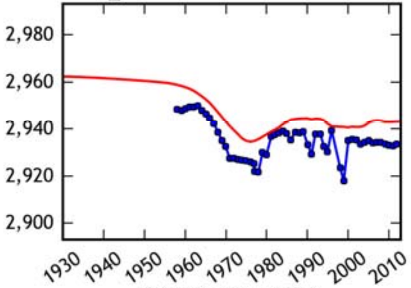

534606 (Gray, TX)
HP_003308 LSD: 2846 TD: 871

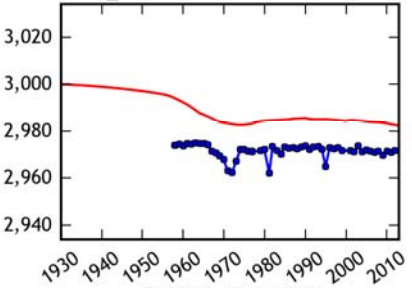

534902 (Gray, TX)
HP_003316 LSD: 2874 TD: 85

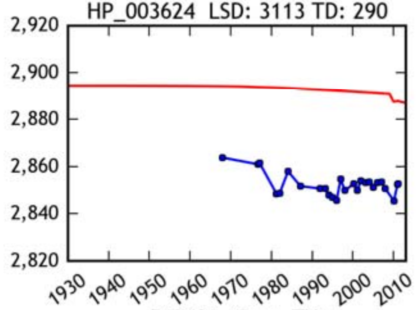

535503 (Gray, TX)
HP_003328 LSD: 2795 TD: 128

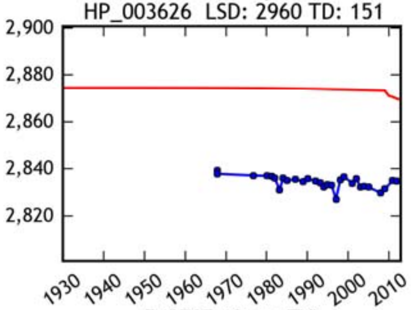

536705 (Gray, TX)
HP_003359 LSD: 2564 TD: 67

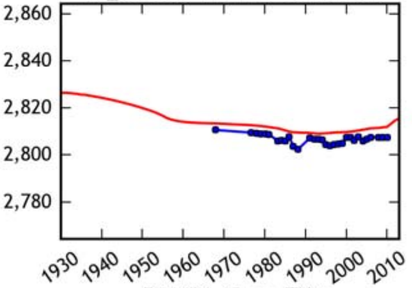

541101 (Gray, TX)
HP_003600 LSD: 3269 TD: 450

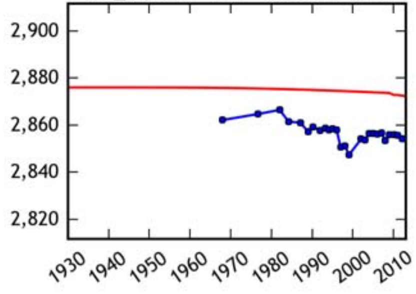

541401 (Gray, TX)
HP_003616 LSD: 3256 TD: 427

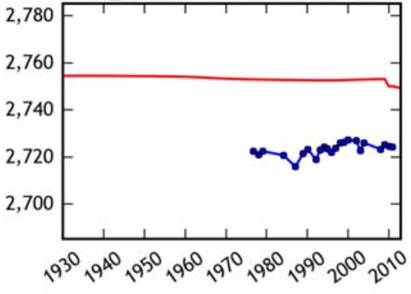

541701 (Gray, TX)
HP_003621 LSD: 3233 TD: 400

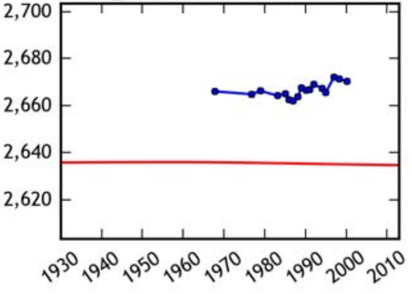

542101 (Gray, TX)
HP_003624 LSD: 3113 TD: 290

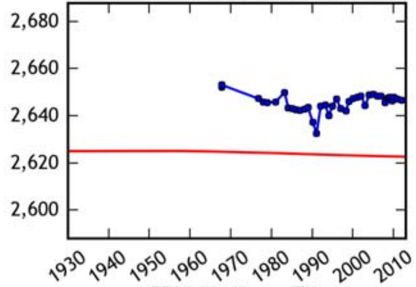

542201 (Gray, TX)
HP_003626 LSD: 2960 TD: 151

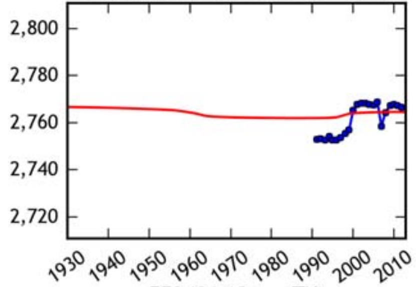

542301 (Gray, TX)
HP_003628 LSD: 2948 TD: 155

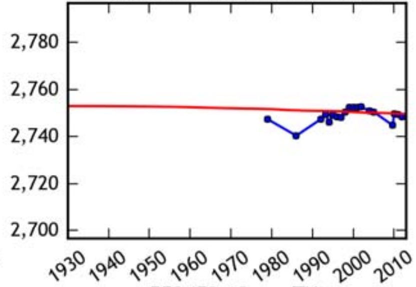

542401 (Gray, TX)
HP_003629 LSD: 3058 TD: 218

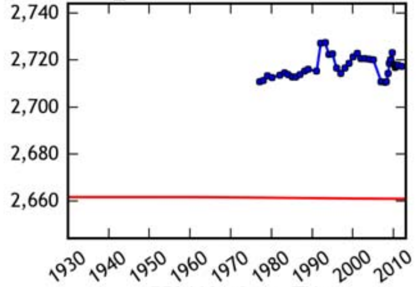

543705 (Gray, TX)
HP_003653 LSD: 2833 TD: 122

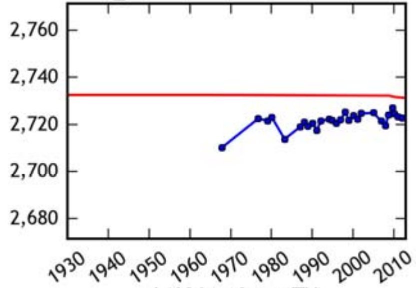

544401 (Gray, TX)
HP_003666 LSD: 2729 TD: 86

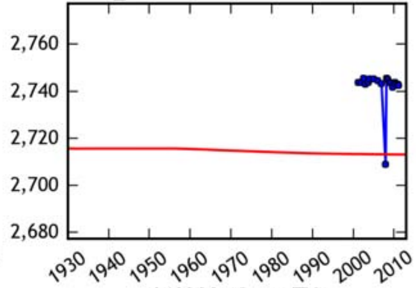

544610 (Gray, TX)
HP_003673 LSD: 2828 TD: 230

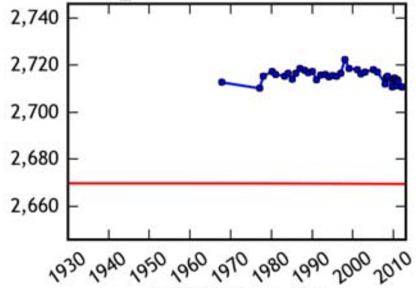

551103 (Gray, TX)
HP_003763 LSD: 2894 TD: 221

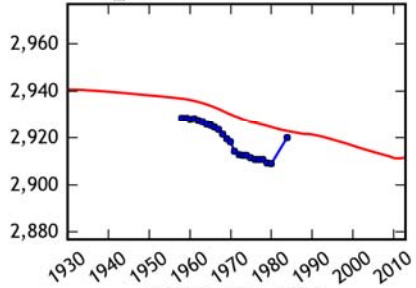

551304 (Gray, TX)
HP_003771 LSD: 2822 TD: 88

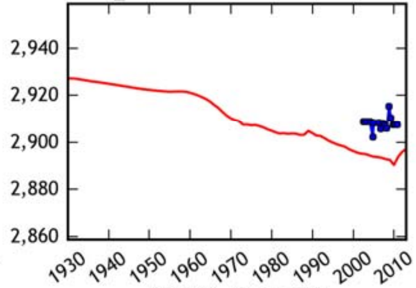

552308 (Gray, TX)
HP_003822 LSD: 2830 TD: 133

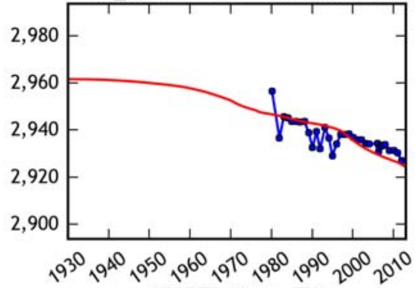

552401 (Gray, TX)
HP_003823 LSD: 2800 TD: 100

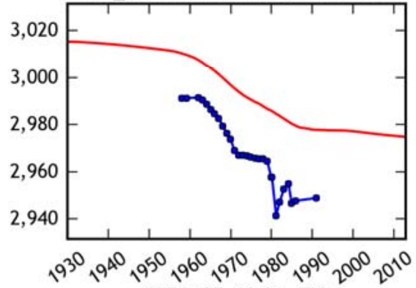

552452 (Gray, TX)
HP_003824 LSD: 2851 TD: 143

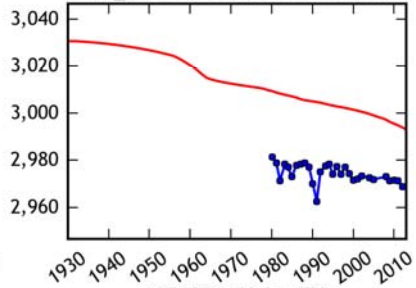

552603 (Gray, TX)
HP_003834 LSD: 2735 TD: 86

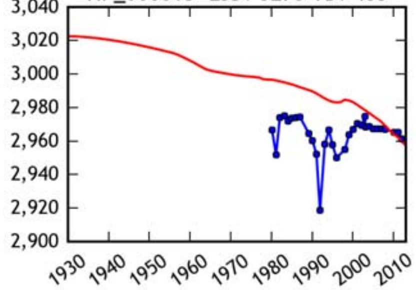

640201 (Gray, TX)
HP_004950 LSD: 3304 TD: 430

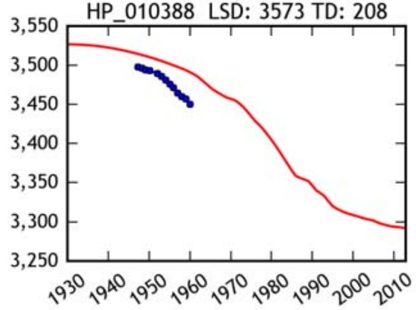

640208 (Gray, TX)
HP_004957 LSD: 3294 TD: 462

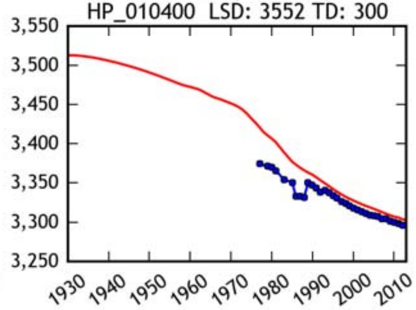

640802 (Gray, TX)
HP_005011 LSD: 3296 TD: 540


648201 (Gray, TX)
HP_005501 LSD: 3301 TD: 419

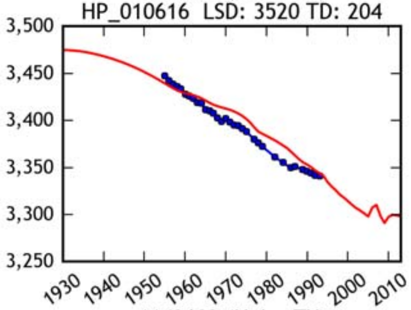

656306 (Gray, TX)
HP_005993 LSD: 3264 TD: 392


656507 (Gray, TX)
HP_006013 LSD: 3273 TD: 485

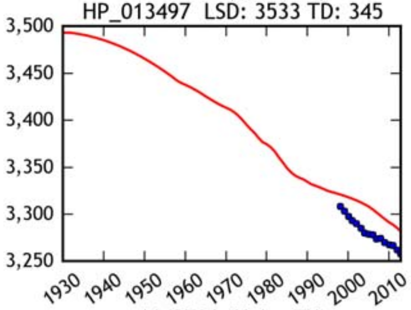

1056405 (Hale, TX)
HP_010388 LSD: 3573 TD: 208


1056801 (Hale, TX)
HP_010400 LSD: 3552 TD: 300

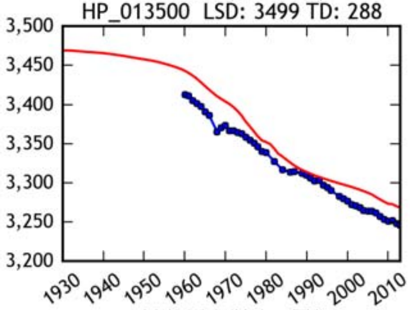
1064201 (Hale, TX)
HP_010616 LSD: 3520 TD: 204



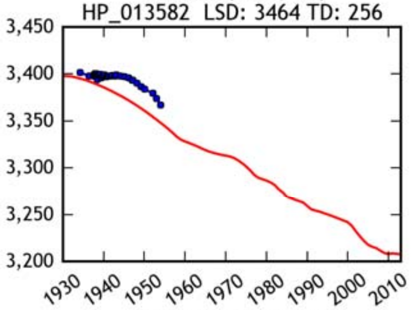
1141506 (Hale, TX)
HP_013497 LSD: 3533 TD: 345



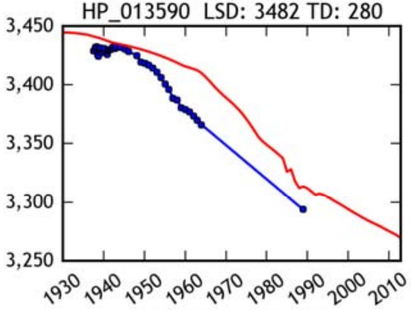
1141602 (Hale, TX)
HP_013500 LSD: 3499 TD: 288



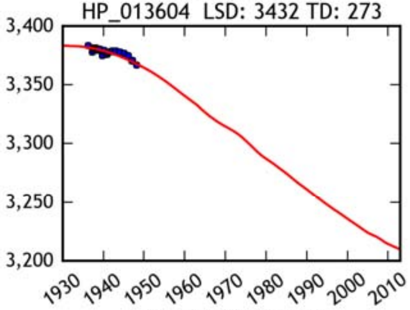
1142602 (Hale, TX)
HP_013582 LSD: 3464 TD: 256



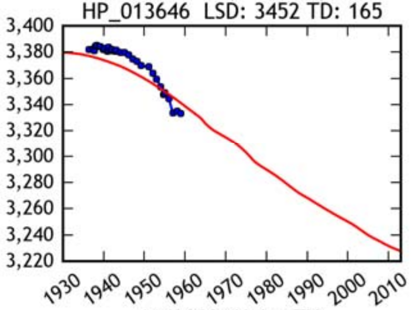
1142701 (Hale, TX)
HP_013590 LSD: 3482 TD: 280



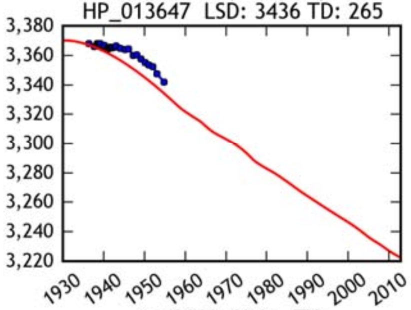
1142904 (Hale, TX)
HP_013604 LSD: 3432 TD: 273



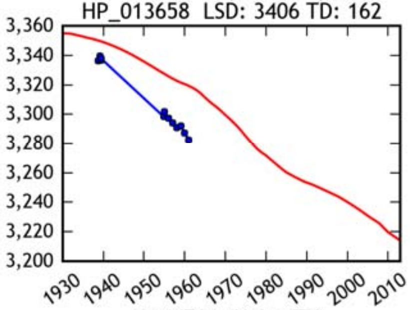
1143412 (Hale, TX)
HP_013646 LSD: 3452 TD: 165



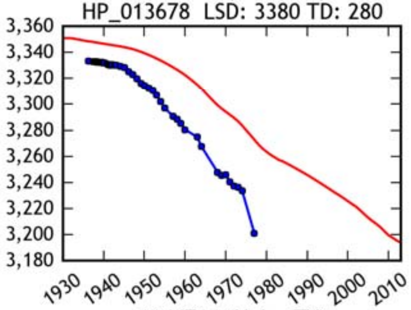
1143413 (Hale, TX)
HP_013647 LSD: 3436 TD: 265



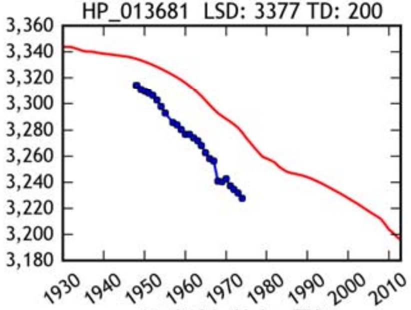
1143505 (Hale, TX)
HP_013658 LSD: 3406 TD: 162



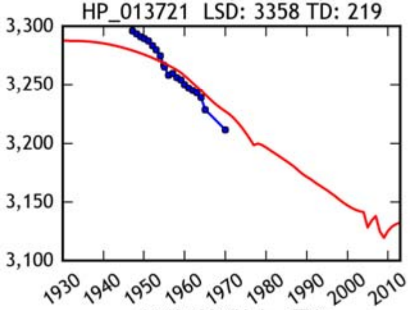
1143803 (Hale, TX)
HP_013678 LSD: 3380 TD: 280



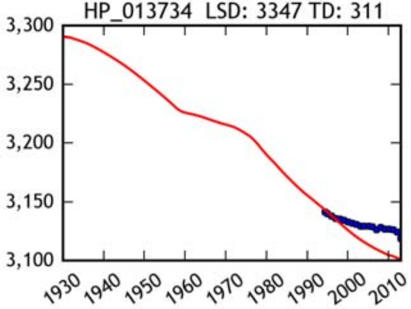
1143902 (Hale, TX)
HP_013681 LSD: 3377 TD: 200



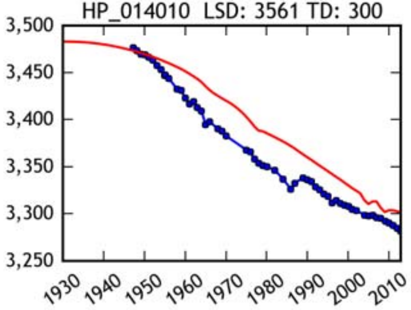
1144701 (Hale, TX)
HP_013721 LSD: 3358 TD: 219



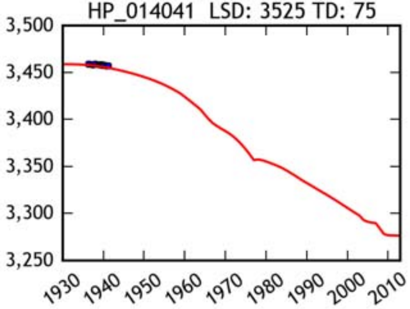
1144714 (Hale, TX)
HP_013734 LSD: 3347 TD: 311



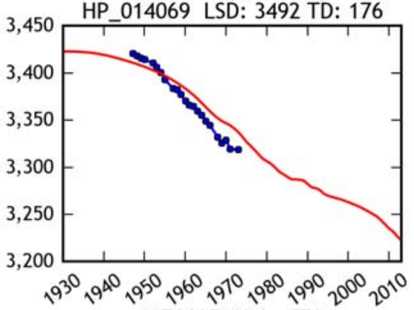
1149101 (Hale, TX)
HP_014010 LSD: 3561 TD: 300



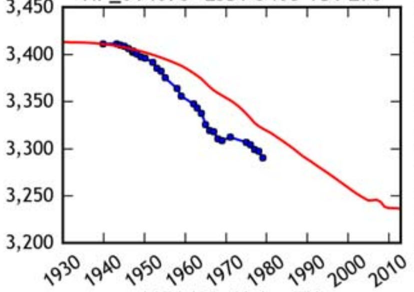
1149402 (Hale, TX)
HP_014041 LSD: 3525 TD: 75



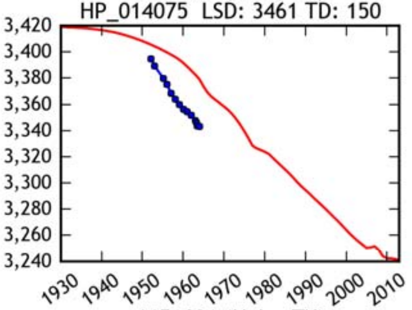
1149901 (Hale, TX)
HP_014069 LSD: 3492 TD: 176



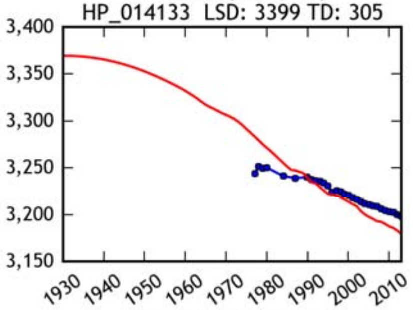
1150101 (Hale, TX)
HP_014073 LSD: 3463 TD: 275



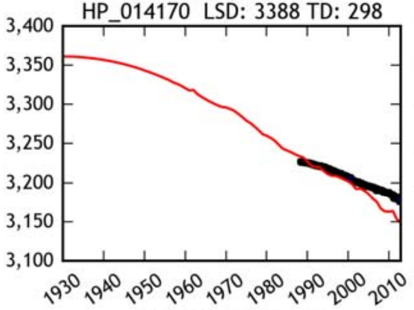
1150103 (Hale, TX)
HP_014075 LSD: 3461 TD: 150



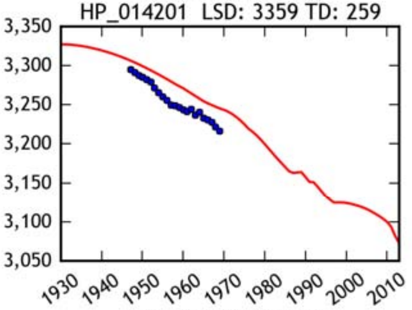
1150605 (Hale, TX)
HP_014133 LSD: 3399 TD: 305



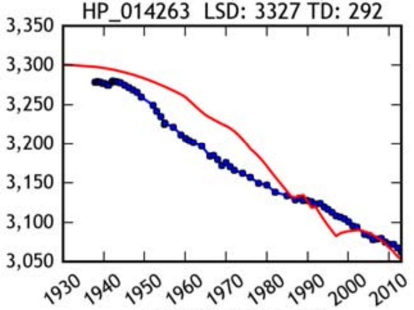
1151403 (Hale, TX)
HP_014170 LSD: 3388 TD: 298



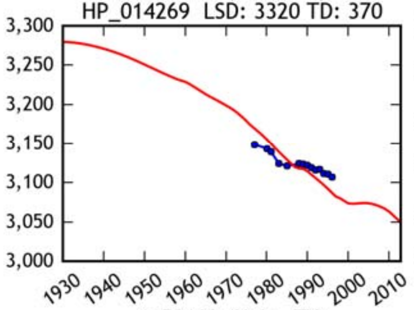
1151601 (Hale, TX)
HP_014201 LSD: 3359 TD: 259



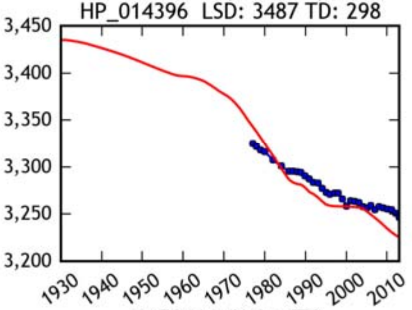
1152703 (Hale, TX)
HP_014263 LSD: 3327 TD: 292



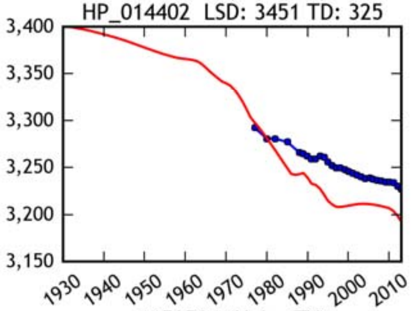
1152711 (Hale, TX)
HP_014269 LSD: 3320 TD: 370



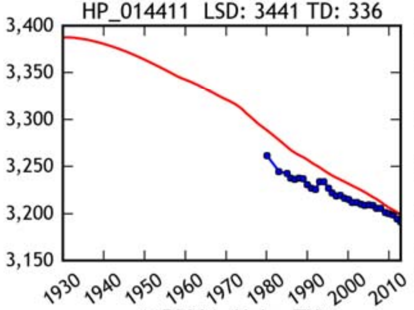
1157202 (Hale, TX)
HP_014396 LSD: 3487 TD: 298



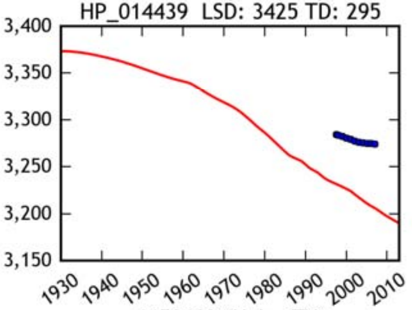
1157601 (Hale, TX)
HP_014402 LSD: 3451 TD: 325



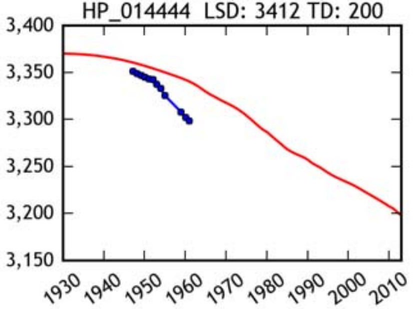
1158103 (Hale, TX)
HP_014411 LSD: 3441 TD: 336



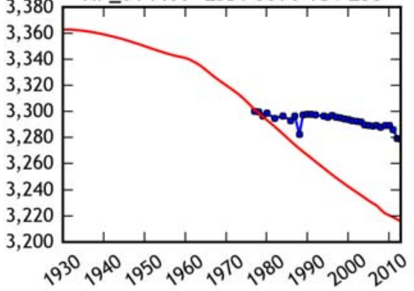
1158414 (Hale, TX)
HP_014439 LSD: 3425 TD: 295



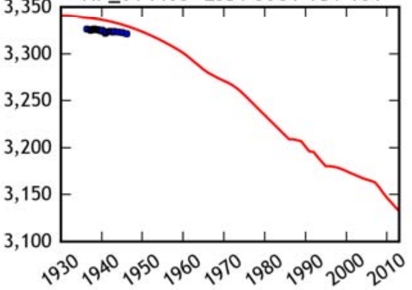
1158504 (Hale, TX)
HP_014444 LSD: 3412 TD: 200

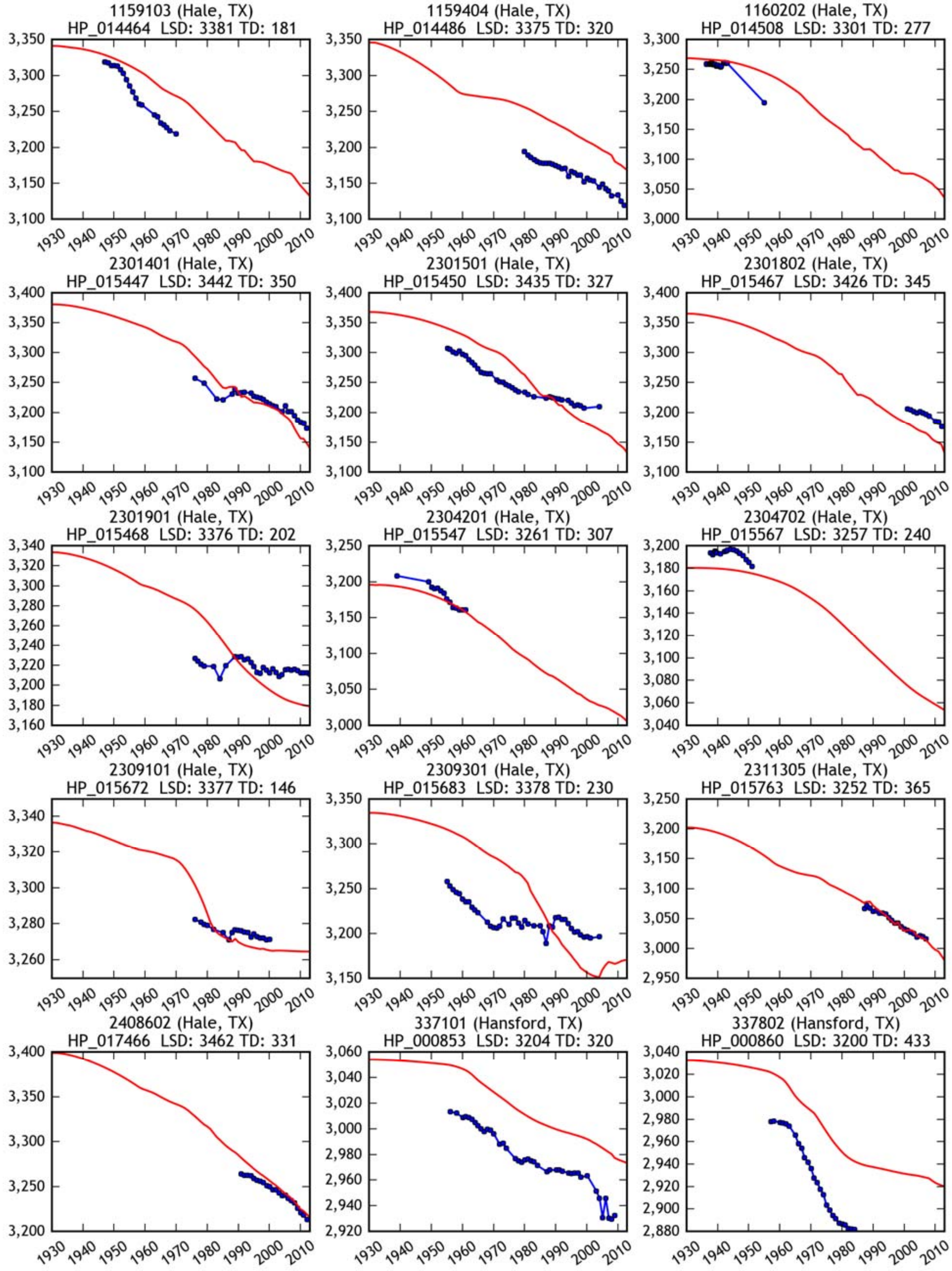


1158801 (Hale, TX)
HP_014460 LSD: 3396 TD: 255



1159102 (Hale, TX)
HP_014463 LSD: 3381 TD: 181





1159103 (Hale, TX)
HP_014464 LSD: 3381 TD: 181

1159404 (Hale, TX)
HP_014486 LSD: 3375 TD: 320

1160202 (Hale, TX)
HP_014508 LSD: 3301 TD: 277

2301401 (Hale, TX)
HP_015447 LSD: 3442 TD: 350

2301501 (Hale, TX)
HP_015450 LSD: 3435 TD: 327

2301802 (Hale, TX)
HP_015467 LSD: 3426 TD: 345

2301901 (Hale, TX)
HP_015468 LSD: 3376 TD: 202

2304201 (Hale, TX)
HP_015547 LSD: 3261 TD: 307

2304702 (Hale, TX)
HP_015567 LSD: 3257 TD: 240

2309101 (Hale, TX)
HP_015672 LSD: 3377 TD: 146

2309301 (Hale, TX)
HP_015683 LSD: 3378 TD: 230

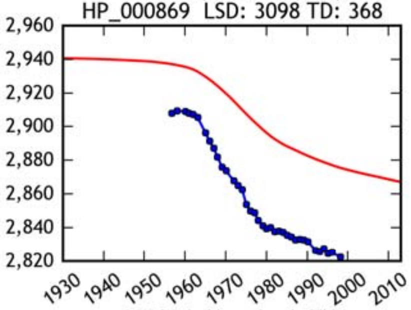
2311305 (Hale, TX)
HP_015763 LSD: 3252 TD: 365

2408602 (Hale, TX)
HP_017466 LSD: 3462 TD: 331

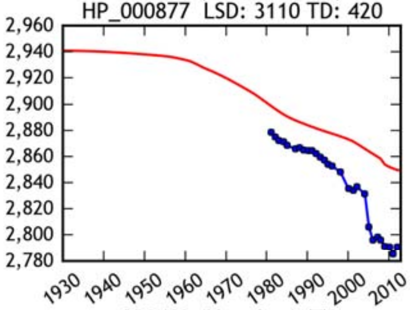
337101 (Hansford, TX)
HP_000853 LSD: 3204 TD: 320

337802 (Hansford, TX)
HP_000860 LSD: 3200 TD: 433

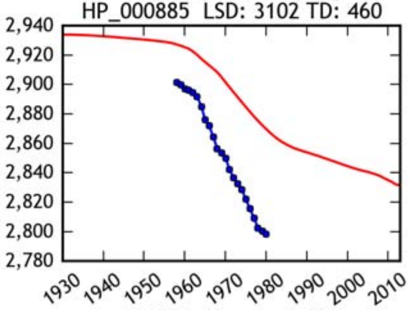
338102 (Hansford, TX)
HP_000869 LSD: 3098 TD: 368



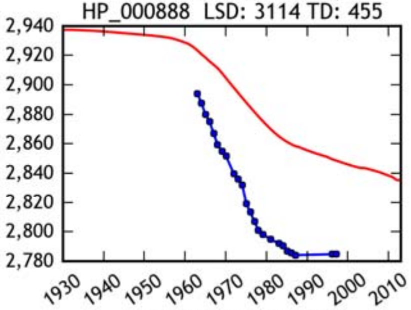
338401 (Hansford, TX)
HP_000877 LSD: 3110 TD: 420



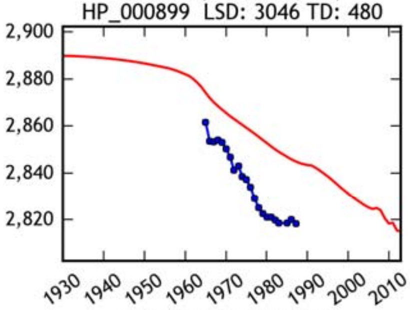
338801 (Hansford, TX)
HP_000885 LSD: 3102 TD: 460



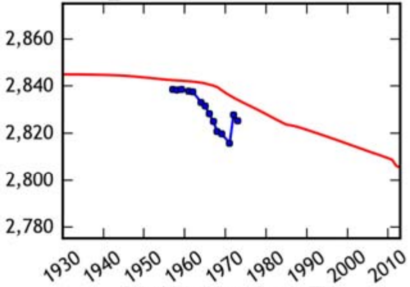
338804 (Hansford, TX)
HP_000888 LSD: 3114 TD: 455



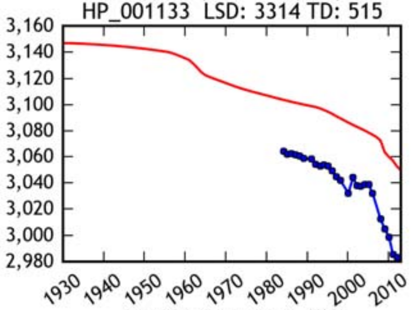
339402 (Hansford, TX)
HP_000899 LSD: 3046 TD: 480



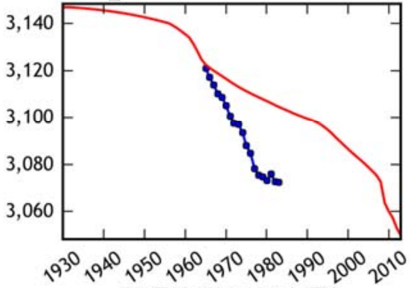
339501 (Hansford, TX)
HP_000900 LSD: 3028 TD: 320



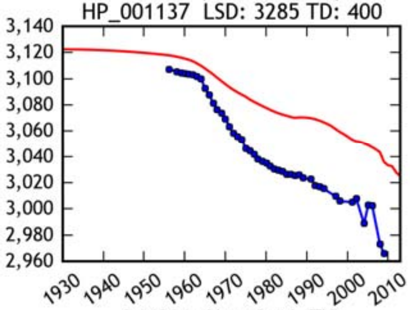
344504 (Hansford, TX)
HP_001133 LSD: 3314 TD: 515



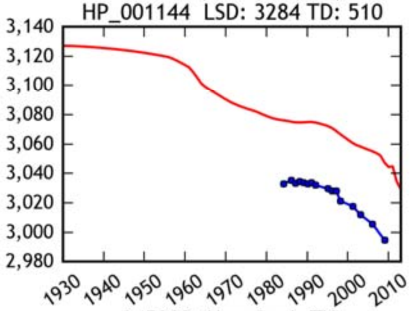
344505 (Hansford, TX)
HP_001134 LSD: 3312 TD: 529



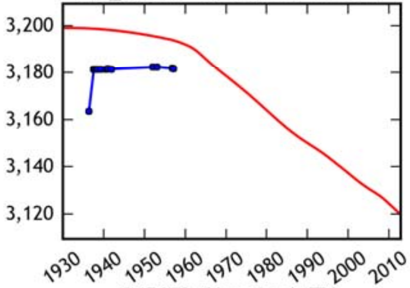
344601 (Hansford, TX)
HP_001137 LSD: 3285 TD: 400



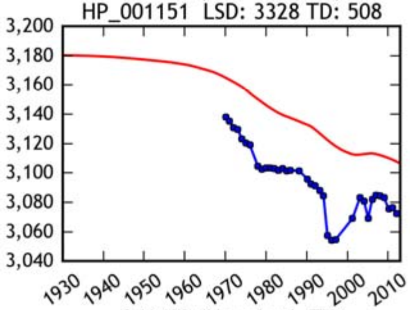
344608 (Hansford, TX)
HP_001144 LSD: 3284 TD: 510



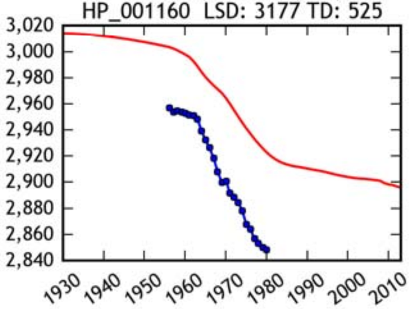
344702 (Hansford, TX)
HP_001147 LSD: 3362 TD: 225



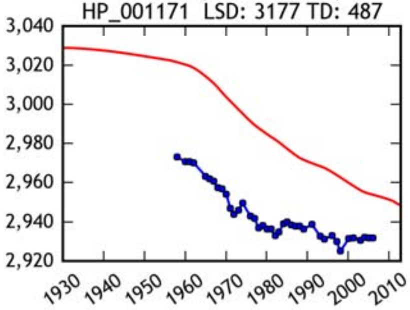
344801 (Hansford, TX)
HP_001151 LSD: 3328 TD: 508



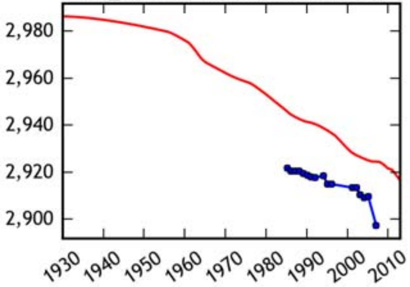
345303 (Hansford, TX)
HP_001160 LSD: 3177 TD: 525



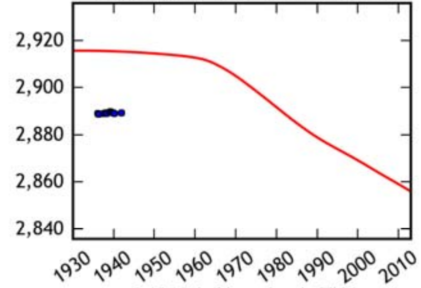
345602 (Hansford, TX)
HP_001171 LSD: 3177 TD: 487



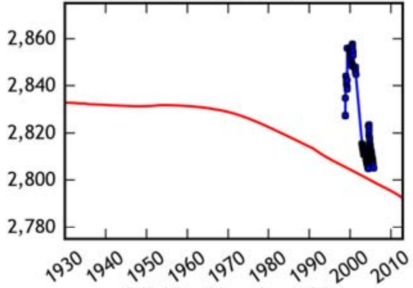
346402 (Hansford, TX)
HP_001232 LSD: 3145 TD: 486



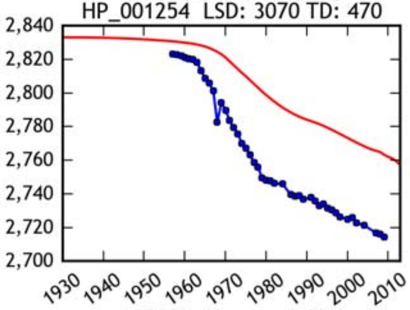
346901 (Hansford, TX)
HP_001245 LSD: 2961 TD: 150



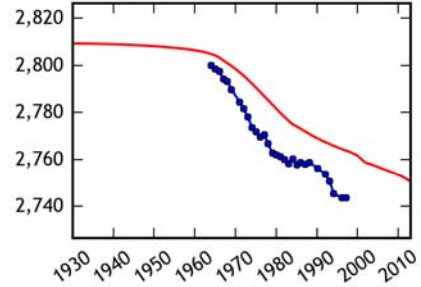
347301 (Hansford, TX)
HP_001252 LSD: 2907 TD: 234



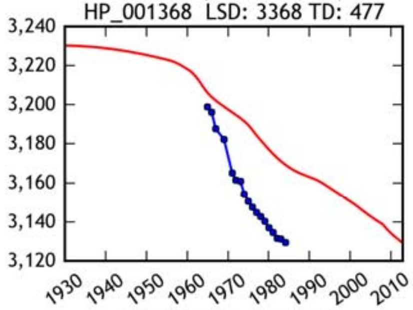
347901 (Hansford, TX)
HP_001254 LSD: 3070 TD: 470



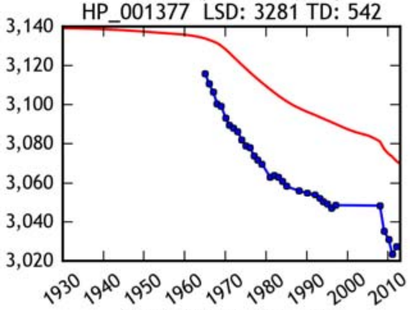
348104 (Hansford, TX)
HP_001258 LSD: 3041 TD: 327



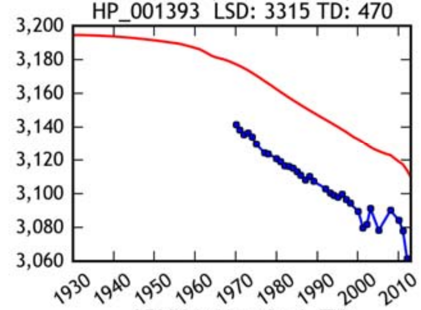
352101 (Hansford, TX)
HP_001368 LSD: 3368 TD: 477



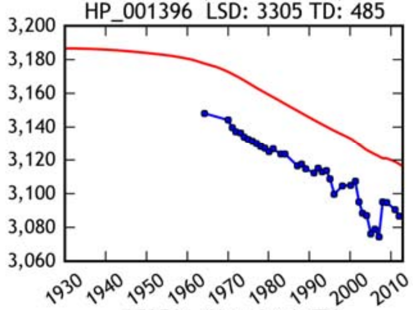
352302 (Hansford, TX)
HP_001377 LSD: 3281 TD: 542



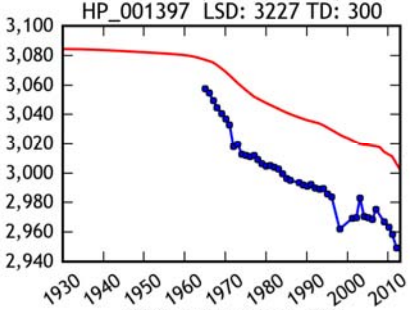
352804 (Hansford, TX)
HP_001393 LSD: 3315 TD: 470



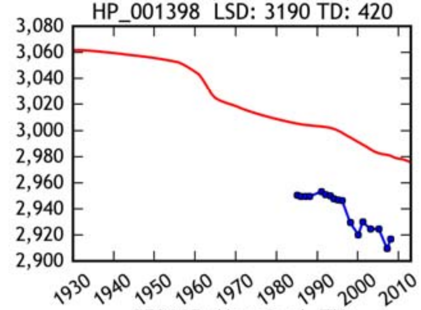
352902 (Hansford, TX)
HP_001396 LSD: 3305 TD: 485



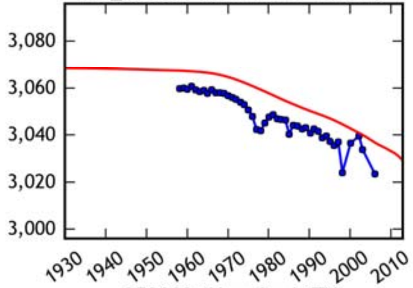
353101 (Hansford, TX)
HP_001397 LSD: 3227 TD: 300



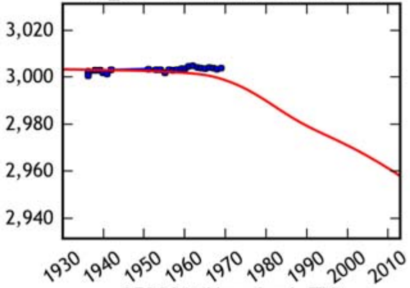
353201 (Hansford, TX)
HP_001398 LSD: 3190 TD: 420



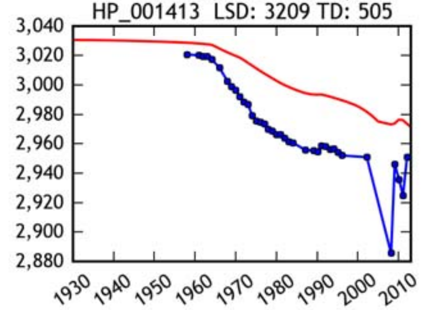
353501 (Hansford, TX)
HP_001405 LSD: 3123 TD: 320



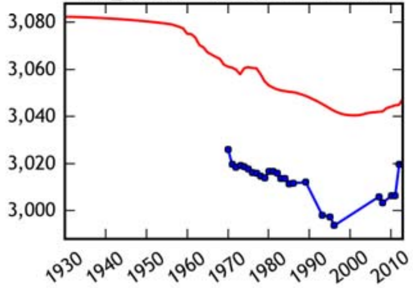
353601 (Hansford, TX)
HP_001409 LSD: 3032 TD: 120



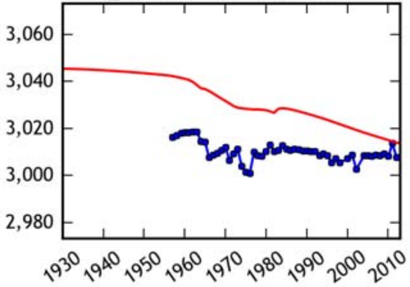
353605 (Hansford, TX)
HP_001413 LSD: 3209 TD: 505



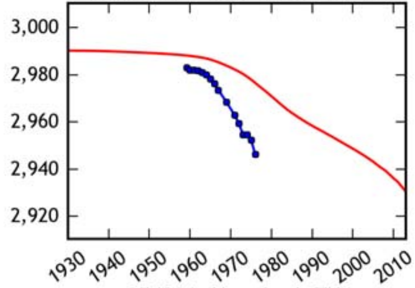
353803 (Hansford, TX)
HP_001417 LSD: 3241 TD: 355



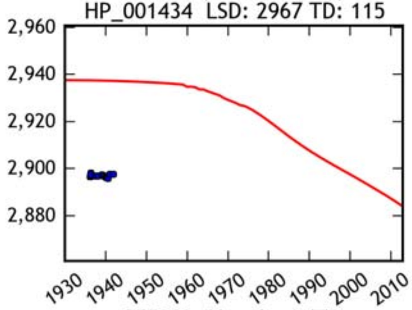
353901 (Hansford, TX)
HP_001420 LSD: 3225 TD: 324



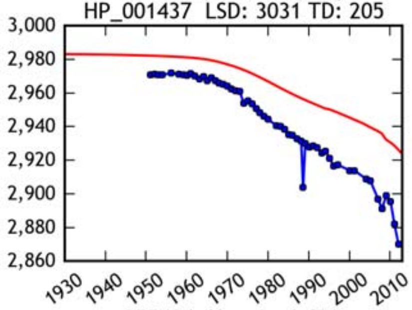
354101 (Hansford, TX)
HP_001422 LSD: 3176 TD: 400



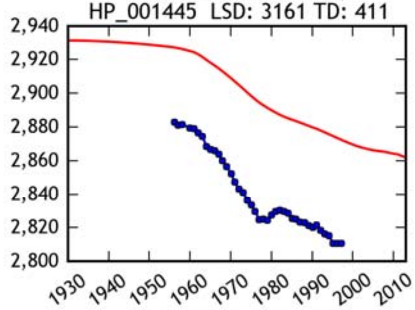
354302 (Hansford, TX)
HP_001434 LSD: 2967 TD: 115



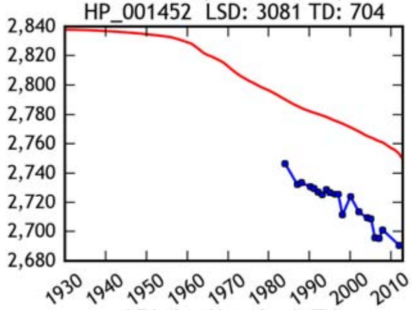
354401 (Hansford, TX)
HP_001437 LSD: 3031 TD: 205



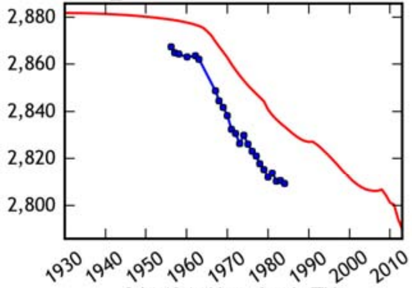
354801 (Hansford, TX)
HP_001445 LSD: 3161 TD: 411



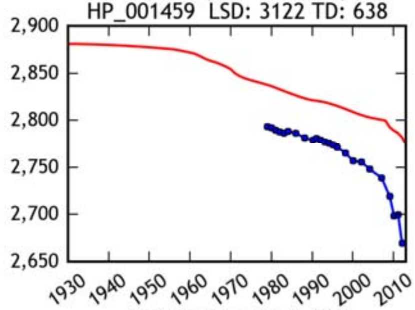
355302 (Hansford, TX)
HP_001452 LSD: 3081 TD: 704



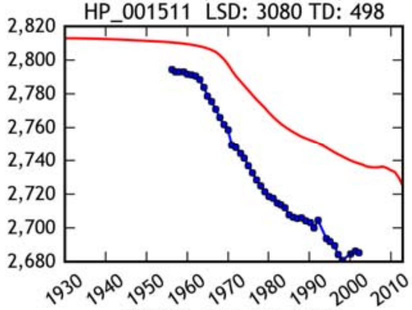
355404 (Hansford, TX)
HP_001455 LSD: 3104 TD: 373



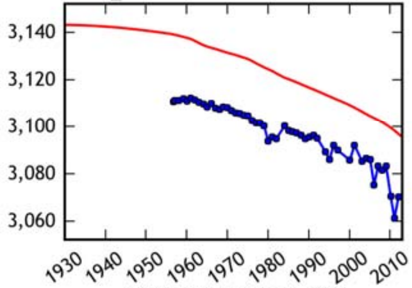
355408 (Hansford, TX)
HP_001459 LSD: 3122 TD: 638



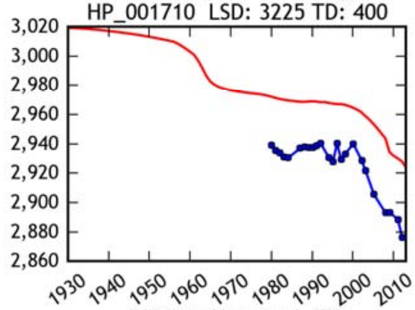
356401 (Hansford, TX)
HP_001511 LSD: 3080 TD: 498



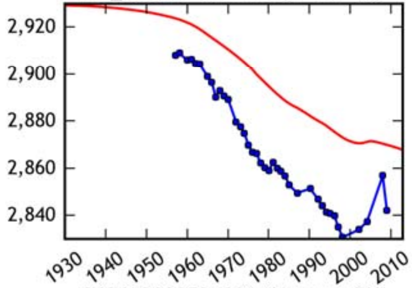
361404 (Hansford, TX)
HP_001688 LSD: 3161 TD: 300



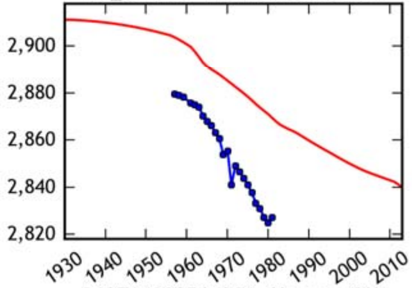
362102 (Hansford, TX)
HP_001710 LSD: 3225 TD: 400



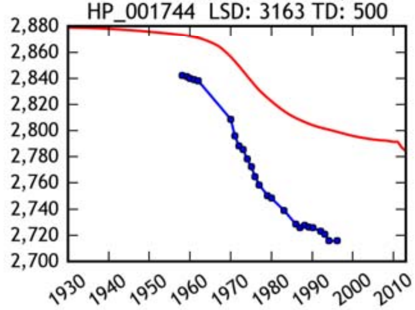
362501 (Hansford, TX)
HP_001719 LSD: 3202 TD: 488



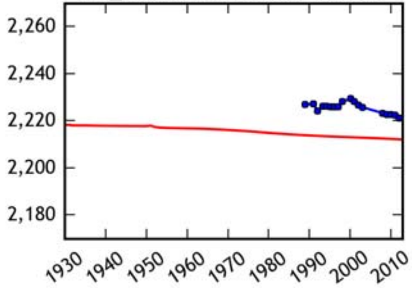
362603 (Hansford, TX)
HP_001723 LSD: 3188 TD: 454



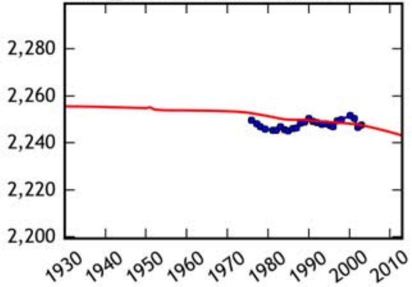
363101 (Hansford, TX)
HP_001744 LSD: 3163 TD: 500



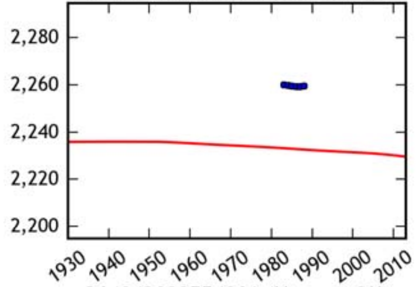
363612099524801 (Harper, OK)
HP_116458 LSD: 2230 TD: unk



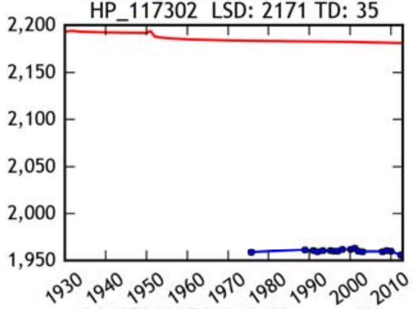
363714099564301 (Harper, OK)
HP_116636 LSD: 2299 TD: 135



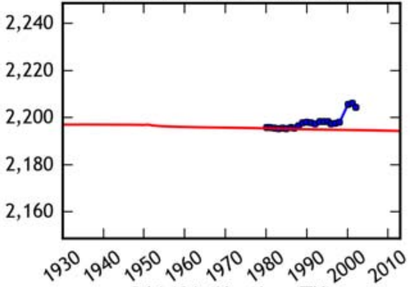
363955099574001 (Harper, OK)
HP_117098 LSD: 2318 TD: 95



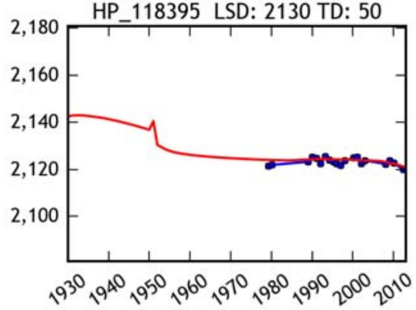
364114099550101 (Harper, OK)
HP_117302 LSD: 2171 TD: 35



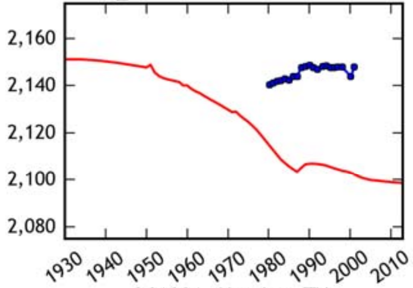
364255099581301 (Harper, OK)
HP_117513 LSD: 2252 TD: 110



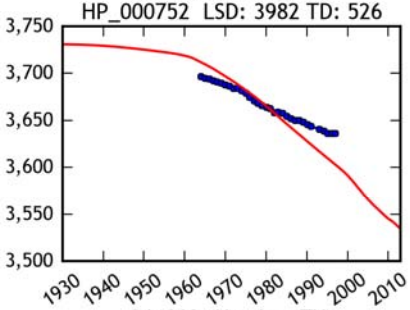
364842099554001 (Harper, OK)
HP_118395 LSD: 2130 TD: 50



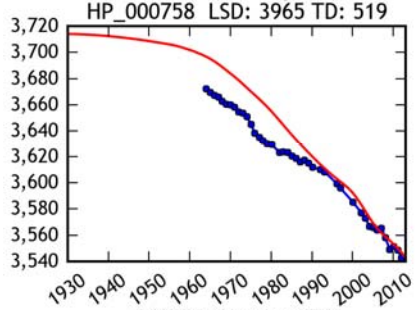
364953099564001 (Harper, OK)
HP_118565 LSD: 2170 TD: 85



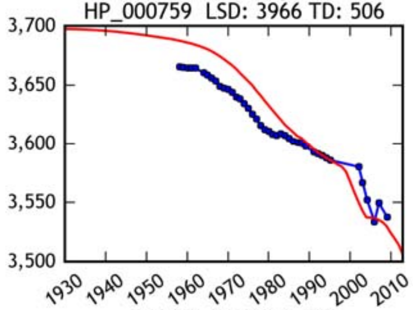
261401 (Hartley, TX)
HP_000752 LSD: 3982 TD: 526



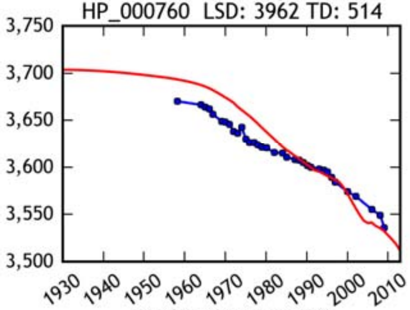
261703 (Hartley, TX)
HP_000758 LSD: 3965 TD: 519



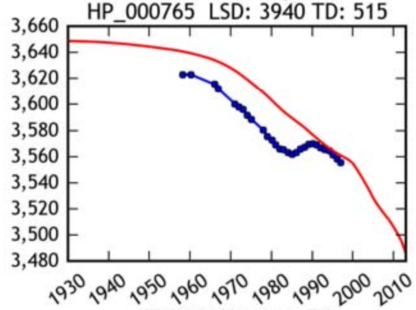
261801 (Hartley, TX)
HP_000759 LSD: 3966 TD: 506



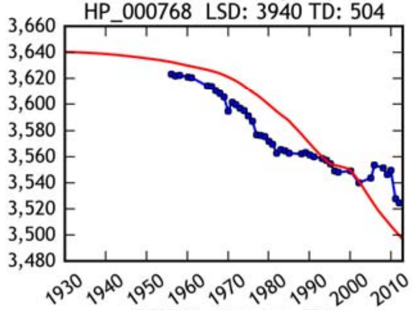
261802 (Hartley, TX)
HP_000760 LSD: 3962 TD: 514



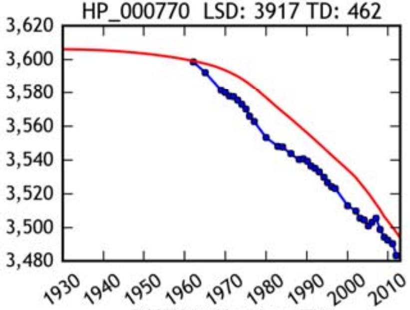
261903 (Hartley, TX)
HP_000765 LSD: 3940 TD: 515



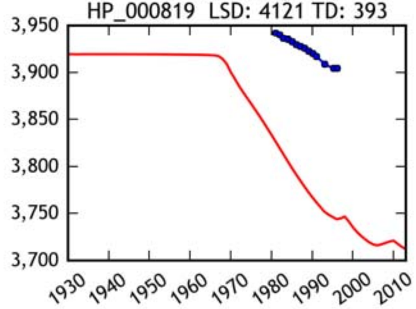
262401 (Hartley, TX)
HP_000768 LSD: 3940 TD: 504



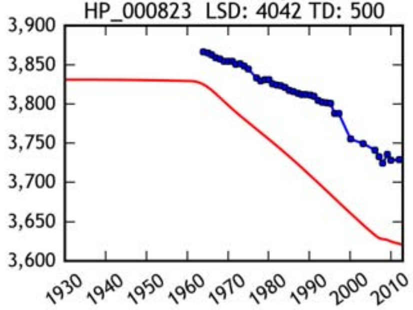
262501 (Hartley, TX)
HP_000770 LSD: 3917 TD: 462



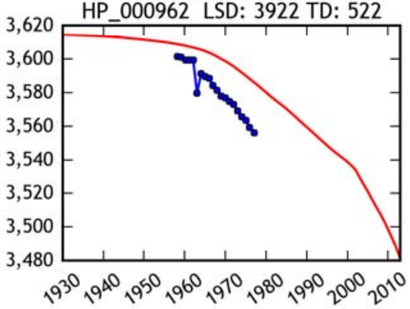
259701 (Hartley, TX)
HP_000819 LSD: 4121 TD: 393



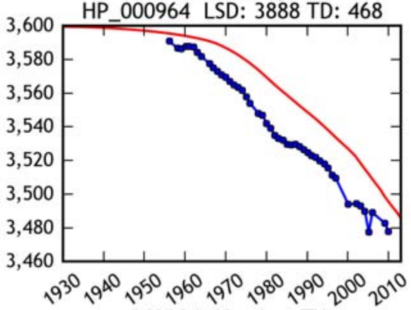
259901 (Hartley, TX)
HP_000823 LSD: 4042 TD: 500



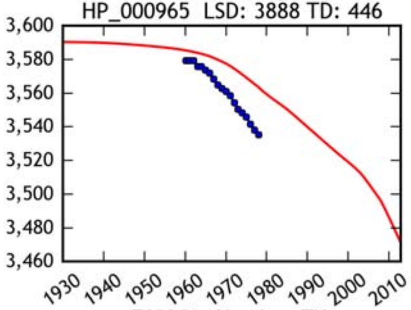
262701 (Hartley, TX)
HP_000962 LSD: 3922 TD: 522



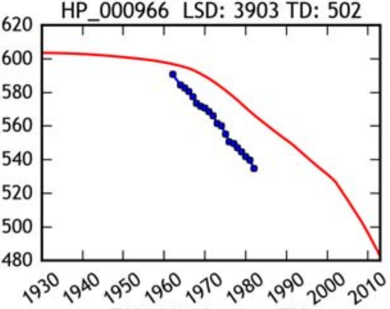
262801 (Hartley, TX)
HP_000964 LSD: 3888 TD: 468



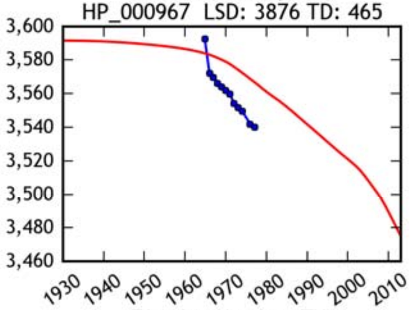
262802 (Hartley, TX)
HP_000965 LSD: 3888 TD: 446



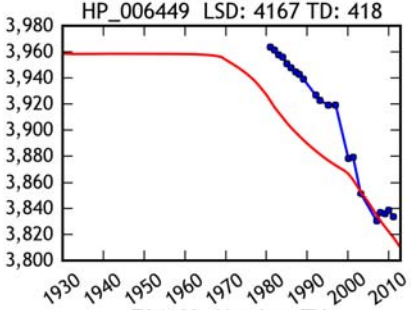
262803 (Hartley, TX)
HP_000966 LSD: 3903 TD: 502



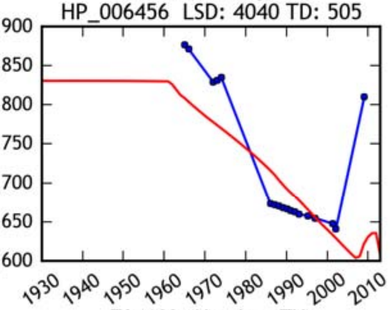
262804 (Hartley, TX)
HP_000967 LSD: 3876 TD: 465



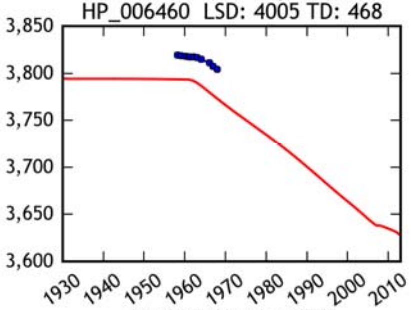
702301 (Hartley, TX)
HP_006449 LSD: 4167 TD: 418



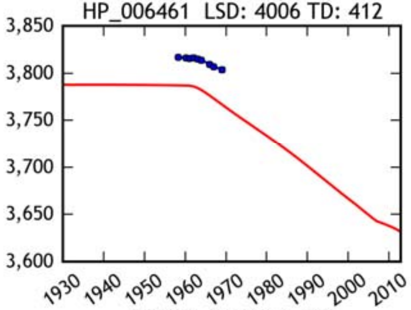
703301 (Hartley, TX)
HP_006456 LSD: 4040 TD: 505



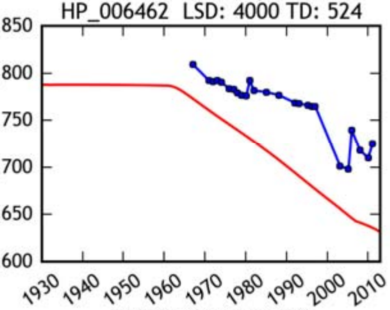
704101 (Hartley, TX)
HP_006460 LSD: 4005 TD: 468



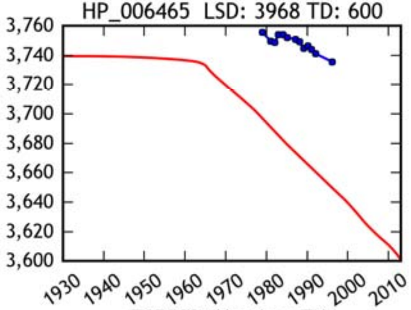
704102 (Hartley, TX)
HP_006461 LSD: 4006 TD: 412



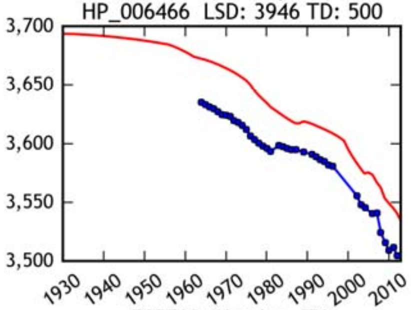
704103 (Hartley, TX)
HP_006462 LSD: 4000 TD: 524



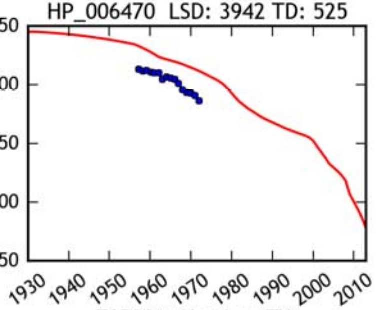
704302 (Hartley, TX)
HP_006465 LSD: 3968 TD: 600



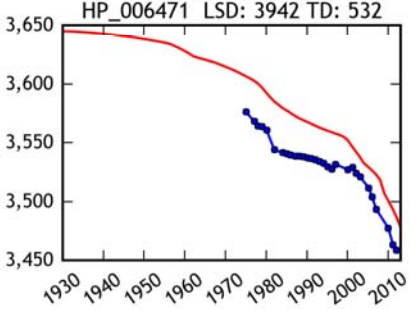
705101 (Hartley, TX)
HP_006466 LSD: 3946 TD: 500



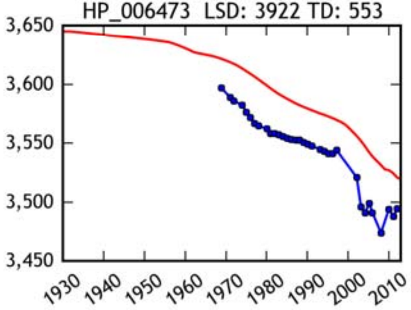
705301 (Hartley, TX)
HP_006470 LSD: 3942 TD: 525



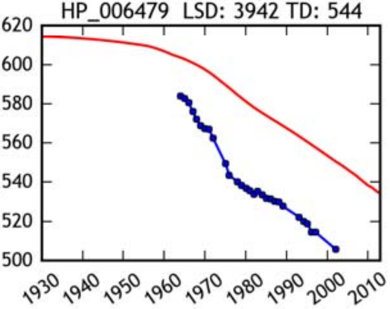
705302 (Hartley, TX)
HP_006471 LSD: 3942 TD: 532



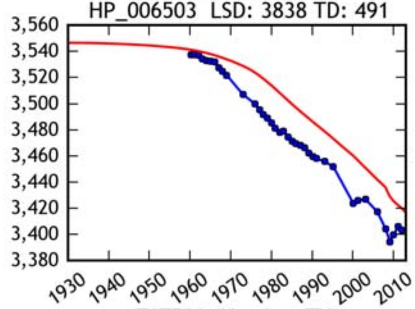
705502 (Hartley, TX)
HP_006473 LSD: 3922 TD: 553



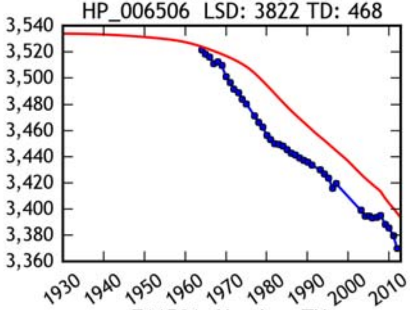
705801 (Hartley, TX)
HP_006479 LSD: 3942 TD: 544



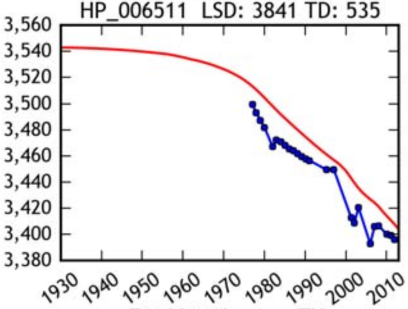
707101 (Hartley, TX)
HP_006503 LSD: 3838 TD: 491



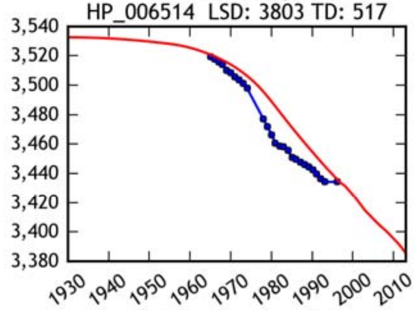
707201 (Hartley, TX)
HP_006506 LSD: 3822 TD: 468



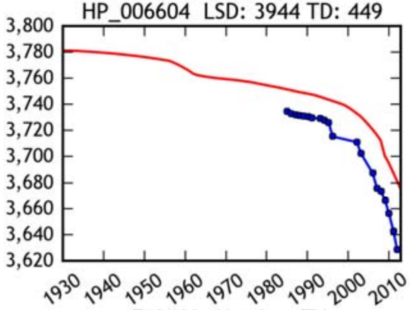
707402 (Hartley, TX)
HP_006511 LSD: 3841 TD: 535



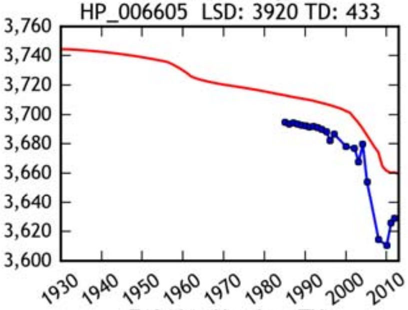
707501 (Hartley, TX)
HP_006514 LSD: 3803 TD: 517



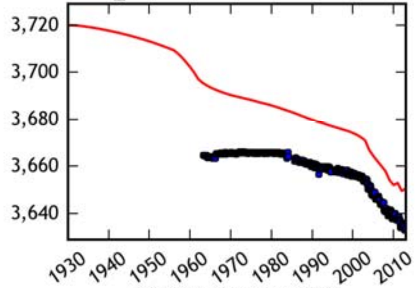
711501 (Hartley, TX)
HP_006604 LSD: 3944 TD: 449



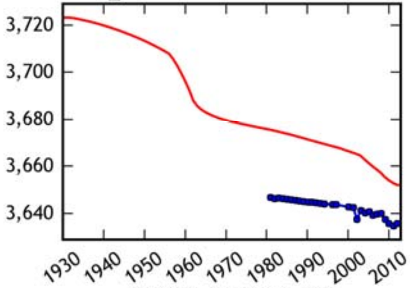
711601 (Hartley, TX)
HP_006605 LSD: 3920 TD: 433



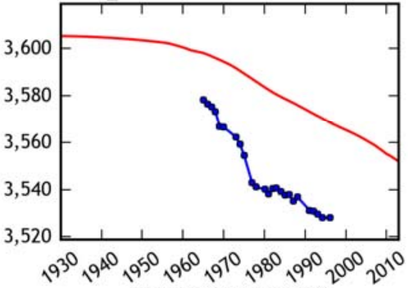
712401 (Hartley, TX)
HP_006608 LSD: 3876 TD: 326



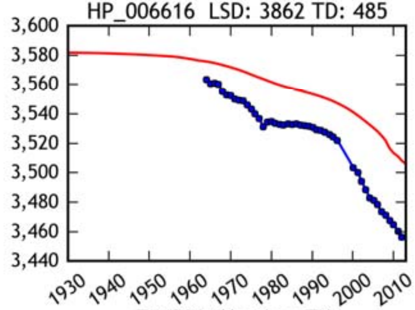
712402 (Hartley, TX)
HP_006609 LSD: 3865 TD: 390



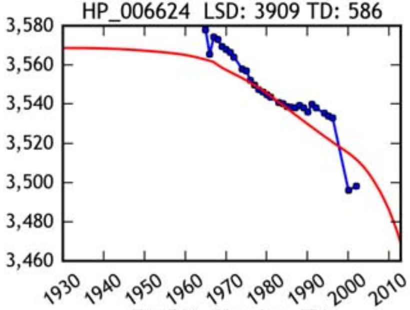
713101 (Hartley, TX)
HP_006612 LSD: 3882 TD: 450



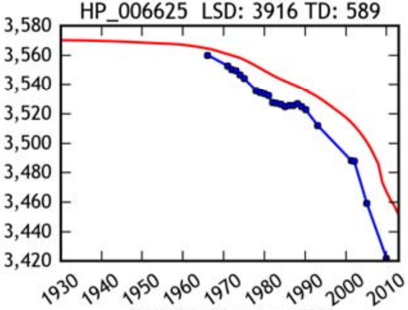
713601 (Hartley, TX)
HP_006616 LSD: 3862 TD: 485



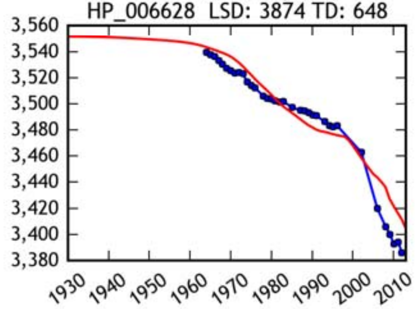
714101 (Hartley, TX)
HP_006624 LSD: 3909 TD: 586



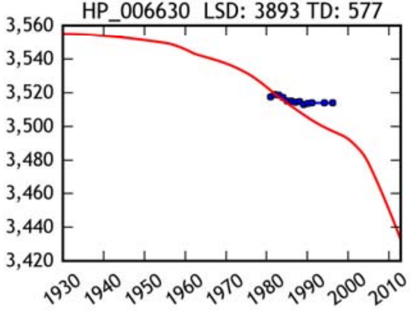
714102 (Hartley, TX)
HP_006625 LSD: 3916 TD: 589



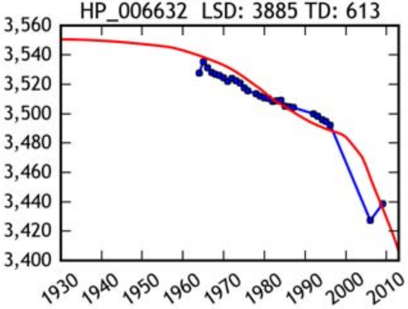
714301 (Hartley, TX)
HP_006628 LSD: 3874 TD: 648



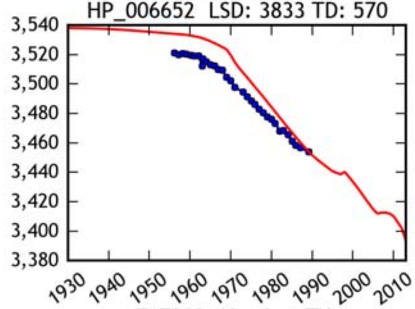
714501 (Hartley, TX)
HP_006630 LSD: 3893 TD: 577



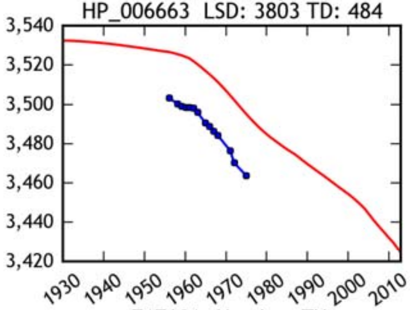
714601 (Hartley, TX)
HP_006632 LSD: 3885 TD: 613



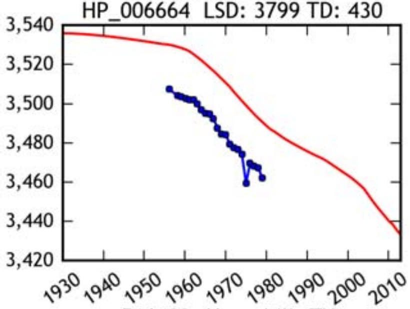
715501 (Hartley, TX)
HP_006652 LSD: 3833 TD: 570



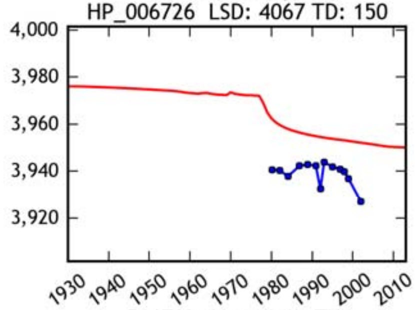
715802 (Hartley, TX)
HP_006663 LSD: 3803 TD: 484



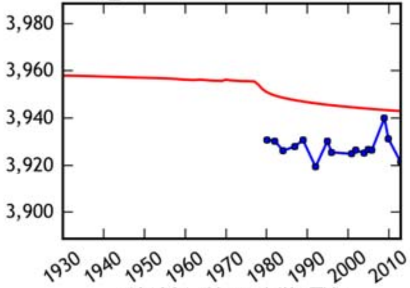
715803 (Hartley, TX)
HP_006664 LSD: 3799 TD: 430



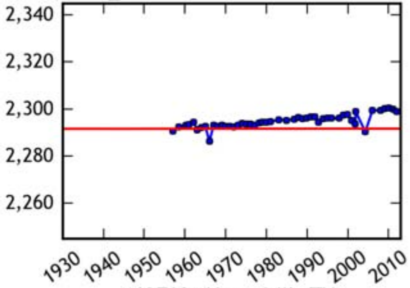
717303 (Hartley, TX)
HP_006726 LSD: 4067 TD: 150



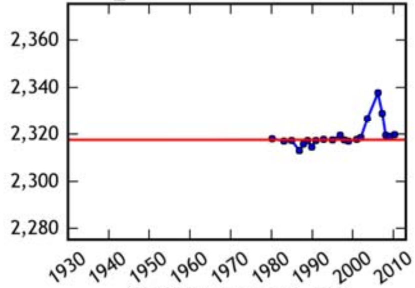
717601 (Hartley, TX)
HP_006730 LSD: 4043 TD: 130



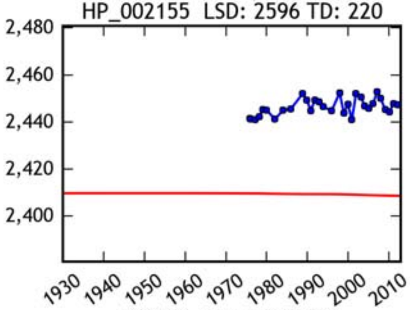
516402 (Hemphill, TX)
HP_001997 LSD: 2378 TD: 156



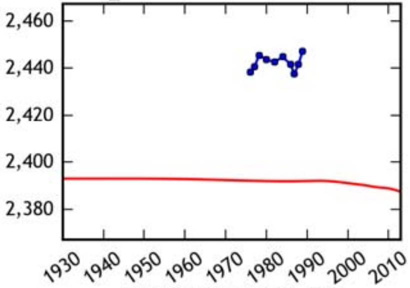
516703 (Hemphill, TX)
HP_002010 LSD: 2476 TD: 210



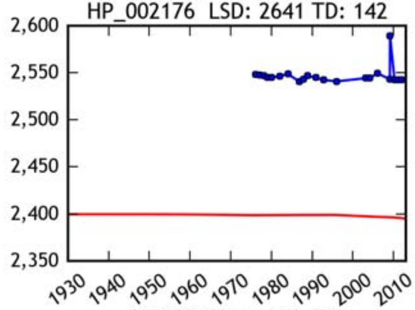
461801 (Hemphill, TX)
HP_002155 LSD: 2596 TD: 220



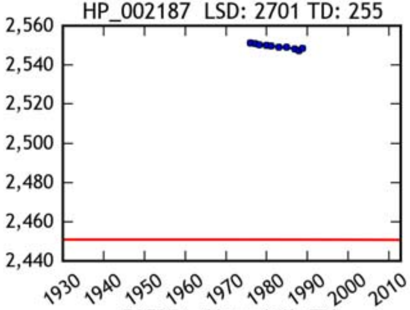
462702 (Hemphill, TX)
HP_002169 LSD: 2681 TD: 360



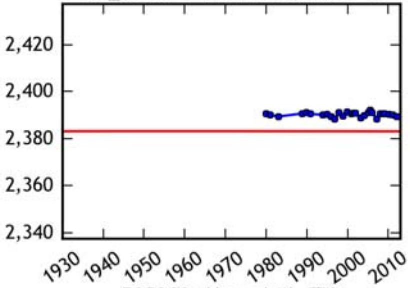
462902 (Hemphill, TX)
HP_002176 LSD: 2641 TD: 142



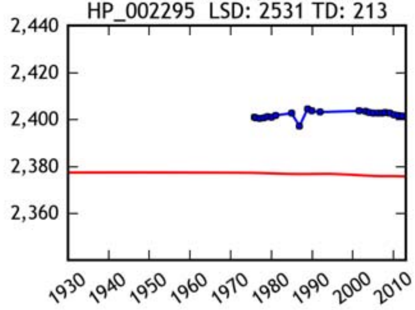
463401 (Hemphill, TX)
HP_002187 LSD: 2701 TD: 255



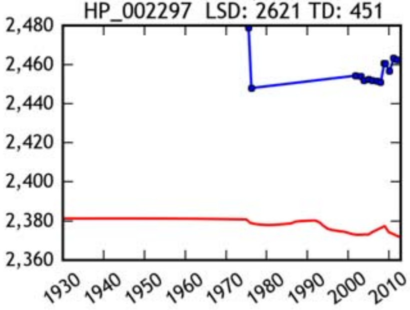
504601 (Hemphill, TX)
HP_002274 LSD: 2426 TD: 142



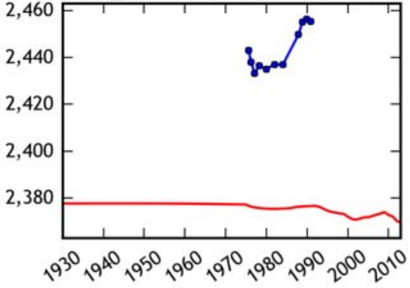
505202 (Hemphill, TX)
HP_002295 LSD: 2531 TD: 213



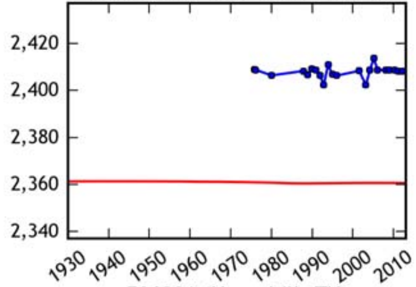
505301 (Hemphill, TX)
HP_002297 LSD: 2621 TD: 451



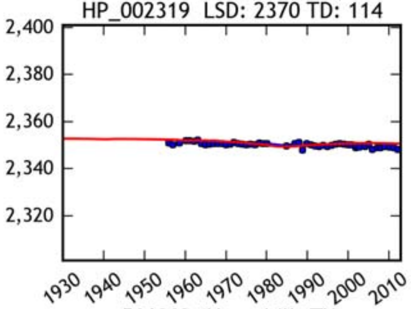
505302 (Hemphill, TX)
HP_002298 LSD: 2575 TD: 411



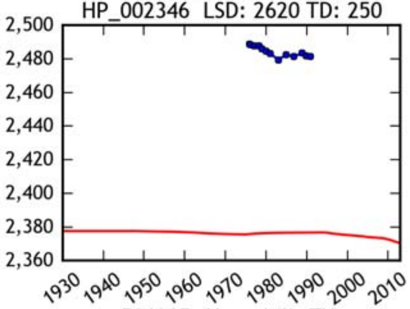
505801 (Hemphill, TX)
HP_002313 LSD: 2506 TD: 230



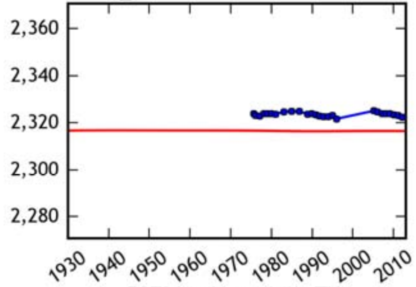
505901 (Hemphill, TX)
HP_002319 LSD: 2370 TD: 114



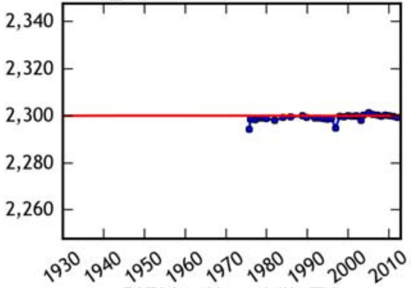
506202 (Hemphill, TX)
HP_002346 LSD: 2620 TD: 250



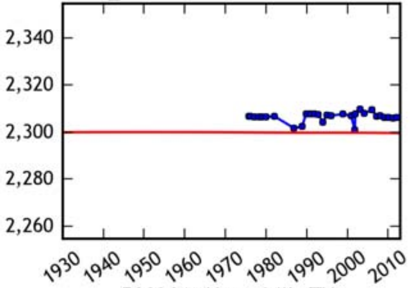
506801 (Hemphill, TX)
HP_002375 LSD: 2340 TD: 66



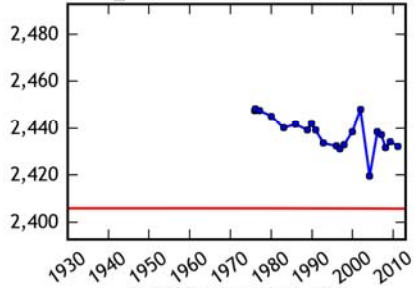
506902 (Hemphill, TX)
HP_002380 LSD: 2398 TD: 181



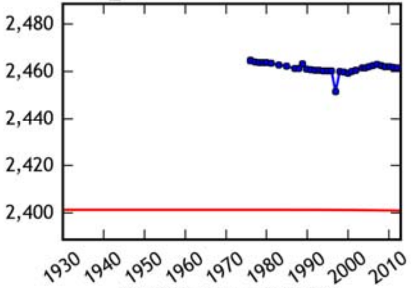
506905 (Hemphill, TX)
HP_002383 LSD: 2423 TD: 188



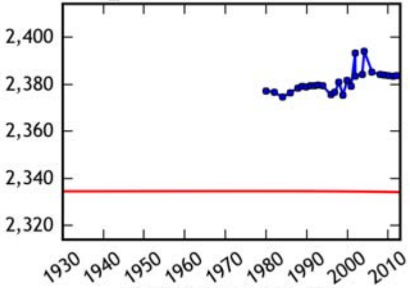
507201 (Hemphill, TX)
HP_002389 LSD: 2608 TD: 260



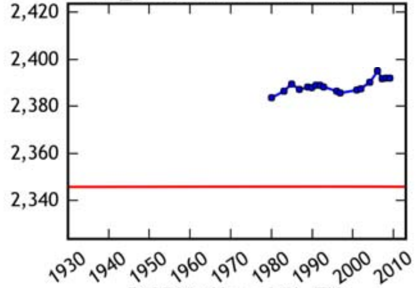
507301 (Hemphill, TX)
HP_002392 LSD: 2595 TD: 365



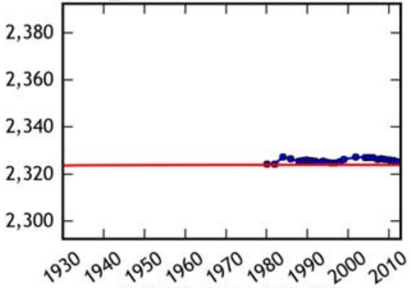
508301 (Hemphill, TX)
HP_002409 LSD: 2497 TD: 160



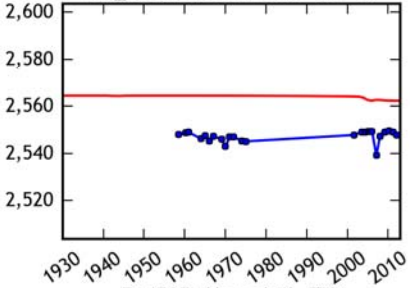
508502 (Hemphill, TX)
HP_002413 LSD: 2454 TD: 86



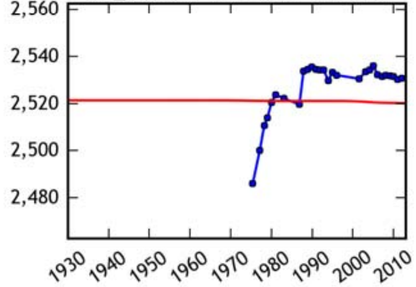
508503 (Hemphill, TX)
HP_002414 LSD: 2359 TD: 140



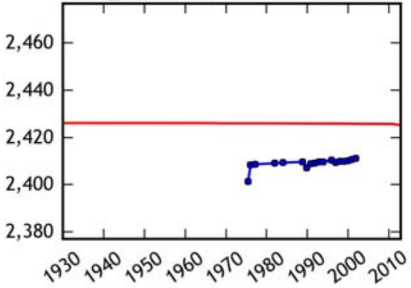
512904 (Hemphill, TX)
HP_002532 LSD: 2579 TD: 90



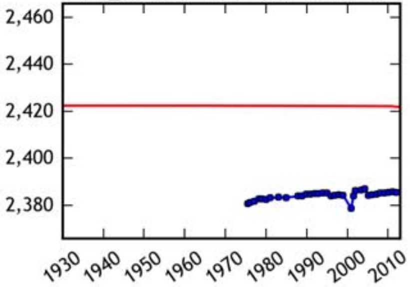
513501 (Hemphill, TX)
HP_002582 LSD: 2767 TD: 368



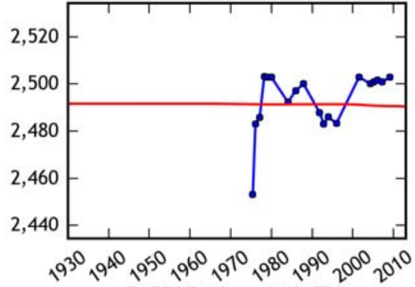
514402 (Hemphill, TX)
HP_002612 LSD: 2518 TD: 184



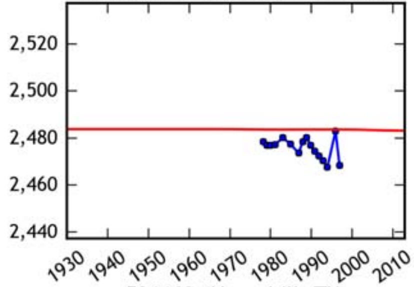
514505 (Hemphill, TX)
HP_002626 LSD: 2607 TD: 316



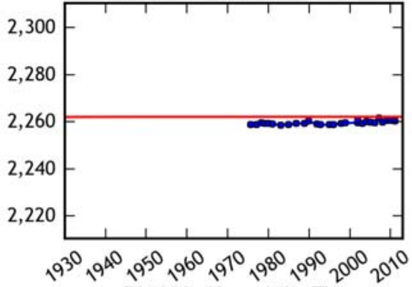
514703 (Hemphill, TX)
HP_002632 LSD: 2635 TD: 353



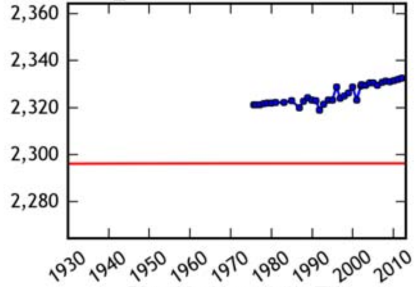
514801 (Hemphill, TX)
HP_002638 LSD: 2681 TD: 417



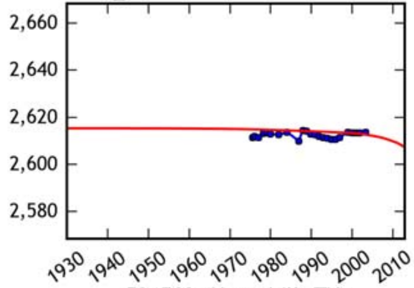
515101 (Hemphill, TX)
HP_002641 LSD: 2275 TD: 90



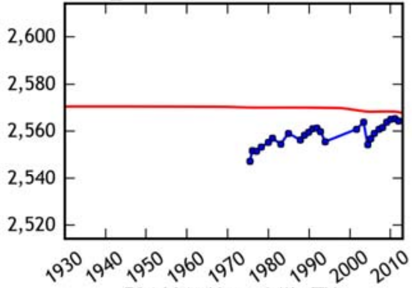
515505 (Hemphill, TX)
HP_002652 LSD: 2448 TD: 203



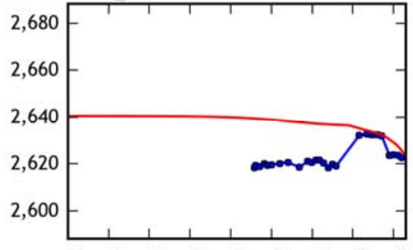
521103 (Hemphill, TX)
HP_002762 LSD: 2681 TD: 203



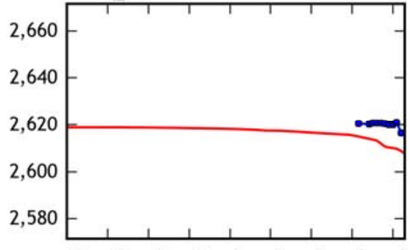
521302 (Hemphill, TX)
HP_002770 LSD: 2643 TD: 260



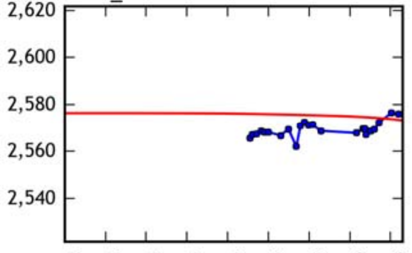
521402 (Hemphill, TX)
HP_002778 LSD: 2780 TD: 325



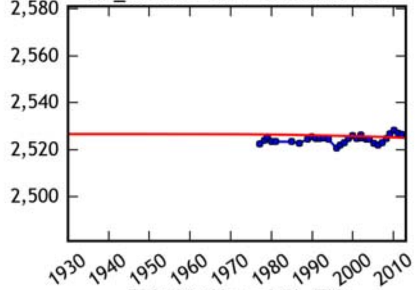
521502 (Hemphill, TX)
HP_002783 LSD: 2716 TD: 175



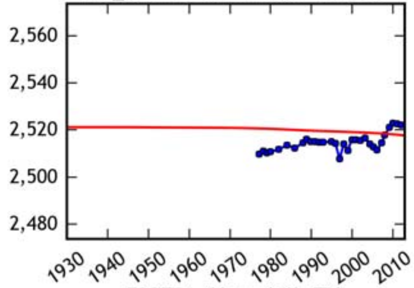
521601 (Hemphill, TX)
HP_002786 LSD: 2671 TD: 323



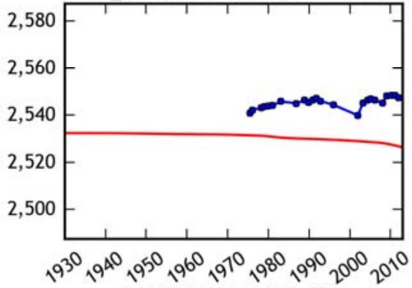
522501 (Hemphill, TX)
HP_002803 LSD: 2572 TD: 200



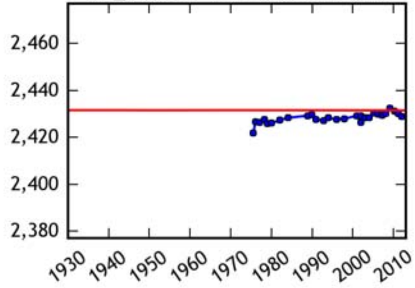
522801 (Hemphill, TX)
HP_002816 LSD: 2665 TD: 366



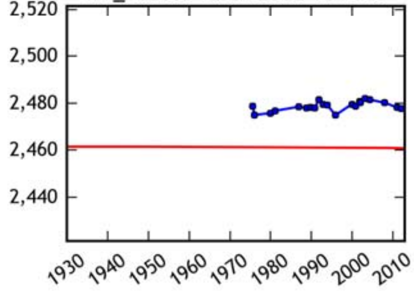
522901 (Hemphill, TX)
HP_002818 LSD: 2595 TD: 120



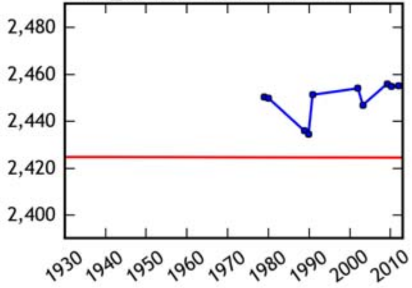
523101 (Hemphill, TX)
HP_002821 LSD: 2493 TD: 255



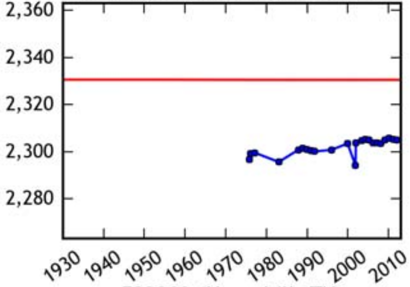
523701 (Hemphill, TX)
HP_002839 LSD: 2582 TD: 303



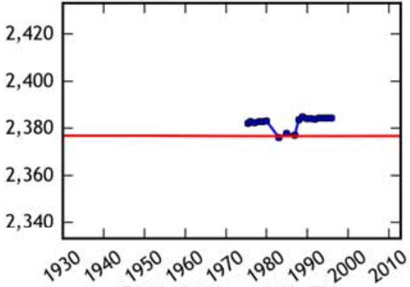
523801 (Hemphill, TX)
HP_002848 LSD: 2495 TD: 100



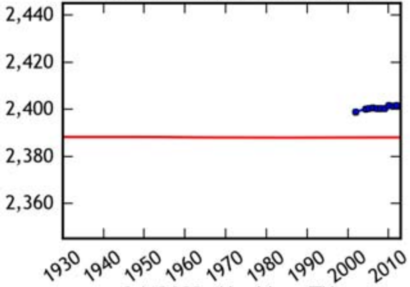
524201 (Hemphill, TX)
HP_002852 LSD: 2363 TD: 98



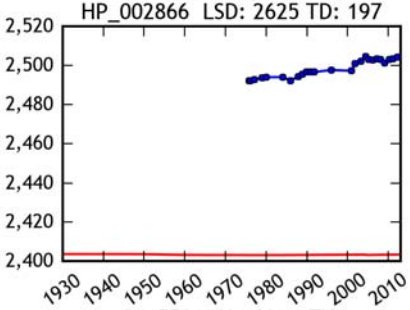
524403 (Hemphill, TX)
HP_002855 LSD: 2475 TD: 205



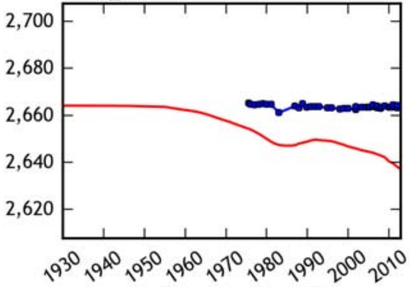
524410 (Hemphill, TX)
HP_002861 LSD: 2531 TD: 307



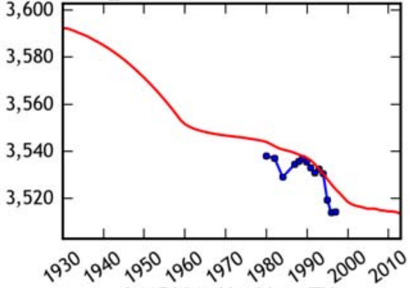
532203 (Hemphill, TX)
HP_002866 LSD: 2625 TD: 197



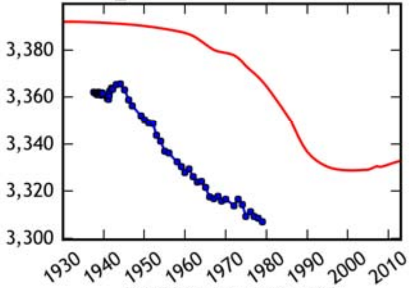
528302 (Hemphill, TX)
HP_003117 LSD: 2966 TD: 412



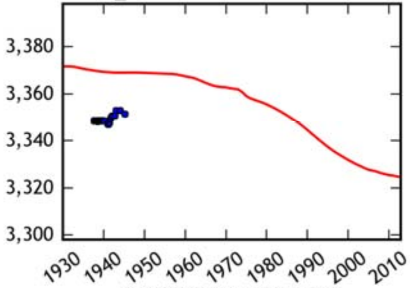
2412802 (Hockley, TX)
HP_017557 LSD: 3661 TD: 212



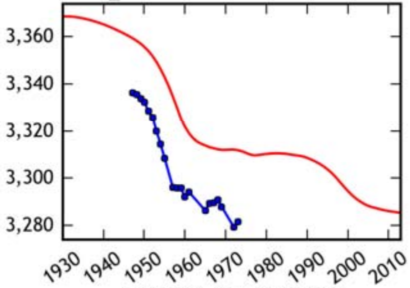
2415501 (Hockley, TX)
HP_017614 LSD: 3394 TD: 92



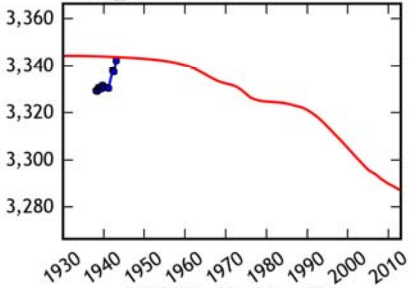
2415606 (Hockley, TX)
HP_017628 LSD: 3376 TD: 50



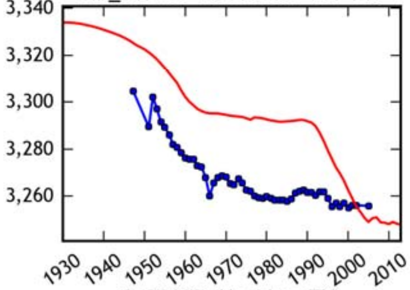
2415801 (Hockley, TX)
HP_017647 LSD: 3422 TD: 183



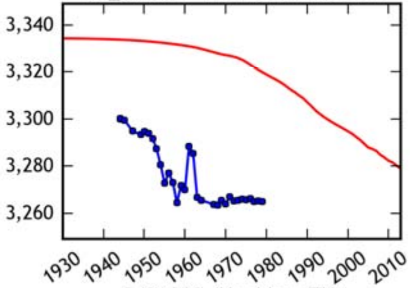
2415903 (Hockley, TX)
HP_017651 LSD: 3357 TD: 40



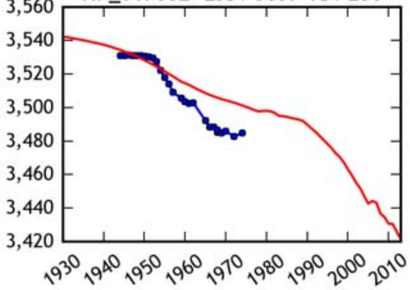
2416702 (Hockley, TX)
HP_017685 LSD: 3360 TD: 140



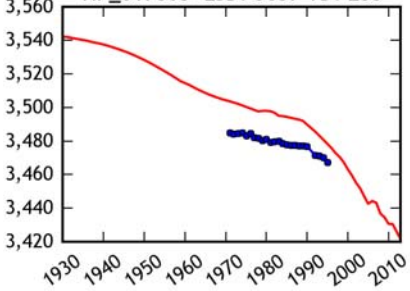
2416704 (Hockley, TX)
HP_017687 LSD: 3371 TD: 129



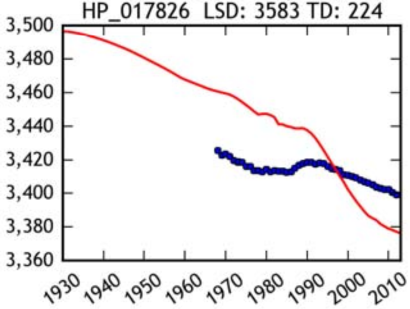
2420601 (Hockley, TX)
HP_017802 LSD: 3637 TD: 230

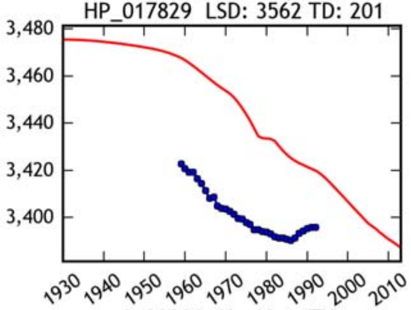


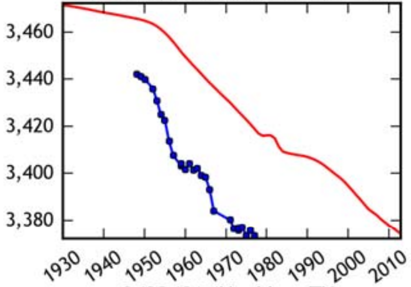
2420602 (Hockley, TX)
HP_017803 LSD: 3637 TD: 255

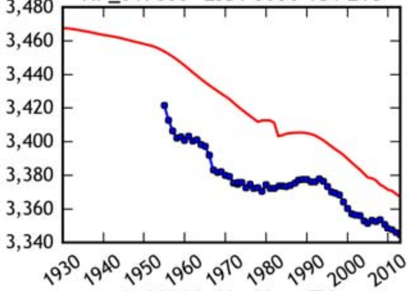


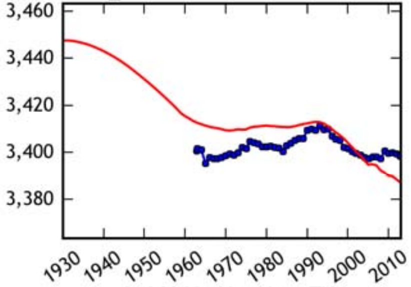
2421803 (Hockley, TX)
HP_017826 LSD: 3583 TD: 224

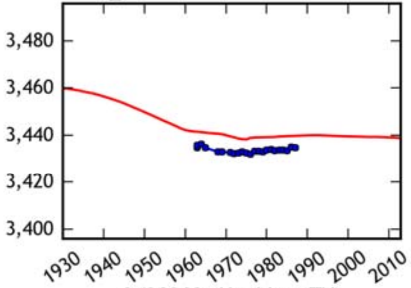


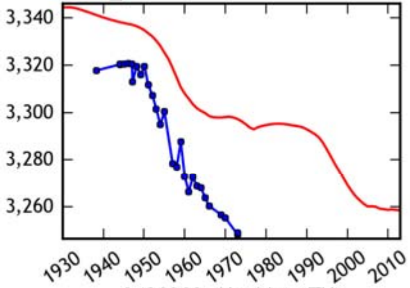

2421901 (Hockley, TX)
HP_017829 LSD: 3562 TD: 201

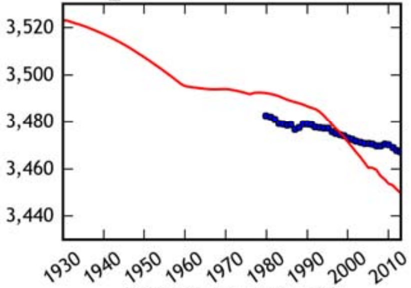

2421902 (Hockley, TX)
HP_017830 LSD: 3555 TD: 223

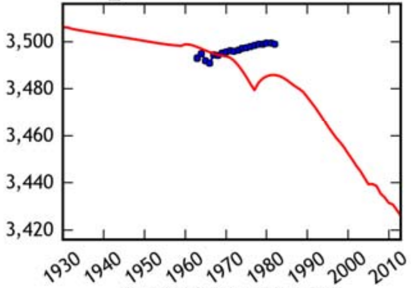

2421905 (Hockley, TX)
HP_017833 LSD: 3556 TD: 218

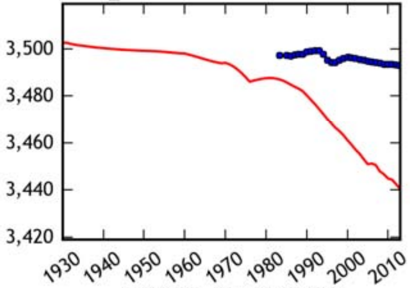

2422201 (Hockley, TX)
HP_017834 LSD: 3477 TD: 116

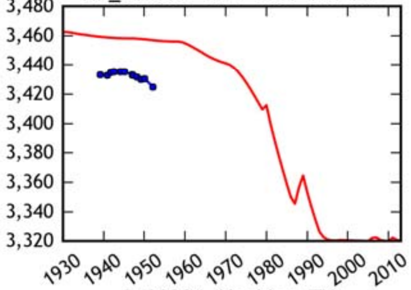

2422401 (Hockley, TX)
HP_017837 LSD: 3516 TD: 142

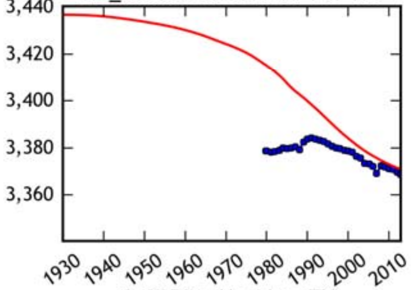

2423201 (Hockley, TX)
HP_017853 LSD: 3459 TD: 221

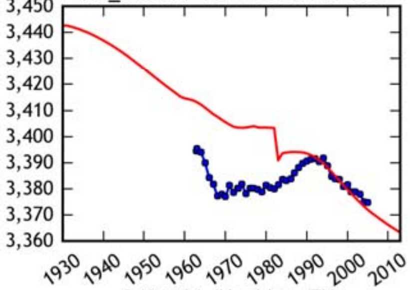

2428203 (Hockley, TX)
HP_017951 LSD: 3626 TD: 219

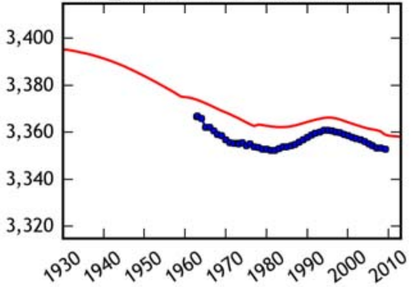

2428302 (Hockley, TX)
HP_017953 LSD: 3622 TD: 186

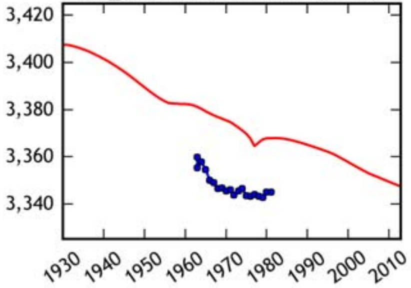

2428303 (Hockley, TX)
HP_017954 LSD: 3622 TD: 210

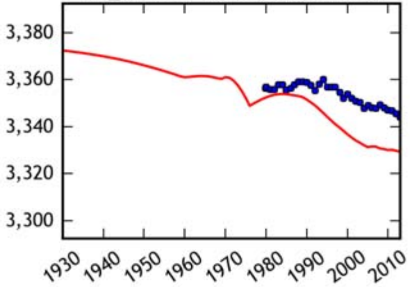

2429301 (Hockley, TX)
HP_017975 LSD: 3537 TD: 105

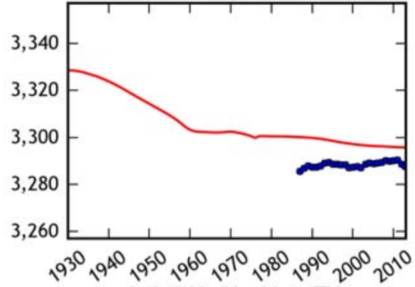

2429603 (Hockley, TX)
HP_018006 LSD: 3514 TD: 173

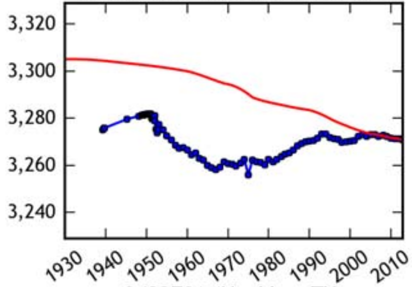

2430102 (Hockley, TX)
HP_018014 LSD: 3520 TD: 190

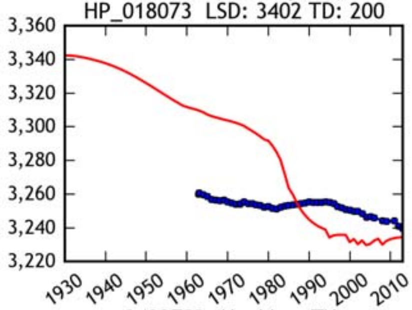

2430304 (Hockley, TX)
HP_018026 LSD: 3464 TD: 146

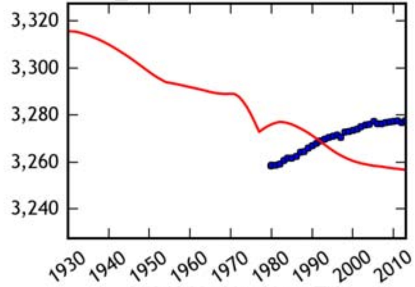

2430501 (Hockley, TX)
HP_018043 LSD: 3474 TD: 190

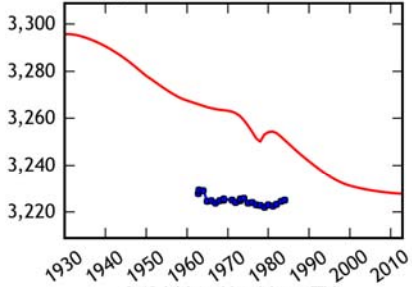

2431101 (Hockley, TX)
HP_018054 LSD: 3428 TD: 132

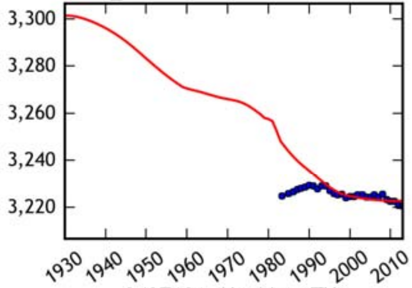

2431304 (Hockley, TX)
HP_018062 LSD: 3391 TD: 140

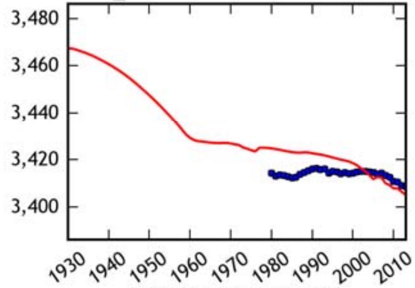

2431601 (Hockley, TX)
HP_018069 LSD: 3381 TD: 146

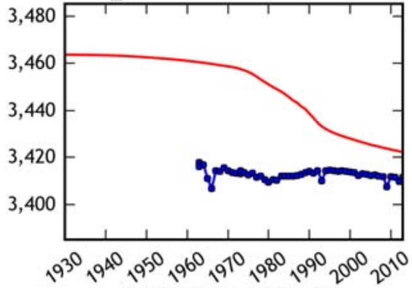

2431801 (Hockley, TX)
HP_018073 LSD: 3402 TD: 200

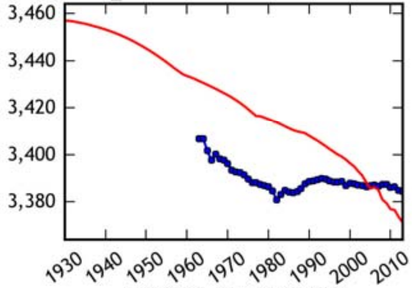

2431902 (Hockley, TX)
HP_018075 LSD: 3387 TD: 161

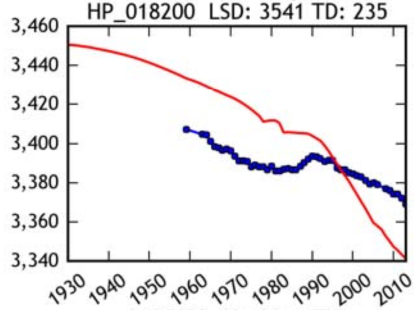

2432701 (Hockley, TX)
HP_018118 LSD: 3346 TD: 144

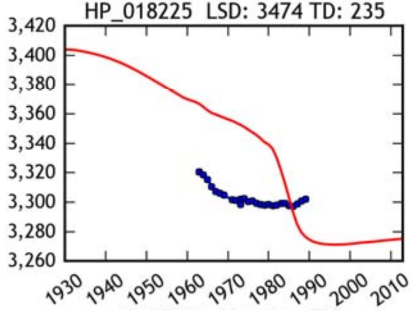

2432702 (Hockley, TX)
HP_018119 LSD: 3356 TD: 176

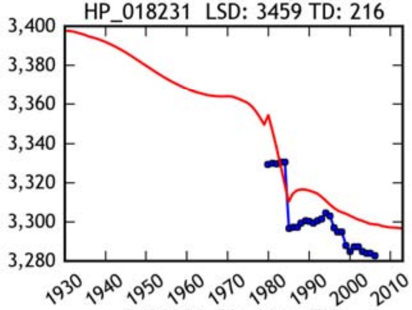

2436302 (Hockley, TX)
HP_018177 LSD: 3589 TD: 224

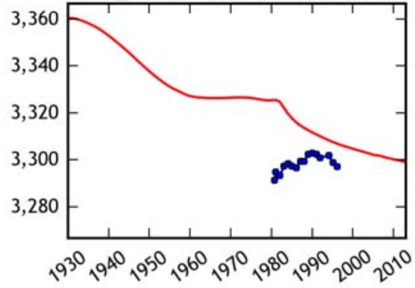

2436601 (Hockley, TX)
HP_018185 LSD: 3561 TD: 177

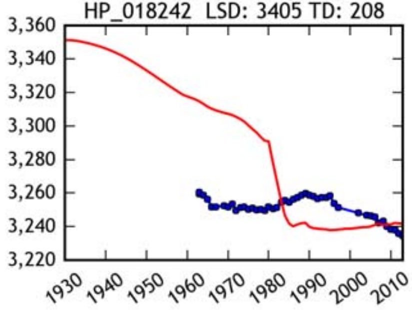

2437101 (Hockley, TX)
HP_018189 LSD: 3544 TD: 207

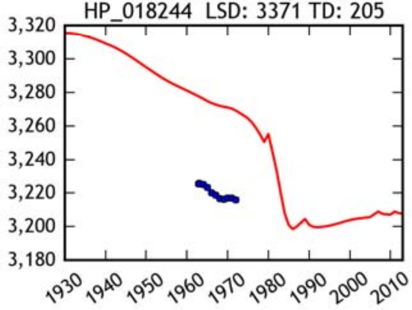

2437204 (Hockley, TX)
HP_018200 LSD: 3541 TD: 235

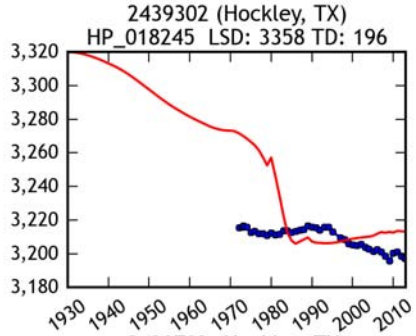

2438201 (Hockley, TX)
HP_018225 LSD: 3474 TD: 235

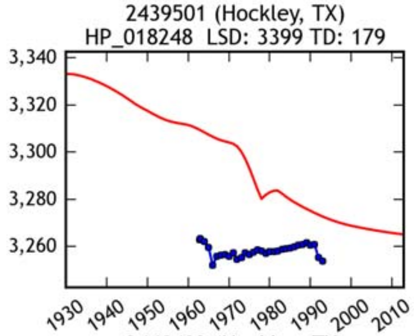

2438501 (Hockley, TX)
HP_018231 LSD: 3459 TD: 216

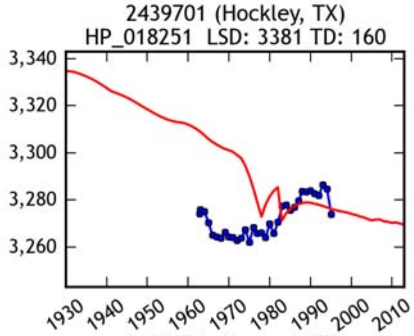

2438602 (Hockley, TX)
HP_018234 LSD: 3419 TD: 181

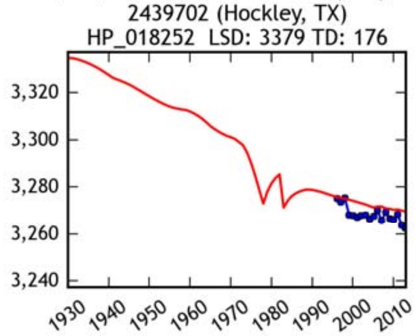

2439101 (Hockley, TX)
HP_018242 LSD: 3405 TD: 208

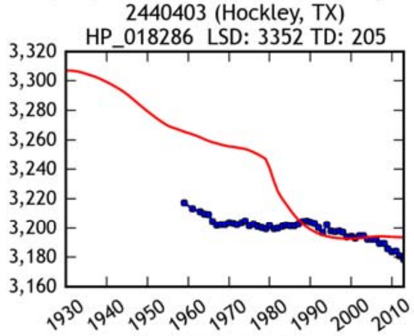

2439301 (Hockley, TX)
HP_018244 LSD: 3371 TD: 205

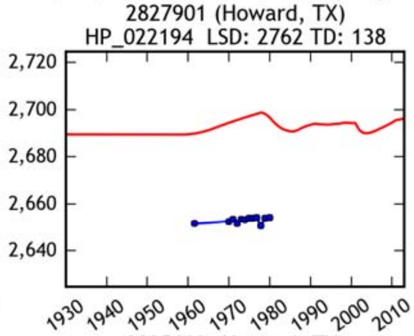

2439302 (Hockley, TX)
HP_018245 LSD: 3358 TD: 196
3,320
3,300
3,280
3,260
3,240
3,220
3,200
3,180
1930
1940
1950
1960
1970
1980
1990
2000
2010

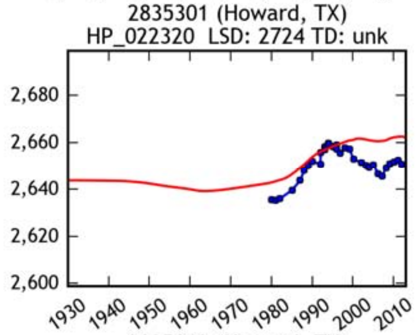

2439501 (Hockley, TX)
HP_018248 LSD: 3399 TD: 179
3,340
3,320
3,300
3,280
3,260
1930
1940
1950
1960
1970
1980
1990
2000
2010

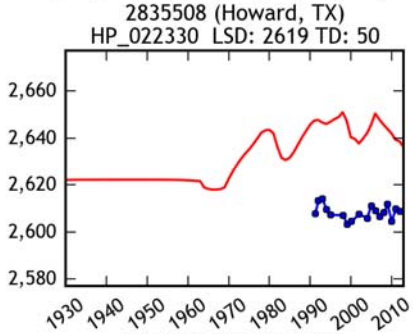

2439701 (Hockley, TX)
HP_018251 LSD: 3381 TD: 160
3,340
3,320
3,300
3,280
3,260
1930
1940
1950
1960
1970
1980
1990
2000
2010

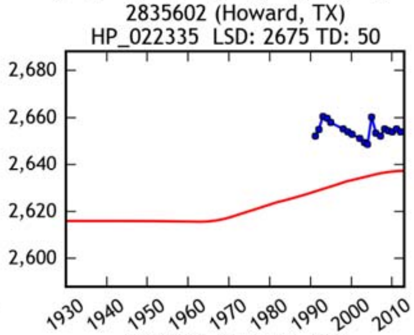

2439702 (Hockley, TX)
HP_018252 LSD: 3379 TD: 176
3,320
3,300
3,280
3,260
3,240
1930
1940
1950
1960
1970
1980
1990
2000
2010

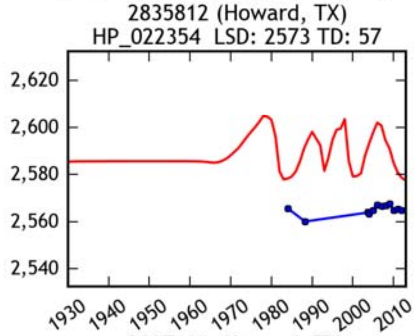

2440403 (Hockley, TX)
HP_018286 LSD: 3352 TD: 205
3,320
3,300
3,280
3,260
3,240
3,220
3,200
3,180
3,160
1930
1940
1950
1960
1970
1980
1990
2000
2010

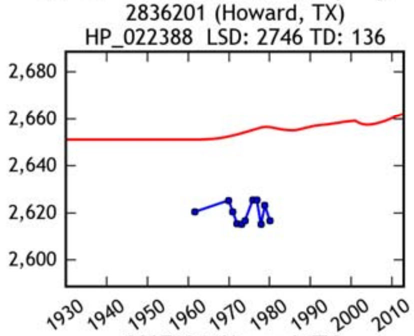

2827901 (Howard, TX)
HP_022194 LSD: 2762 TD: 138
2,720
2,700
2,680
2,660
2,640
1930
1940
1950
1960
1970
1980
1990
2000
2010

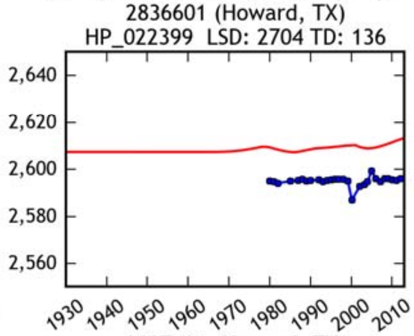

2835301 (Howard, TX)
HP_022320 LSD: 2724 TD: unk
2,680
2,660
2,640
2,620
2,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

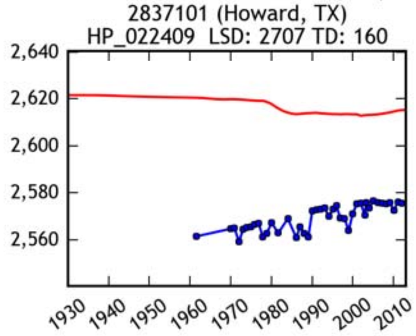

2835508 (Howard, TX)
HP_022330 LSD: 2619 TD: 50
2,660
2,640
2,620
2,600
2,580
1930
1940
1950
1960
1970
1980
1990
2000
2010

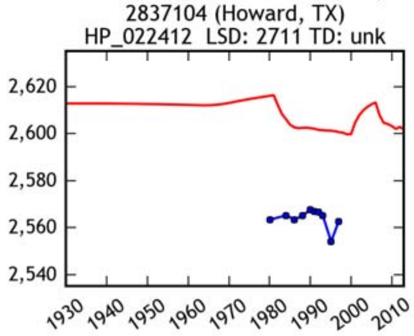

2835602 (Howard, TX)
HP_022335 LSD: 2675 TD: 50
2,680
2,660
2,640
2,620
2,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

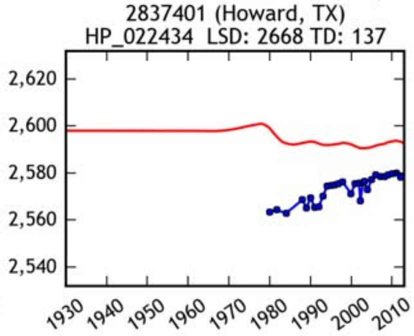

2835812 (Howard, TX)
HP_022354 LSD: 2573 TD: 57
2,620
2,600
2,580
2,560
2,540
1930
1940
1950
1960
1970
1980
1990
2000
2010


2836201 (Howard, TX)
HP_022388 LSD: 2746 TD: 136
2,680
2,660
2,640
2,620
2,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

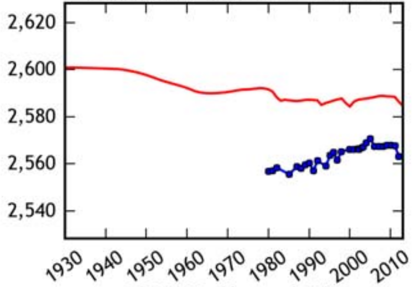

2836601 (Howard, TX)
HP_022399 LSD: 2704 TD: 136
2,640
2,620
2,600
2,580
2,560
1930
1940
1950
1960
1970
1980
1990
2000
2010


2837101 (Howard, TX)
HP_022409 LSD: 2707 TD: 160
2,640
2,620
2,600
2,580
2,560
1930
1940
1950
1960
1970
1980
1990
2000
2010

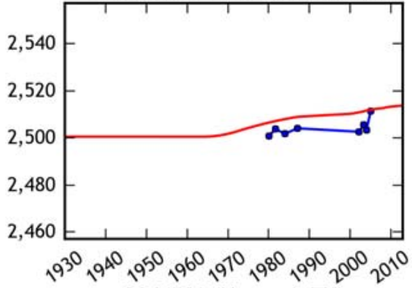

2837104 (Howard, TX)
HP_022412 LSD: 2711 TD: unk
2,620
2,600
2,580
2,560
2,540
1930
1940
1950
1960
1970
1980
1990
2000
2010


2837401 (Howard, TX)
HP_022434 LSD: 2668 TD: 137
2,620
2,600
2,580
2,560
2,540
1930
1940
1950
1960
1970
1980
1990
2000
2010

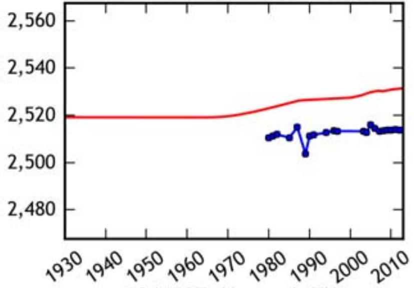
2837503 (Howard, TX)
HP_022447 LSD: 2687 TD: 165



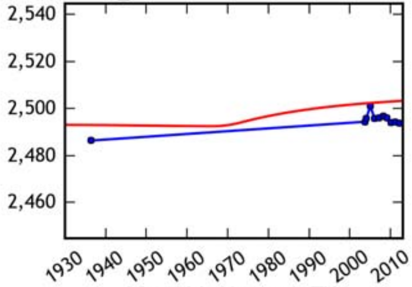
2838403 (Howard, TX)
HP_022473 LSD: 2573 TD: 99



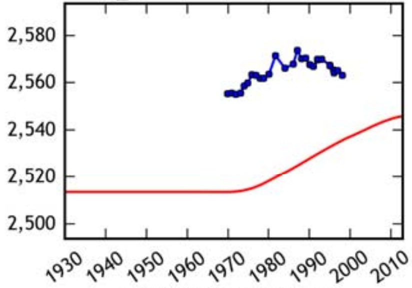
2838404 (Howard, TX)
HP_022474 LSD: 2595 TD: 107



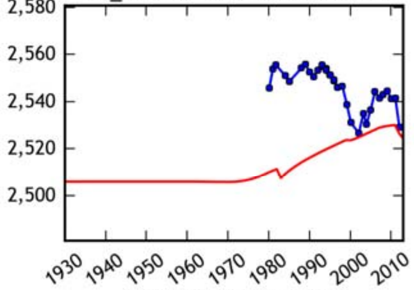
2838802 (Howard, TX)
HP_022486 LSD: 2532 TD: 51



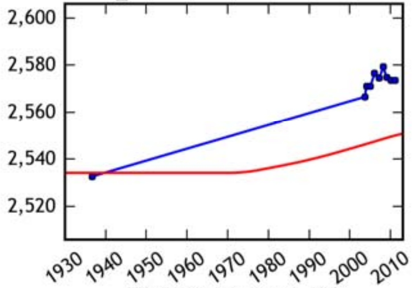
2844501 (Howard, TX)
HP_022677 LSD: 2590 TD: 50



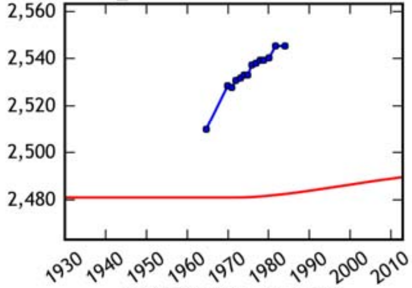
2844507 (Howard, TX)
HP_022683 LSD: 2567 TD: unk



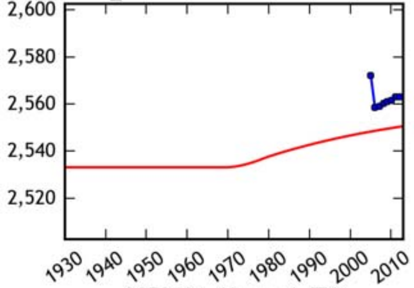
2844606 (Howard, TX)
HP_022693 LSD: 2595 TD: 67



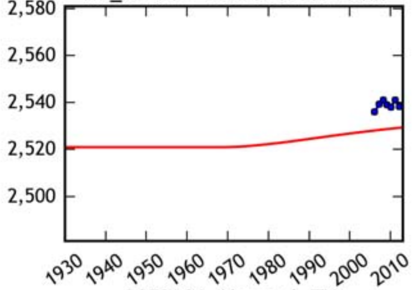
2844902 (Howard, TX)
HP_022700 LSD: 2576 TD: 77



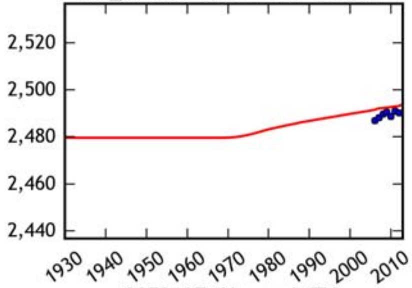
2845102 (Howard, TX)
HP_022710 LSD: 2642 TD: unk



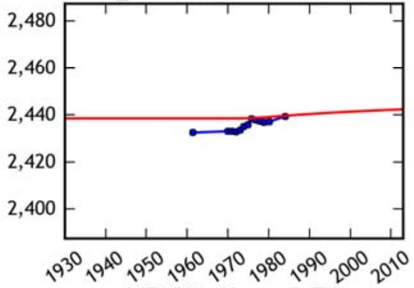
2845306 (Howard, TX)
HP_022719 LSD: 2578 TD: unk



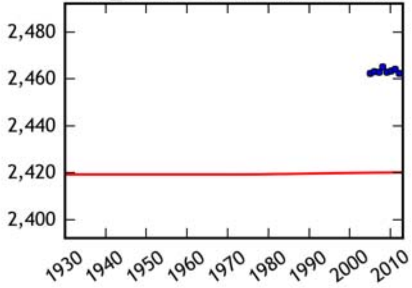
2845506 (Howard, TX)
HP_022731 LSD: 2553 TD: unk



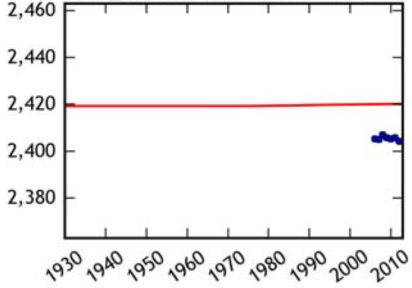
2852101 (Howard, TX)
HP_022978 LSD: 2467 TD: 50



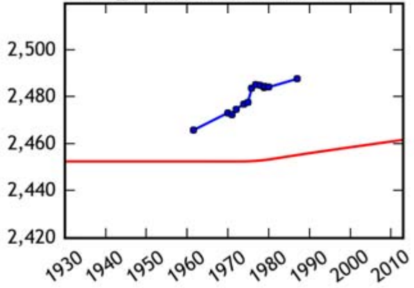
2852106 (Howard, TX)
HP_022983 LSD: 2470 TD: unk



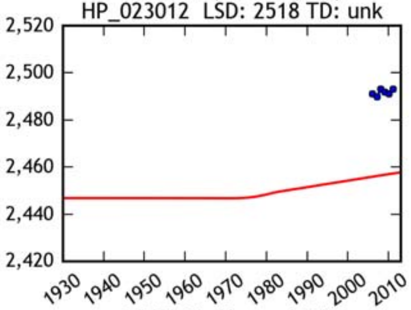
2852107 (Howard, TX)
HP_022984 LSD: 2466 TD: unk



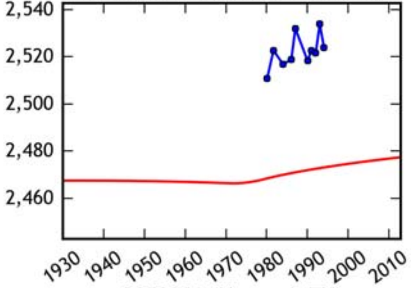
2852501 (Howard, TX)
HP_022998 LSD: 2510 TD: 75



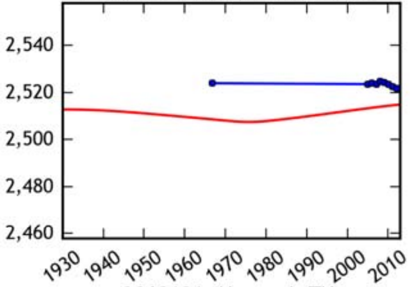
2852515 (Howard, TX)
HP_023012 LSD: 2518 TD: unk



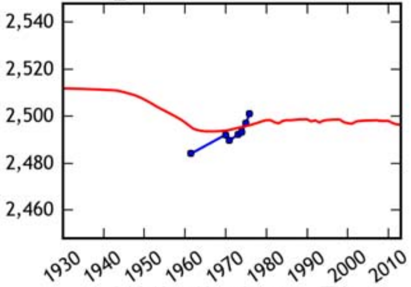
2852606 (Howard, TX)
HP_023018 LSD: 2579 TD: unk



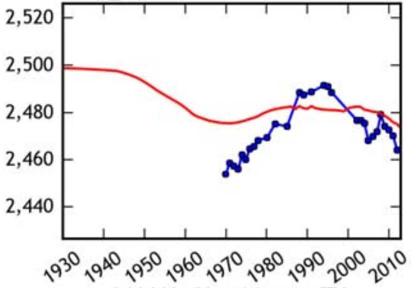
2853708 (Howard, TX)
HP_023166 LSD: 2595 TD: 75



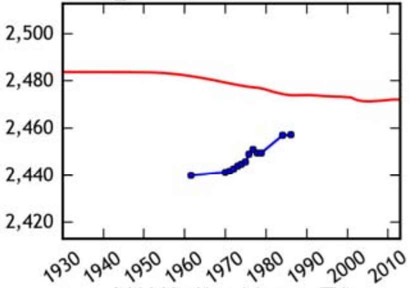
2859201 (Howard, TX)
HP_023311 LSD: 2531 TD: 70



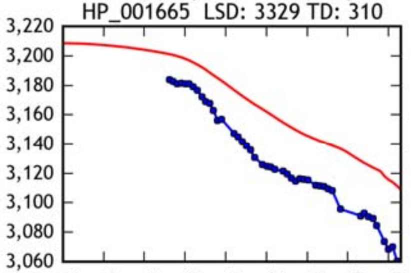
2859301 (Howard, TX)
HP_023312 LSD: 2519 TD: 108



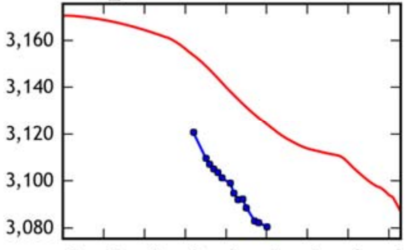
2860101 (Howard, TX)
HP_023335 LSD: 2499 TD: 70



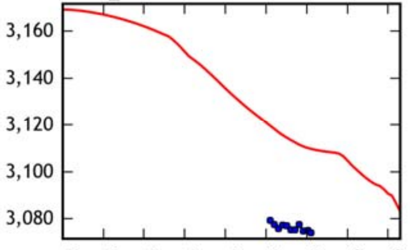
360401 (Hutchinson, TX)
HP_001665 LSD: 3329 TD: 310



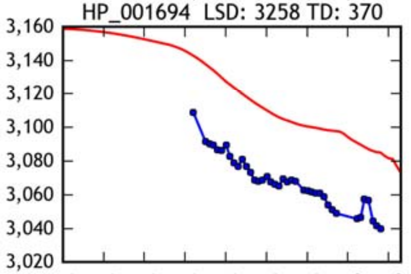
360602 (Hutchinson, TX)
HP_001675 LSD: 3280 TD: 389



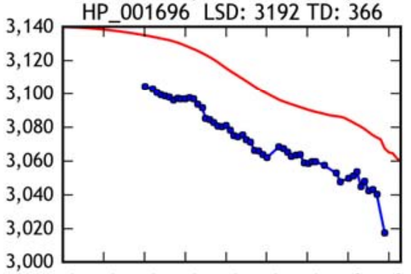
360902 (Hutchinson, TX)
HP_001681 LSD: 3279 TD: 480



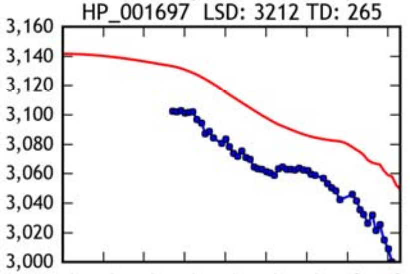
361701 (Hutchinson, TX)
HP_001694 LSD: 3258 TD: 370



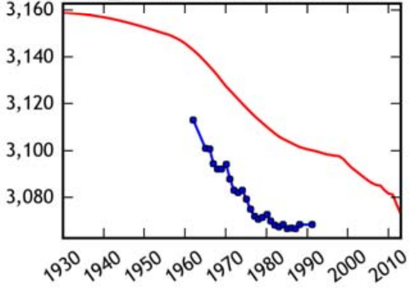
361703 (Hutchinson, TX)
HP_001696 LSD: 3192 TD: 366



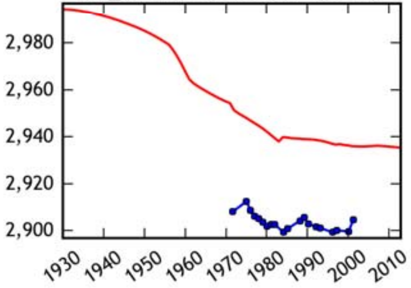
361704 (Hutchinson, TX)
HP_001697 LSD: 3212 TD: 265



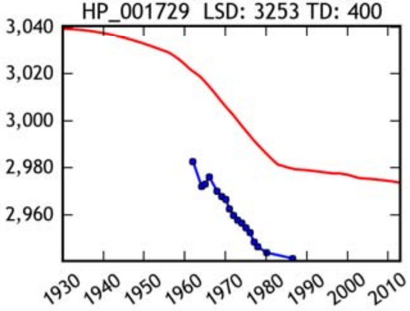
361707 (Hutchinson, TX)
HP_001700 LSD: 3264 TD: 394

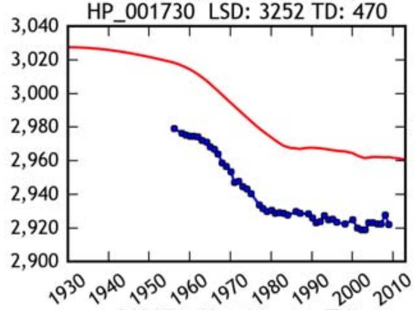


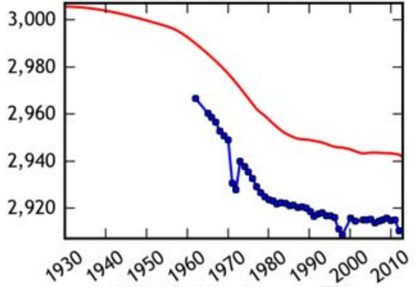
362401 (Hutchinson, TX)
HP_001718 LSD: 3224 TD: 440

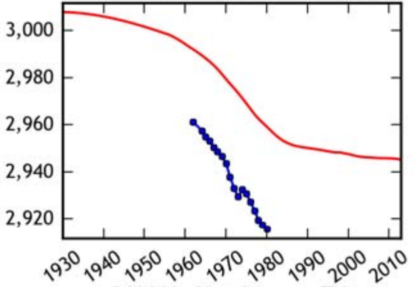


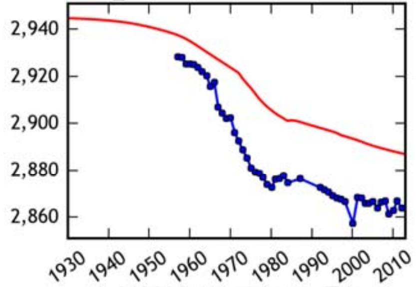
362704 (Hutchinson, TX)
HP_001729 LSD: 3253 TD: 400

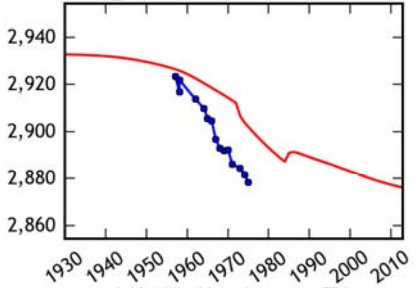


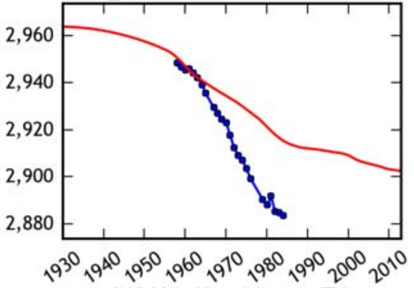

362705 (Hutchinson, TX)
HP_001730 LSD: 3252 TD: 470

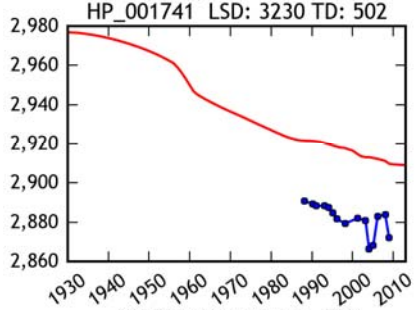

362706 (Hutchinson, TX)
HP_001731 LSD: 3250 TD: 484

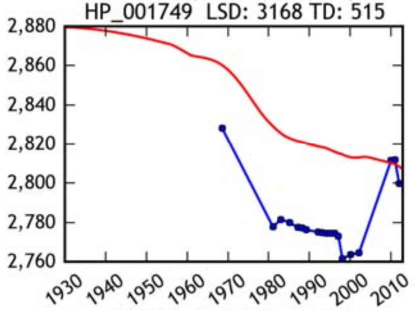

362707 (Hutchinson, TX)
HP_001732 LSD: 3247 TD: 486

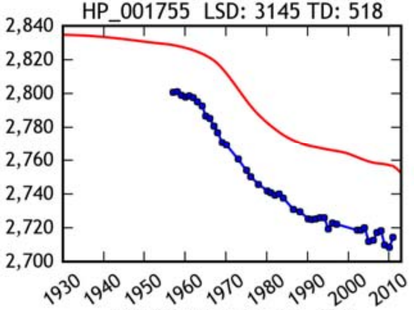

362801 (Hutchinson, TX)
HP_001736 LSD: 3217 TD: 514

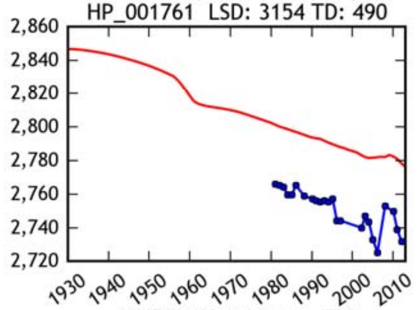

362802 (Hutchinson, TX)
HP_001737 LSD: 3212 TD: 514

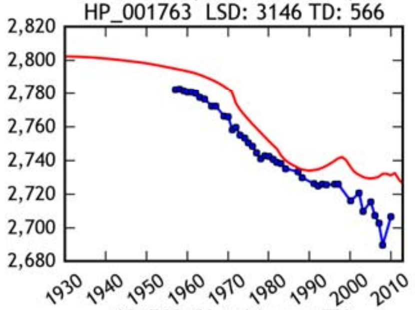

362803 (Hutchinson, TX)
HP_001738 LSD: 3230 TD: 509

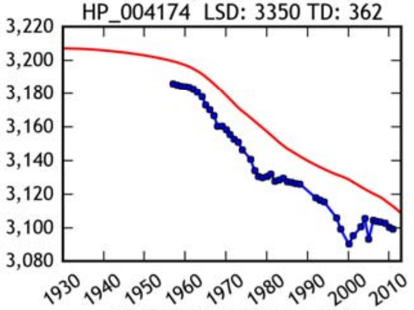

362806 (Hutchinson, TX)
HP_001741 LSD: 3230 TD: 502

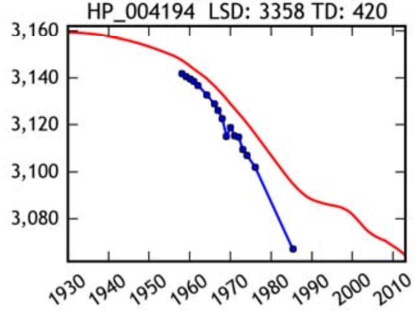

363401 (Hutchinson, TX)
HP_001749 LSD: 3168 TD: 515

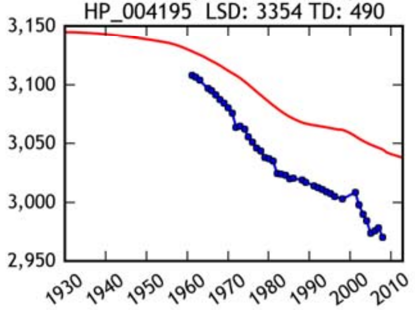

363601 (Hutchinson, TX)
HP_001755 LSD: 3145 TD: 518

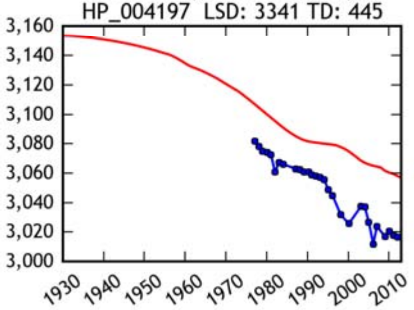

363803 (Hutchinson, TX)
HP_001761 LSD: 3154 TD: 490


363901 (Hutchinson, TX)
HP_001763 LSD: 3146 TD: 566

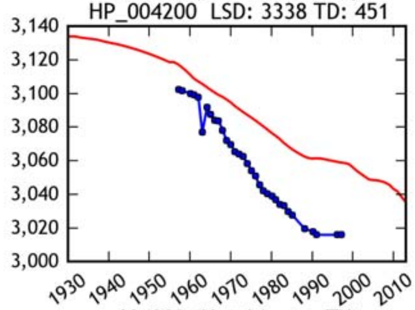

604102 (Hutchinson, TX)
HP_004174 LSD: 3350 TD: 362


604502 (Hutchinson, TX)
HP_004194 LSD: 3358 TD: 420

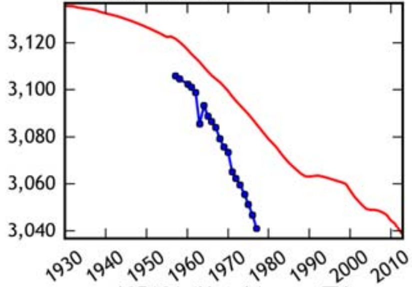

604503 (Hutchinson, TX)
HP_004195 LSD: 3354 TD: 490


604505 (Hutchinson, TX)
HP_004197 LSD: 3341 TD: 445

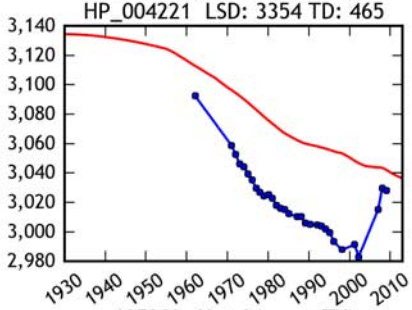
604601 (Hutchinson, TX)
HP_004200 LSD: 3338 TD: 451



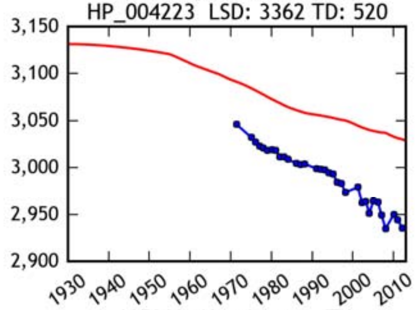
604603 (Hutchinson, TX)
HP_004202 LSD: 3346 TD: 406



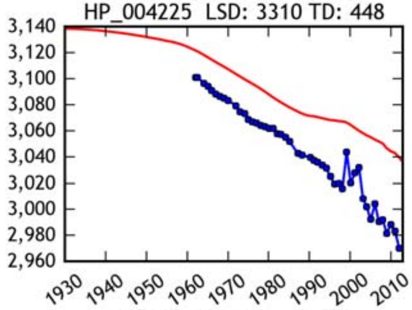
604901 (Hutchinson, TX)
HP_004221 LSD: 3354 TD: 465



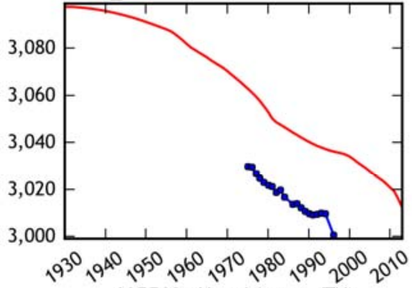
604903 (Hutchinson, TX)
HP_004223 LSD: 3362 TD: 520



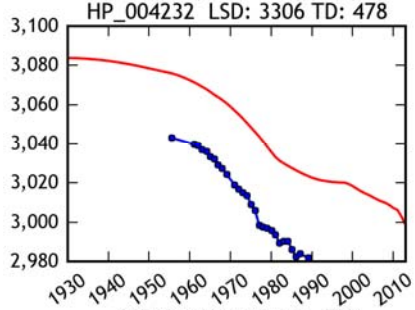
605101 (Hutchinson, TX)
HP_004225 LSD: 3310 TD: 448



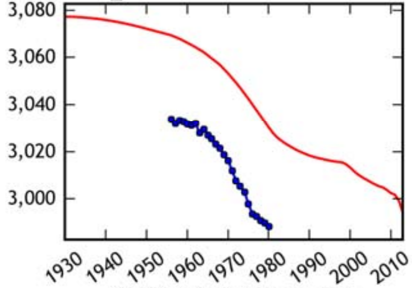
605202 (Hutchinson, TX)
HP_004228 LSD: 3245 TD: 440



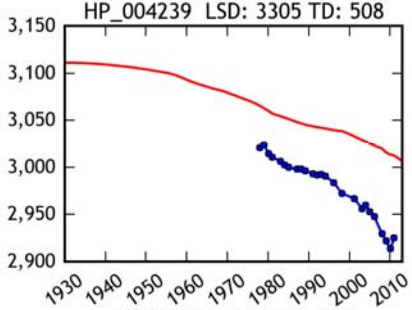
605302 (Hutchinson, TX)
HP_004232 LSD: 3306 TD: 478



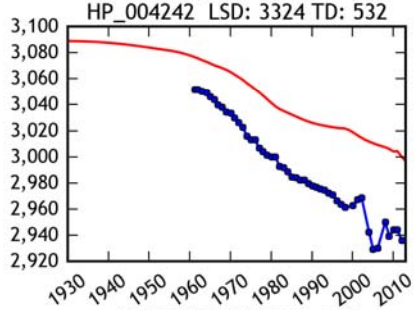
605303 (Hutchinson, TX)
HP_004233 LSD: 3300 TD: 500



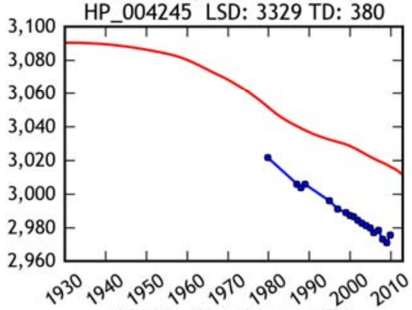
605502 (Hutchinson, TX)
HP_004239 LSD: 3305 TD: 508



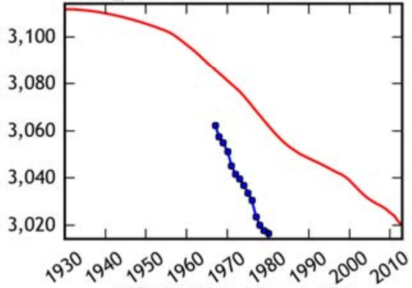
605601 (Hutchinson, TX)
HP_004242 LSD: 3324 TD: 532



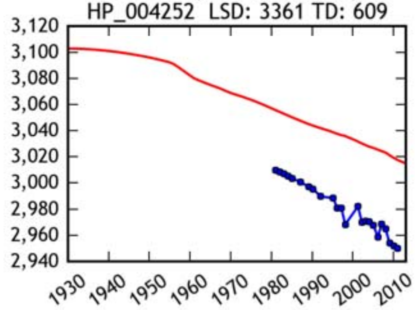
605604 (Hutchinson, TX)
HP_004245 LSD: 3329 TD: 380



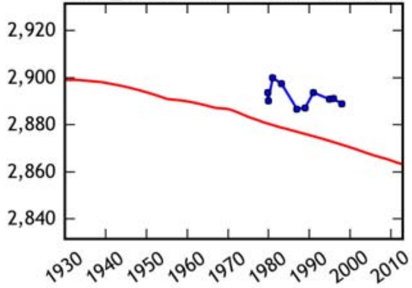
605703 (Hutchinson, TX)
HP_004249 LSD: 3362 TD: 591



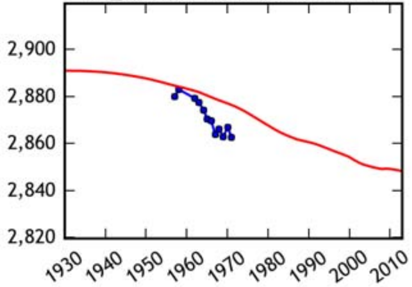
605802 (Hutchinson, TX)
HP_004252 LSD: 3361 TD: 609



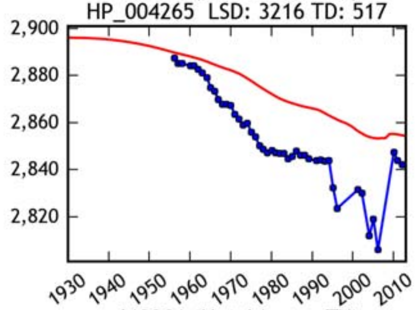
606601 (Hutchinson, TX)
HP_004261 LSD: 3183 TD: 310



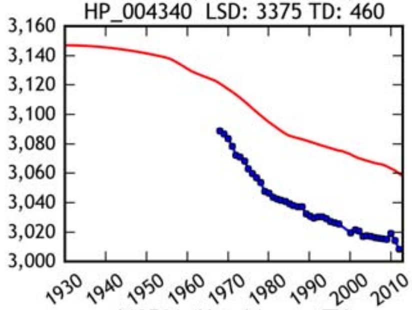
607101 (Hutchinson, TX)
HP_004264 LSD: 3216 TD: 515



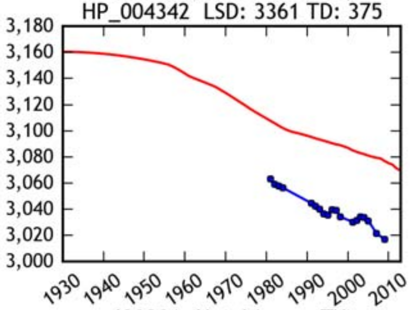
607102 (Hutchinson, TX)
HP_004265 LSD: 3216 TD: 517



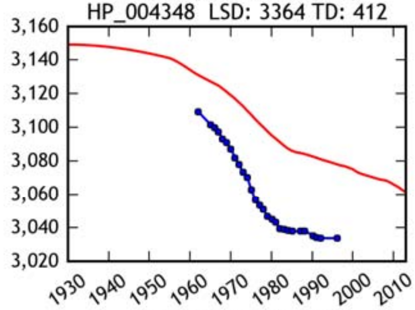
612101 (Hutchinson, TX)
HP_004340 LSD: 3375 TD: 460



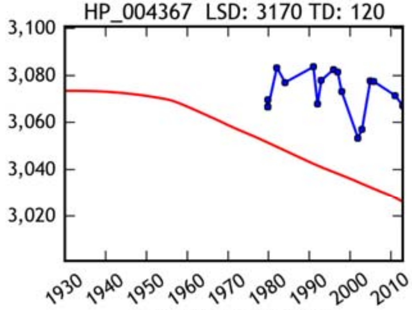
612103 (Hutchinson, TX)
HP_004342 LSD: 3361 TD: 375



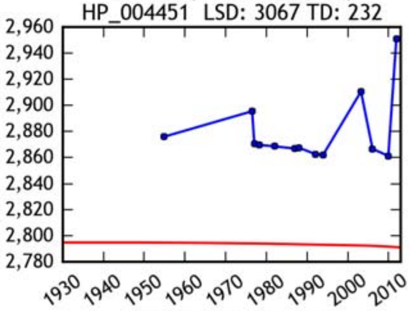
612201 (Hutchinson, TX)
HP_004348 LSD: 3364 TD: 412



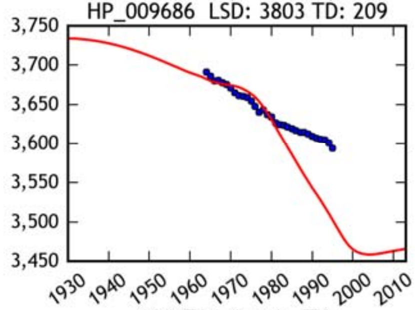
613501 (Hutchinson, TX)
HP_004367 LSD: 3170 TD: 120



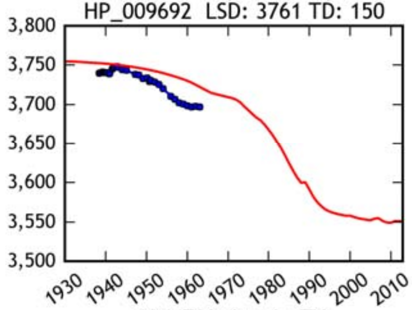
623201 (Hutchinson, TX)
HP_004451 LSD: 3067 TD: 232



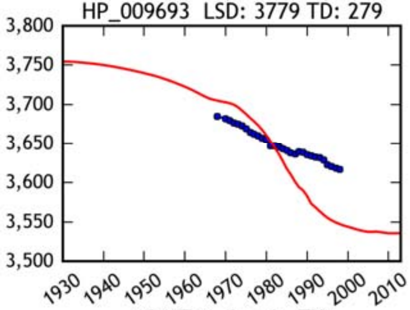
1044501 (Lamb, TX)
HP_009686 LSD: 3803 TD: 209



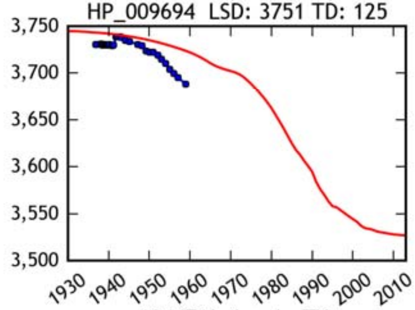
1044702 (Lamb, TX)
HP_009692 LSD: 3761 TD: 150



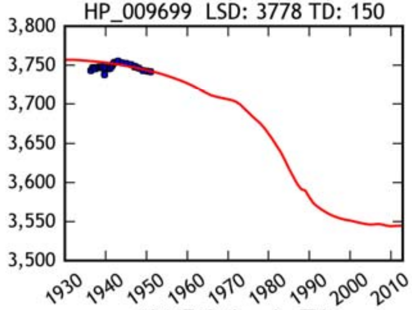
1044703 (Lamb, TX)
HP_009693 LSD: 3779 TD: 279



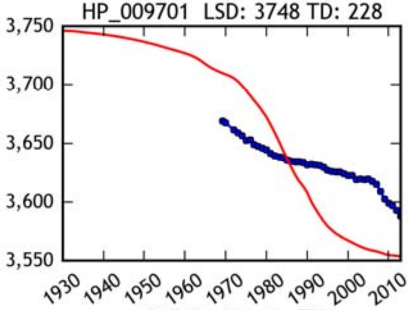
1044704 (Lamb, TX)
HP_009694 LSD: 3751 TD: 125



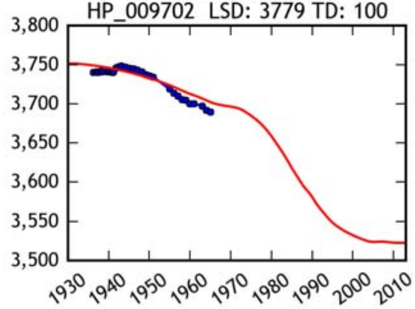
1044709 (Lamb, TX)
HP_009699 LSD: 3778 TD: 150



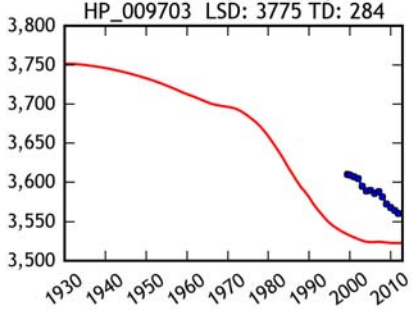
1044711 (Lamb, TX)
HP_009701 LSD: 3748 TD: 228



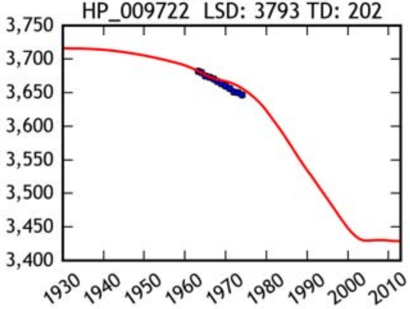
1044712 (Lamb, TX)
HP_009702 LSD: 3779 TD: 100



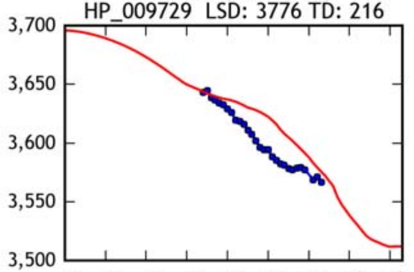
1044713 (Lamb, TX)
HP_009703 LSD: 3775 TD: 284



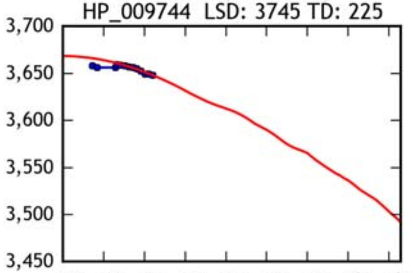
1045401 (Lamb, TX)
HP_009722 LSD: 3793 TD: 202



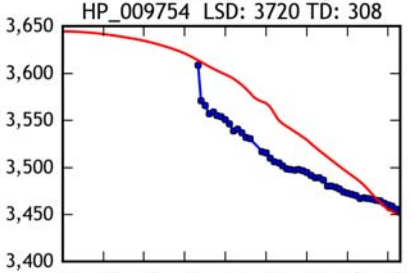
1045801 (Lamb, TX)
HP_009729 LSD: 3776 TD: 216



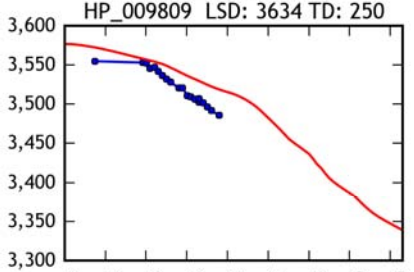
1046403 (Lamb, TX)
HP_009744 LSD: 3745 TD: 225



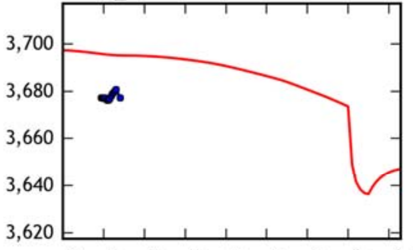
1046601 (Lamb, TX)
HP_009754 LSD: 3720 TD: 308



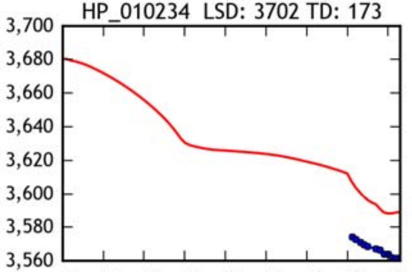
1048401 (Lamb, TX)
HP_009809 LSD: 3634 TD: 250



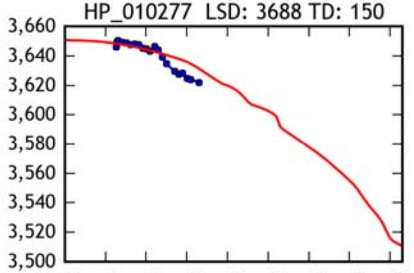
1052903 (Lamb, TX)
HP_010233 LSD: 3712 TD: 46



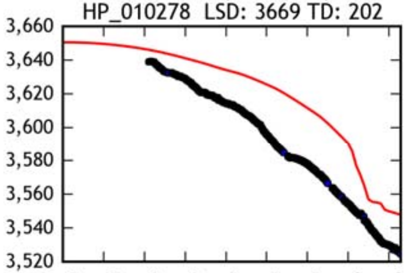
1052904 (Lamb, TX)
HP_010234 LSD: 3702 TD: 173



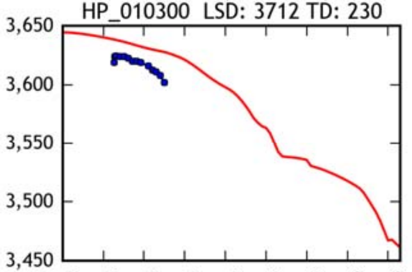
1053601 (Lamb, TX)
HP_010277 LSD: 3688 TD: 150



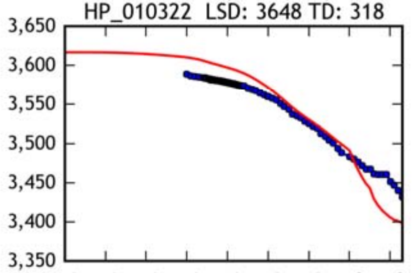
1053602 (Lamb, TX)
HP_010278 LSD: 3669 TD: 202



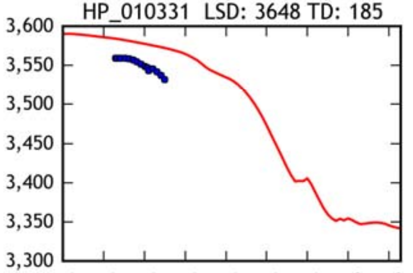
1054201 (Lamb, TX)
HP_010300 LSD: 3712 TD: 230



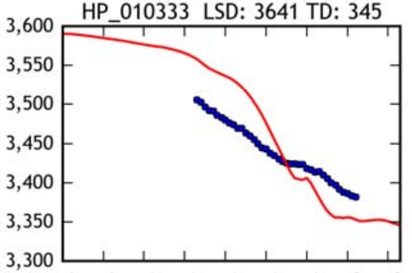
1054801 (Lamb, TX)
HP_010322 LSD: 3648 TD: 318



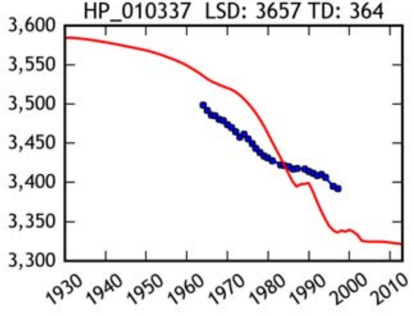
1055201 (Lamb, TX)
HP_010331 LSD: 3648 TD: 185



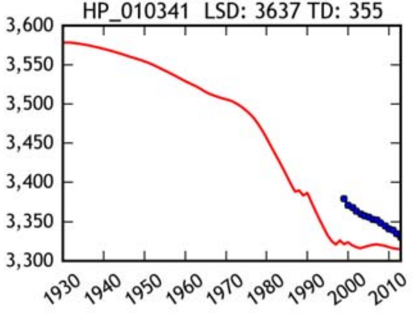
1055203 (Lamb, TX)
HP_010333 LSD: 3641 TD: 345



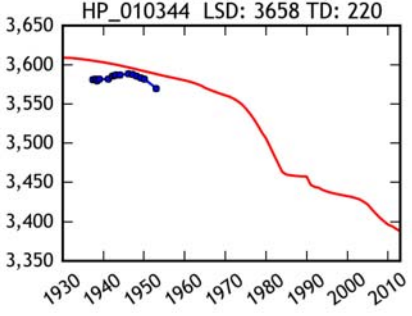
1055207 (Lamb, TX)
HP_010337 LSD: 3657 TD: 364

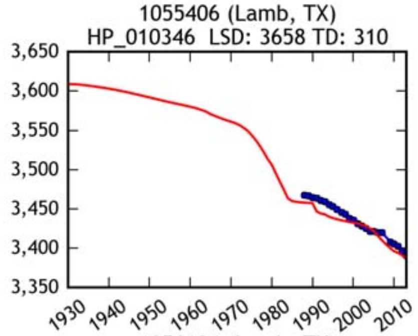


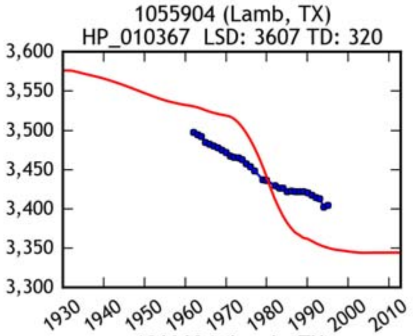
1055305 (Lamb, TX)
HP_010341 LSD: 3637 TD: 355

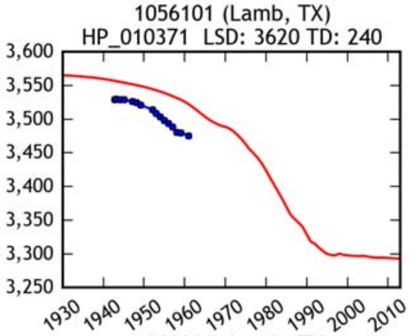


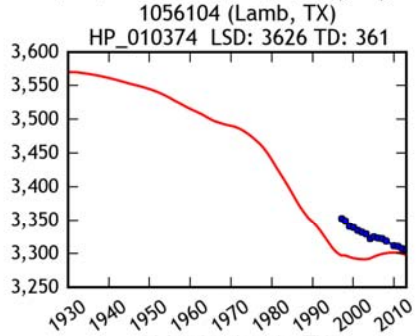
1055403 (Lamb, TX)
HP_010344 LSD: 3658 TD: 220

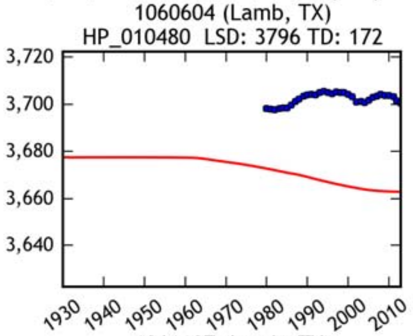


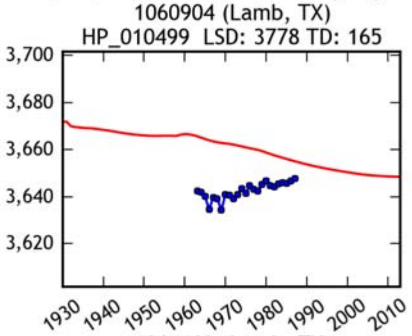

1055406 (Lamb, TX)
HP_010346 LSD: 3658 TD: 310
3,650
3,600
3,550
3,500
3,450
3,400
3,350
1930
1940
1950
1960
1970
1980
1990
2000
2010

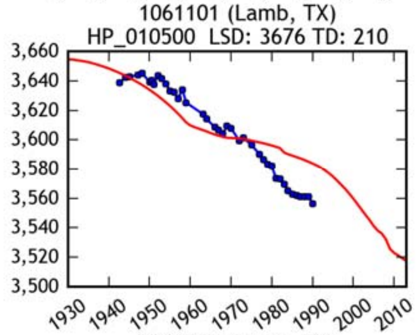

1055904 (Lamb, TX)
HP_010367 LSD: 3607 TD: 320
3,600
3,550
3,500
3,450
3,400
3,350
3,300
1930
1940
1950
1960
1970
1980
1990
2000
2010

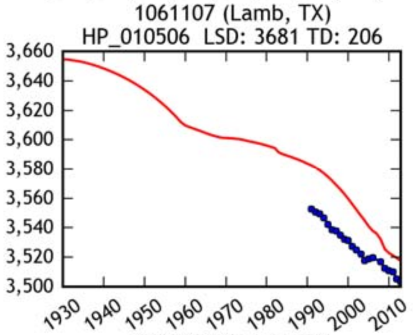

1056101 (Lamb, TX)
HP_010371 LSD: 3620 TD: 240
3,600
3,550
3,500
3,450
3,400
3,350
3,300
3,250
1930
1940
1950
1960
1970
1980
1990
2000
2010

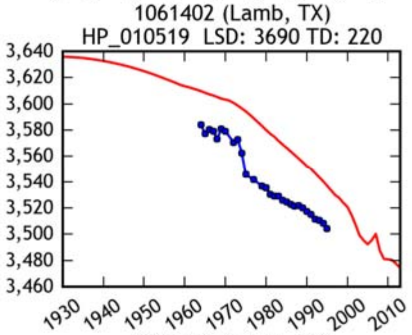

1056104 (Lamb, TX)
HP_010374 LSD: 3626 TD: 361
3,600
3,550
3,500
3,450
3,400
3,350
3,300
3,250
1930
1940
1950
1960
1970
1980
1990
2000
2010

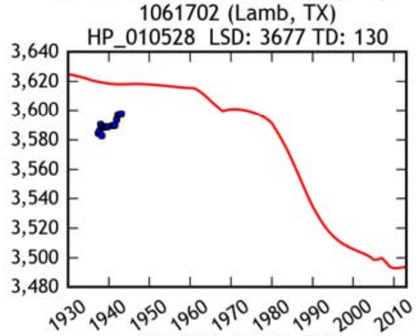

1060604 (Lamb, TX)
HP_010480 LSD: 3796 TD: 172
3,720
3,700
3,680
3,660
3,640
1930
1940
1950
1960
1970
1980
1990
2000
2010

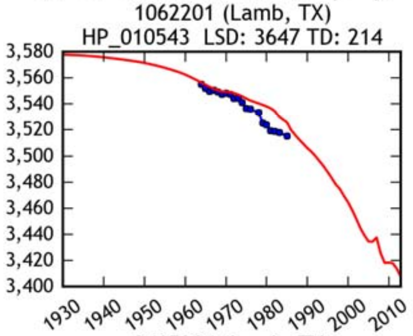

1060904 (Lamb, TX)
HP_010499 LSD: 3778 TD: 165
3,700
3,680
3,660
3,640
3,620
1930
1940
1950
1960
1970
1980
1990
2000
2010

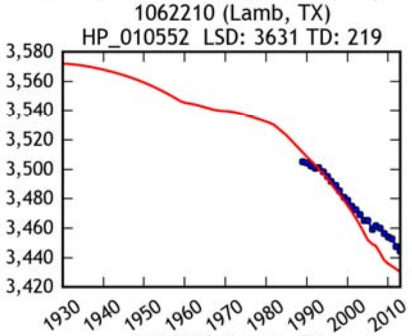

1061101 (Lamb, TX)
HP_010500 LSD: 3676 TD: 210
3,660
3,640
3,620
3,600
3,580
3,560
3,540
3,520
3,500
1930
1940
1950
1960
1970
1980
1990
2000
2010

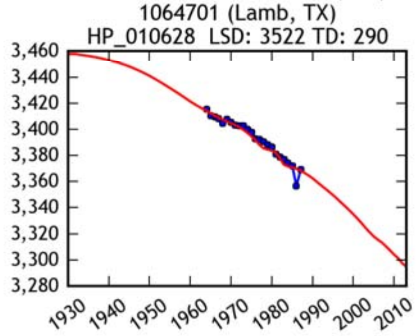

1061107 (Lamb, TX)
HP_010506 LSD: 3681 TD: 206
3,660
3,640
3,620
3,600
3,580
3,560
3,540
3,520
3,500
1930
1940
1950
1960
1970
1980
1990
2000
2010

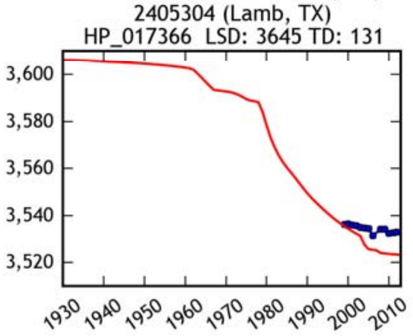

1061402 (Lamb, TX)
HP_010519 LSD: 3690 TD: 220
3,640
3,620
3,600
3,580
3,560
3,540
3,520
3,500
3,480
3,460
1930
1940
1950
1960
1970
1980
1990
2000
2010

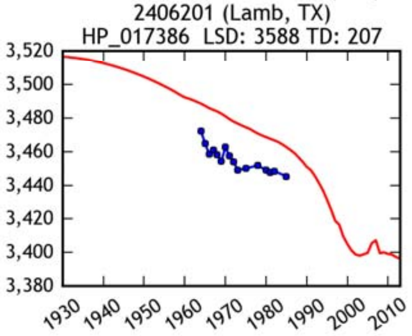

1061702 (Lamb, TX)
HP_010528 LSD: 3677 TD: 130
3,640
3,620
3,600
3,580
3,560
3,540
3,520
3,500
3,480
1930
1940
1950
1960
1970
1980
1990
2000
2010


1062201 (Lamb, TX)
HP_010543 LSD: 3647 TD: 214
3,580
3,560
3,540
3,520
3,500
3,480
3,460
3,440
3,420
3,400
1930
1940
1950
1960
1970
1980
1990
2000
2010

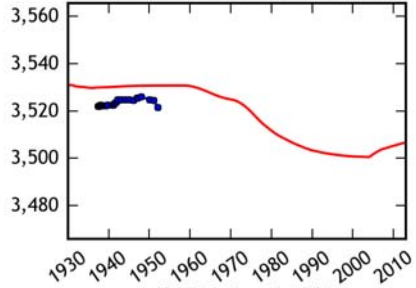

1062210 (Lamb, TX)
HP_010552 LSD: 3631 TD: 219
3,580
3,560
3,540
3,520
3,500
3,480
3,460
3,440
3,420
1930
1940
1950
1960
1970
1980
1990
2000
2010


1064701 (Lamb, TX)
HP_010628 LSD: 3522 TD: 290
3,460
3,440
3,420
3,400
3,380
3,360
3,340
3,320
3,300
3,280
1930
1940
1950
1960
1970
1980
1990
2000
2010

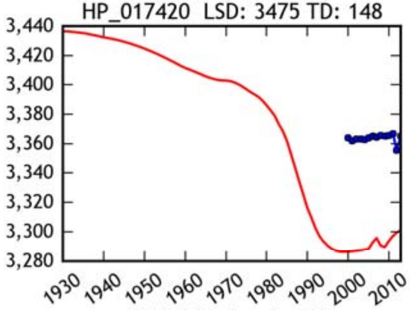

2405304 (Lamb, TX)
HP_017366 LSD: 3645 TD: 131
3,600
3,580
3,560
3,540
3,520
1930
1940
1950
1960
1970
1980
1990
2000
2010


2406201 (Lamb, TX)
HP_017386 LSD: 3588 TD: 207
3,520
3,500
3,480
3,460
3,440
3,420
3,400
3,380
1930
1940
1950
1960
1970
1980
1990
2000
2010

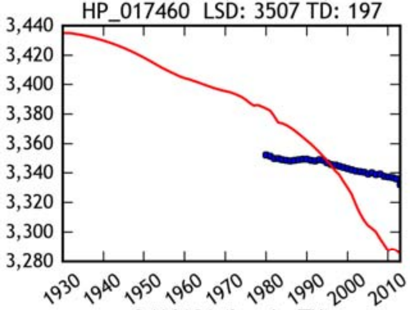
2406401 (Lamb, TX)
HP_017390 LSD: 3596 TD: 130



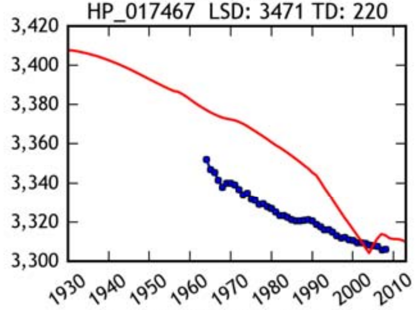
2406903 (Lamb, TX)
HP_017420 LSD: 3475 TD: 148



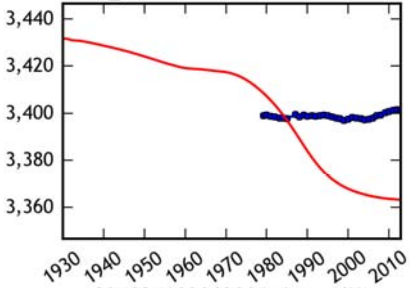
2408402 (Lamb, TX)
HP_017460 LSD: 3507 TD: 197



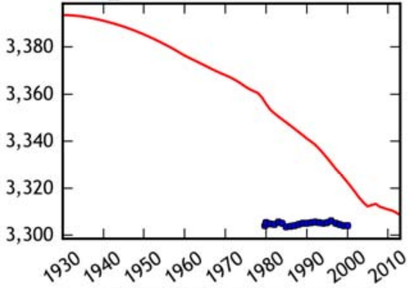
2408701 (Lamb, TX)
HP_017467 LSD: 3471 TD: 220



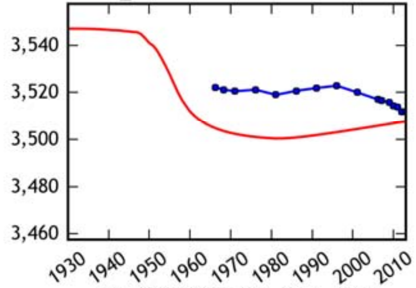
2414301 (Lamb, TX)
HP_017574 LSD: 3456 TD: 108



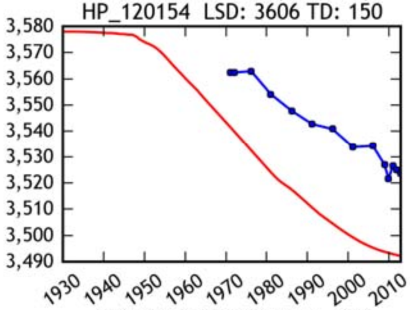
2416101 (Lamb, TX)
HP_017655 LSD: 3472 TD: 196



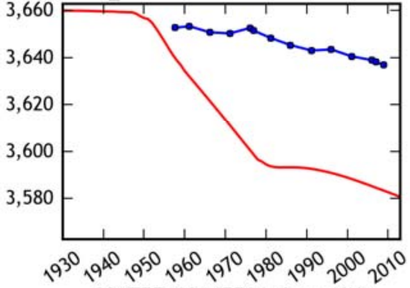
323555103053201 (Lea, NM)
HP_120115 LSD: 3590 TD: 96



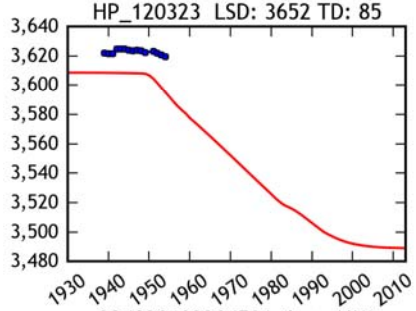
324024103063801 (Lea, NM)
HP_120154 LSD: 3606 TD: 150



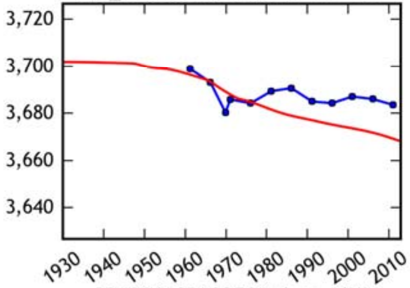
324327103125101 (Lea, NM)
HP_120191 LSD: 3675 TD: 100



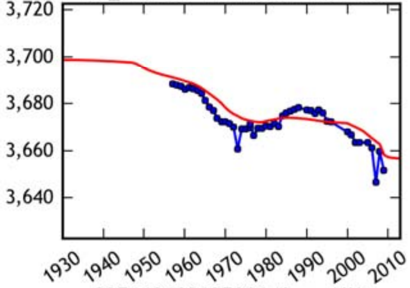
324636103072101 (Lea, NM)
HP_120323 LSD: 3652 TD: 85



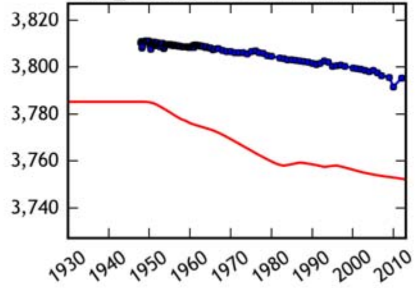
324648103151101 (Lea, NM)
HP_120335 LSD: 3737 TD: 102



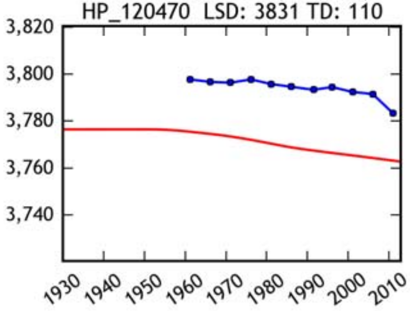
324755103145501 (Lea, NM)
HP_120403 LSD: 3733 TD: 100



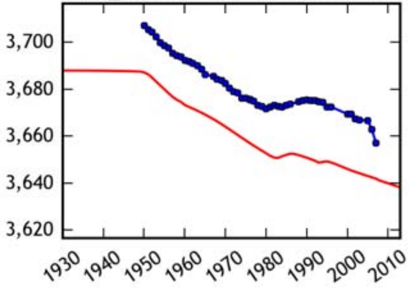
324820103204501 (Lea, NM)
HP_120430 LSD: 3845 TD: 100



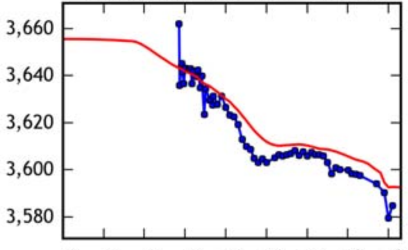
324906103193501 (Lea, NM)
HP_120470 LSD: 3831 TD: 110



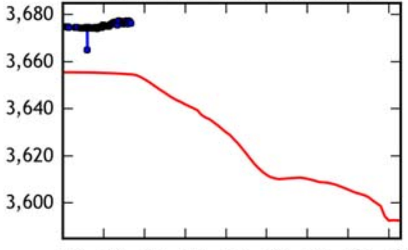
325113103125001 (Lea, NM)
HP_120566 LSD: 3748 TD: 140



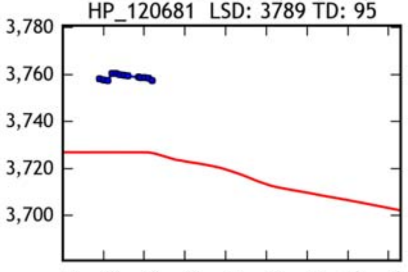
325250103082501 (Lea, NM)
HP_120656 LSD: 3707 TD: 130



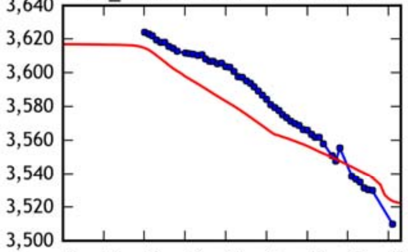
325310103084001 (Lea, NM)
HP_120674 LSD: 3710 TD: 52



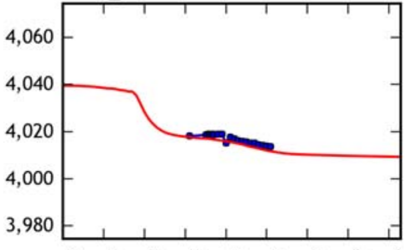
325315103150001 (Lea, NM)
HP_120681 LSD: 3789 TD: 95



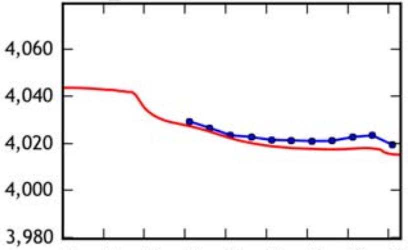
325435103035001 (Lea, NM)
HP_120756 LSD: 3676 TD: 172



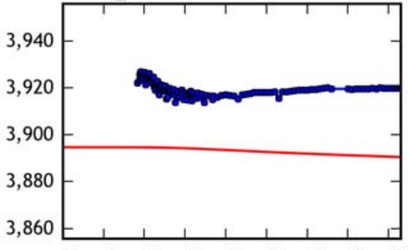
325455103343001 (Lea, NM)
HP_120781 LSD: 4124 TD: 200



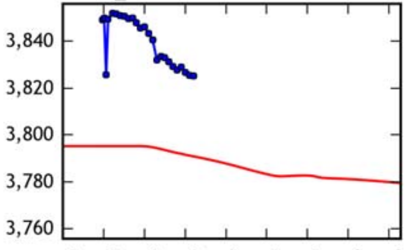
325543103343601 (Lea, NM)
HP_120823 LSD: 4135 TD: 180



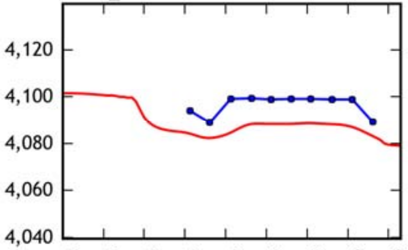
325545103243001 (Lea, NM)
HP_120826 LSD: 3970 TD: 82



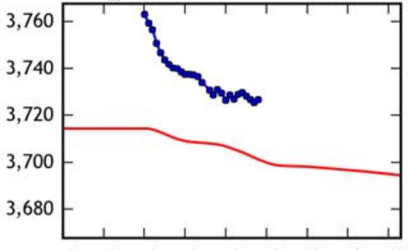
325612103202701 (Lea, NM)
HP_120851 LSD: 3902 TD: 85



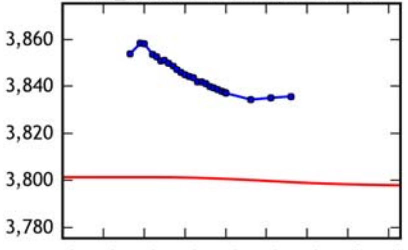
325615103470901 (Lea, NM)
HP_120856 LSD: 4361 TD: 280



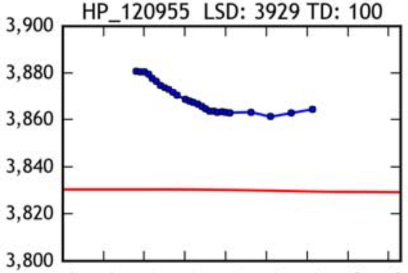
325808103123301 (Lea, NM)
HP_120940 LSD: 3800 TD: 125



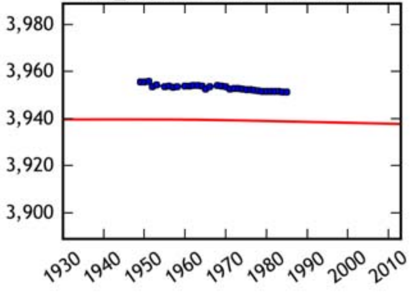
325820103194501 (Lea, NM)
HP_120954 LSD: 3912 TD: 90



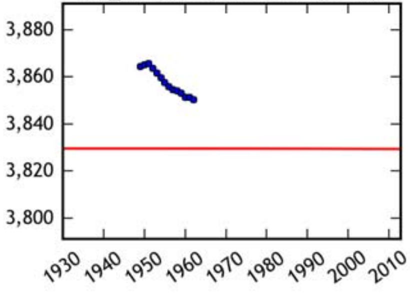
325825103210001 (Lea, NM)
HP_120955 LSD: 3929 TD: 100



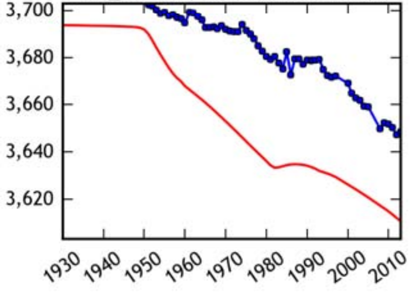
325825103261001 (Lea, NM)
HP_120956 LSD: 4009 TD: 70



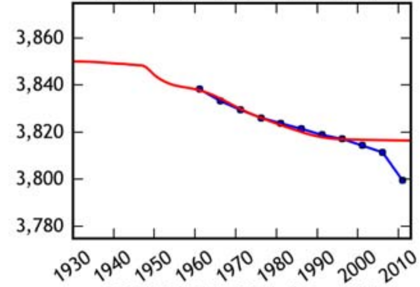
325910103195501 (Lea, NM)
HP_121008 LSD: 3914 TD: 100



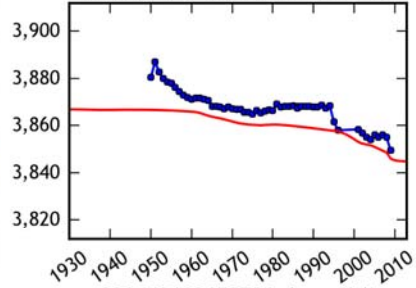
330138103051001 (Lea, NM)
HP_121130 LSD: 3735 TD: 155



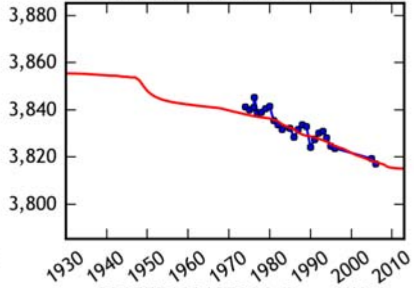
330225103164101 (Lea, NM)
HP_121177 LSD: 3898 TD: 100



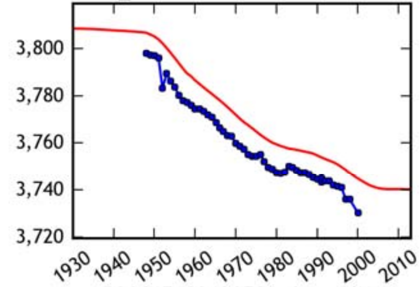
330315103192001 (Lea, NM)
HP_121233 LSD: 3941 TD: 128



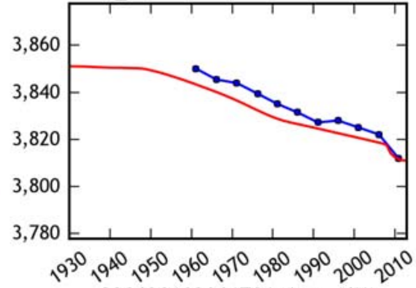
330349103165301 (Lea, NM)
HP_121265 LSD: 3911 TD: 136



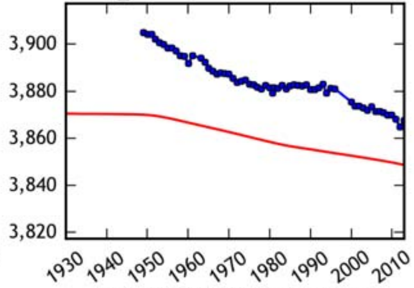
330430103120501 (Lea, NM)
HP_121303 LSD: 3834 TD: 130



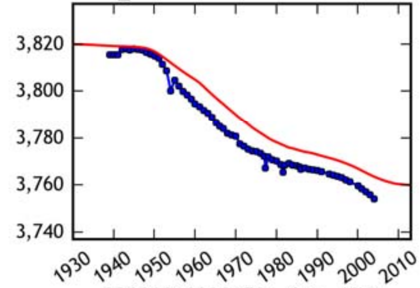
330449103153701 (Lea, NM)
HP_121323 LSD: 3905 TD: 127



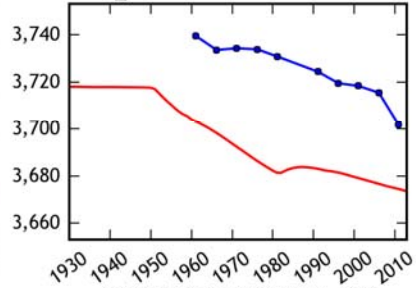
330555103185001 (Lea, NM)
HP_121385 LSD: 3949 TD: 95



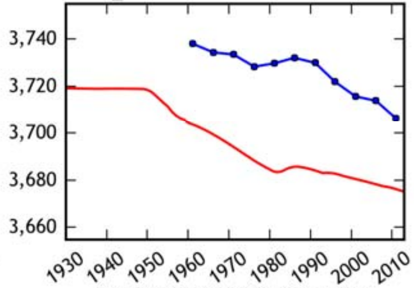
330615103120501 (Lea, NM)
HP_121393 LSD: 3848 TD: 117



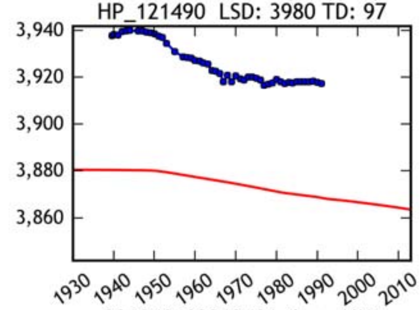
330620103061701 (Lea, NM)
HP_121395 LSD: 3794 TD: 157



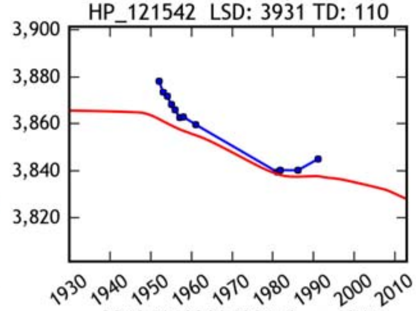
330718103053201 (Lea, NM)
HP_121450 LSD: 3806 TD: 165



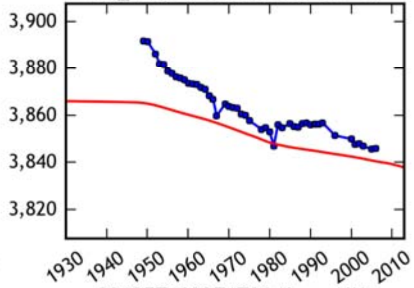
330800103201501 (Lea, NM)
HP_121490 LSD: 3980 TD: 97



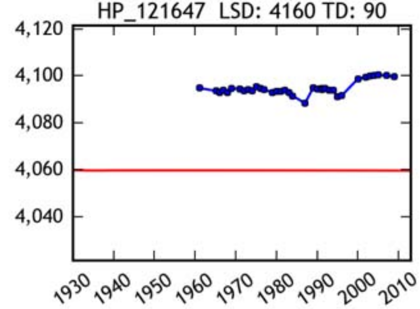
330845103164001 (Lea, NM)
HP_121542 LSD: 3931 TD: 110



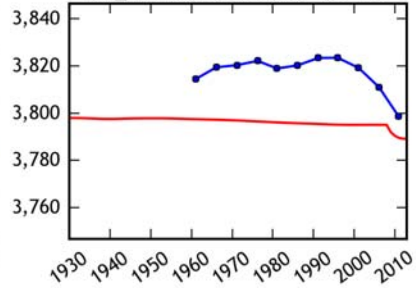
330945103163001 (Lea, NM)
HP_121589 LSD: 3933 TD: 90



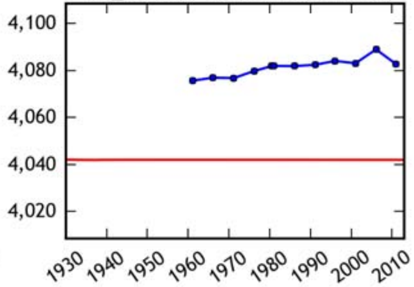
331048103312401 (Lea, NM)
HP_121647 LSD: 4160 TD: 90



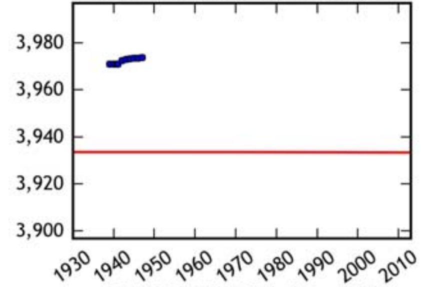
331241103094001 (Lea, NM)
HP_121742 LSD: 3872 TD: 126



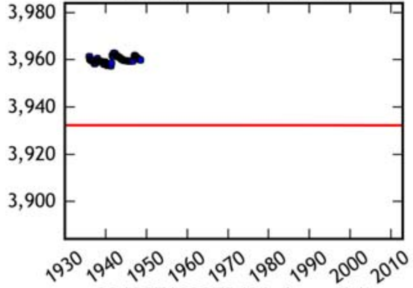
331257103271701 (Lea, NM)
HP_121757 LSD: 4118 TD: 115



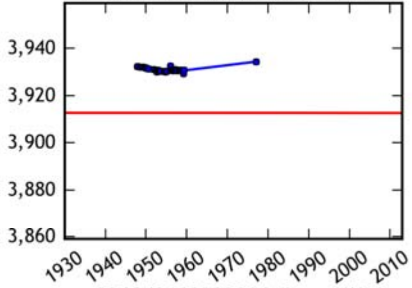
331340103203001 (Lea, NM)
HP_121794 LSD: 4008 TD: 37



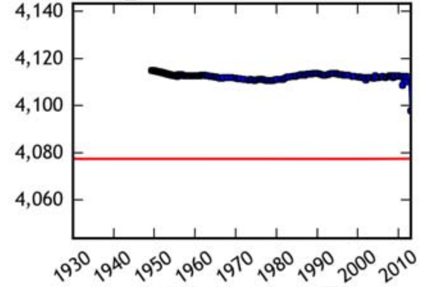
331510103174501 (Lea, NM)
HP_121863 LSD: 3996 TD: 40



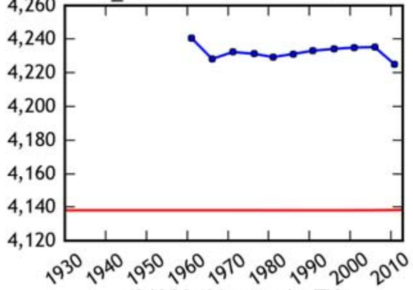
331511103151401 (Lea, NM)
HP_121869 LSD: 3958 TD: 33



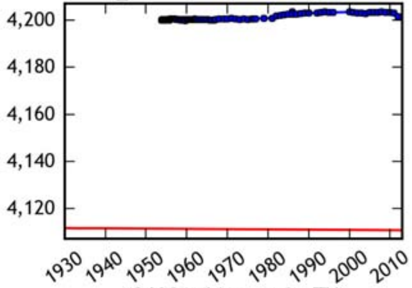
331713103283301 (Lea, NM)
HP_121970 LSD: 4145 TD: 88



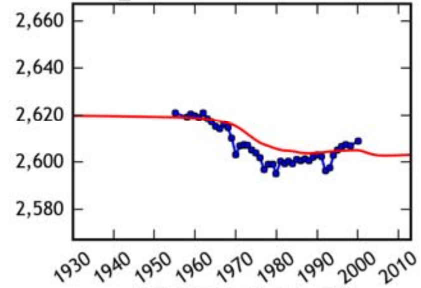
331927103373401 (Lea, NM)
HP_122048 LSD: 4278 TD: 135



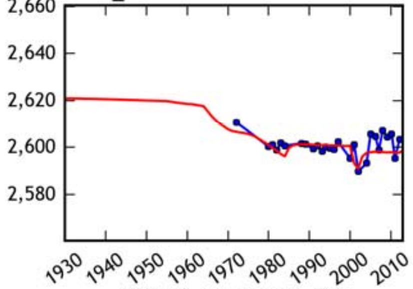
331943103332801 (Lea, NM)
HP_122058 LSD: 4216 TD: 69



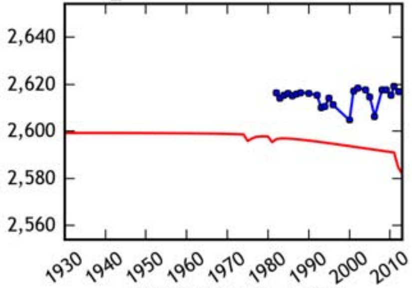
436202 (Lipscomb, TX)
HP_001833 LSD: 2831 TD: 430



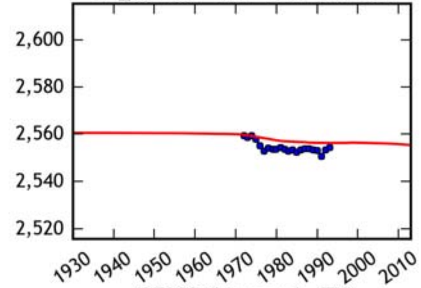
436209 (Lipscomb, TX)
HP_001840 LSD: 2826 TD: 441



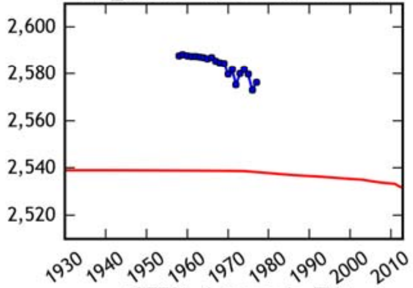
436901 (Lipscomb, TX)
HP_001859 LSD: 2808 TD: 487



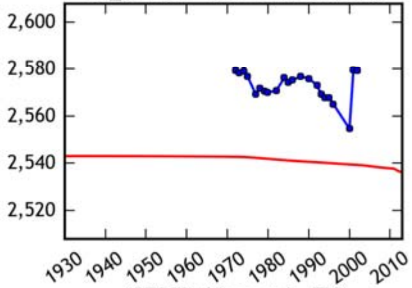
437101 (Lipscomb, TX)
HP_001860 LSD: 2778 TD: 406



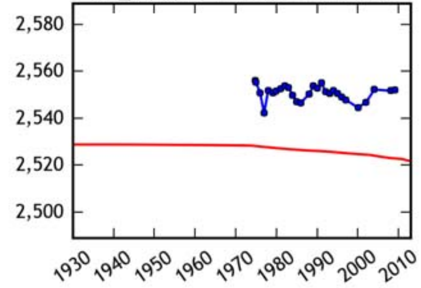
437201 (Lipscomb, TX)
HP_001861 LSD: 2788 TD: 405



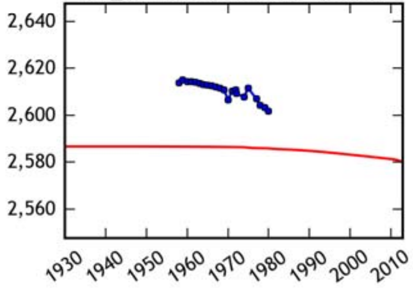
437202 (Lipscomb, TX)
HP_001862 LSD: 2800 TD: unk



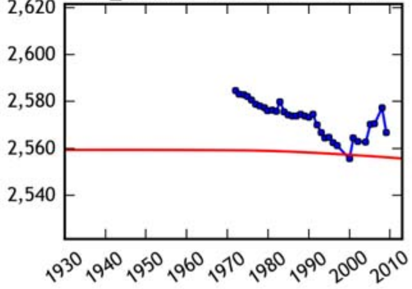
437302 (Lipscomb, TX)
HP_001864 LSD: 2741 TD: 350



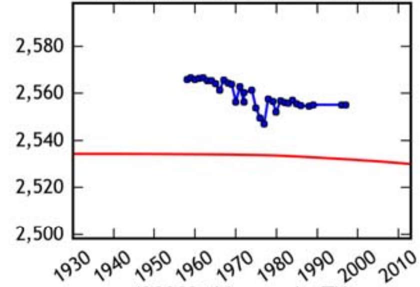
437701 (Lipscomb, TX)
HP_001870 LSD: 2800 TD: 368



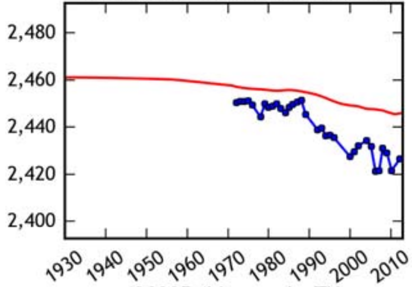
437802 (Lipscomb, TX)
HP_001872 LSD: 2811 TD: unk



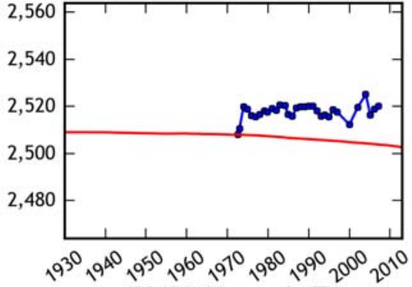
437901 (Lipscomb, TX)
HP_001873 LSD: 2741 TD: 348



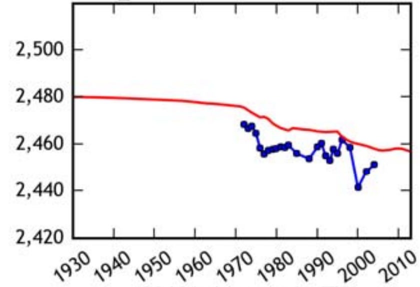
438301 (Lipscomb, TX)
HP_001874 LSD: 2485 TD: unk



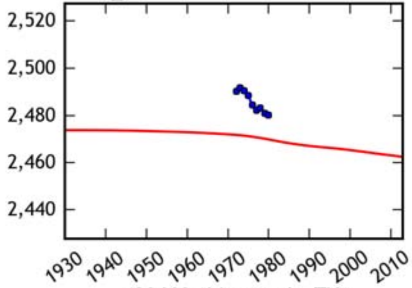
438401 (Lipscomb, TX)
HP_001876 LSD: 2557 TD: 176



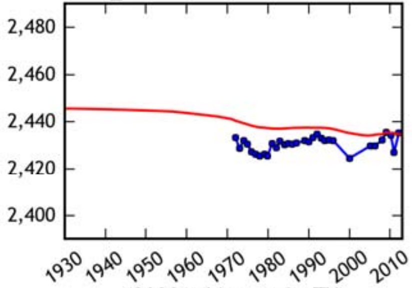
438902 (Lipscomb, TX)
HP_001883 LSD: 2703 TD: 437



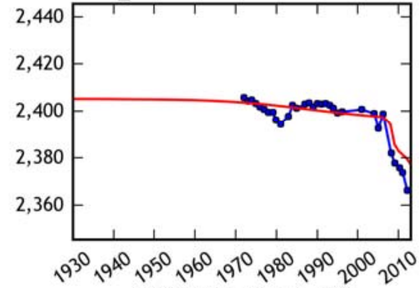
438905 (Lipscomb, TX)
HP_001886 LSD: 2655 TD: 435



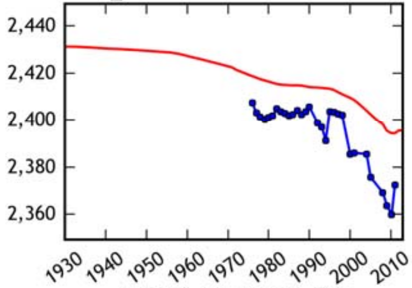
439401 (Lipscomb, TX)
HP_001888 LSD: 2692 TD: 460



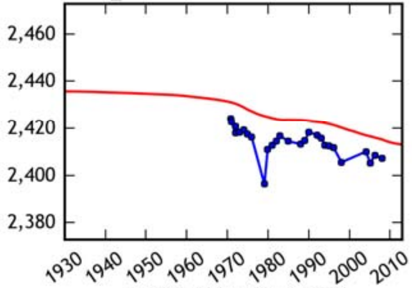
439601 (Lipscomb, TX)
HP_001890 LSD: 2517 TD: unk



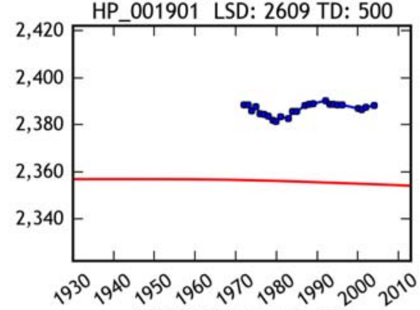
439603 (Lipscomb, TX)
HP_001892 LSD: 2573 TD: 378



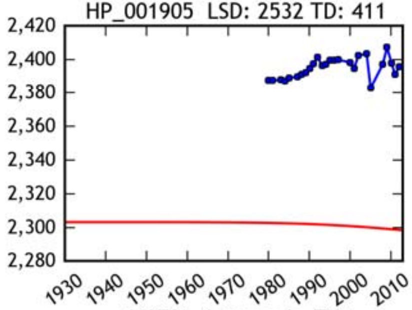
439801 (Lipscomb, TX)
HP_001897 LSD: 2559 TD: 386



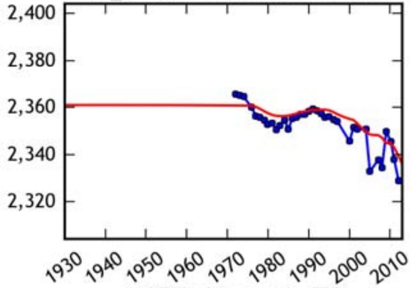
440101 (Lipscomb, TX)
HP_001901 LSD: 2609 TD: 500



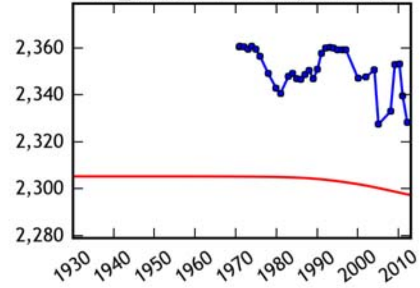
440301 (Lipscomb, TX)
HP_001905 LSD: 2532 TD: 411



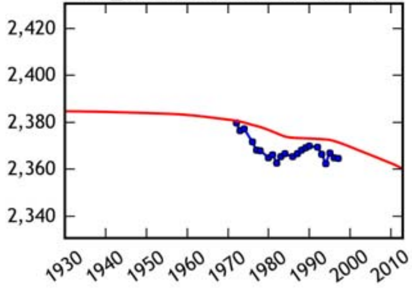
440501 (Lipscomb, TX)
HP_001906 LSD: 2504 TD: 344



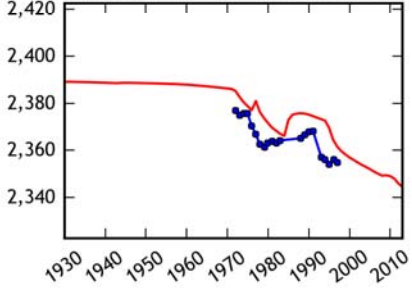
440601 (Lipscomb, TX)
HP_001908 LSD: 2416 TD: 369



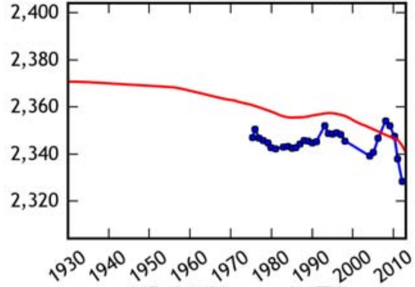
440701 (Lipscomb, TX)
HP_001910 LSD: 2522 TD: 420



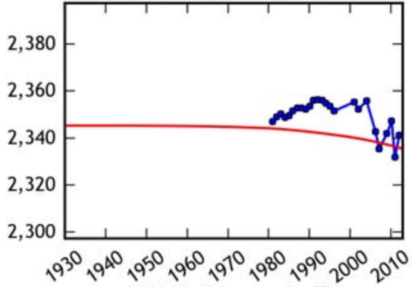
440702 (Lipscomb, TX)
HP_001911 LSD: 2477 TD: 390



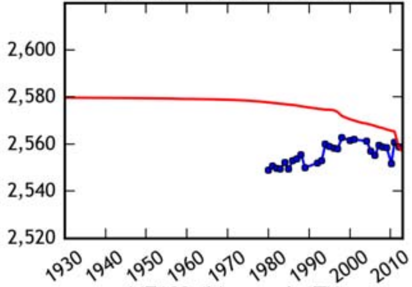
440704 (Lipscomb, TX)
HP_001913 LSD: 2482 TD: 365



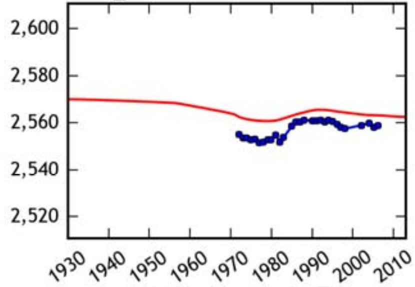
440802 (Lipscomb, TX)
HP_001915 LSD: 2521 TD: 454



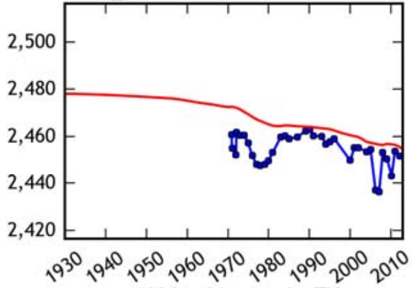
444902 (Lipscomb, TX)
HP_002017 LSD: 2642 TD: 292



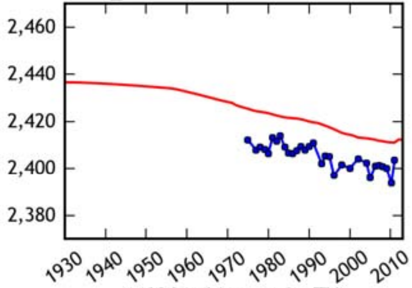
445401 (Lipscomb, TX)
HP_002022 LSD: 2565 TD: 160



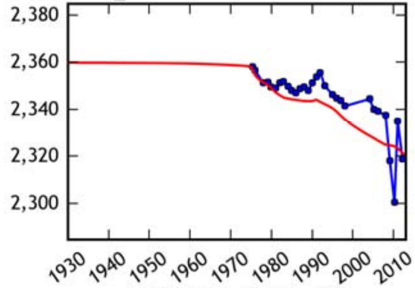
446301 (Lipscomb, TX)
HP_002026 LSD: 2703 TD: 545



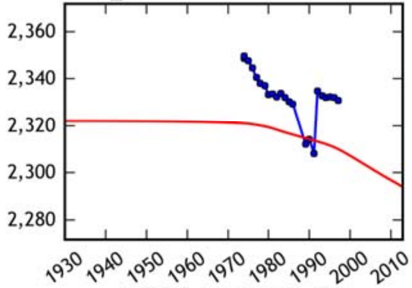
447102 (Lipscomb, TX)
HP_002035 LSD: 2553 TD: 347



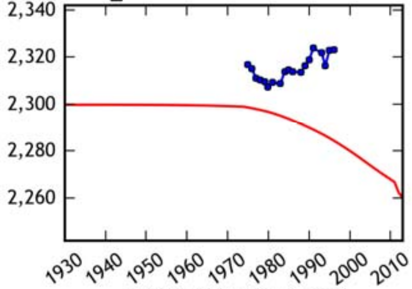
448103 (Lipscomb, TX)
HP_002041 LSD: 2482 TD: 456



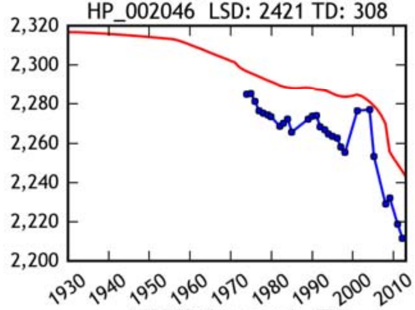
448201 (Lipscomb, TX)
HP_002042 LSD: 2431 TD: 350



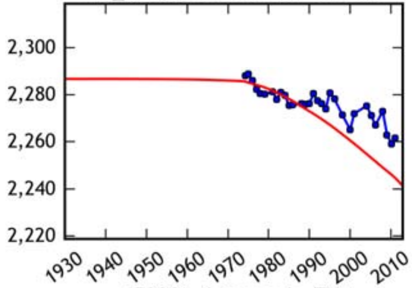
448301 (Lipscomb, TX)
HP_002044 LSD: 2415 TD: 389



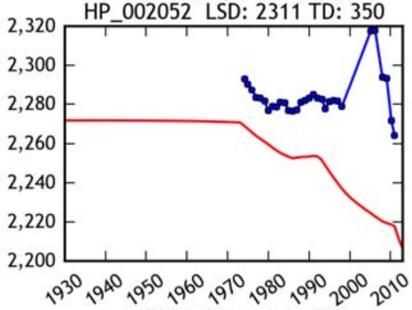
448501 (Lipscomb, TX)
HP_002046 LSD: 2421 TD: 308



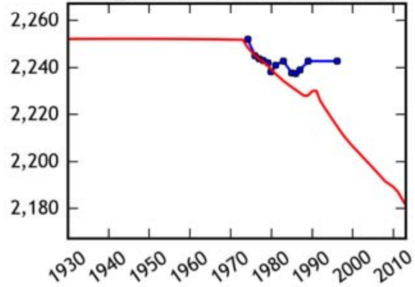
448601 (Lipscomb, TX)
HP_002048 LSD: 2344 TD: 311



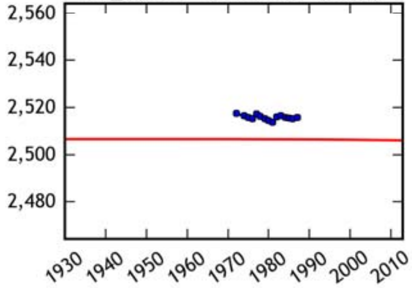
448901 (Lipscomb, TX)
HP_002052 LSD: 2311 TD: 350



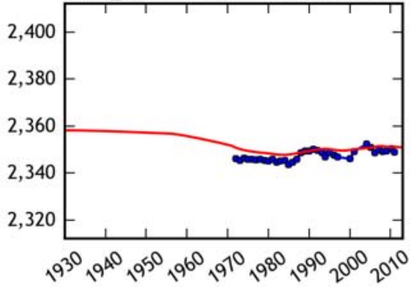
448902 (Lipscomb, TX)
HP_002053 LSD: 2280 TD: 320



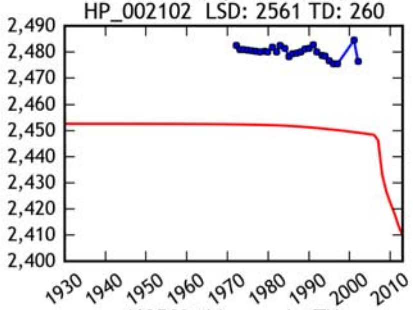
452901 (Lipscomb, TX)
HP_002089 LSD: 2829 TD: 350



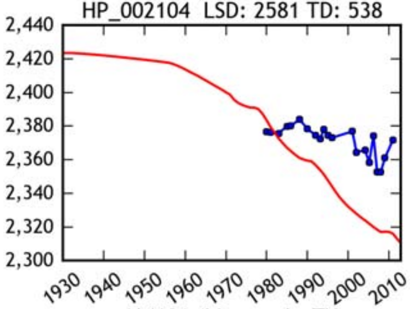
455301 (Lipscomb, TX)
HP_002099 LSD: 2348 TD: 190



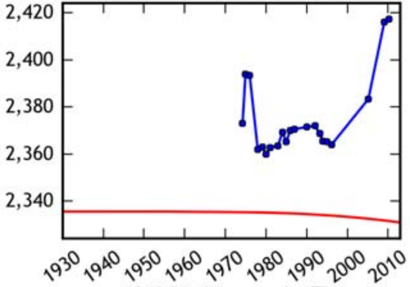
455801 (Lipscomb, TX)
HP_002102 LSD: 2561 TD: 260



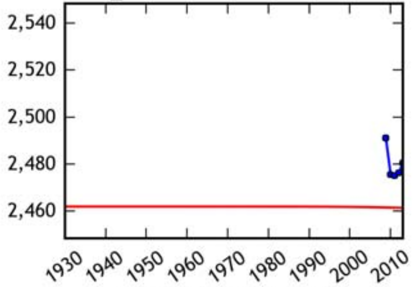
456701 (Lipscomb, TX)
HP_002104 LSD: 2581 TD: 538



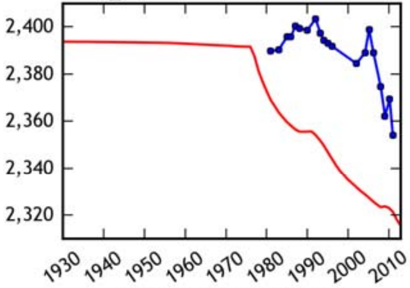
456901 (Lipscomb, TX)
HP_002106 LSD: 2547 TD: 320



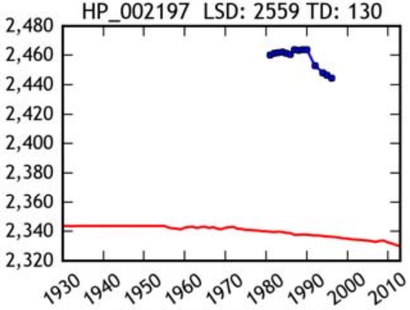
463502 (Lipscomb, TX)
HP_002190 LSD: 2706 TD: 590



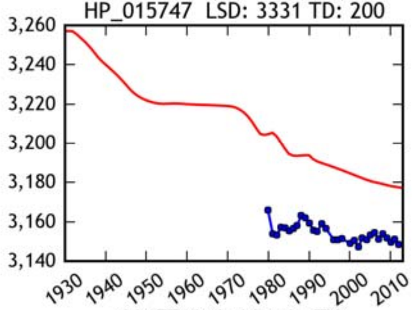
464101 (Lipscomb, TX)
HP_002195 LSD: 2620 TD: 542



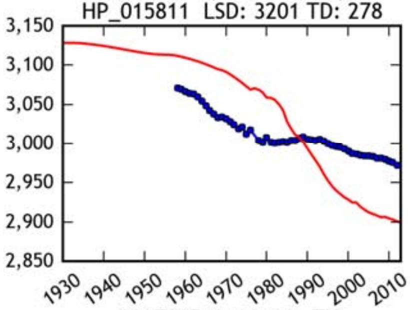
464301 (Lipscomb, TX)
HP_002197 LSD: 2559 TD: 130



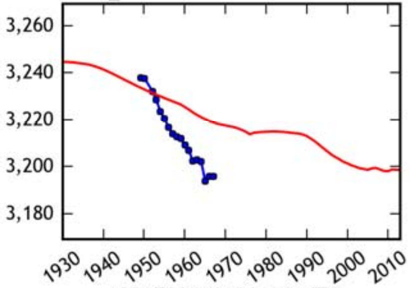
2310703 (Lubbock, TX)
HP_015747 LSD: 3331 TD: 200



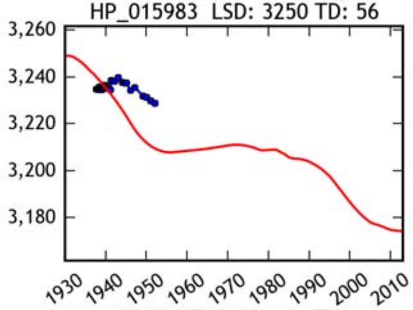
2312803 (Lubbock, TX)
HP_015811 LSD: 3201 TD: 278



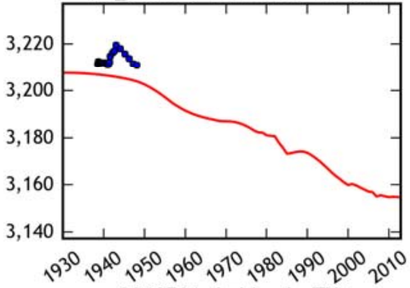
2317201 (Lubbock, TX)
HP_015937 LSD: 3336 TD: 162



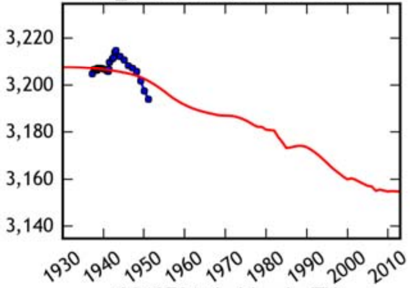
2317710 (Lubbock, TX)
HP_015983 LSD: 3250 TD: 56



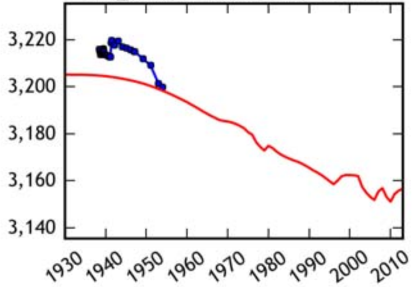
2317805 (Lubbock, TX)
HP_015990 LSD: 3241 TD: 50



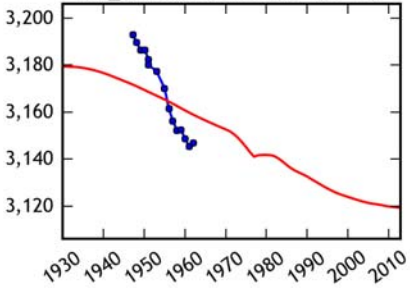
2317904 (Lubbock, TX)
HP_015999 LSD: 3236 TD: 51



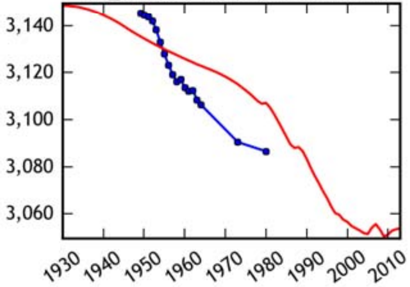
2318407 (Lubbock, TX)
HP_016049 LSD: 3248 TD: 52



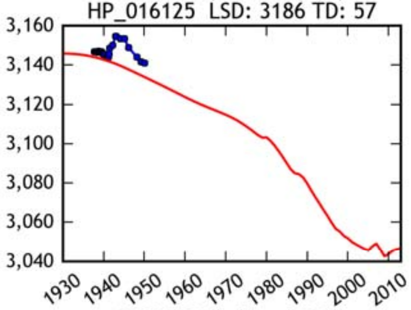
2318501 (Lubbock, TX)
HP_016052 LSD: 3263 TD: 180



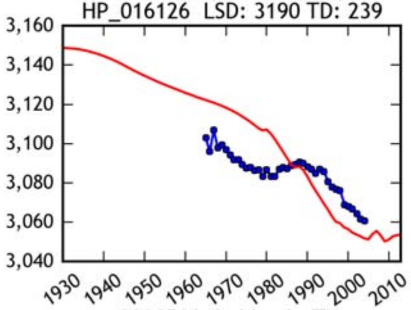
2319701 (Lubbock, TX)
HP_016123 LSD: 3191 TD: 108



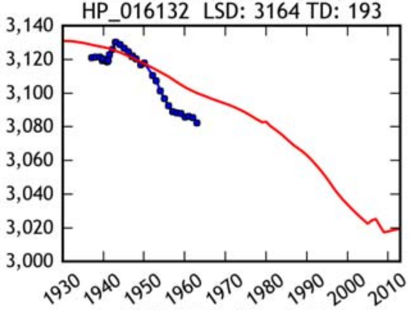
2319703 (Lubbock, TX)
HP_016125 LSD: 3186 TD: 57



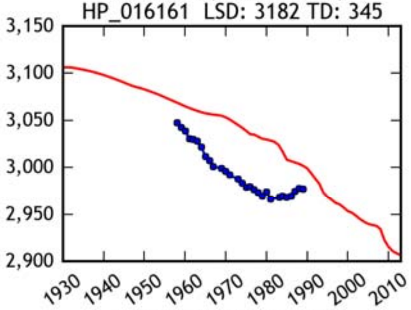
2319704 (Lubbock, TX)
HP_016126 LSD: 3190 TD: 239



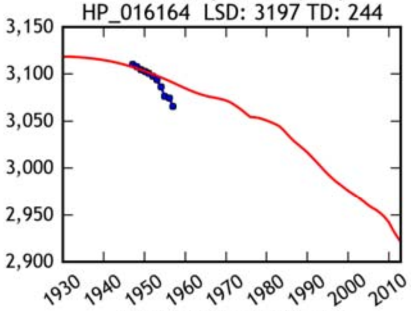
2319803 (Lubbock, TX)
HP_016132 LSD: 3164 TD: 193



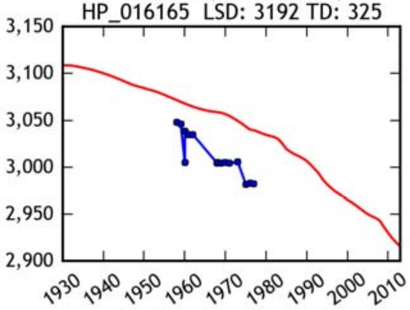
2320503 (Lubbock, TX)
HP_016161 LSD: 3182 TD: 345



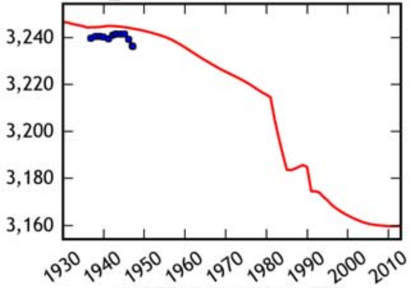
2320506 (Lubbock, TX)
HP_016164 LSD: 3197 TD: 244



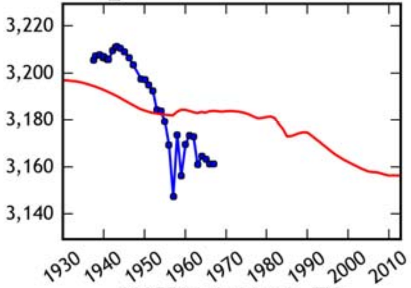
2320507 (Lubbock, TX)
HP_016165 LSD: 3192 TD: 325



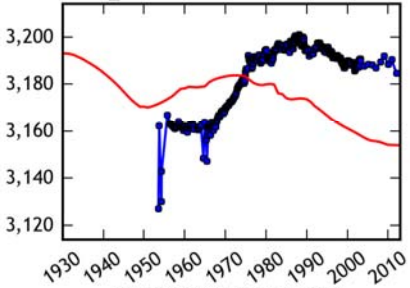
2325103 (Lubbock, TX)
HP_016322 LSD: 3318 TD: 100



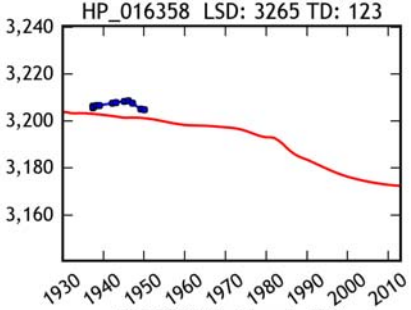
2325303 (Lubbock, TX)
HP_016338 LSD: 3244 TD: 160



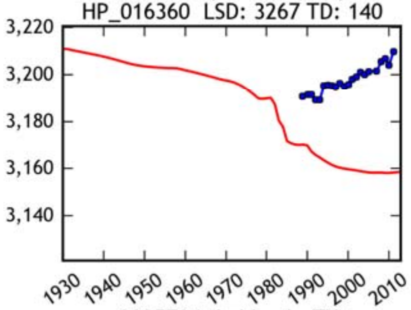
2325304 (Lubbock, TX)
HP_016339 LSD: 3229 TD: 136



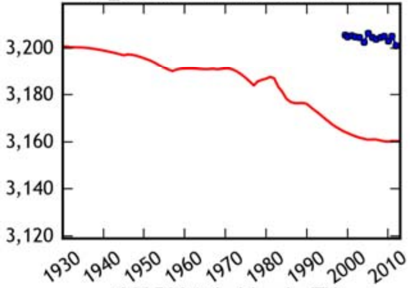
2325502 (Lubbock, TX)
HP_016358 LSD: 3265 TD: 123



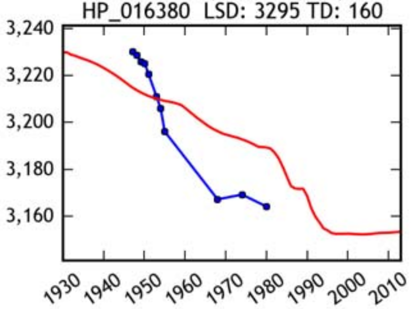
2325504 (Lubbock, TX)
HP_016360 LSD: 3267 TD: 140



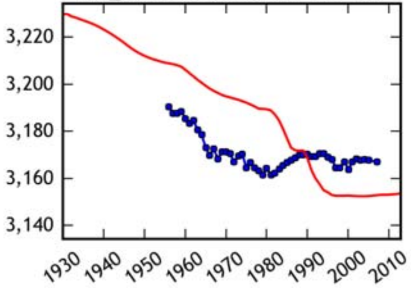
2325614 (Lubbock, TX)
HP_016379 LSD: 3240 TD: 127



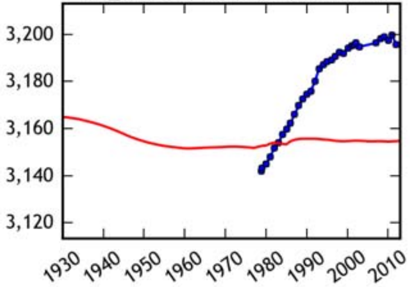
2325701 (Lubbock, TX)
HP_016380 LSD: 3295 TD: 160



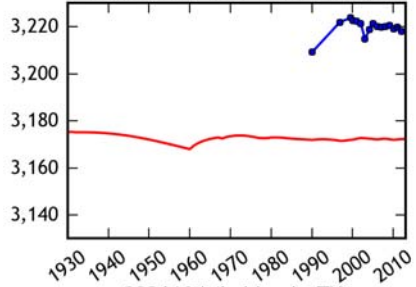
2325704 (Lubbock, TX)
HP_016382 LSD: 3296 TD: 175



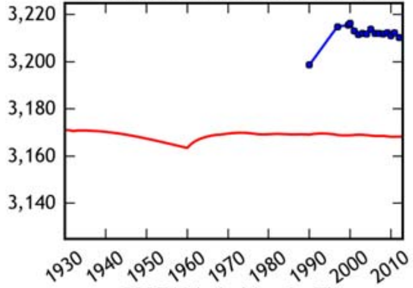
2325904 (Lubbock, TX)
HP_016390 LSD: 3230 TD: 108



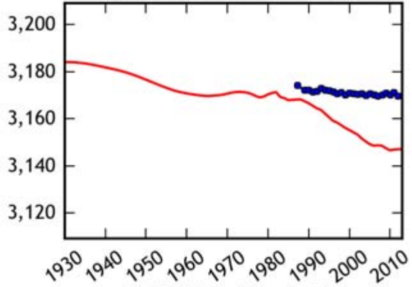
2325909 (Lubbock, TX)
HP_016395 LSD: 3233 TD: 106



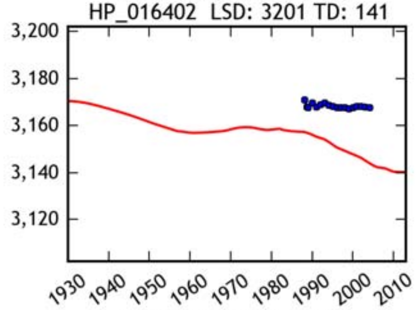
2325910 (Lubbock, TX)
HP_016396 LSD: 3228 TD: 110



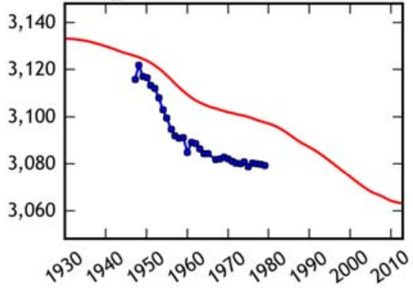
2326103 (Lubbock, TX)
HP_016401 LSD: 3215 TD: 106



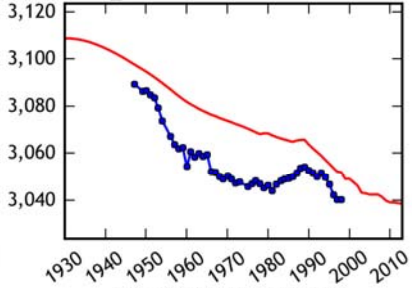
2326104 (Lubbock, TX)
HP_016402 LSD: 3201 TD: 141



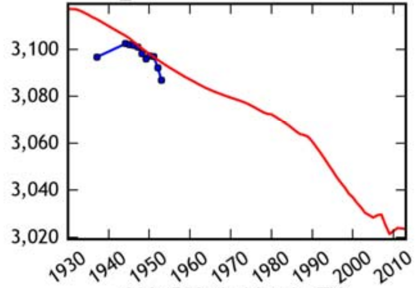
2327101 (Lubbock, TX)
HP_016535 LSD: 3178 TD: 133



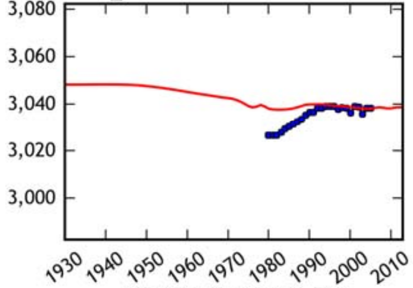
2327204 (Lubbock, TX)
HP_016546 LSD: 3140 TD: 168



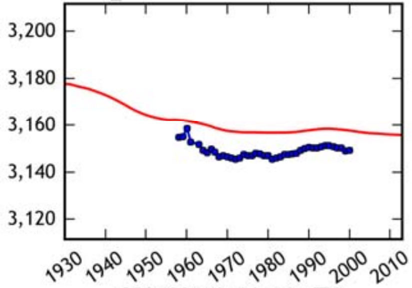
2327205 (Lubbock, TX)
HP_016547 LSD: 3150 TD: 78



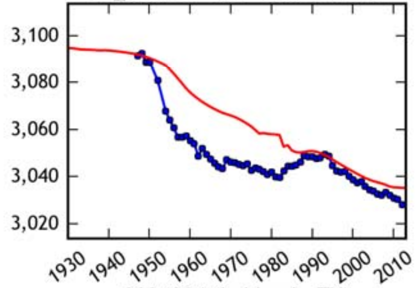
2327801 (Lubbock, TX)
HP_016611 LSD: 3157 TD: 170



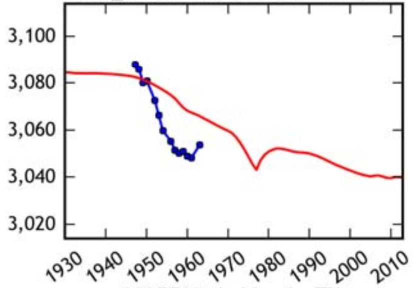
2333501 (Lubbock, TX)
HP_016697 LSD: 3257 TD: 138



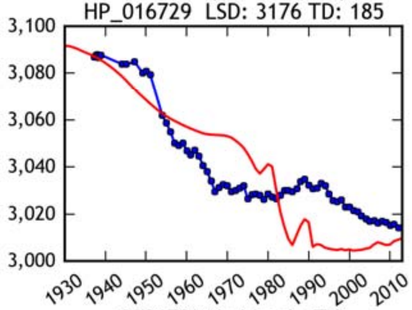
2334503 (Lubbock, TX)
HP_016720 LSD: 3169 TD: 170



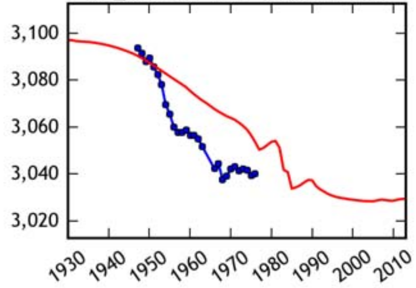
2334602 (Lubbock, TX)
HP_016725 LSD: 3171 TD: 163



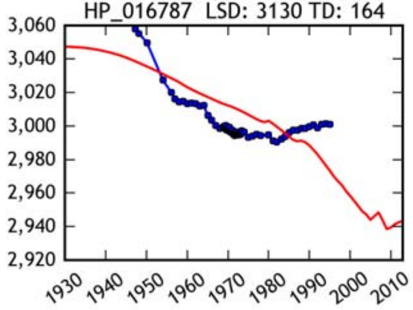
2334801 (Lubbock, TX)
HP_016729 LSD: 3176 TD: 185



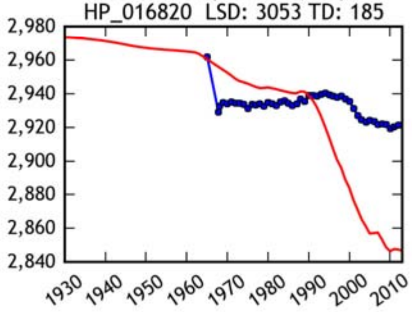
2334804 (Lubbock, TX)
HP_016732 LSD: 3178 TD: 180

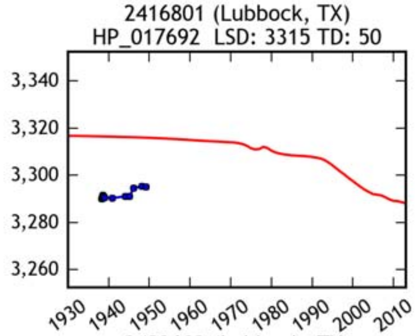


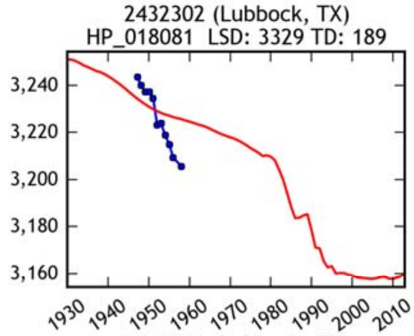
2335703 (Lubbock, TX)
HP_016787 LSD: 3130 TD: 164

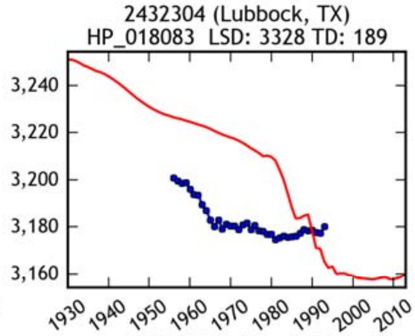


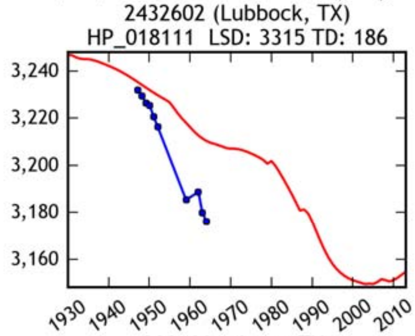
2336701 (Lubbock, TX)
HP_016820 LSD: 3053 TD: 185

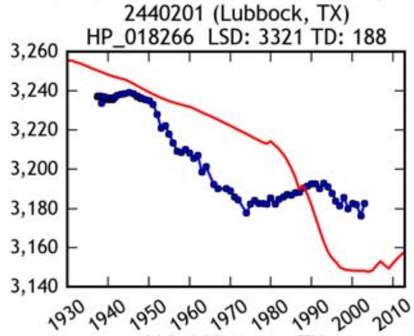


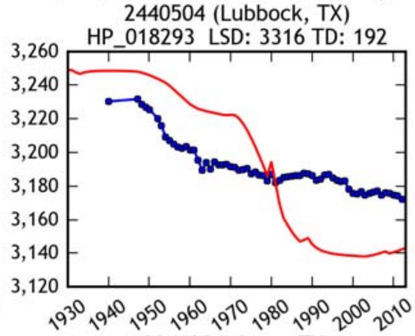

2416801 (Lubbock, TX)
HP_017692 LSD: 3315 TD: 50
3,340
3,320
3,300
3,280
3,260
1930
1940
1950
1960
1970
1980
1990
2000
2010

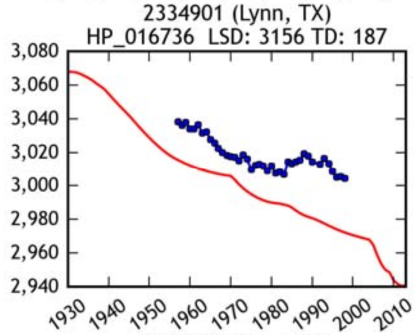

2432302 (Lubbock, TX)
HP_018081 LSD: 3329 TD: 189
3,240
3,220
3,200
3,180
3,160
1930
1940
1950
1960
1970
1980
1990
2000
2010

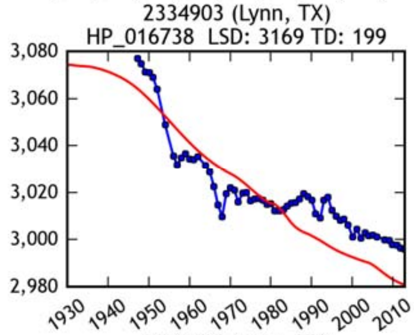

2432304 (Lubbock, TX)
HP_018083 LSD: 3328 TD: 189
3,240
3,220
3,200
3,180
3,160
1930
1940
1950
1960
1970
1980
1990
2000
2010

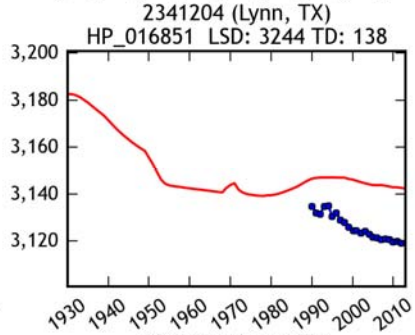

2432602 (Lubbock, TX)
HP_018111 LSD: 3315 TD: 186
3,240
3,220
3,200
3,180
3,160
1930
1940
1950
1960
1970
1980
1990
2000
2010

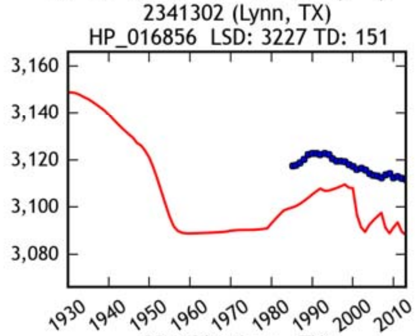

2440201 (Lubbock, TX)
HP_018266 LSD: 3321 TD: 188
3,260
3,240
3,220
3,200
3,180
3,160
3,140
1930
1940
1950
1960
1970
1980
1990
2000
2010

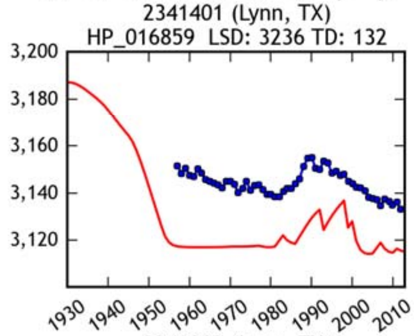

2440504 (Lubbock, TX)
HP_018293 LSD: 3316 TD: 192
3,260
3,240
3,220
3,200
3,180
3,160
3,140
3,120
1930
1940
1950
1960
1970
1980
1990
2000
2010

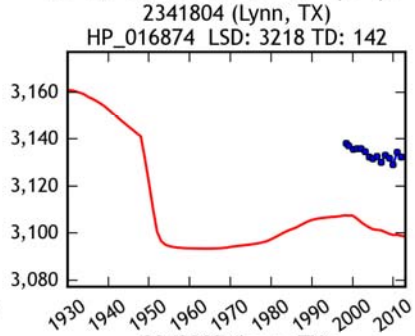

2334901 (Lynn, TX)
HP_016736 LSD: 3156 TD: 187
3,080
3,060
3,040
3,020
3,000
2,980
2,960
2,940
1930
1940
1950
1960
1970
1980
1990
2000
2010

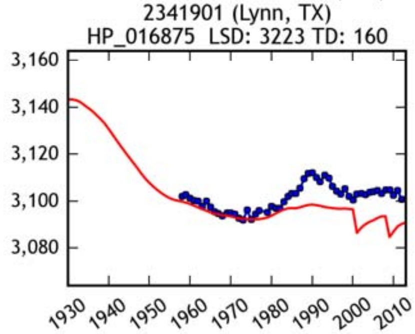

2334903 (Lynn, TX)
HP_016738 LSD: 3169 TD: 199
3,080
3,060
3,040
3,020
3,000
2,980
1930
1940
1950
1960
1970
1980
1990
2000
2010

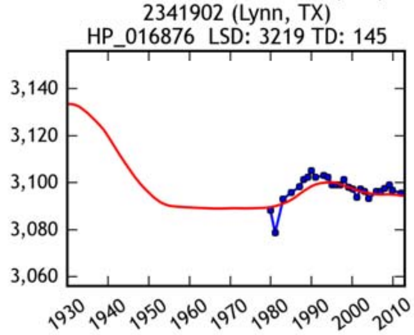

2341204 (Lynn, TX)
HP_016851 LSD: 3244 TD: 138
3,200
3,180
3,160
3,140
3,120
1930
1940
1950
1960
1970
1980
1990
2000
2010

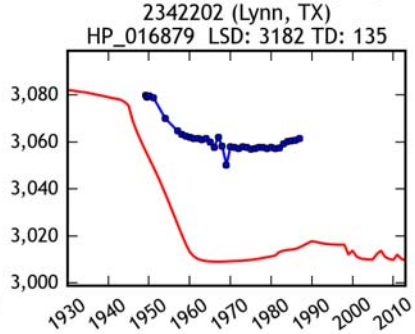

2341302 (Lynn, TX)
HP_016856 LSD: 3227 TD: 151
3,160
3,140
3,120
3,100
3,080
1930
1940
1950
1960
1970
1980
1990
2000
2010


2341401 (Lynn, TX)
HP_016859 LSD: 3236 TD: 132
3,200
3,180
3,160
3,140
3,120
1930
1940
1950
1960
1970
1980
1990
2000
2010

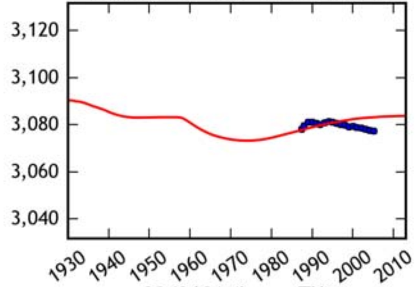

2341804 (Lynn, TX)
HP_016874 LSD: 3218 TD: 142
3,160
3,140
3,120
3,100
3,080
1930
1940
1950
1960
1970
1980
1990
2000
2010


2341901 (Lynn, TX)
HP_016875 LSD: 3223 TD: 160
3,160
3,140
3,120
3,100
3,080
1930
1940
1950
1960
1970
1980
1990
2000
2010

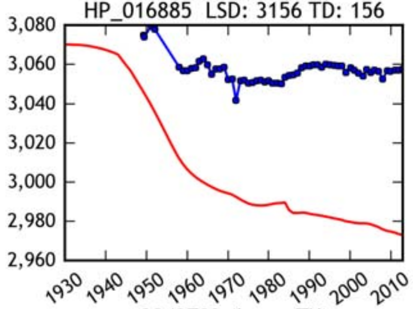

2341902 (Lynn, TX)
HP_016876 LSD: 3219 TD: 145
3,140
3,120
3,100
3,080
3,060
1930
1940
1950
1960
1970
1980
1990
2000
2010


2342202 (Lynn, TX)
HP_016879 LSD: 3182 TD: 135
3,080
3,060
3,040
3,020
3,000
1930
1940
1950
1960
1970
1980
1990
2000
2010

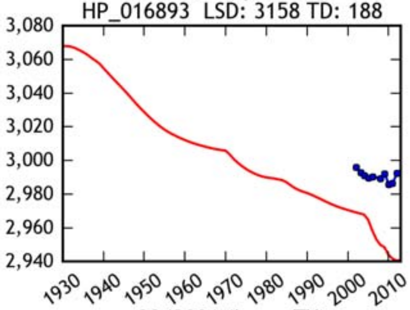
2342205 (Lynn, TX)
HP_016882 LSD: 3172 TD: 132



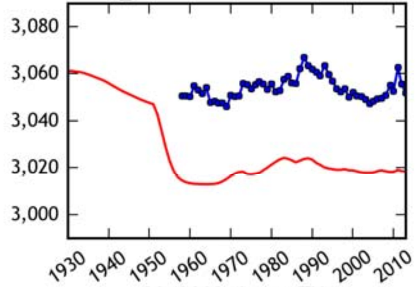
2342301 (Lynn, TX)
HP_016885 LSD: 3156 TD: 156



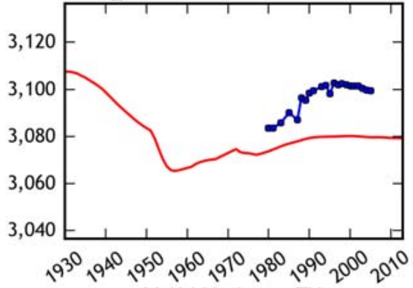
2342309 (Lynn, TX)
HP_016893 LSD: 3158 TD: 188



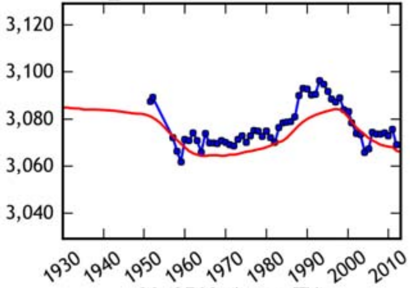
2342601 (Lynn, TX)
HP_016900 LSD: 3095 TD: 93



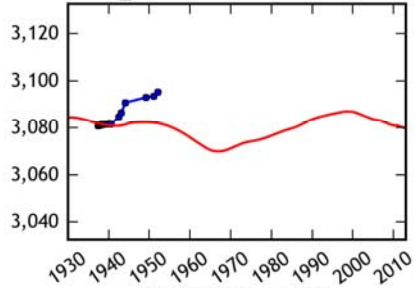
2342702 (Lynn, TX)
HP_016904 LSD: 3175 TD: 145



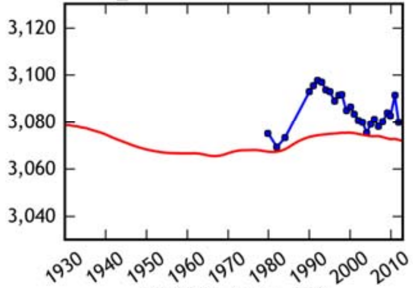
2342801 (Lynn, TX)
HP_016907 LSD: 3136 TD: 103



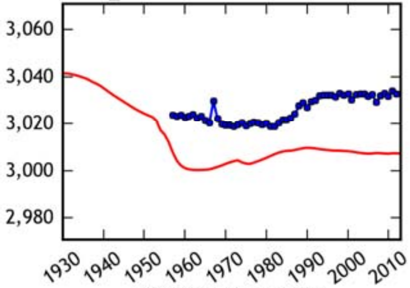
2342802 (Lynn, TX)
HP_016908 LSD: 3150 TD: 79



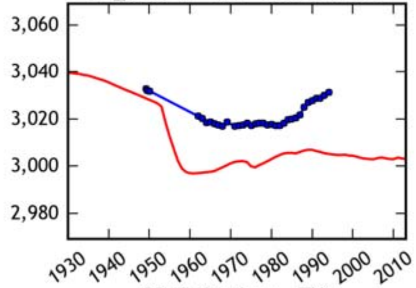
2342803 (Lynn, TX)
HP_016909 LSD: 3126 TD: 98



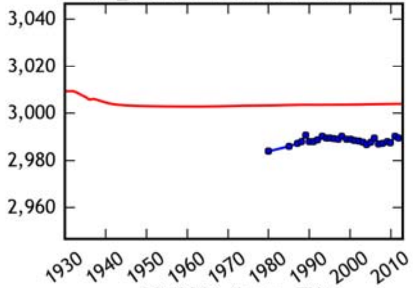
2343502 (Lynn, TX)
HP_016940 LSD: 3099 TD: 118



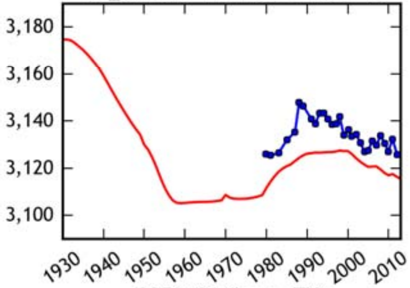
2343503 (Lynn, TX)
HP_016941 LSD: 3102 TD: 120



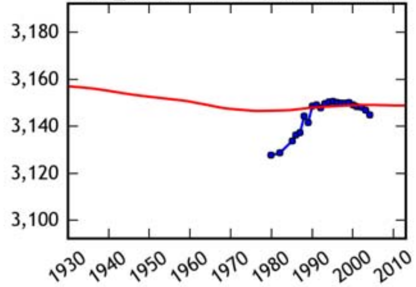
2343902 (Lynn, TX)
HP_016953 LSD: 3019 TD: 50



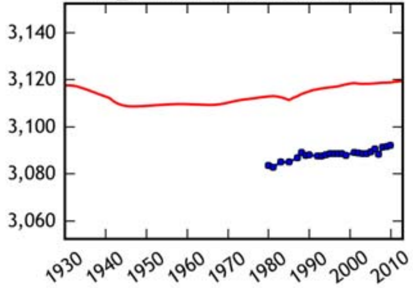
2349101 (Lynn, TX)
HP_017049 LSD: 3223 TD: 140



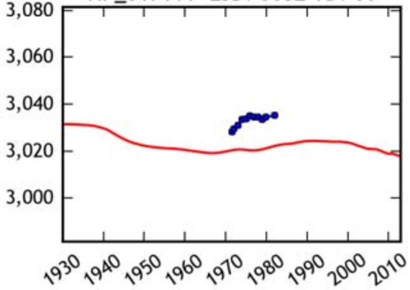
2349401 (Lynn, TX)
HP_017056 LSD: 3199 TD: 112



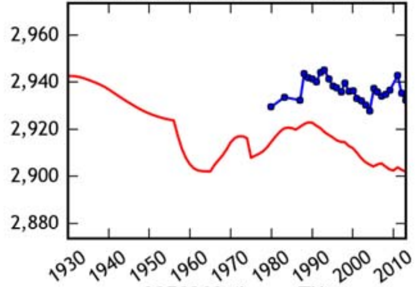
2349801 (Lynn, TX)
HP_017064 LSD: 3156 TD: 85



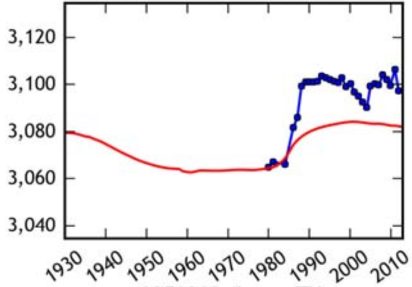
2351401 (Lynn, TX)
HP_017111 LSD: 3052 TD: 66



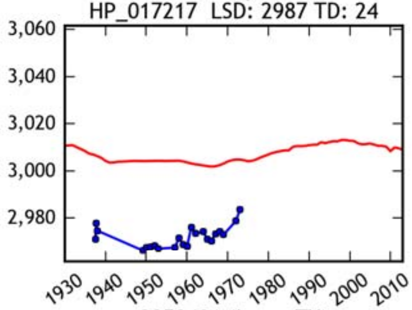
2351901 (Lynn, TX)
HP_017124 LSD: 2957 TD: 75



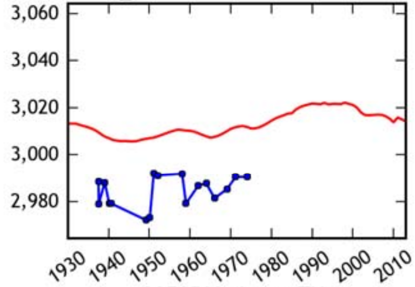
2357501 (Lynn, TX)
HP_017195 LSD: 3117 TD: 90



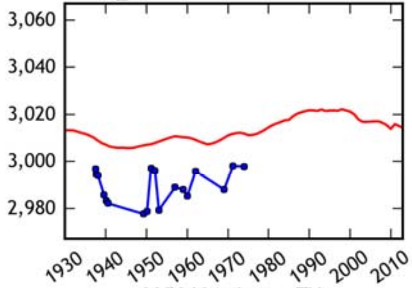
2358201 (Lynn, TX)
HP_017217 LSD: 2987 TD: 24



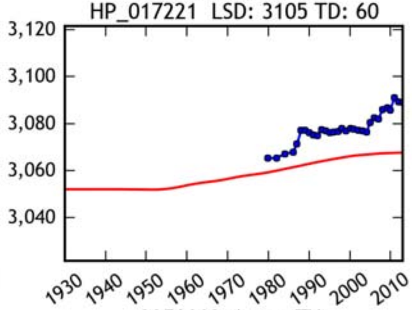
2358202 (Lynn, TX)
HP_017218 LSD: 3011 TD: 23



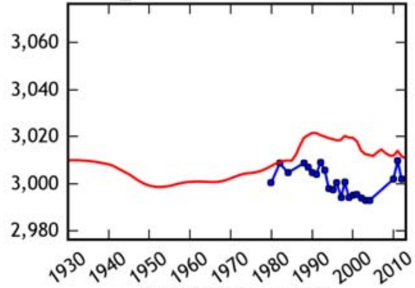
2358203 (Lynn, TX)
HP_017219 LSD: 3001 TD: 24



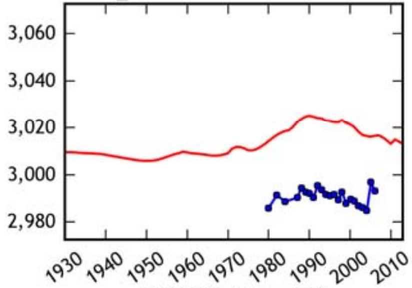
2358401 (Lynn, TX)
HP_017221 LSD: 3105 TD: 60



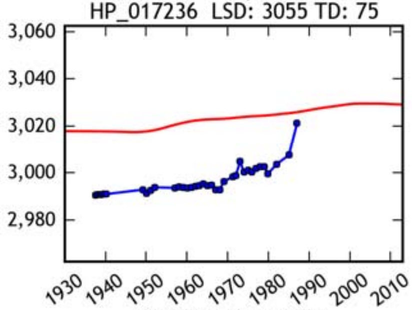
2358503 (Lynn, TX)
HP_017224 LSD: 3011 TD: 35



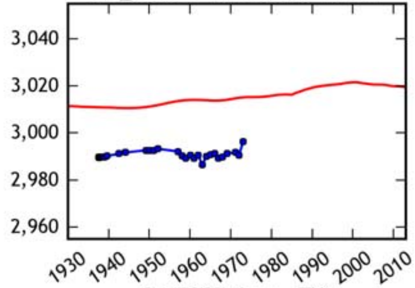
2358601 (Lynn, TX)
HP_017228 LSD: 3002 TD: 28



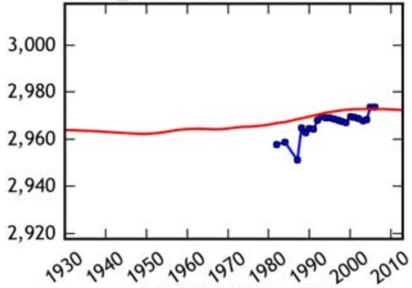
2358802 (Lynn, TX)
HP_017236 LSD: 3055 TD: 75



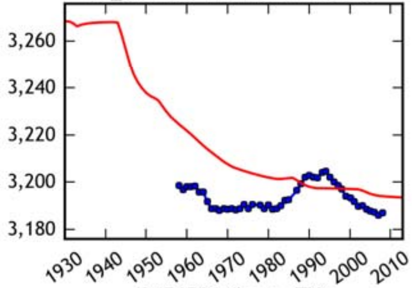
2358803 (Lynn, TX)
HP_017237 LSD: 3056 TD: 72



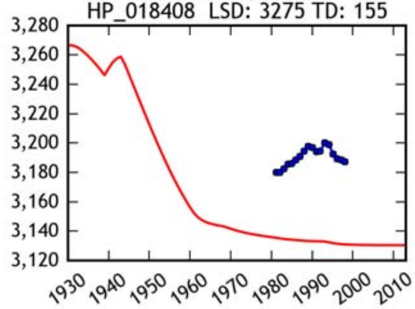
2359501 (Lynn, TX)
HP_017251 LSD: 3006 TD: 72



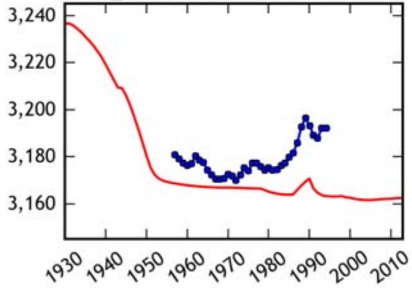
2448201 (Lynn, TX)
HP_018406 LSD: 3291 TD: 137



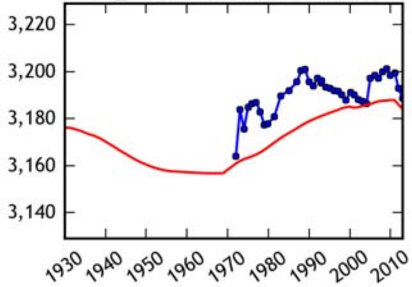
2448203 (Lynn, TX)
HP_018408 LSD: 3275 TD: 155



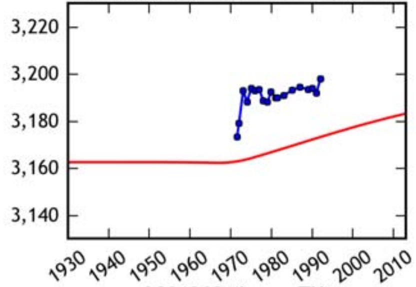
2448601 (Lynn, TX)
HP_018417 LSD: 3264 TD: 122



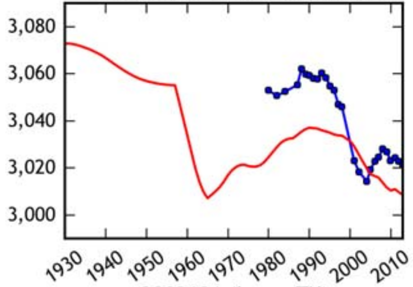
2456501 (Lynn, TX)
HP_018631 LSD: 3217 TD: 84



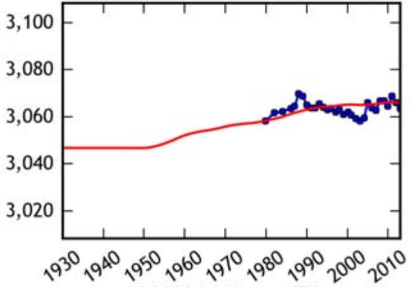
2456901 (Lynn, TX)
HP_018645 LSD: 3202 TD: 46



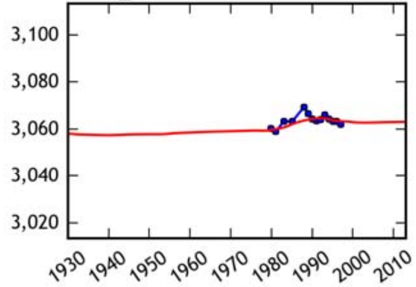
2708301 (Lynn, TX)
HP_019703 LSD: 3084 TD: 85



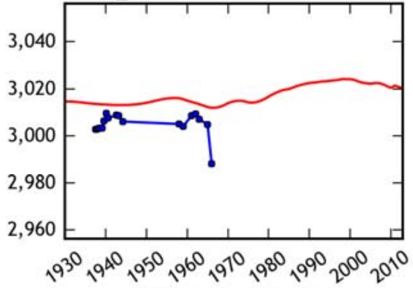
2801201 (Lynn, TX)
HP_021612 LSD: 3075 TD: 65



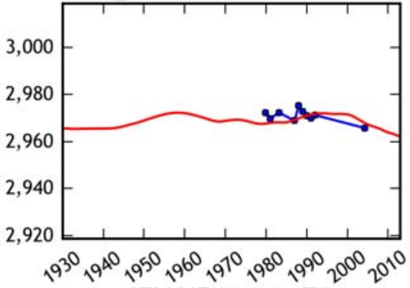
2801202 (Lynn, TX)
HP_021613 LSD: 3083 TD: 50



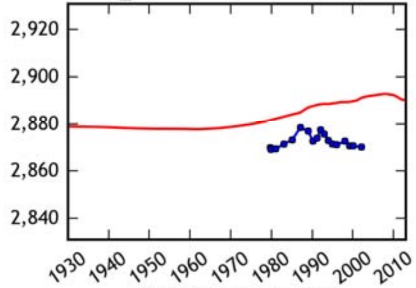
2802101 (Lynn, TX)
HP_021638 LSD: 3042 TD: 77



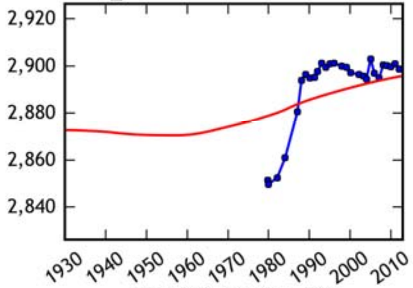
2803201 (Lynn, TX)
HP_021674 LSD: 2986 TD: 50



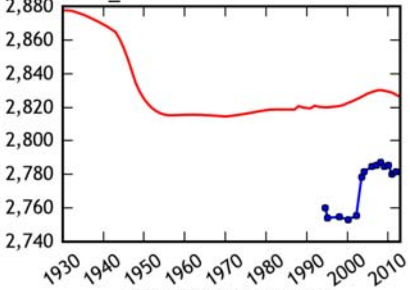
2732701 (Martin, TX)
HP_021037 LSD: 2890 TD: 68



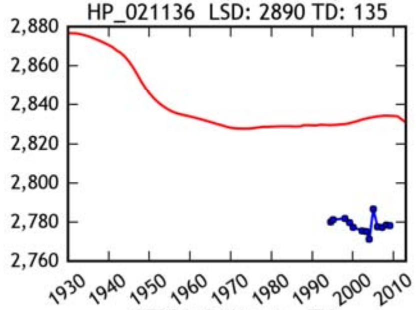
2732801 (Martin, TX)
HP_021040 LSD: 2925 TD: 110



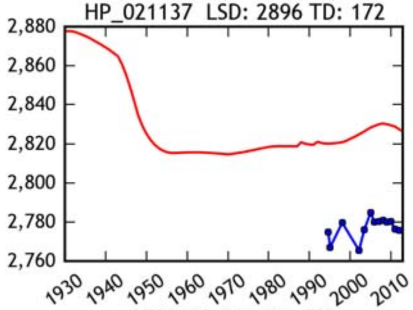
2739607 (Martin, TX)
HP_021135 LSD: 2897 TD: 160



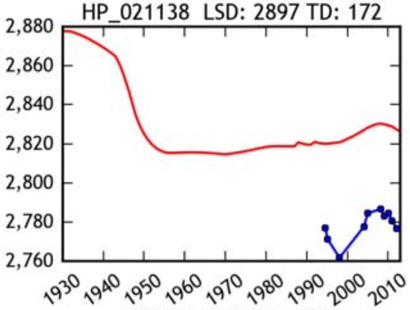
2739608 (Martin, TX)
HP_021136 LSD: 2890 TD: 135



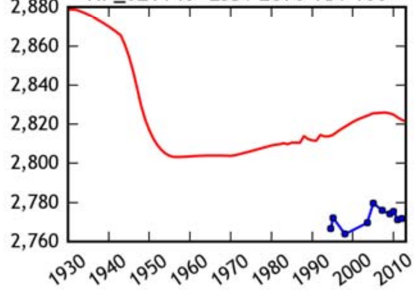
2739609 (Martin, TX)
HP_021137 LSD: 2896 TD: 172



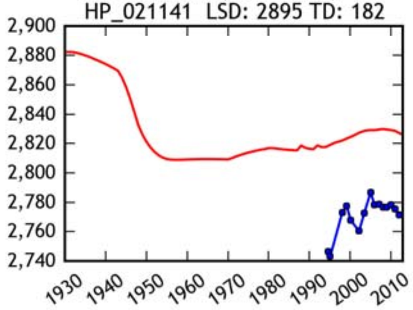
2739610 (Martin, TX)
HP_021138 LSD: 2897 TD: 172



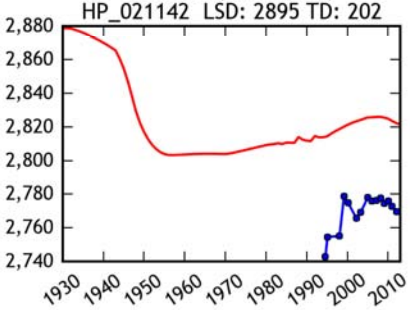
2739612 (Martin, TX)
HP_021140 LSD: 2896 TD: 180



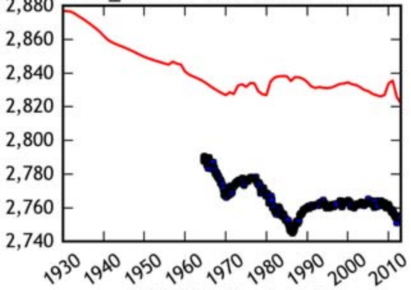
2739613 (Martin, TX)
HP_021141 LSD: 2895 TD: 182



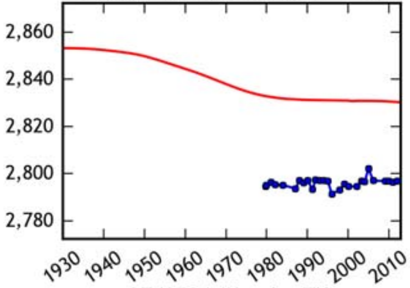
2739614 (Martin, TX)
HP_021142 LSD: 2895 TD: 202



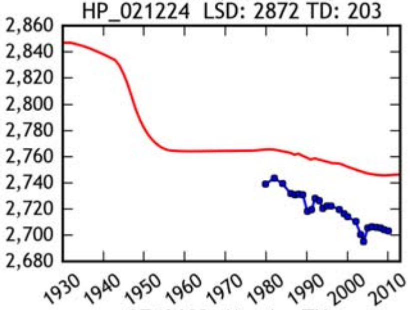
2739903 (Martin, TX)
HP_021145 LSD: 2896 TD: 182



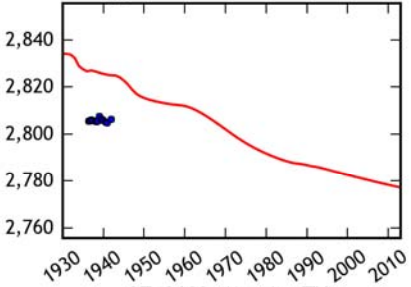
2740801 (Martin, TX)
HP_021161 LSD: 2875 TD: 121



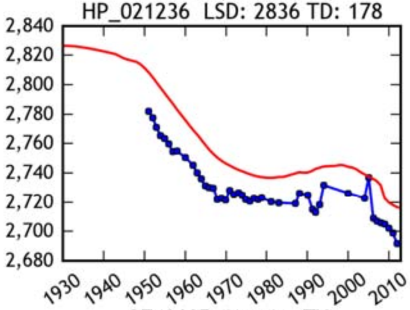
2748102 (Martin, TX)
HP_021224 LSD: 2872 TD: 203



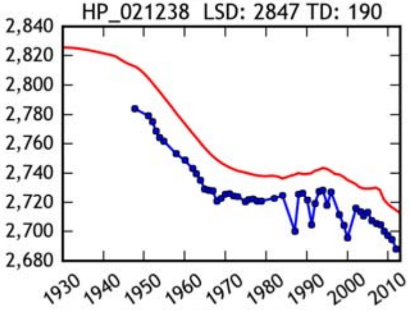
2748502 (Martin, TX)
HP_021234 LSD: 2828 TD: 37



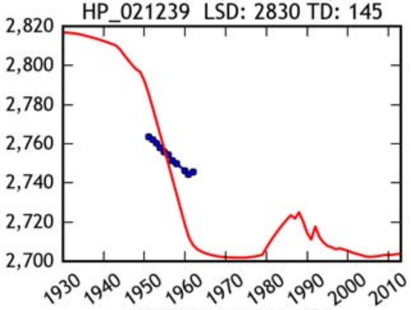
2748504 (Martin, TX)
HP_021236 LSD: 2836 TD: 178



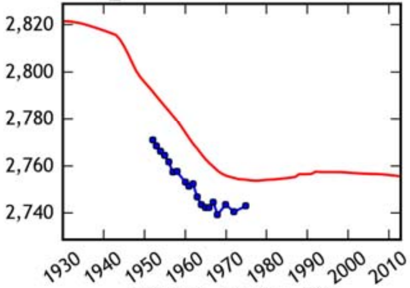
2748602 (Martin, TX)
HP_021238 LSD: 2847 TD: 190



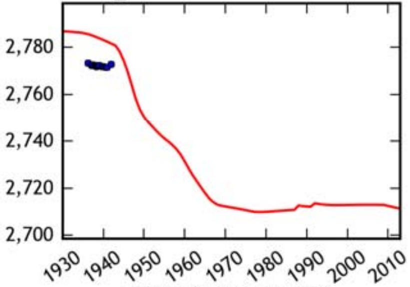
2748603 (Martin, TX)
HP_021239 LSD: 2830 TD: 145



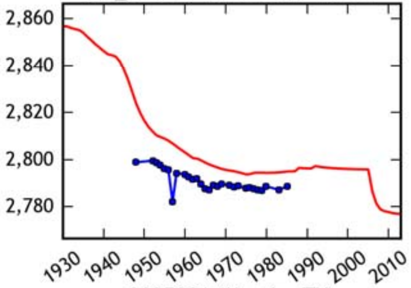
2748605 (Martin, TX)
HP_021241 LSD: 2835 TD: 125



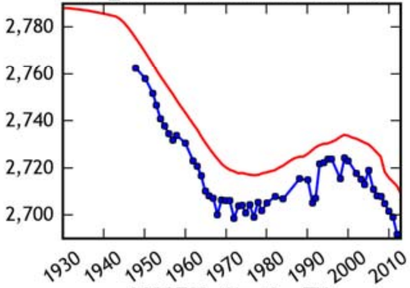
2748907 (Martin, TX)
HP_021255 LSD: 2799 TD: 90



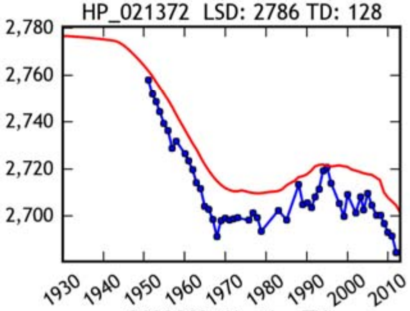
2755301 (Martin, TX)
HP_021359 LSD: 2841 TD: 82



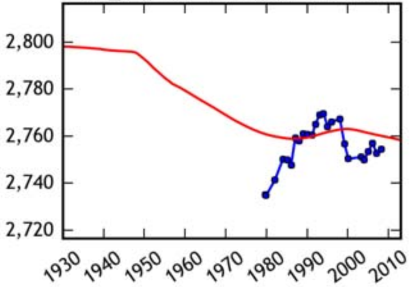
2756202 (Martin, TX)
HP_021369 LSD: 2795 TD: 140



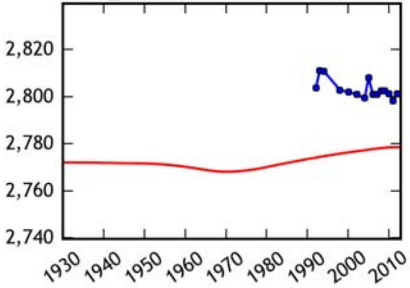
2756301 (Martin, TX)
HP_021372 LSD: 2786 TD: 128



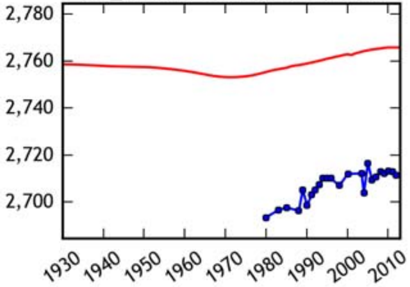
2825801 (Martin, TX)
HP_022115 LSD: 2787 TD: 140

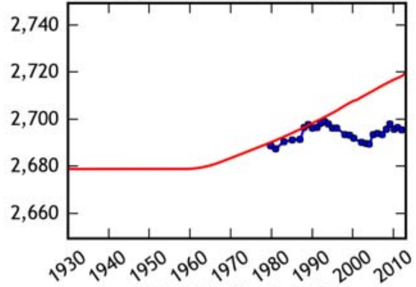


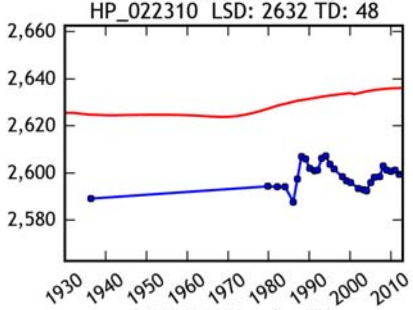
2833702 (Martin, TX)
HP_022298 LSD: 2842 TD: 100

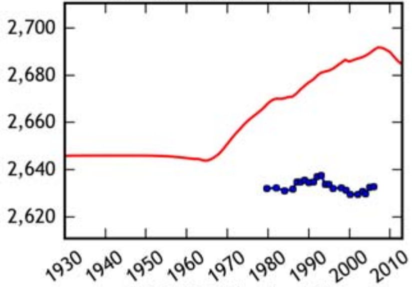


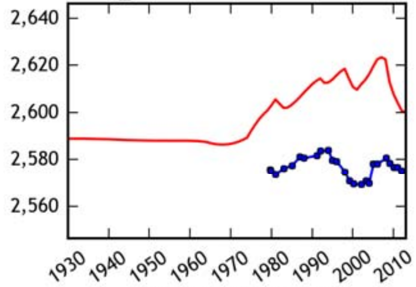
2833802 (Martin, TX)
HP_022300 LSD: 2789 TD: 131

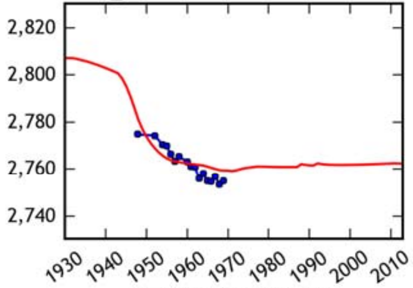


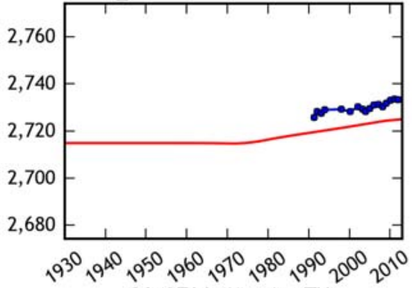

2834201 (Martin, TX)
HP_022303 LSD: 2716 TD: 60

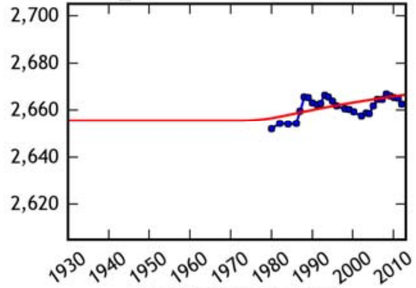

2834701 (Martin, TX)
HP_022310 LSD: 2632 TD: 48

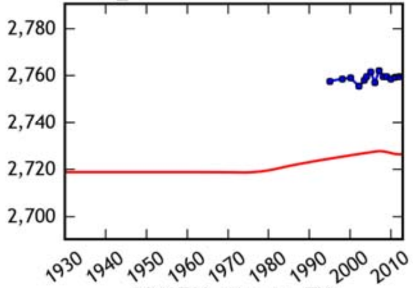

2835503 (Martin, TX)
HP_022325 LSD: 2643 TD: 30

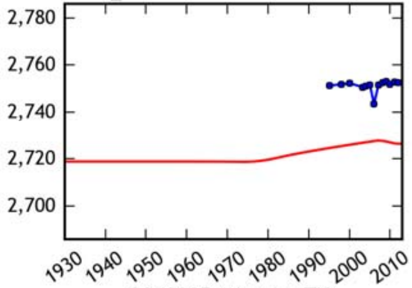

2835801 (Martin, TX)
HP_022343 LSD: 2582 TD: 40

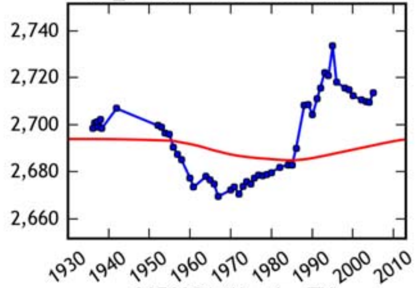

2841401 (Martin, TX)
HP_022593 LSD: 2831 TD: 128

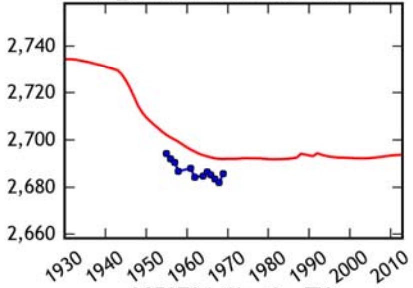

2842402 (Martin, TX)
HP_022619 LSD: 2759 TD: 40

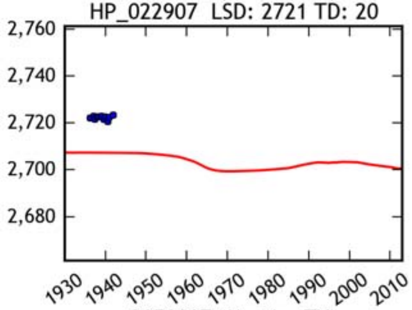

2842501 (Martin, TX)
HP_022620 LSD: 2688 TD: 40

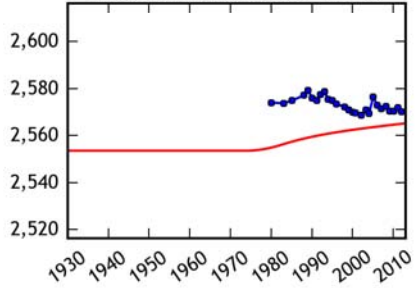

2842704 (Martin, TX)
HP_022626 LSD: 2805 TD: 80

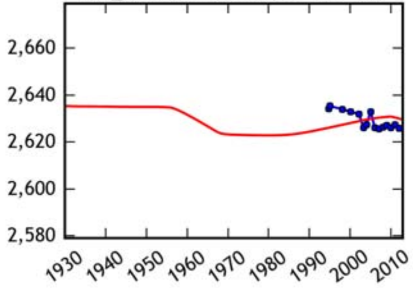

2842706 (Martin, TX)
HP_022628 LSD: 2807 TD: 120

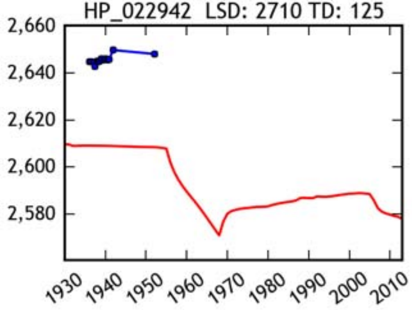

2849602 (Martin, TX)
HP_022897 LSD: 2764 TD: 144

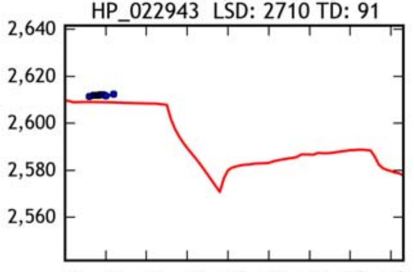

2849703 (Martin, TX)
HP_022901 LSD: 2735 TD: 60

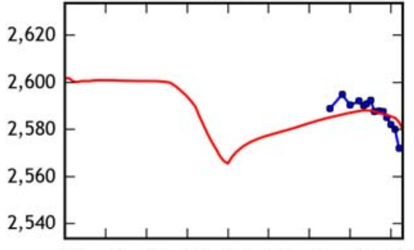

2849805 (Martin, TX)
HP_022907 LSD: 2721 TD: 20

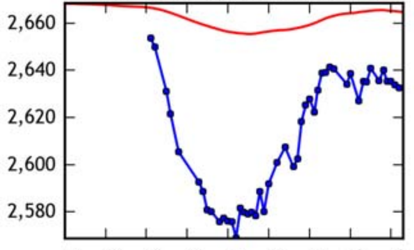

2850301 (Martin, TX)
HP_022924 LSD: 2593 TD: 39

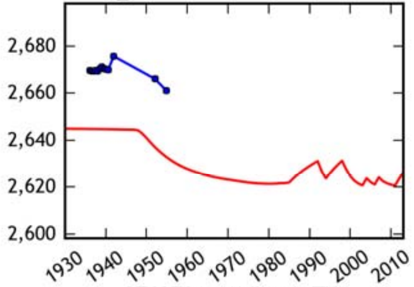

2850704 (Martin, TX)
HP_022935 LSD: 2679 TD: 135

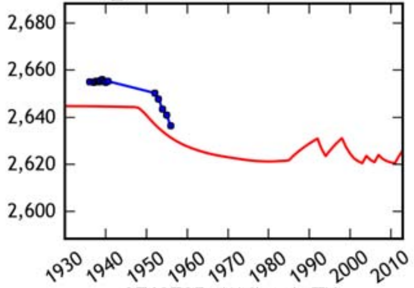

2850807 (Martin, TX)
HP_022942 LSD: 2710 TD: 125

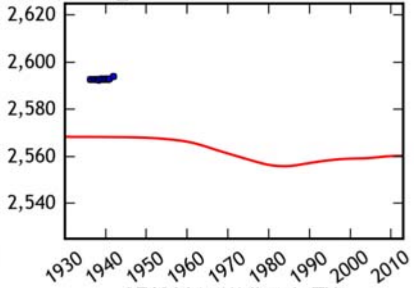

2850808 (Martin, TX)
HP_022943 LSD: 2710 TD: 91

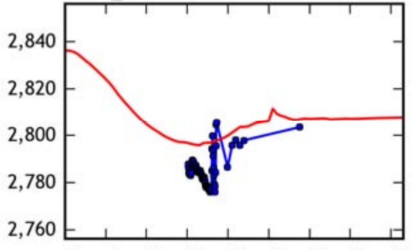

2850814 (Martin, TX)
HP_022949 LSD: 2692 TD: 184

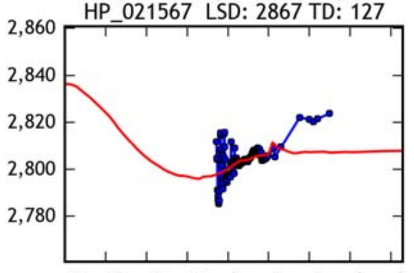

2857301 (Martin, TX)
HP_023244 LSD: 2691 TD: 154

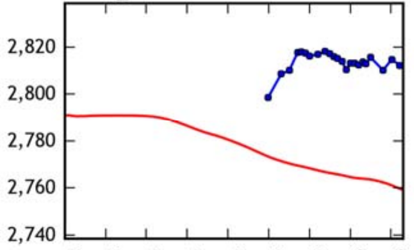

2858108 (Martin, TX)
HP_023272 LSD: 2699 TD: 45

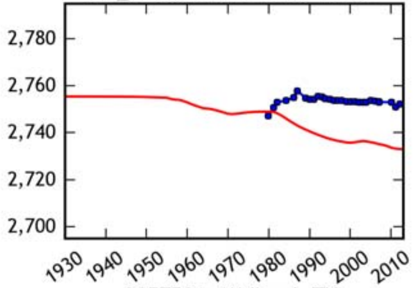

2858111 (Martin, TX)
HP_023275 LSD: 2699 TD: 115

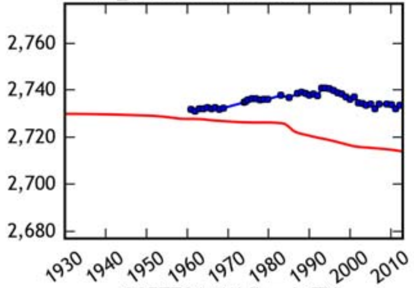

2858302 (Martin, TX)
HP_023283 LSD: 2660 TD: 85

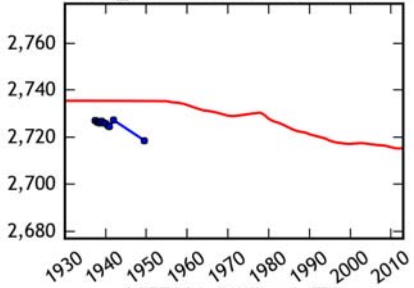

2763701 (Midland, TX)
HP_021564 LSD: 2868 TD: 123

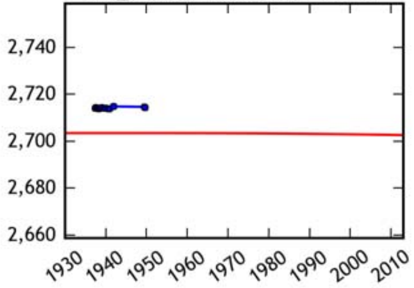

2763705 (Midland, TX)
HP_021567 LSD: 2867 TD: 127

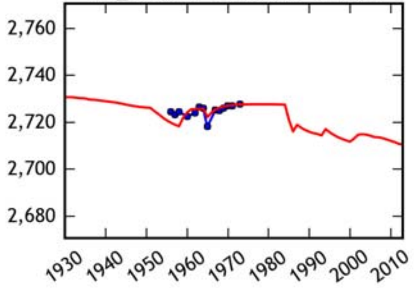

2763901 (Midland, TX)
HP_021580 LSD: 2835 TD: 90

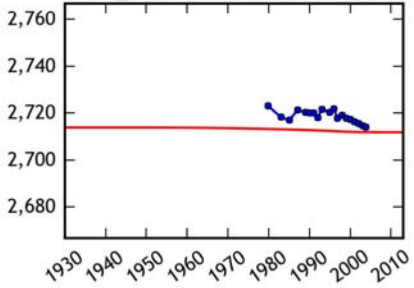

2764802 (Midland, TX)
HP_021602 LSD: 2776 TD: 68

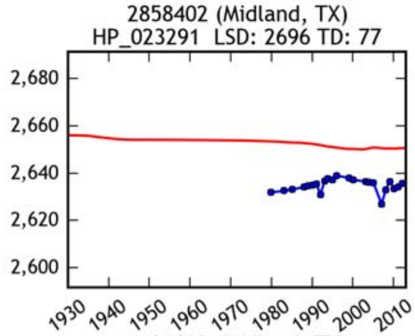

2764901 (Midland, TX)
HP_021605 LSD: 2785 TD: 69

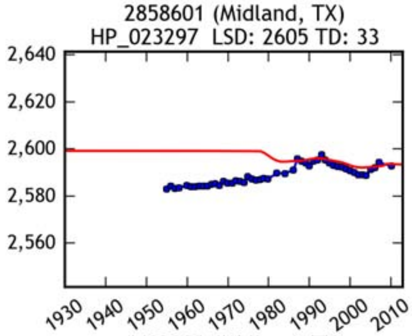

2764903 (Midland, TX)
HP_021607 LSD: 2755 TD: 76

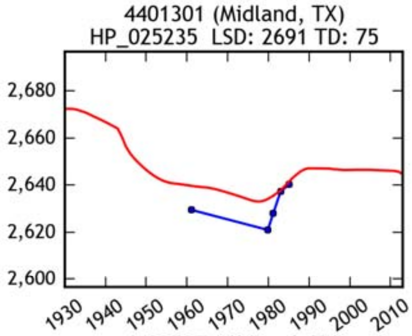

2857501 (Midland, TX)
HP_023250 LSD: 2751 TD: 58

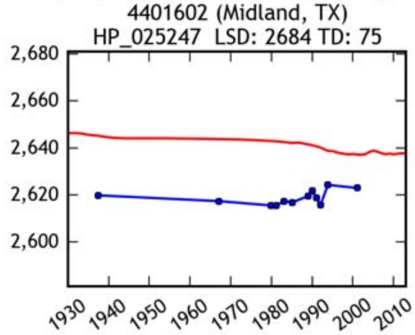

2857701 (Midland, TX)
HP_023254 LSD: 2777 TD: 86

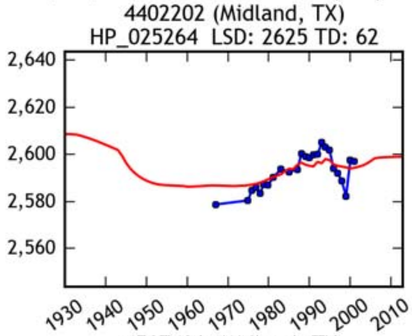

2857801 (Midland, TX)
HP_023258 LSD: 2757 TD: 75

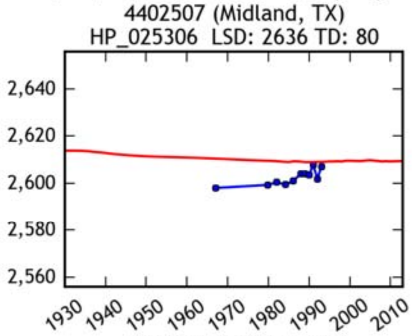

2858402 (Midland, TX)
HP_023291 LSD: 2696 TD: 77

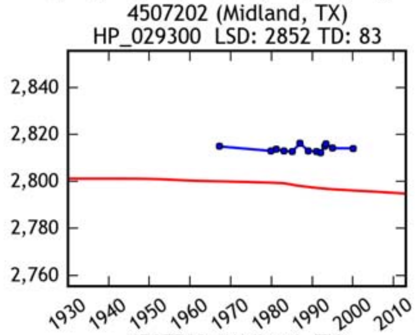

2858601 (Midland, TX)
HP_023297 LSD: 2605 TD: 33

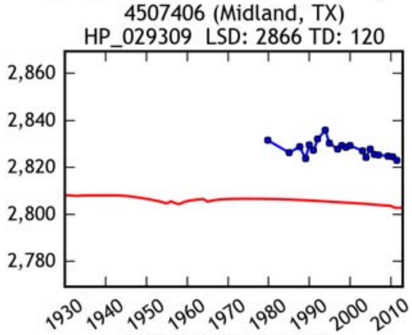

4401301 (Midland, TX)
HP_025235 LSD: 2691 TD: 75

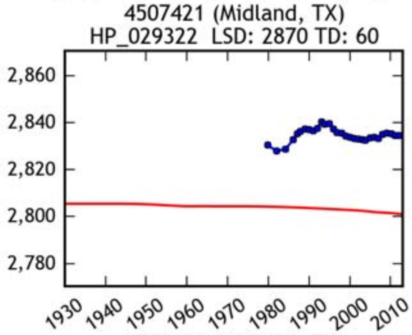

4401602 (Midland, TX)
HP_025247 LSD: 2684 TD: 75

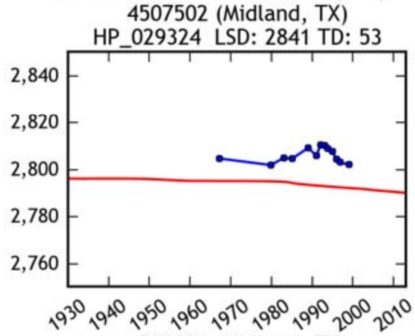

4402202 (Midland, TX)
HP_025264 LSD: 2625 TD: 62

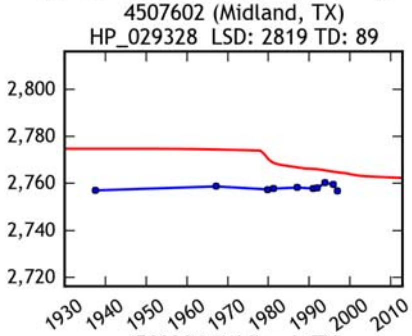

4402507 (Midland, TX)
HP_025306 LSD: 2636 TD: 80

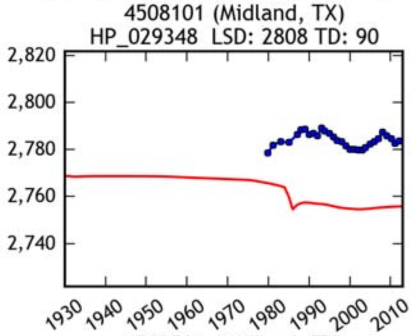

4507202 (Midland, TX)
HP_029300 LSD: 2852 TD: 83

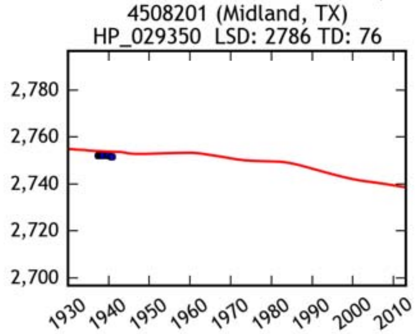

4507406 (Midland, TX)
HP_029309 LSD: 2866 TD: 120

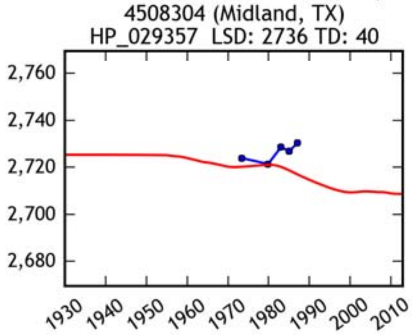

4507421 (Midland, TX)
HP_029322 LSD: 2870 TD: 60

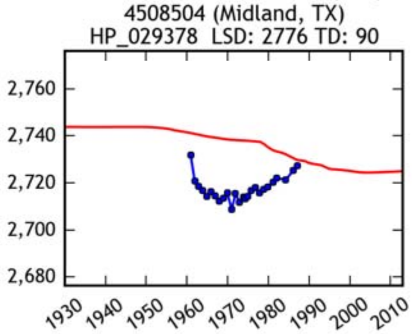

4507502 (Midland, TX)
HP_029324 LSD: 2841 TD: 53

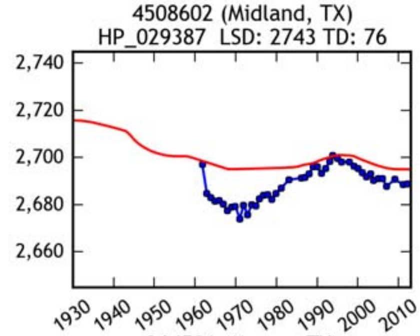

4507602 (Midland, TX)
HP_029328 LSD: 2819 TD: 89

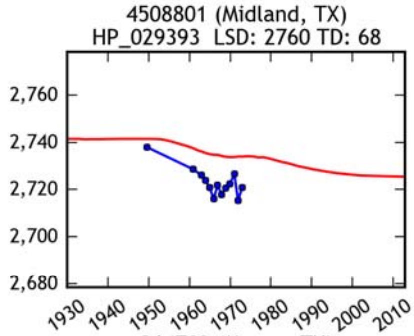

4508101 (Midland, TX)
HP_029348 LSD: 2808 TD: 90

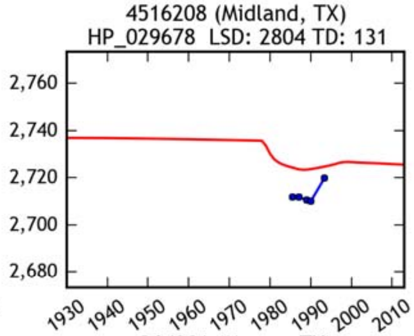

4508201 (Midland, TX)
HP_029350 LSD: 2786 TD: 76

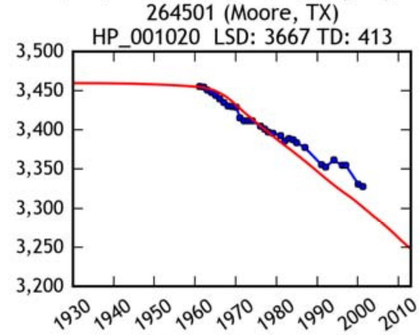

4508304 (Midland, TX)
HP_029357 LSD: 2736 TD: 40

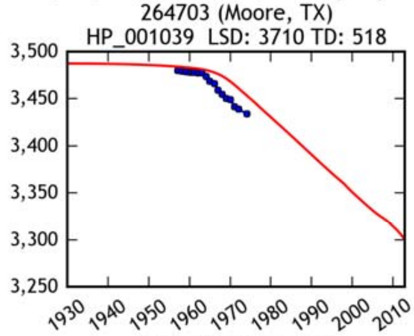

4508504 (Midland, TX)
HP_029378 LSD: 2776 TD: 90

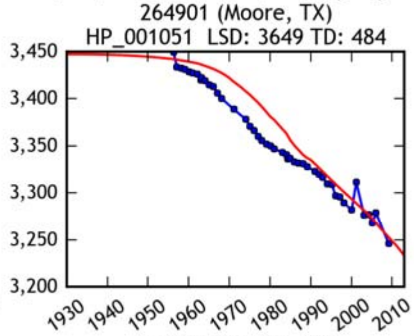

4508602 (Midland, TX)
HP_029387 LSD: 2743 TD: 76

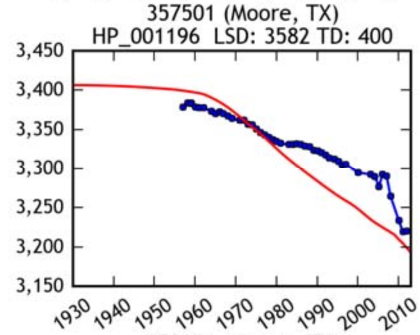

4508801 (Midland, TX)
HP_029393 LSD: 2760 TD: 68

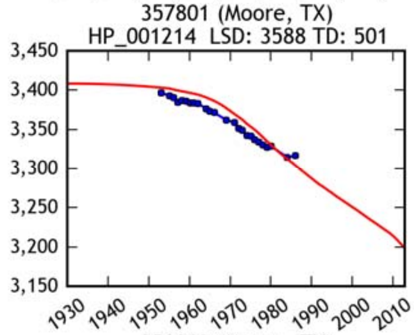

4516208 (Midland, TX)
HP_029678 LSD: 2804 TD: 131

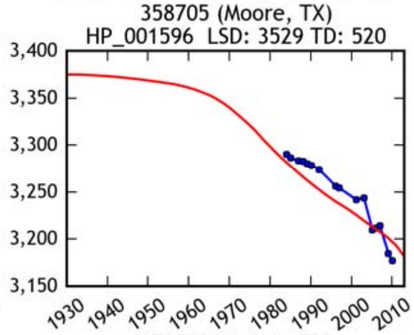

264501 (Moore, TX)
HP_001020 LSD: 3667 TD: 413

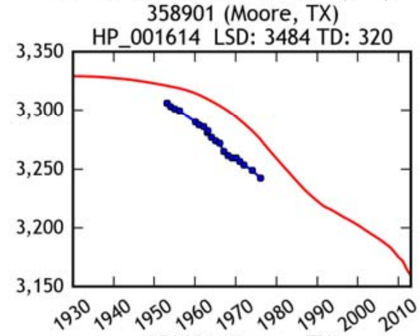

264703 (Moore, TX)
HP_001039 LSD: 3710 TD: 518

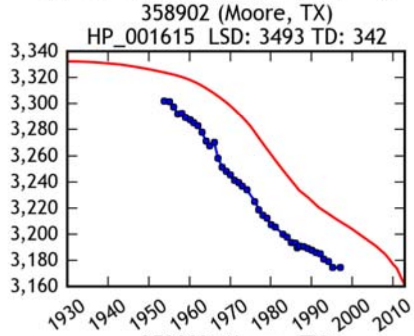

264901 (Moore, TX)
HP_001051 LSD: 3649 TD: 484

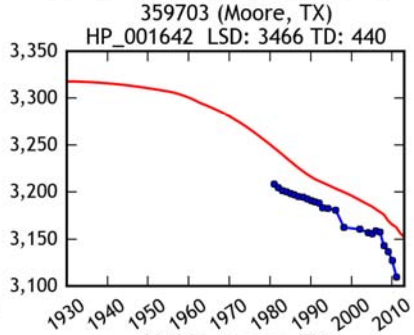

357501 (Moore, TX)
HP_001196 LSD: 3582 TD: 400

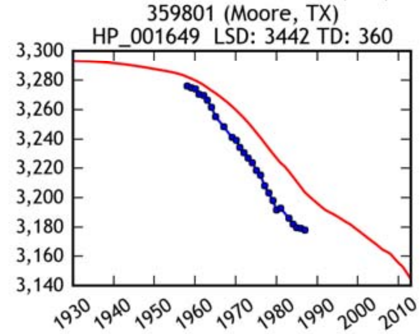

357801 (Moore, TX)
HP_001214 LSD: 3588 TD: 501

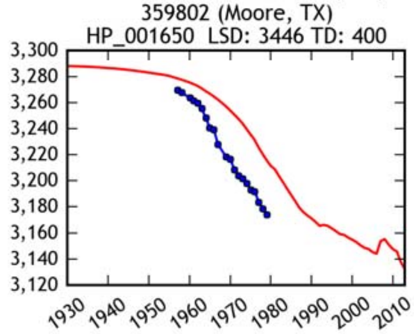

358705 (Moore, TX)
HP_001596 LSD: 3529 TD: 520

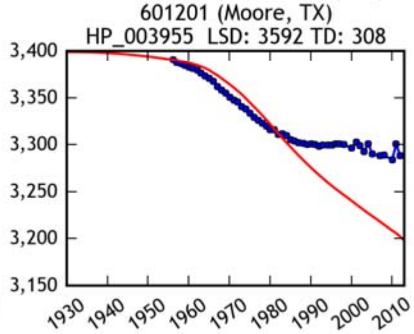

358901 (Moore, TX)
HP_001614 LSD: 3484 TD: 320


358902 (Moore, TX)
HP_001615 LSD: 3493 TD: 342

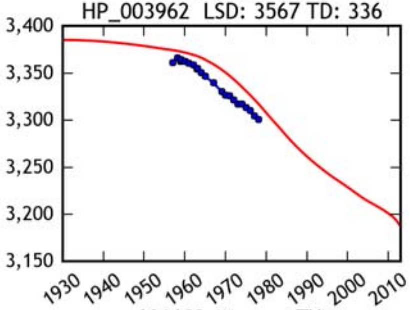

359703 (Moore, TX)
HP_001642 LSD: 3466 TD: 440


359801 (Moore, TX)
HP_001649 LSD: 3442 TD: 360

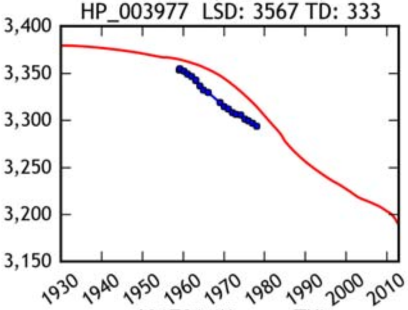

359802 (Moore, TX)
HP_001650 LSD: 3446 TD: 400


601201 (Moore, TX)
HP_003955 LSD: 3592 TD: 308

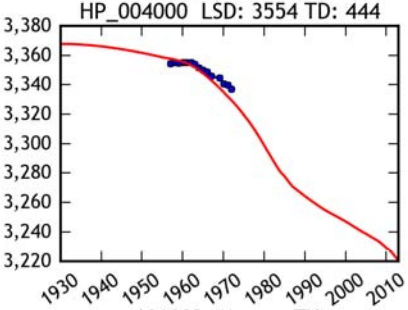
601301 (Moore, TX)
HP_003962 LSD: 3567 TD: 336



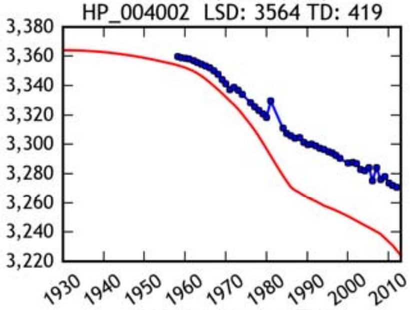
601316 (Moore, TX)
HP_003977 LSD: 3567 TD: 333



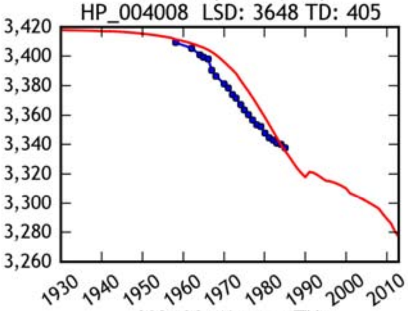
601601 (Moore, TX)
HP_004000 LSD: 3554 TD: 444



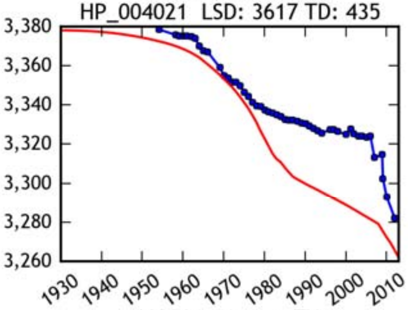
601603 (Moore, TX)
HP_004002 LSD: 3564 TD: 419



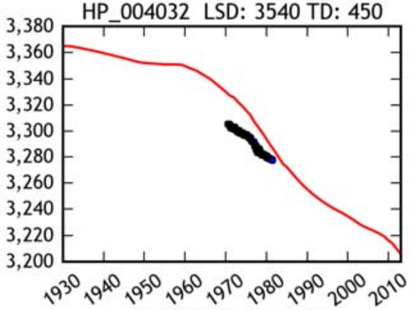
601701 (Moore, TX)
HP_004008 LSD: 3648 TD: 405



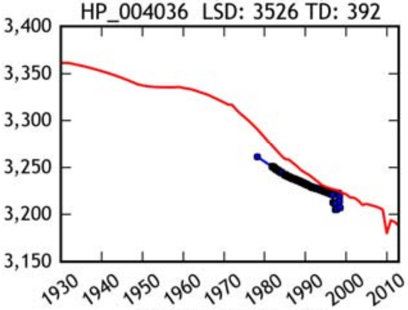
601803 (Moore, TX)
HP_004021 LSD: 3617 TD: 435



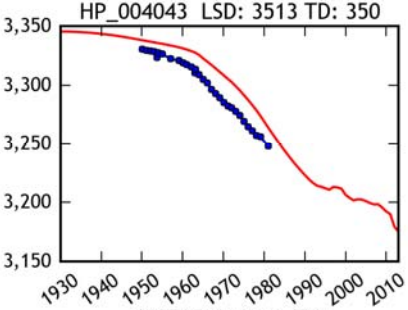
602104 (Moore, TX)
HP_004032 LSD: 3540 TD: 450



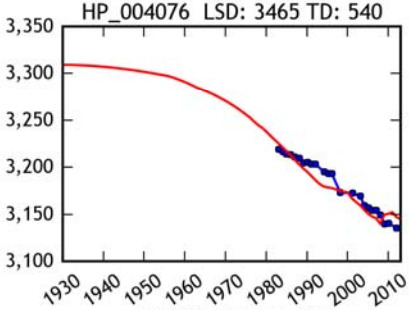
602108 (Moore, TX)
HP_004036 LSD: 3526 TD: 392



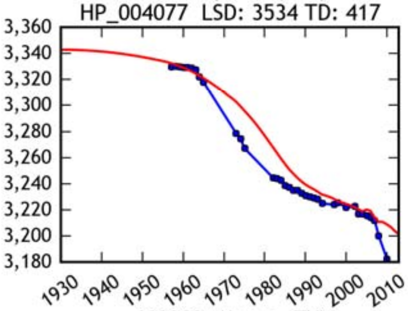
602201 (Moore, TX)
HP_004043 LSD: 3513 TD: 350



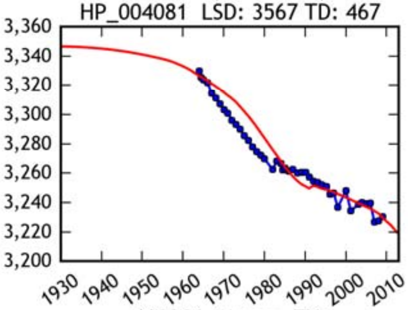
602609 (Moore, TX)
HP_004076 LSD: 3465 TD: 540



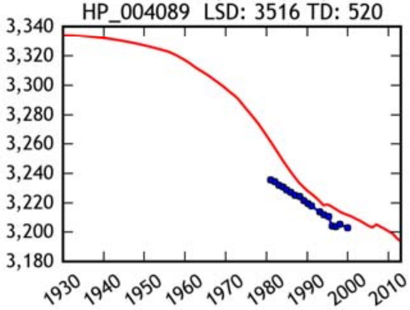
602701 (Moore, TX)
HP_004077 LSD: 3534 TD: 417



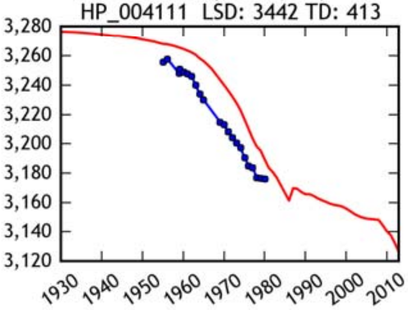
602705 (Moore, TX)
HP_004081 LSD: 3567 TD: 467



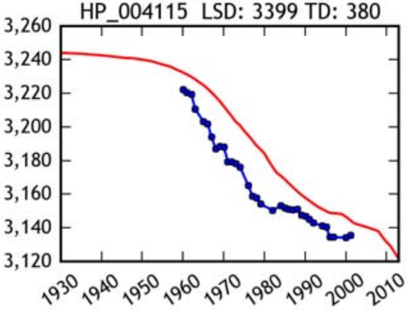
602807 (Moore, TX)
HP_004089 LSD: 3516 TD: 520



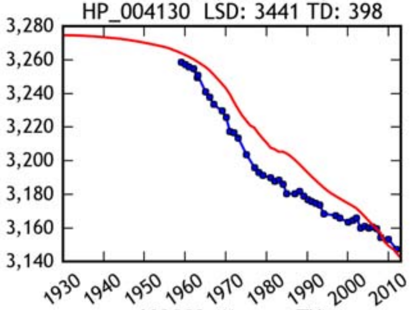
603202 (Moore, TX)
HP_004111 LSD: 3442 TD: 413



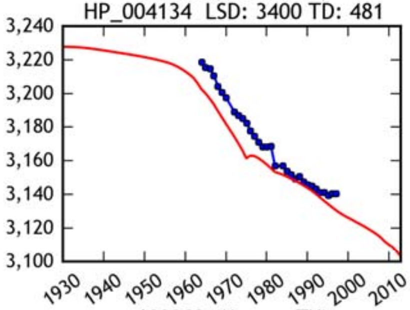
603206 (Moore, TX)
HP_004115 LSD: 3399 TD: 380



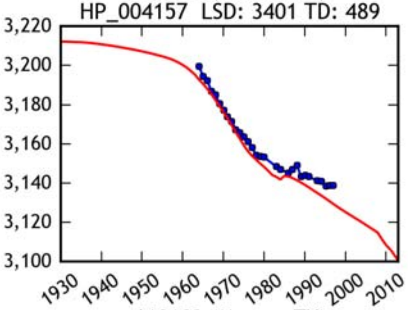
603402 (Moore, TX)
HP_004130 LSD: 3441 TD: 398



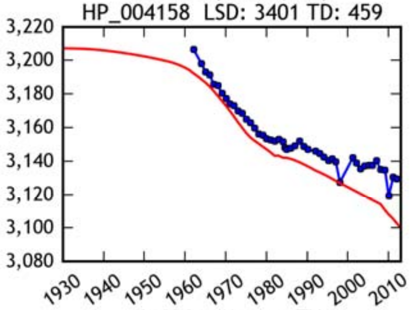
603501 (Moore, TX)
HP_004134 LSD: 3400 TD: 481



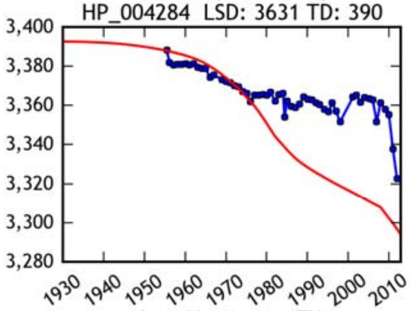
603802 (Moore, TX)
HP_004157 LSD: 3401 TD: 489



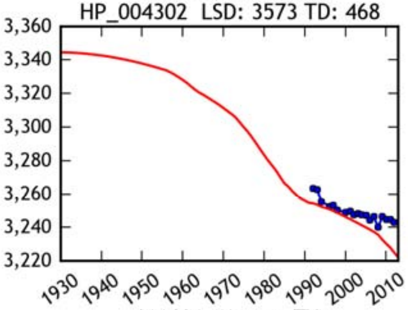
603803 (Moore, TX)
HP_004158 LSD: 3401 TD: 459



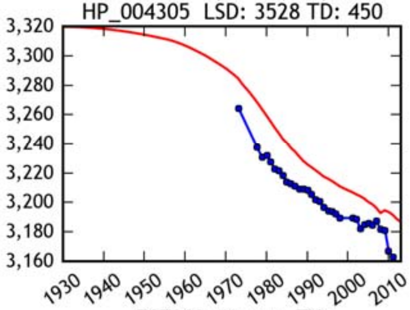
609202 (Moore, TX)
HP_004284 LSD: 3631 TD: 390



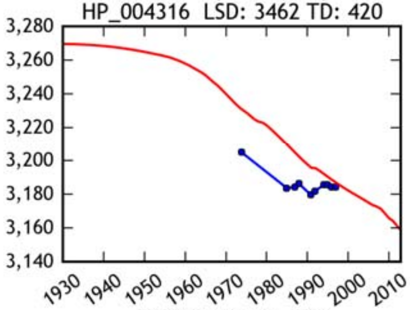
610102 (Moore, TX)
HP_004302 LSD: 3573 TD: 468



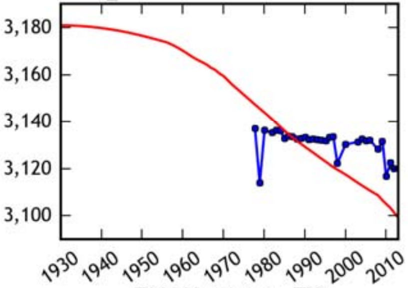
610201 (Moore, TX)
HP_004305 LSD: 3528 TD: 450



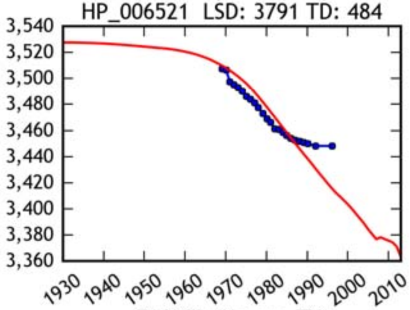
611102 (Moore, TX)
HP_004316 LSD: 3462 TD: 420



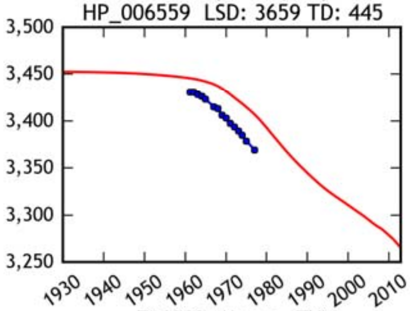
611601 (Moore, TX)
HP_004338 LSD: 3382 TD: 429



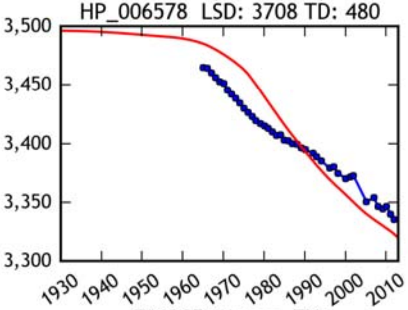
707902 (Moore, TX)
HP_006521 LSD: 3791 TD: 484



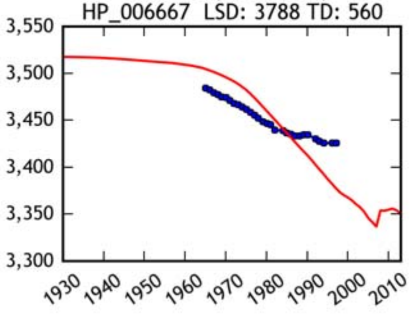
708603 (Moore, TX)
HP_006559 LSD: 3659 TD: 445



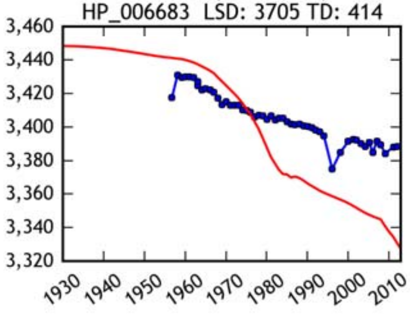
708802 (Moore, TX)
HP_006578 LSD: 3708 TD: 480



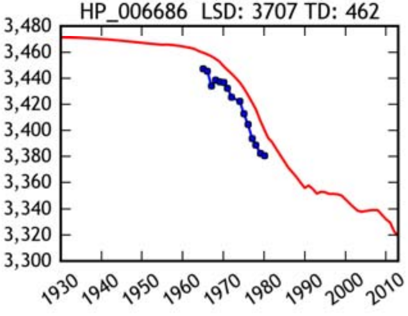
716102 (Moore, TX)
HP_006667 LSD: 3788 TD: 560

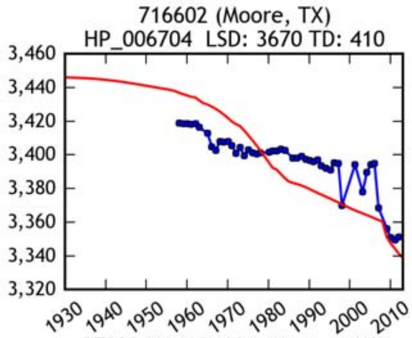


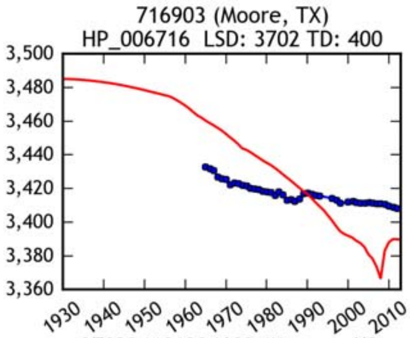
716302 (Moore, TX)
HP_006683 LSD: 3705 TD: 414

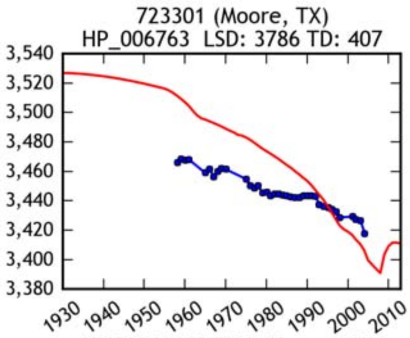


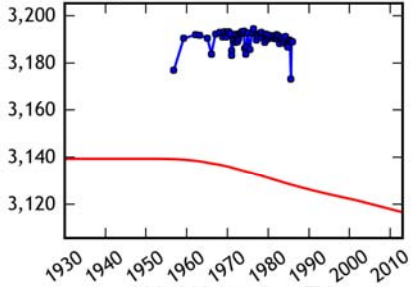
716305 (Moore, TX)
HP_006686 LSD: 3707 TD: 462

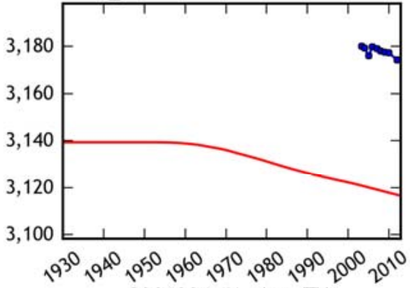


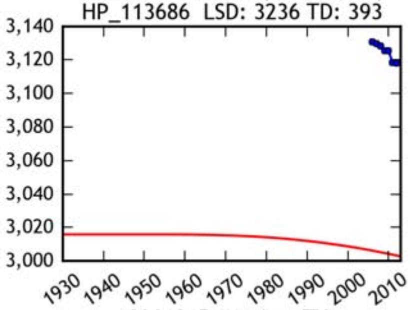

716602 (Moore, TX)
HP_006704 LSD: 3670 TD: 410

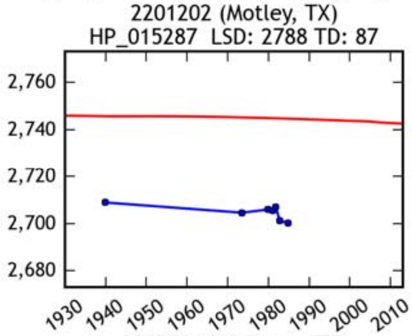

716903 (Moore, TX)
HP_006716 LSD: 3702 TD: 400

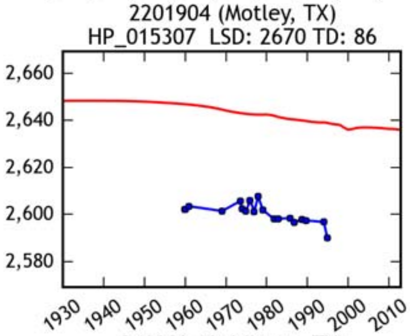

723301 (Moore, TX)
HP_006763 LSD: 3786 TD: 407

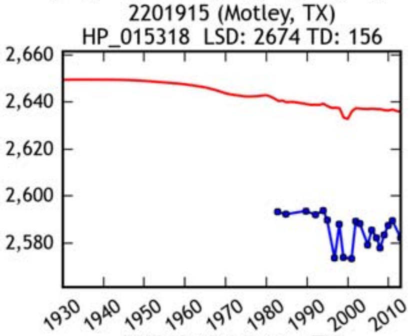

370224101394601 (Morton, KS)
HP_112881 LSD: 3367 TD: 385

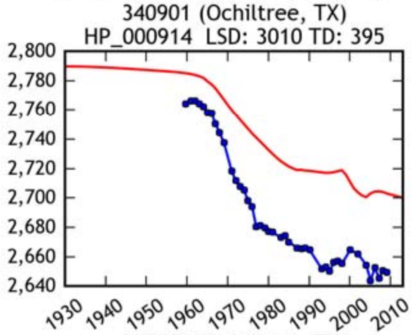

370224101394603 (Morton, KS)
HP_112883 LSD: 3367 TD: 380

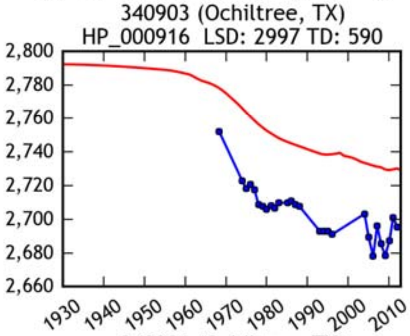

371223101334701 (Morton, KS)
HP_113686 LSD: 3236 TD: 393

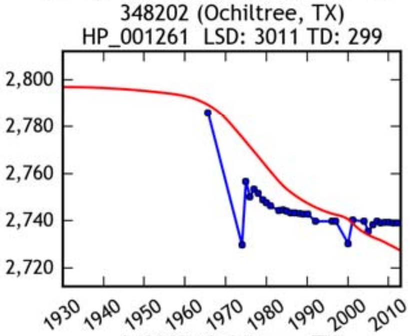

2201202 (Motley, TX)
HP_015287 LSD: 2788 TD: 87

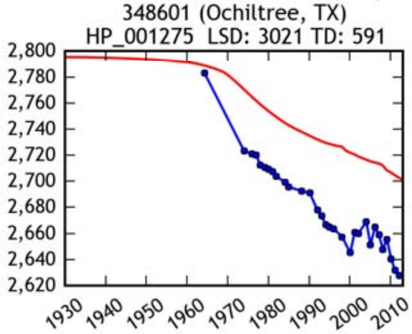

2201904 (Motley, TX)
HP_015307 LSD: 2670 TD: 86

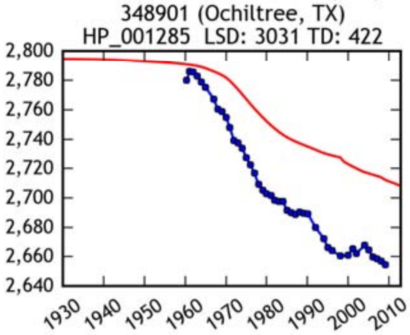

2201915 (Motley, TX)
HP_015318 LSD: 2674 TD: 156

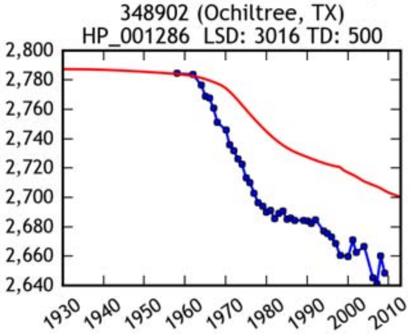

340901 (Ochiltree, TX)
HP_000914 LSD: 3010 TD: 395

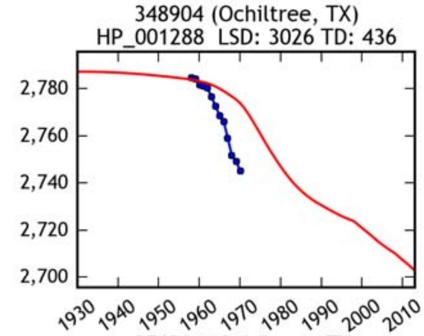

340903 (Ochiltree, TX)
HP_000916 LSD: 2997 TD: 590

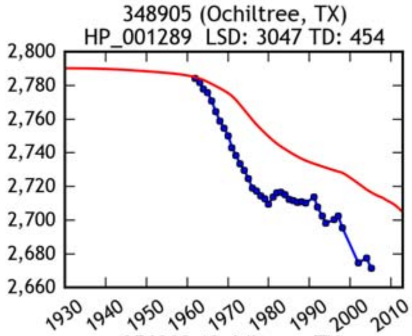

348202 (Ochiltree, TX)
HP_001261 LSD: 3011 TD: 299

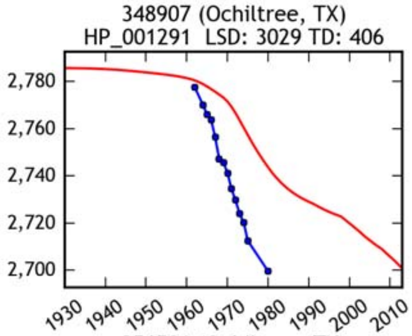

348601 (Ochiltree, TX)
HP_001275 LSD: 3021 TD: 591

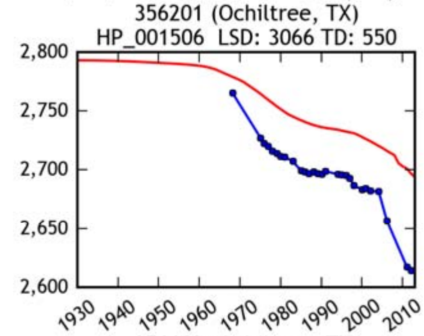

348901 (Ochiltree, TX)
HP_001285 LSD: 3031 TD: 422

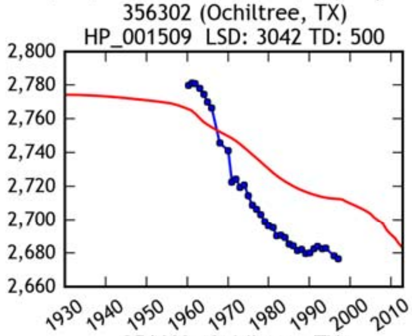

348902 (Ochiltree, TX)
HP_001286 LSD: 3016 TD: 500

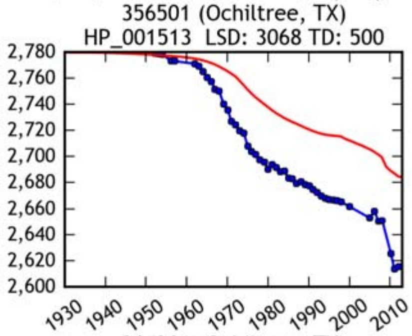

348904 (Ochiltree, TX)
HP_001288 LSD: 3026 TD: 436

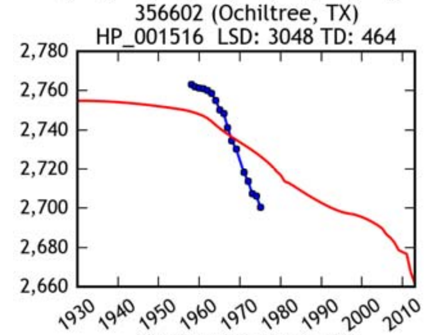

348905 (Ochiltree, TX)
HP_001289 LSD: 3047 TD: 454

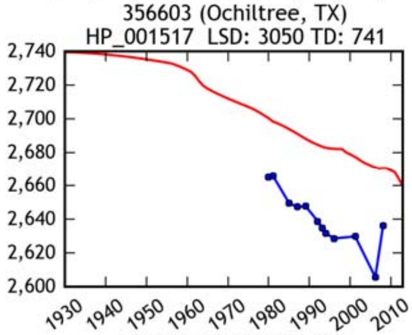

348907 (Ochiltree, TX)
HP_001291 LSD: 3029 TD: 406

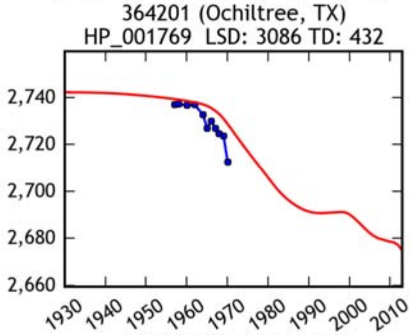

356201 (Ochiltree, TX)
HP_001506 LSD: 3066 TD: 550

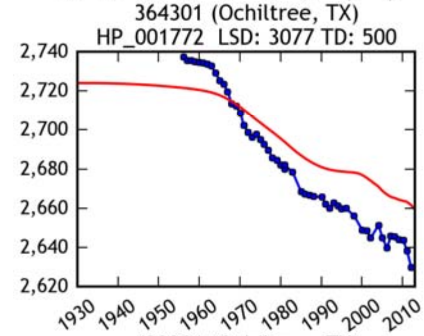

356302 (Ochiltree, TX)
HP_001509 LSD: 3042 TD: 500

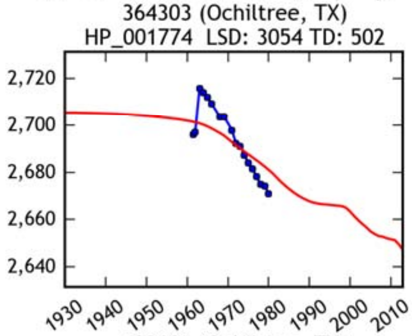

356501 (Ochiltree, TX)
HP_001513 LSD: 3068 TD: 500

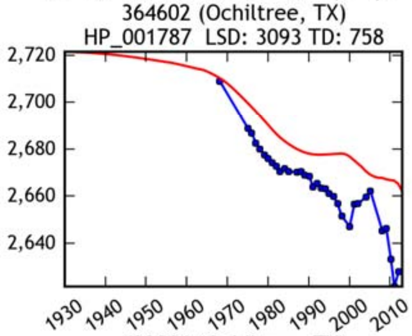

356602 (Ochiltree, TX)
HP_001516 LSD: 3048 TD: 464

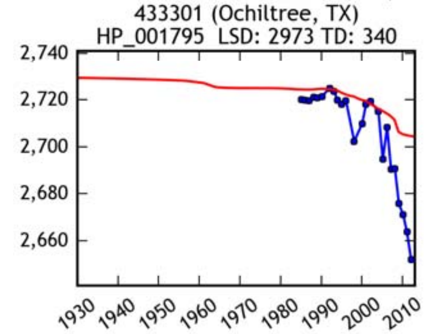

356603 (Ochiltree, TX)
HP_001517 LSD: 3050 TD: 741

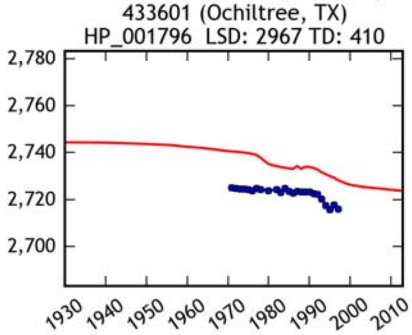

364201 (Ochiltree, TX)
HP_001769 LSD: 3086 TD: 432

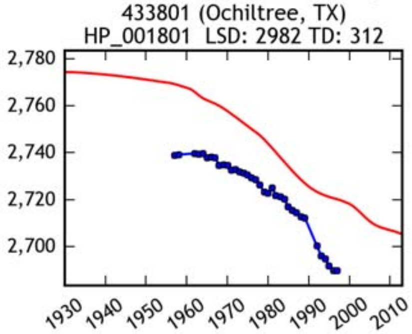

364301 (Ochiltree, TX)
HP_001772 LSD: 3077 TD: 500

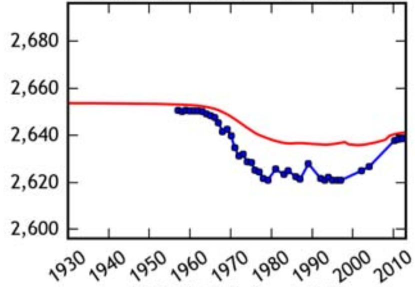

364303 (Ochiltree, TX)
HP_001774 LSD: 3054 TD: 502

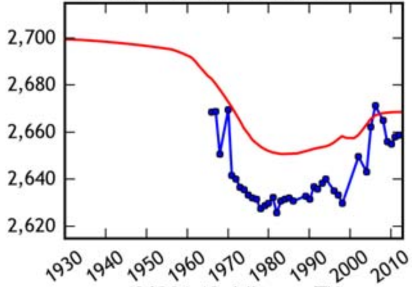

364602 (Ochiltree, TX)
HP_001787 LSD: 3093 TD: 758

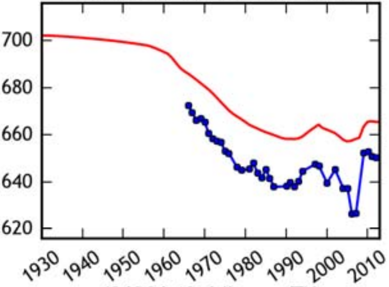

433301 (Ochiltree, TX)
HP_001795 LSD: 2973 TD: 340

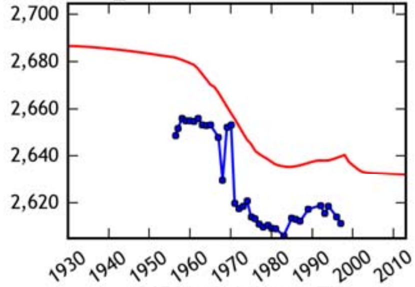

433601 (Ochiltree, TX)
HP_001796 LSD: 2967 TD: 410

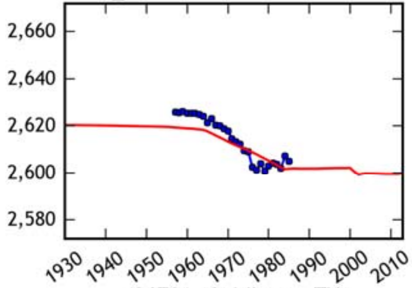

433801 (Ochiltree, TX)
HP_001801 LSD: 2982 TD: 312

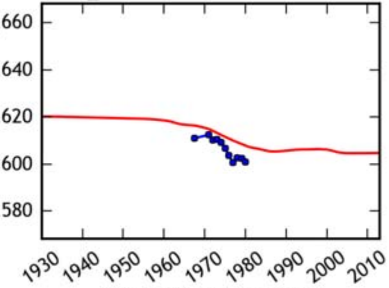

435302 (Ochiltree, TX)
HP_001817 LSD: 2866 TD: 300

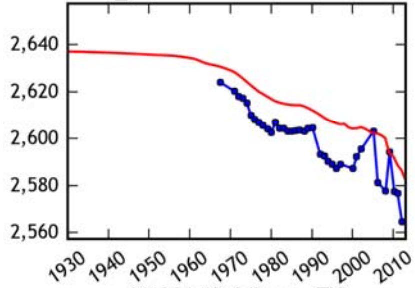

435701 (Ochiltree, TX)
HP_001822 LSD: 2907 TD: 390

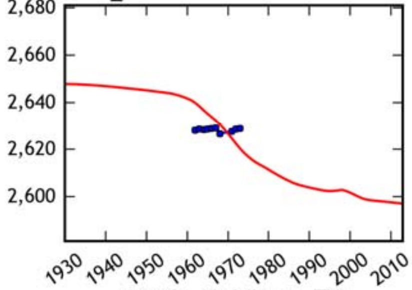

435702 (Ochiltree, TX)
HP_001823 LSD: 2914 TD: 362

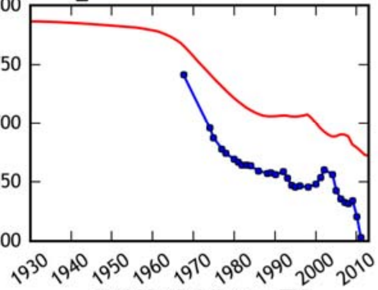

435801 (Ochiltree, TX)
HP_001824 LSD: 2901 TD: 396

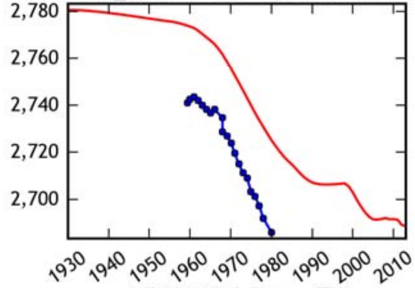

436201 (Ochiltree, TX)
HP_001832 LSD: 2833 TD: 481

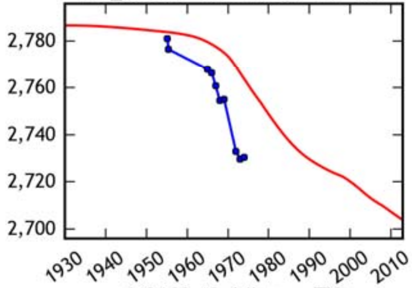

436206 (Ochiltree, TX)
HP_001837 LSD: 2831 TD: 400

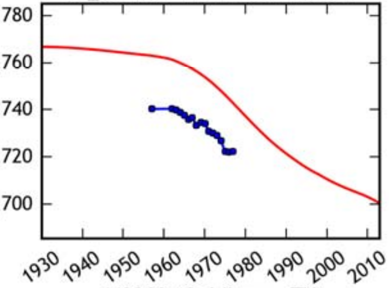

436501 (Ochiltree, TX)
HP_001848 LSD: 2835 TD: 411

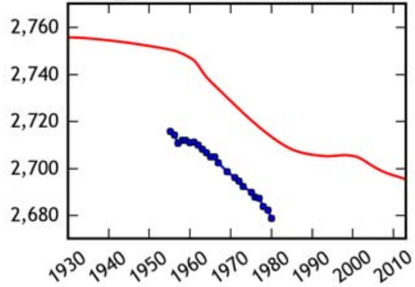

436701 (Ochiltree, TX)
HP_001853 LSD: 2843 TD: 350

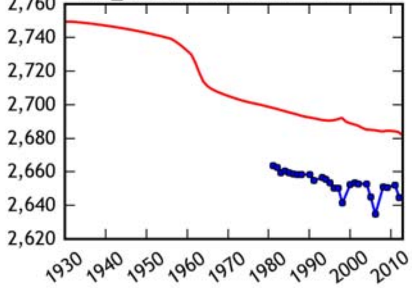

441105 (Ochiltree, TX)
HP_001920 LSD: 3001 TD: 583

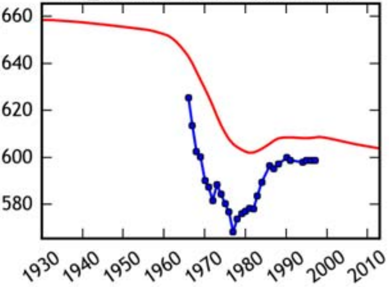

441201 (Ochiltree, TX)
HP_001921 LSD: 2995 TD: 350


441401 (Ochiltree, TX)
HP_001929 LSD: 3006 TD: 407

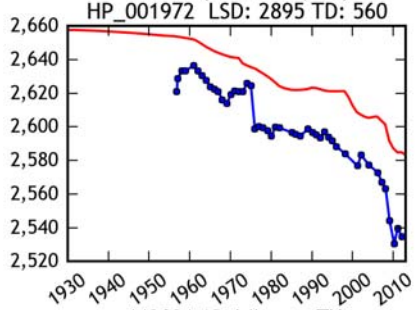

441802 (Ochiltree, TX)
HP_001935 LSD: 2985 TD: 347


442101 (Ochiltree, TX)
HP_001937 LSD: 2961 TD: 310

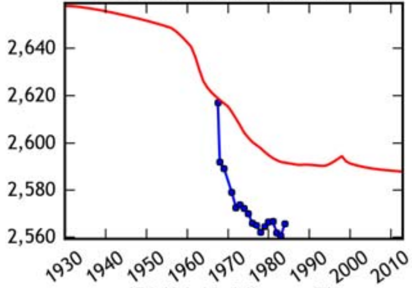

442102 (Ochiltree, TX)
HP_001938 LSD: 2951 TD: 365


443303 (Ochiltree, TX)
HP_001965 LSD: 2856 TD: 537

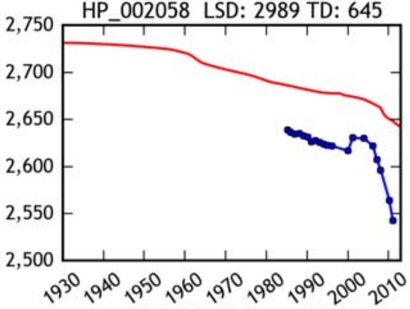
443901 (Ochiltree, TX)
HP_001972 LSD: 2895 TD: 560



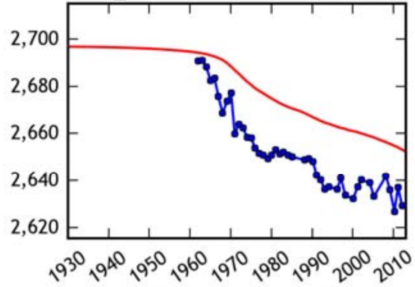
444104 (Ochiltree, TX)
HP_001975 LSD: 2867 TD: 405



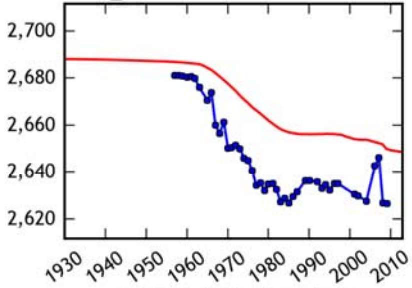
449402 (Ochiltree, TX)
HP_002058 LSD: 2989 TD: 645



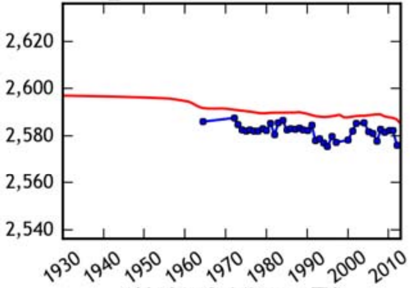
449601 (Ochiltree, TX)
HP_002061 LSD: 3000 TD: 498



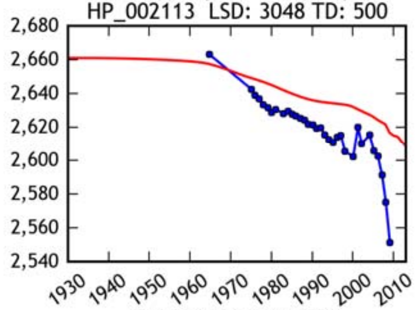
450401 (Ochiltree, TX)
HP_002076 LSD: 2983 TD: 400



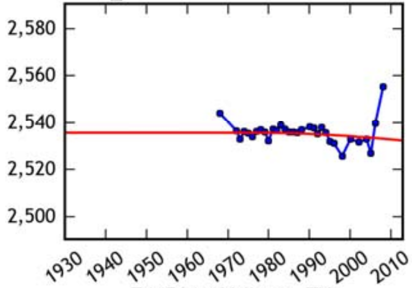
452101 (Ochiltree, TX)
HP_002087 LSD: 2605 TD: 232



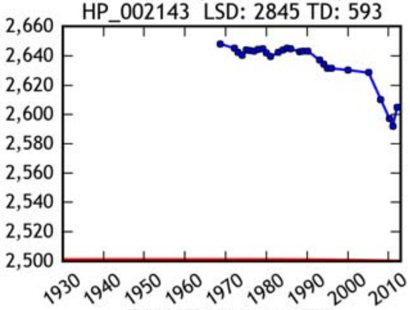
457301 (Ochiltree, TX)
HP_002113 LSD: 3048 TD: 500



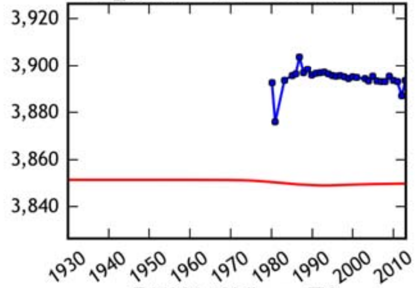
459201 (Ochiltree, TX)
HP_002132 LSD: 2944 TD: 698



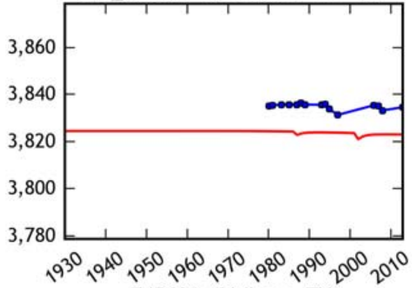
460101 (Ochiltree, TX)
HP_002143 LSD: 2845 TD: 593



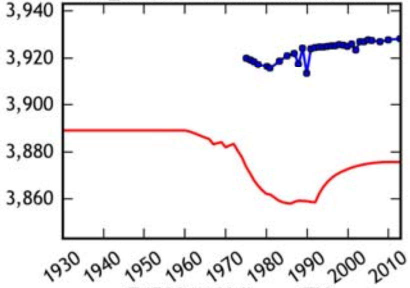
743604 (Oldham, TX)
HP_006888 LSD: 3979 TD: 118



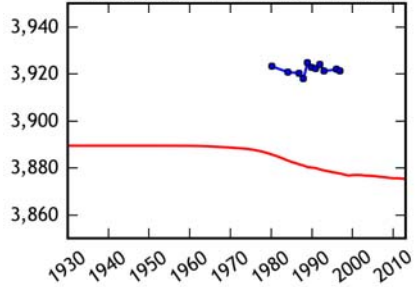
744501 (Oldham, TX)
HP_006891 LSD: 3962 TD: 165



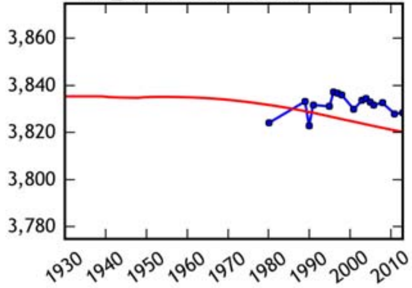
744807 (Oldham, TX)
HP_006899 LSD: 4086 TD: 247



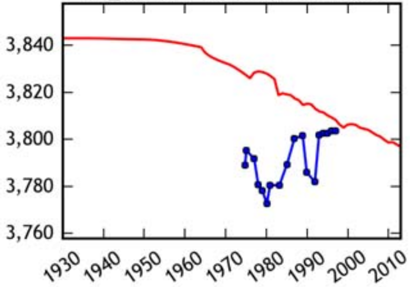
744901 (Oldham, TX)
HP_006909 LSD: 4063 TD: 152



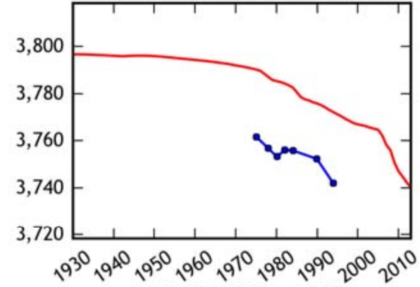
745601 (Oldham, TX)
HP_006912 LSD: 3980 TD: 185



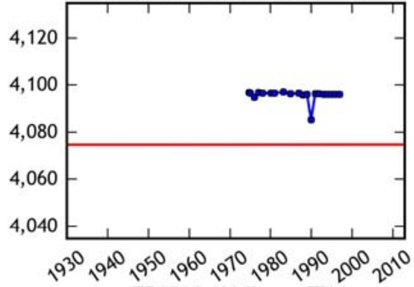
745801 (Oldham, TX)
HP_006914 LSD: 4011 TD: 280



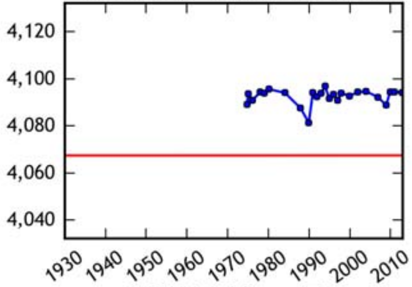
746810 (Oldham, TX)
HP_006955 LSD: 3993 TD: 300



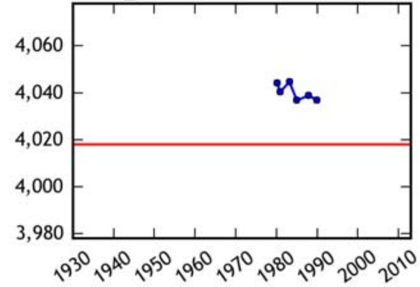
750602 (Oldham, TX)
HP_006986 LSD: 4240 TD: 180



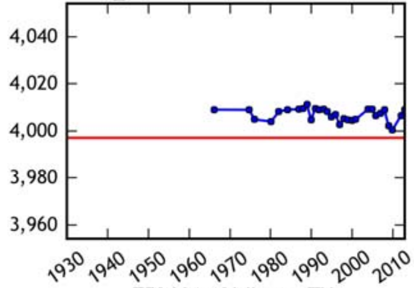
751101 (Oldham, TX)
HP_006990 LSD: 4243 TD: 181



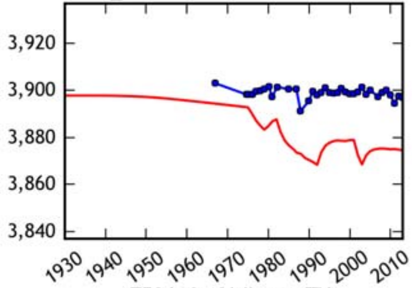
751202 (Oldham, TX)
HP_006992 LSD: 4065 TD: 30



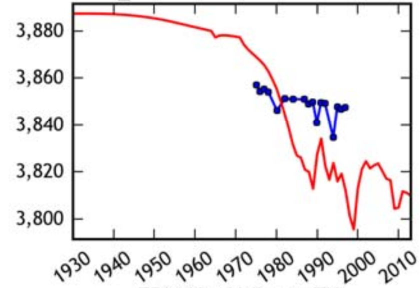
751601 (Oldham, TX)
HP_006995 LSD: 4167 TD: 175



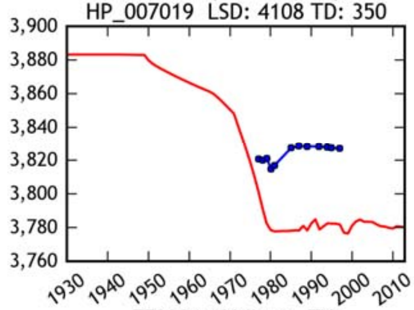
752101 (Oldham, TX)
HP_006999 LSD: 4113 TD: 282



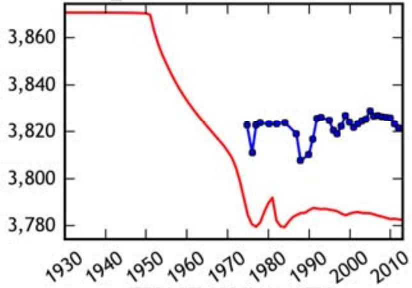
752501 (Oldham, TX)
HP_007017 LSD: 4093 TD: 347



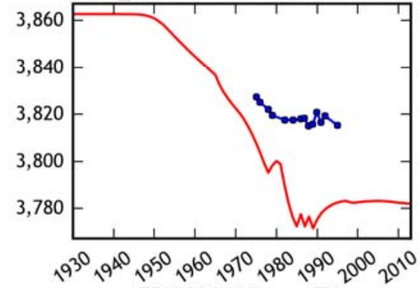
752601 (Oldham, TX)
HP_007019 LSD: 4108 TD: 350



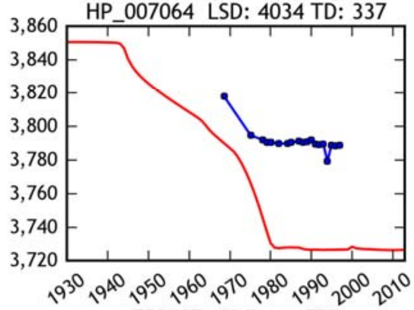
752610 (Oldham, TX)
HP_007028 LSD: 4092 TD: 340



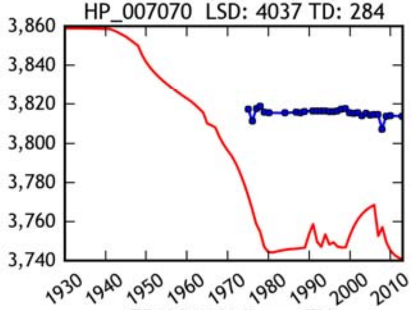
753102 (Oldham, TX)
HP_007039 LSD: 4070 TD: 290



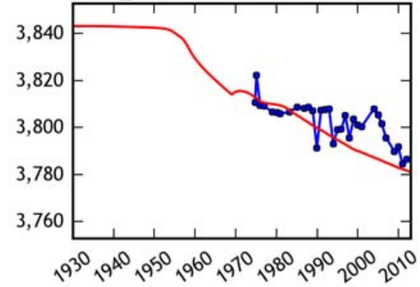
753221 (Oldham, TX)
HP_007064 LSD: 4034 TD: 337



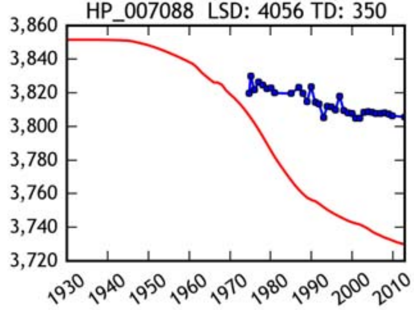
753227 (Oldham, TX)
HP_007070 LSD: 4037 TD: 284



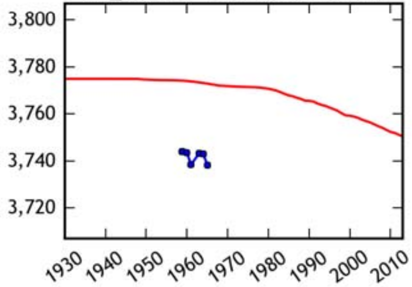
753308 (Oldham, TX)
HP_007079 LSD: 4007 TD: 258

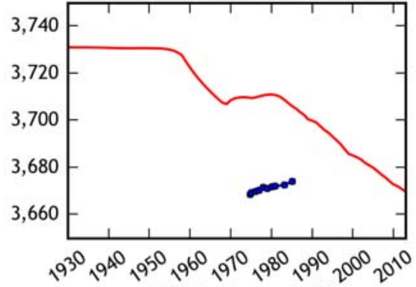


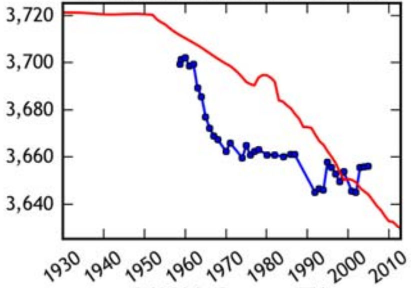
753407 (Oldham, TX)
HP_007088 LSD: 4056 TD: 350

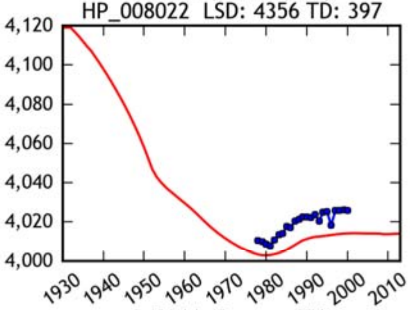


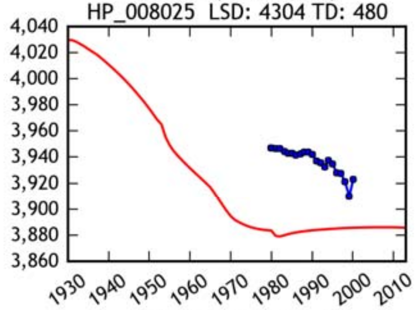
754301 (Oldham, TX)
HP_007196 LSD: 3944 TD: unk

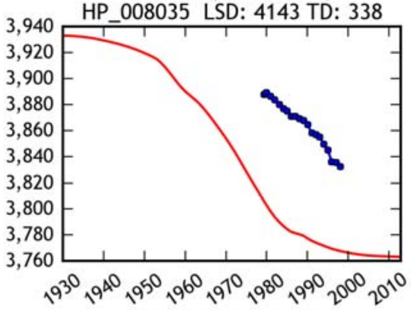


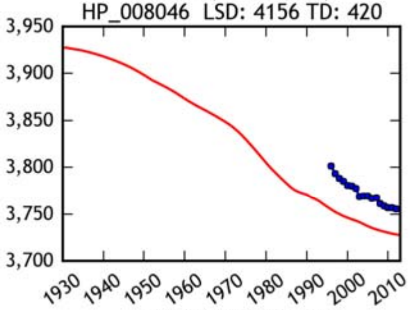

755106 (Oldham, TX)
HP_007236 LSD: 3935 TD: 300

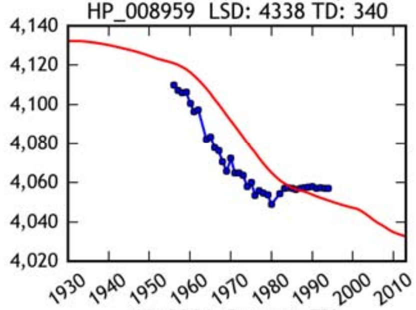

755501 (Oldham, TX)
HP_007266 LSD: 3901 TD: 298

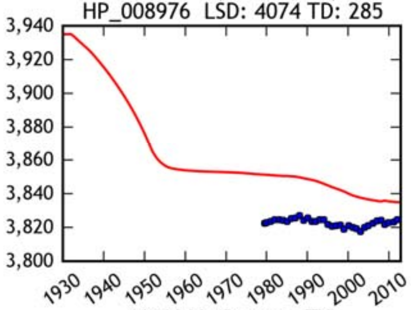

932303 (Parmer, TX)
HP_008022 LSD: 4356 TD: 397

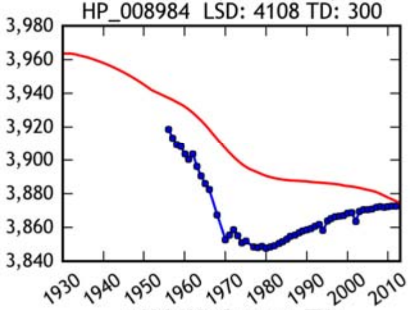

932501 (Parmer, TX)
HP_008025 LSD: 4304 TD: 480

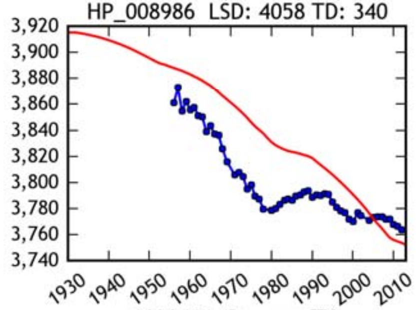

940801 (Parmer, TX)
HP_008035 LSD: 4143 TD: 338

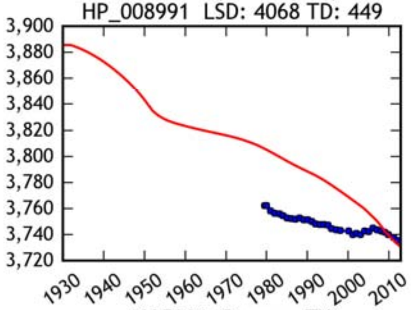

940911 (Parmer, TX)
HP_008046 LSD: 4156 TD: 420

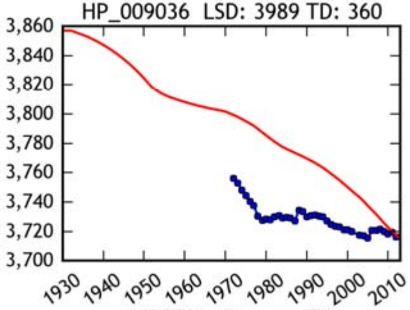

1017401 (Parmer, TX)
HP_008959 LSD: 4338 TD: 340

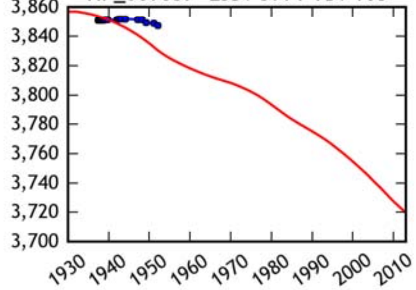

1018302 (Parmer, TX)
HP_008976 LSD: 4074 TD: 285

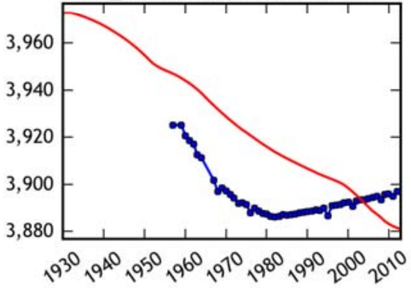

1018701 (Parmer, TX)
HP_008984 LSD: 4108 TD: 300

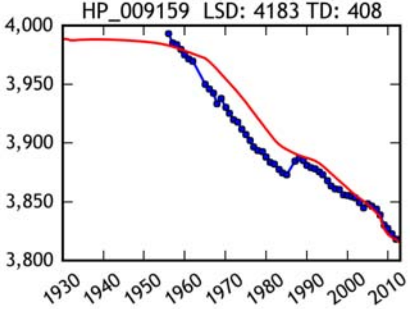

1018901 (Parmer, TX)
HP_008986 LSD: 4058 TD: 340

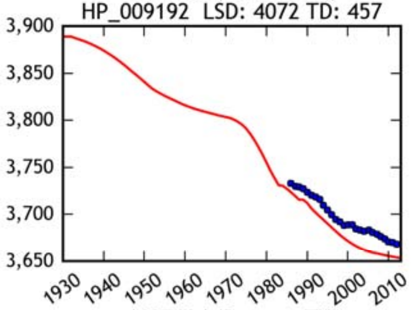

1019202 (Parmer, TX)
HP_008991 LSD: 4068 TD: 449

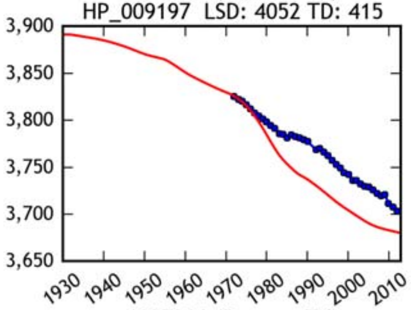

1020402 (Parmer, TX)
HP_009036 LSD: 3989 TD: 360

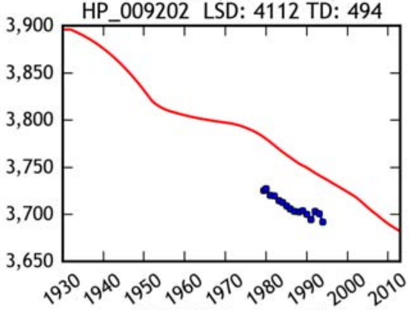

1020411 (Parmer, TX)
HP_009037 LSD: 3991 TD: 165

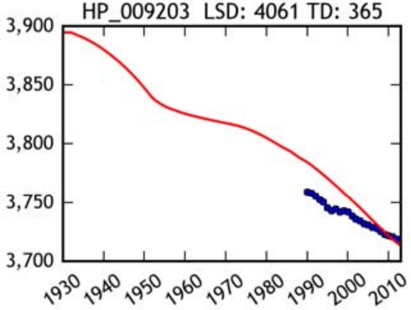

1025301 (Parmer, TX)
HP_009150 LSD: 4193 TD: 361

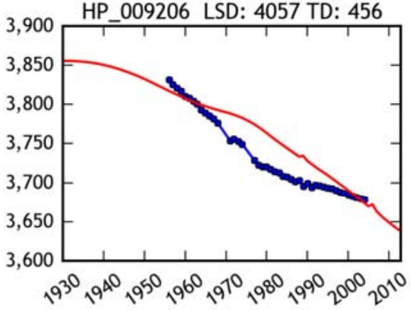

1025701 (Parmer, TX)
HP_009159 LSD: 4183 TD: 408

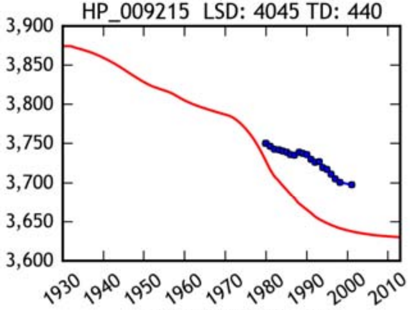

1026603 (Parmer, TX)
HP_009192 LSD: 4072 TD: 457

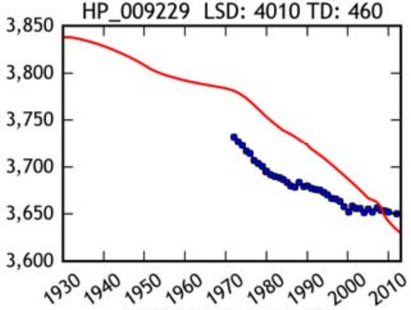

1026802 (Parmer, TX)
HP_009197 LSD: 4052 TD: 415

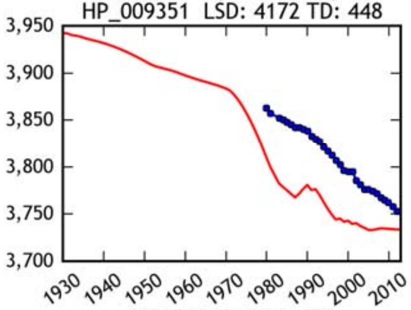

1027103 (Parmer, TX)
HP_009202 LSD: 4112 TD: 494

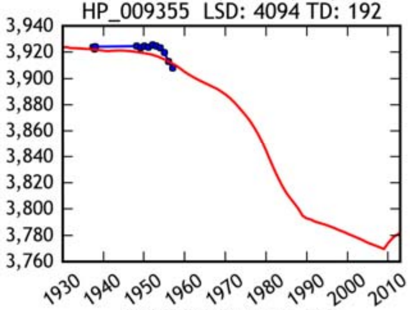

1027104 (Parmer, TX)
HP_009203 LSD: 4061 TD: 365

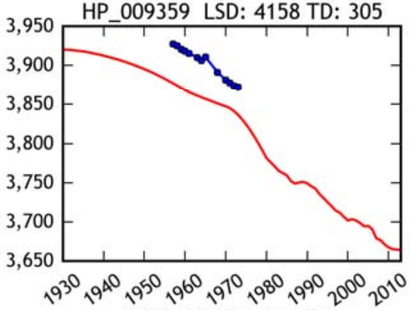

1027301 (Parmer, TX)
HP_009206 LSD: 4057 TD: 456

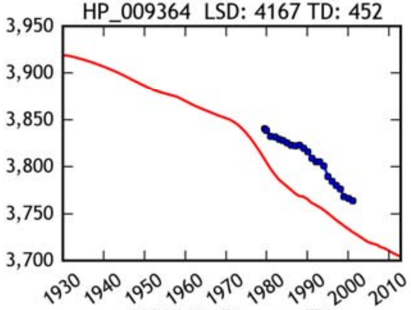

1027702 (Parmer, TX)
HP_009215 LSD: 4045 TD: 440

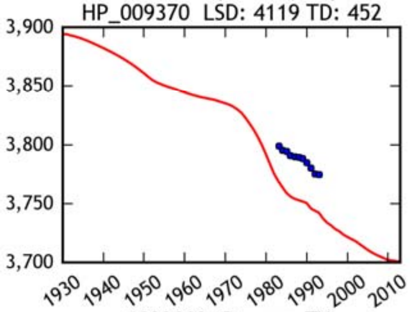

1028202 (Parmer, TX)
HP_009229 LSD: 4010 TD: 460

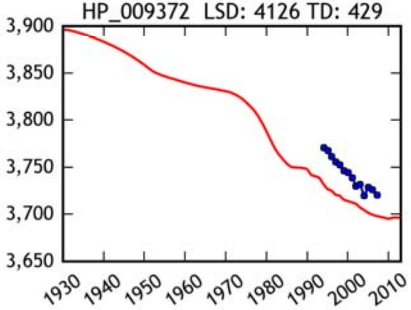

1033103 (Parmer, TX)
HP_009351 LSD: 4172 TD: 448

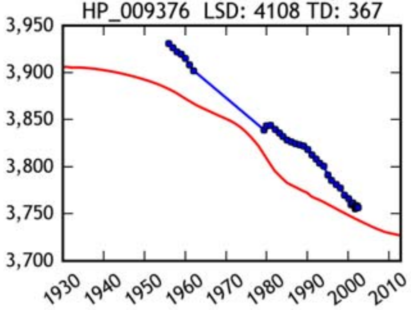

1033308 (Parmer, TX)
HP_009355 LSD: 4094 TD: 192

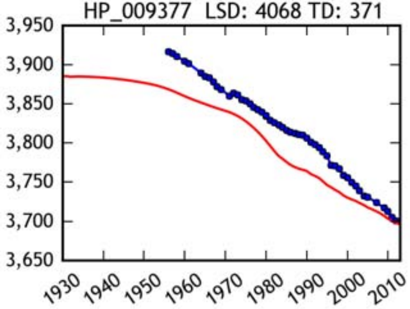

1033401 (Parmer, TX)
HP_009359 LSD: 4158 TD: 305

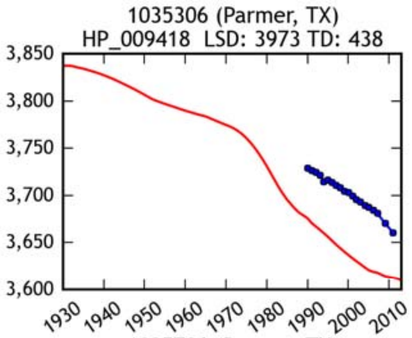

1033502 (Parmer, TX)
HP_009364 LSD: 4167 TD: 452

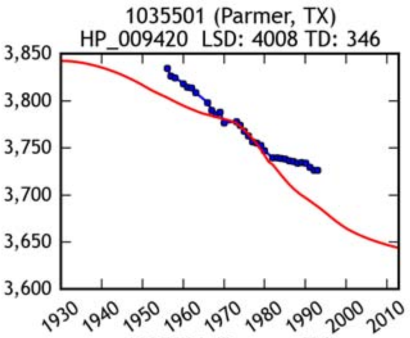

1033603 (Parmer, TX)
HP_009370 LSD: 4119 TD: 452

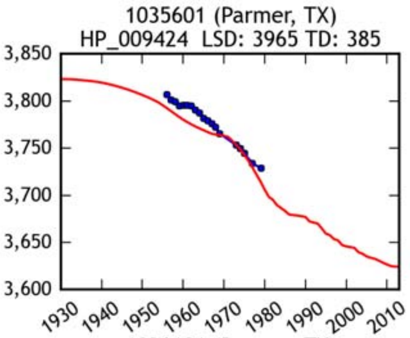

1033605 (Parmer, TX)
HP_009372 LSD: 4126 TD: 429

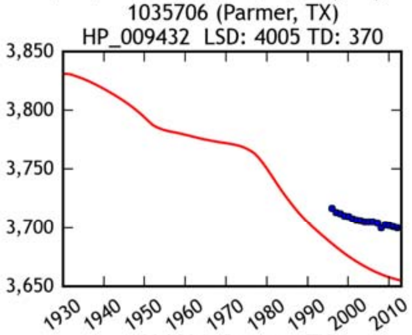

1033801 (Parmer, TX)
HP_009376 LSD: 4108 TD: 367

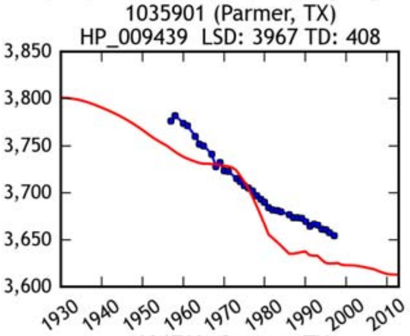

1033802 (Parmer, TX)
HP_009377 LSD: 4068 TD: 371

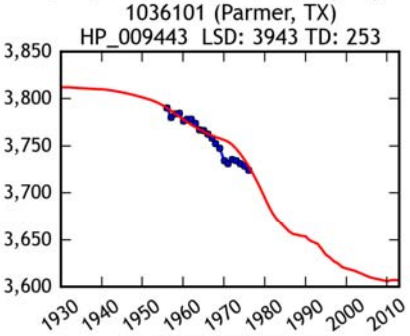

1035306 (Parmer, TX)
HP_009418 LSD: 3973 TD: 438
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

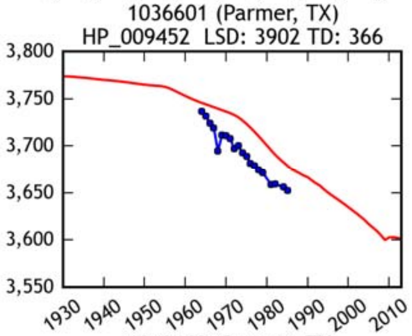

1035501 (Parmer, TX)
HP_009420 LSD: 4008 TD: 346
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

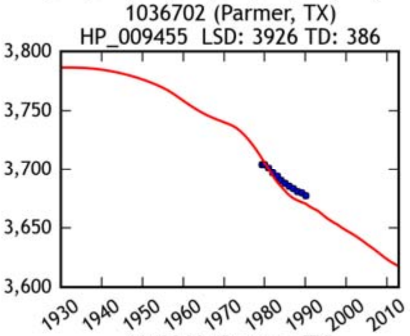

1035601 (Parmer, TX)
HP_009424 LSD: 3965 TD: 385
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

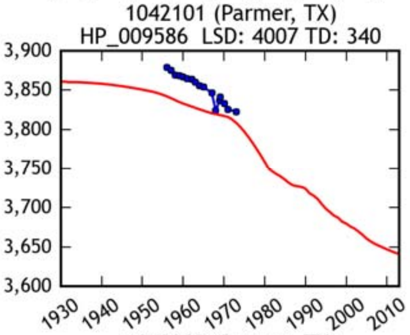

1035706 (Parmer, TX)
HP_009432 LSD: 4005 TD: 370
3,850
3,800
3,750
3,700
3,650
1930
1940
1950
1960
1970
1980
1990
2000
2010

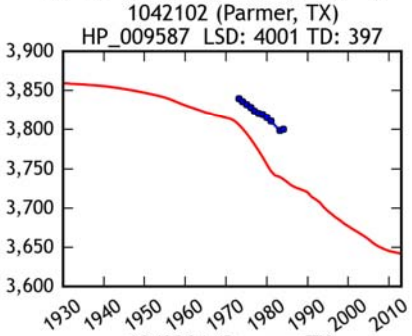

1035901 (Parmer, TX)
HP_009439 LSD: 3967 TD: 408
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

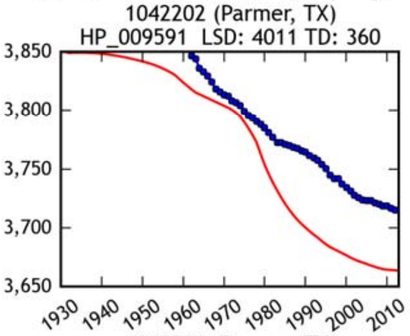

1036101 (Parmer, TX)
HP_009443 LSD: 3943 TD: 253
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

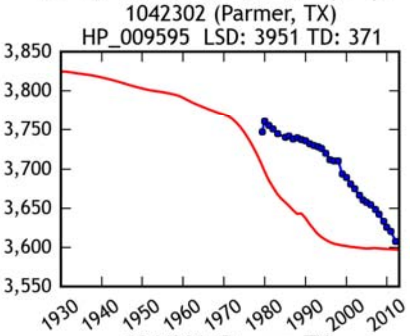

1036601 (Parmer, TX)
HP_009452 LSD: 3902 TD: 366
3,800
3,750
3,700
3,650
3,600
3,550
1930
1940
1950
1960
1970
1980
1990
2000
2010

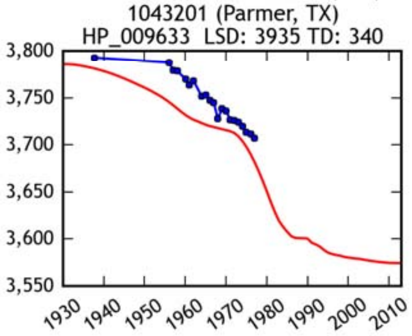

1036702 (Parmer, TX)
HP_009455 LSD: 3926 TD: 386
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

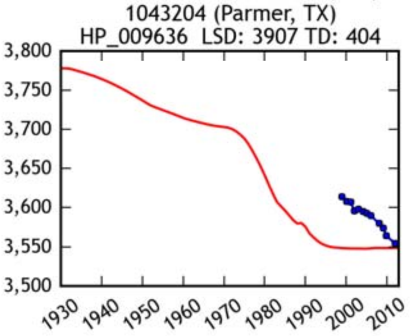

1042101 (Parmer, TX)
HP_009586 LSD: 4007 TD: 340
3,900
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

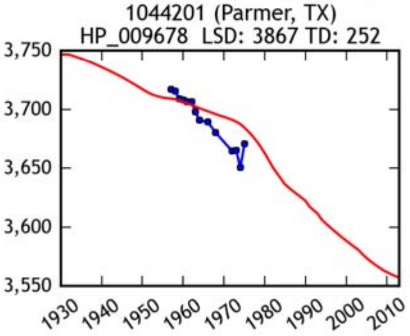

1042102 (Parmer, TX)
HP_009587 LSD: 4001 TD: 397
3,900
3,850
3,800
3,750
3,700
3,650
3,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

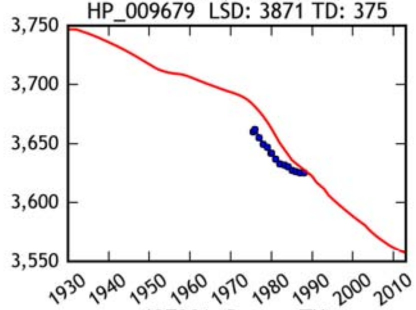

1042202 (Parmer, TX)
HP_009591 LSD: 4011 TD: 360
3,850
3,800
3,750
3,700
3,650
1930
1940
1950
1960
1970
1980
1990
2000
2010

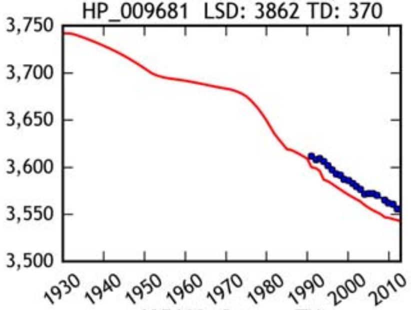

1042302 (Parmer, TX)
HP_009595 LSD: 3951 TD: 371
3,850
3,800
3,750
3,700
3,650
3,600
3,550
1930
1940
1950
1960
1970
1980
1990
2000
2010

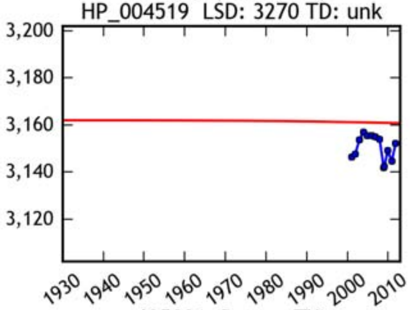

1043201 (Parmer, TX)
HP_009633 LSD: 3935 TD: 340
3,800
3,750
3,700
3,650
3,600
3,550
1930
1940
1950
1960
1970
1980
1990
2000
2010

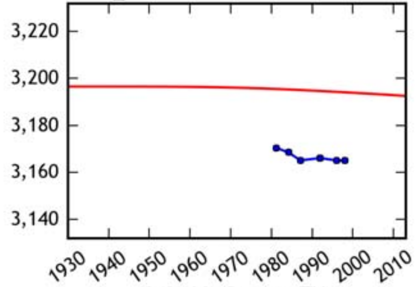

1043204 (Parmer, TX)
HP_009636 LSD: 3907 TD: 404
3,800
3,750
3,700
3,650
3,600
3,550
3,500
1930
1940
1950
1960
1970
1980
1990
2000
2010

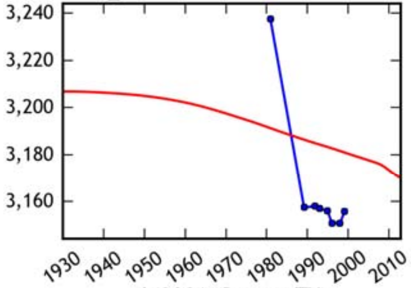

1044201 (Parmer, TX)
HP_009678 LSD: 3867 TD: 252
3,750
3,700
3,650
3,600
3,550
1930
1940
1950
1960
1970
1980
1990
2000
2010

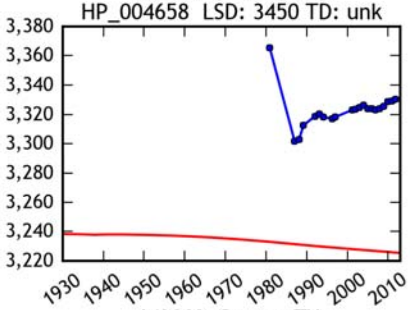

1044202 (Parmer, TX)
HP_009679 LSD: 3871 TD: 375

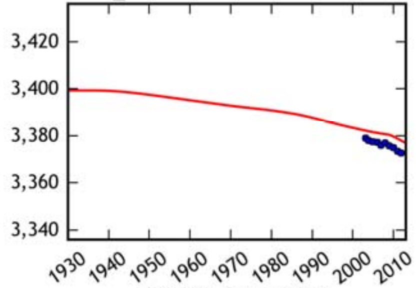

1044204 (Parmer, TX)
HP_009681 LSD: 3862 TD: 370

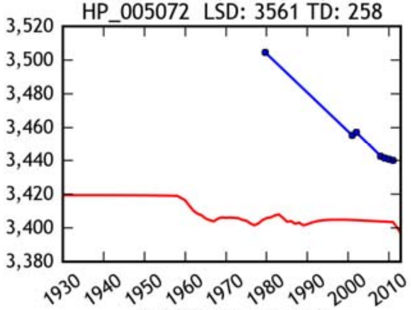

627605 (Potter, TX)
HP_004519 LSD: 3270 TD: unk

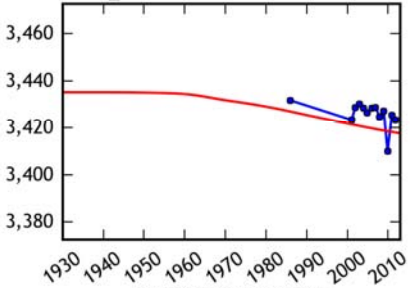

627901 (Potter, TX)
HP_004523 LSD: 3407 TD: unk

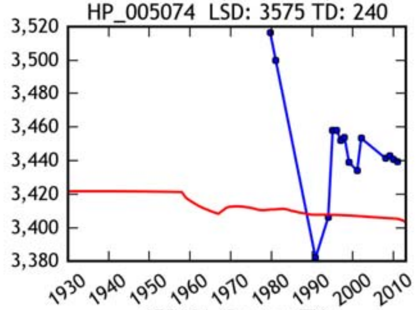

635603 (Potter, TX)
HP_004648 LSD: 3437 TD: unk

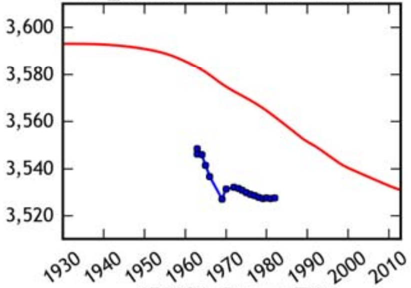

635801 (Potter, TX)
HP_004658 LSD: 3450 TD: unk

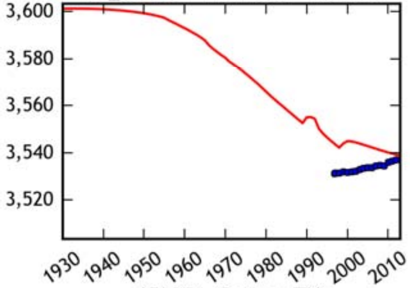

642409 (Potter, TX)
HP_005062 LSD: 3443 TD: unk

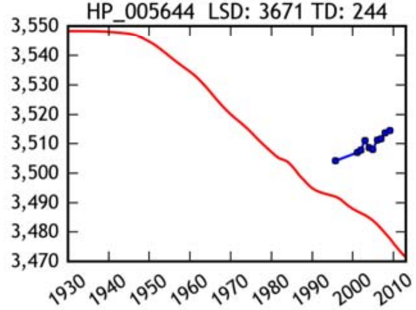

642901 (Potter, TX)
HP_005072 LSD: 3561 TD: 258

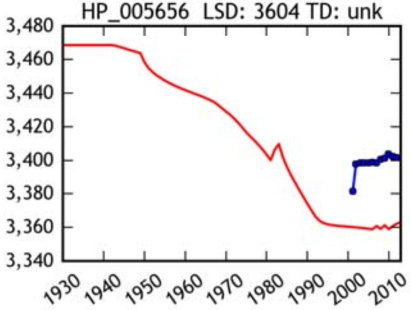

642902 (Potter, TX)
HP_005073 LSD: 3653 TD: 279

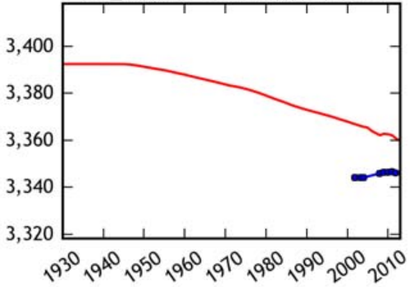

642903 (Potter, TX)
HP_005074 LSD: 3575 TD: 240

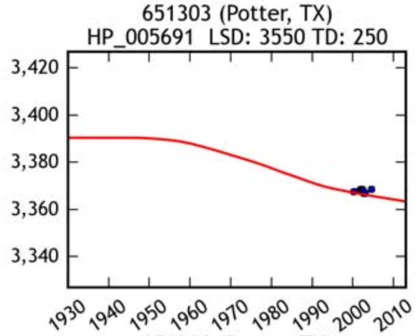

649501 (Potter, TX)
HP_005560 LSD: 3726 TD: unk

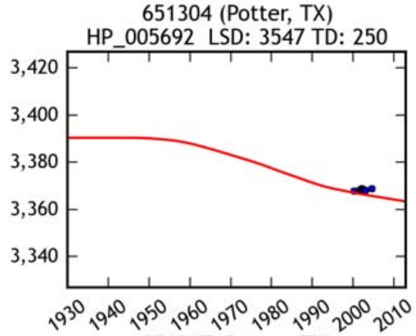

649503 (Potter, TX)
HP_005562 LSD: 3737 TD: 256

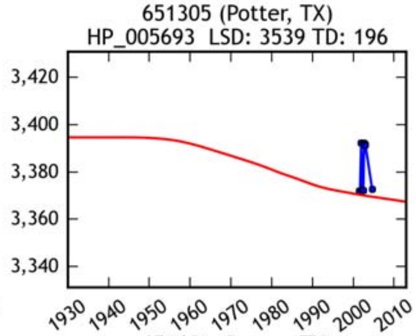

650401 (Potter, TX)
HP_005644 LSD: 3671 TD: 244

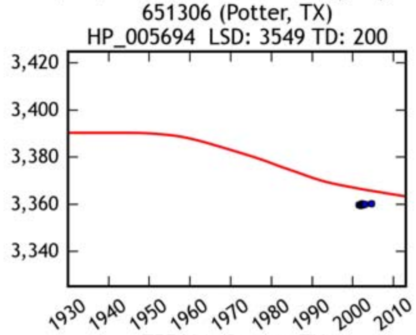

650604 (Potter, TX)
HP_005656 LSD: 3604 TD: unk

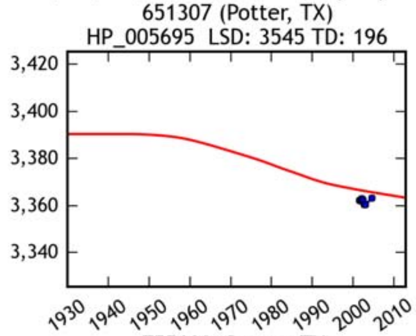

651301 (Potter, TX)
HP_005689 LSD: 3558 TD: 311

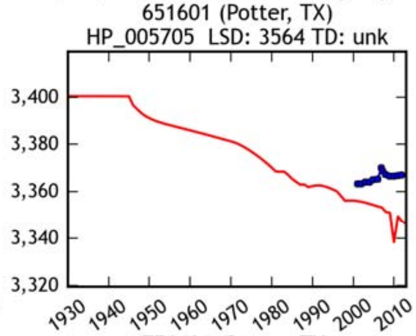

651303 (Potter, TX)
HP_005691 LSD: 3550 TD: 250

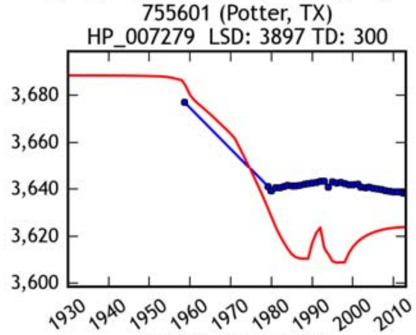

651304 (Potter, TX)
HP_005692 LSD: 3547 TD: 250

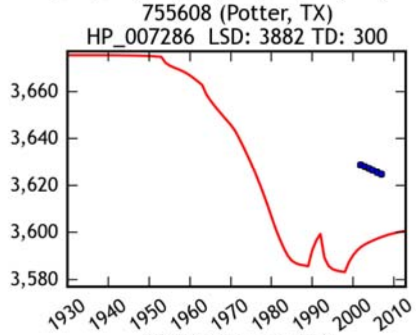

651305 (Potter, TX)
HP_005693 LSD: 3539 TD: 196

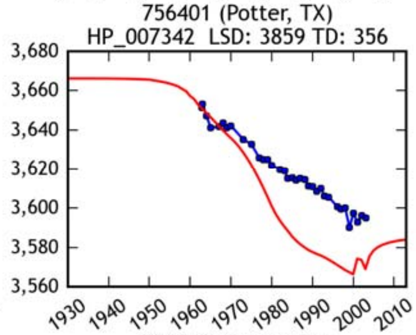

651306 (Potter, TX)
HP_005694 LSD: 3549 TD: 200

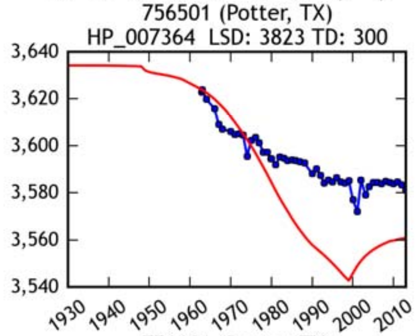

651307 (Potter, TX)
HP_005695 LSD: 3545 TD: 196

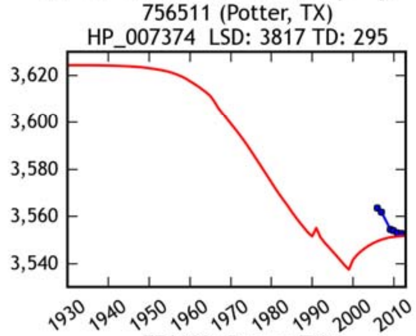

651601 (Potter, TX)
HP_005705 LSD: 3564 TD: unk

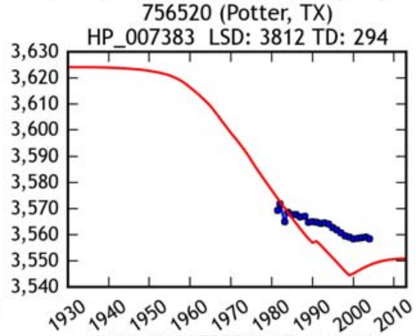

755601 (Potter, TX)
HP_007279 LSD: 3897 TD: 300

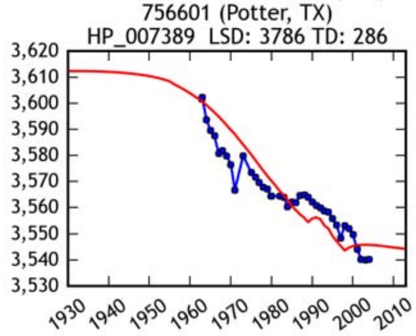

755608 (Potter, TX)
HP_007286 LSD: 3882 TD: 300

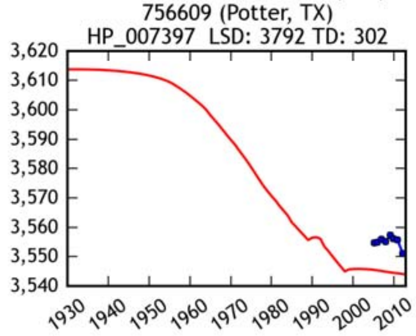

756401 (Potter, TX)
HP_007342 LSD: 3859 TD: 356

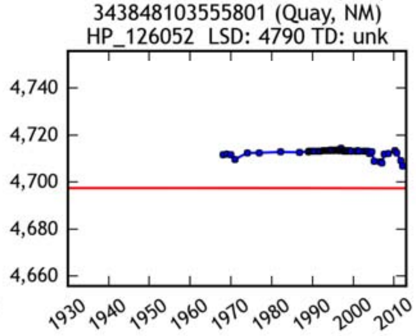

756501 (Potter, TX)
HP_007364 LSD: 3823 TD: 300


756511 (Potter, TX)
HP_007374 LSD: 3817 TD: 295

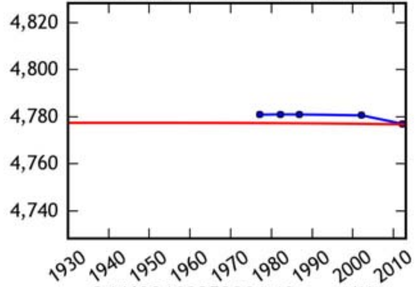

756520 (Potter, TX)
HP_007383 LSD: 3812 TD: 294


756601 (Potter, TX)
HP_007389 LSD: 3786 TD: 286

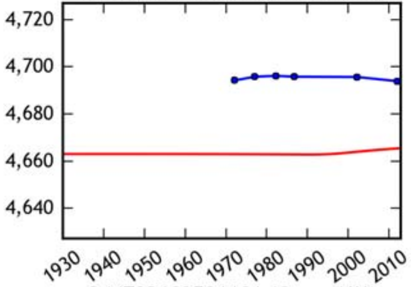

756609 (Potter, TX)
HP_007397 LSD: 3792 TD: 302


343848103555801 (Quay, NM)
HP_126052 LSD: 4790 TD: unk

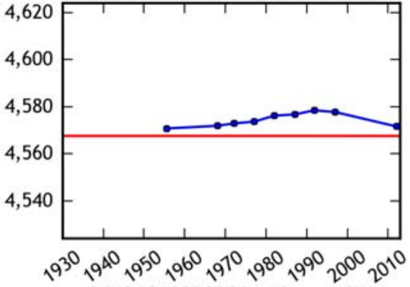
344037103581301 (Quay, NM)
HP_126101 LSD: 4863 TD: unk



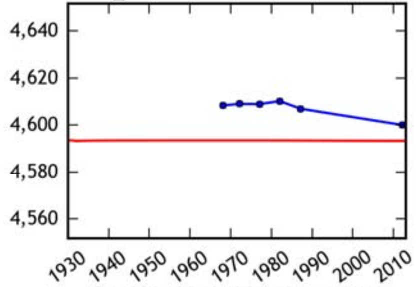
344203103513301 (Quay, NM)
HP_126124 LSD: 4736 TD: unk



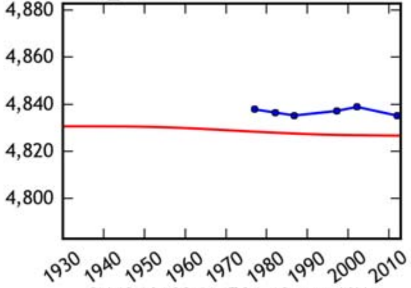
344505103354701 (Quay, NM)
HP_126189 LSD: 4674 TD: unk



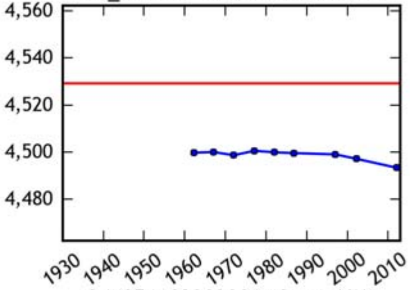
344633103353301 (Quay, NM)
HP_126210 LSD: 4690 TD: unk



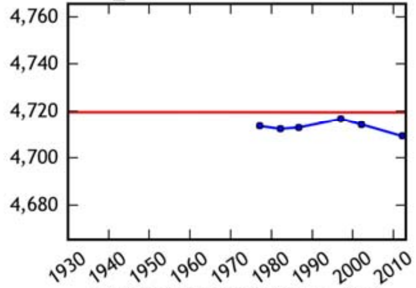
344733103581101 (Quay, NM)
HP_126224 LSD: 4936 TD: unk



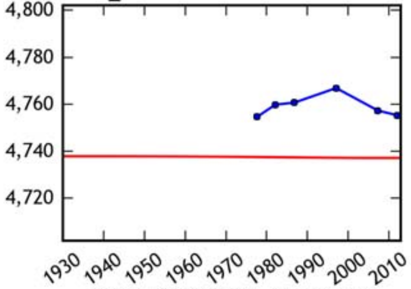
344816103292001 (Quay, NM)
HP_126239 LSD: 4685 TD: unk



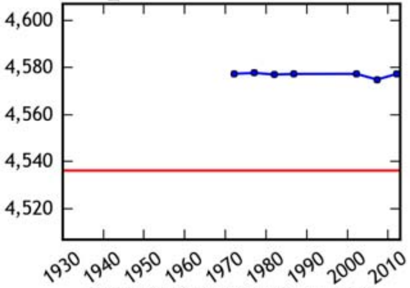
344822103404901 (Quay, NM)
HP_126241 LSD: 4853 TD: unk



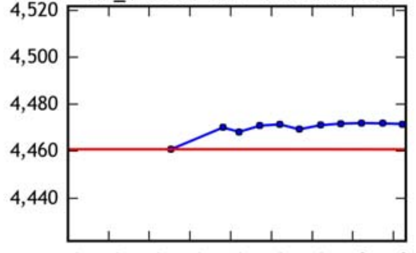
344946103414501 (Quay, NM)
HP_126257 LSD: 4892 TD: 186



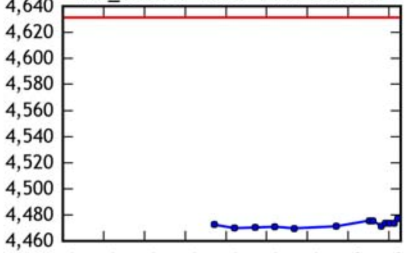
344951103282901 (Quay, NM)
HP_126259 LSD: 4682 TD: unk



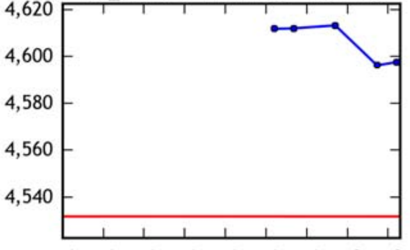
344952103232501 (Quay, NM)
HP_126260 LSD: 4618 TD: 249



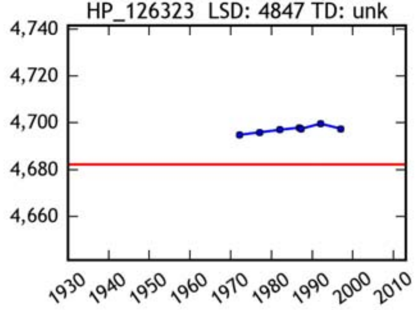
345044103205201 (Quay, NM)
HP_126269 LSD: 4836 TD: unk



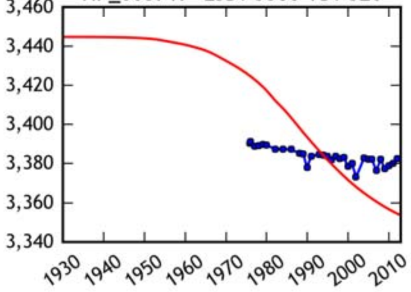
345120103294101 (Quay, NM)
HP_126279 LSD: 4737 TD: 180



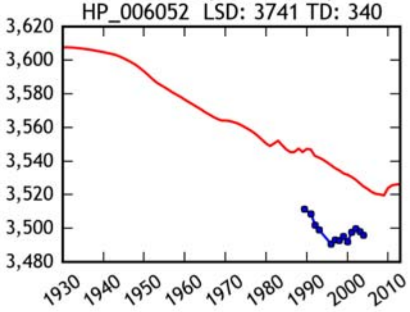
345556103241501 (Quay, NM)
HP_126323 LSD: 4847 TD: unk

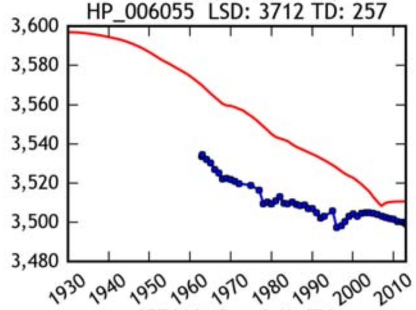


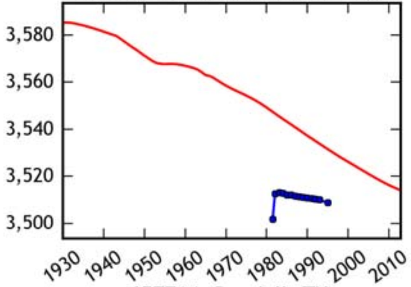
651710 (Randall, TX)
HP_005717 LSD: 3586 TD: 326

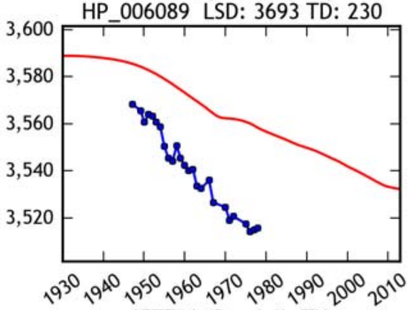


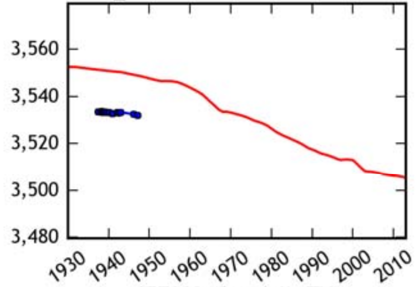
657123 (Randall, TX)
HP_006052 LSD: 3741 TD: 340

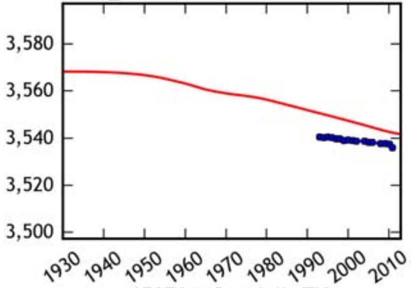


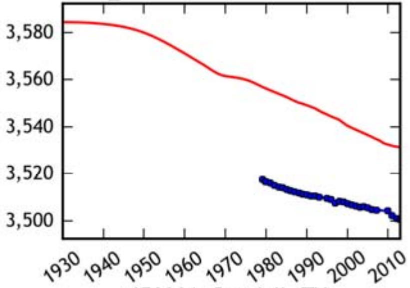

657202 (Randall, TX)
HP_006055 LSD: 3712 TD: 257

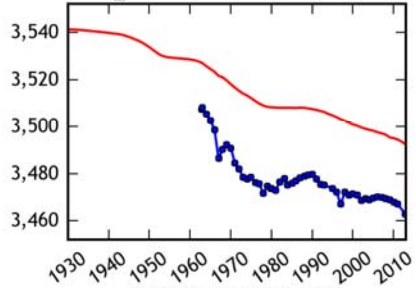

657315 (Randall, TX)
HP_006086 LSD: 3667 TD: 175

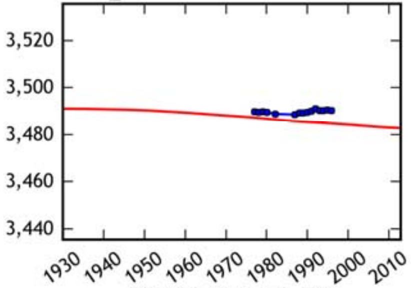

657401 (Randall, TX)
HP_006089 LSD: 3693 TD: 230

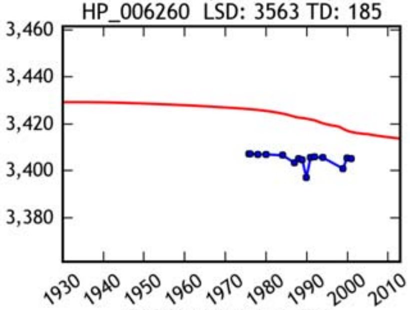

657602 (Randall, TX)
HP_006146 LSD: 3640 TD: 115

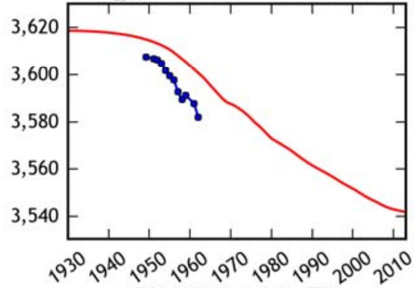

657714 (Randall, TX)
HP_006171 LSD: 3660 TD: 156

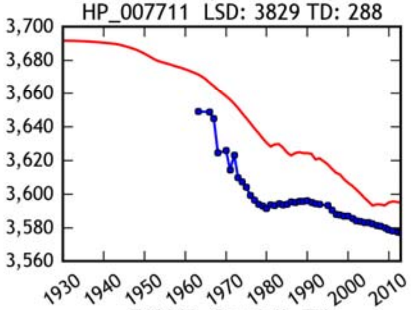

657716 (Randall, TX)
HP_006172 LSD: 3684 TD: 202

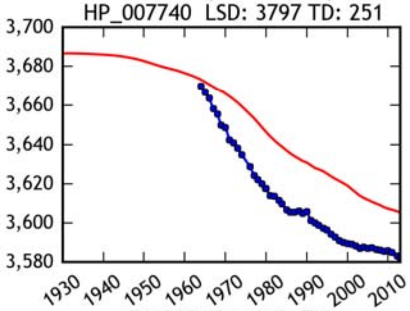

657802 (Randall, TX)
HP_006175 LSD: 3636 TD: 230

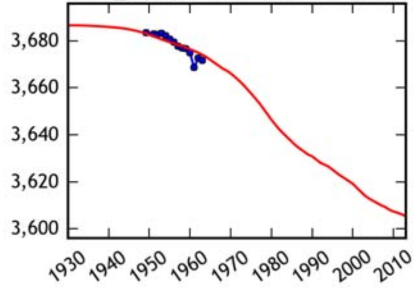

658701 (Randall, TX)
HP_006256 LSD: 3617 TD: 162

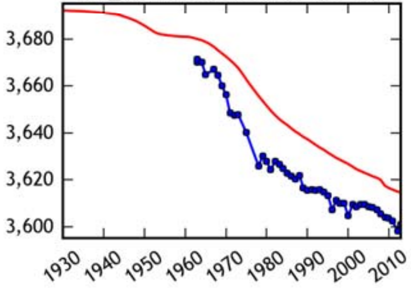

658901 (Randall, TX)
HP_006260 LSD: 3563 TD: 185

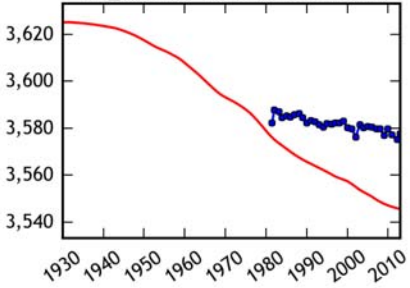

756901 (Randall, TX)
HP_007463 LSD: 3767 TD: 293

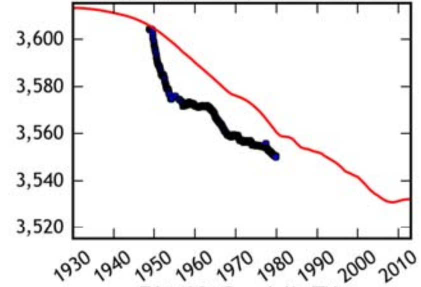

763301 (Randall, TX)
HP_007711 LSD: 3829 TD: 288

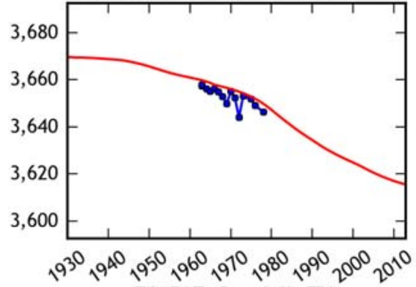

763601 (Randall, TX)
HP_007740 LSD: 3797 TD: 251

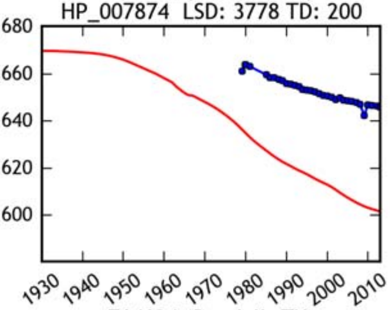

763628 (Randall, TX)
HP_007767 LSD: 3797 TD: 240

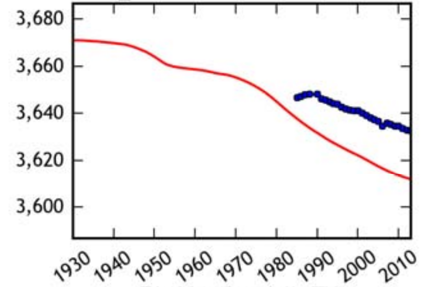

763902 (Randall, TX)
HP_007770 LSD: 3787 TD: 190

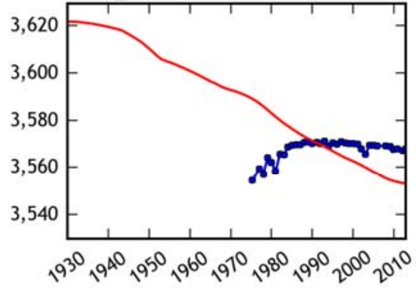

764202 (Randall, TX)
HP_007835 LSD: 3773 TD: 225

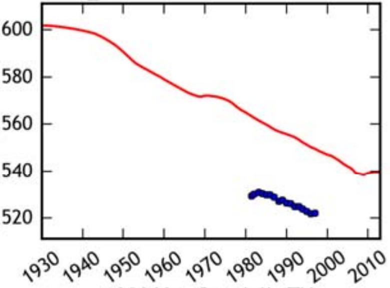

764302 (Randall, TX)
HP_007844 LSD: 3703 TD: 162

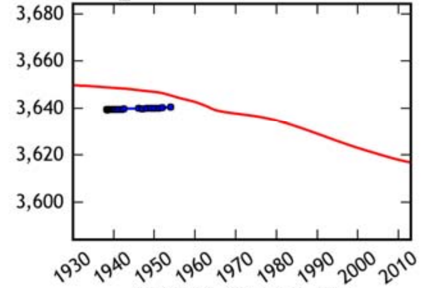

764402 (Randall, TX)
HP_007866 LSD: 3758 TD: 152

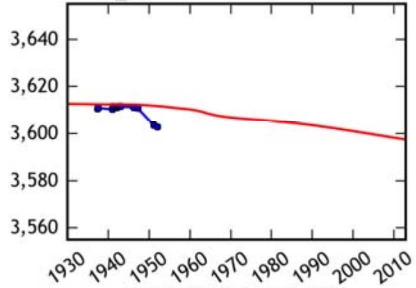

764411 (Randall, TX)
HP_007874 LSD: 3778 TD: 200

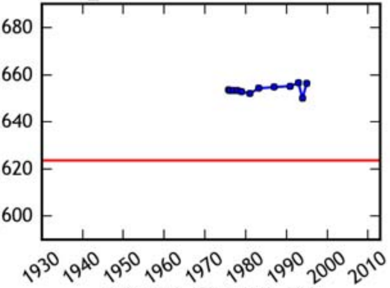

764422 (Randall, TX)
HP_007885 LSD: 3756 TD: 183

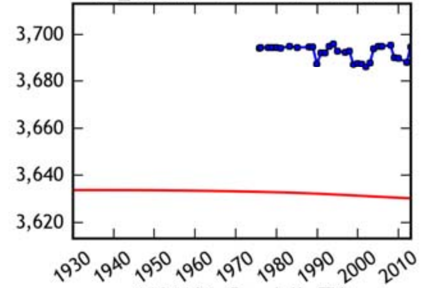

764507 (Randall, TX)
HP_007892 LSD: 3731 TD: 201

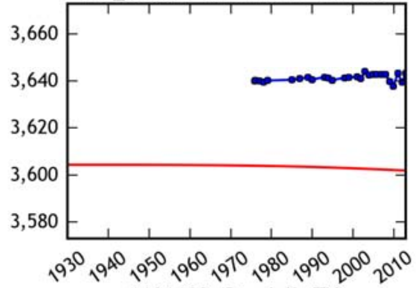

764624 (Randall, TX)
HP_007916 LSD: 3703 TD: 293

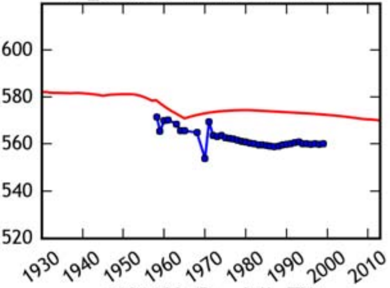

764801 (Randall, TX)
HP_007938 LSD: 3751 TD: 122

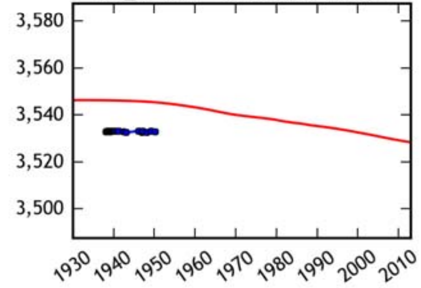

1008501 (Randall, TX)
HP_008602 LSD: 3710 TD: 121

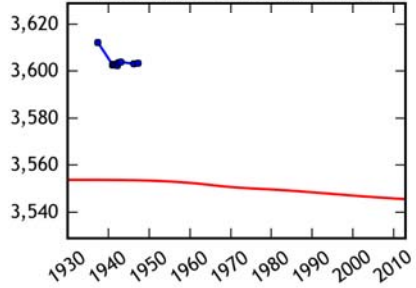

1008601 (Randall, TX)
HP_008605 LSD: 3738 TD: 106

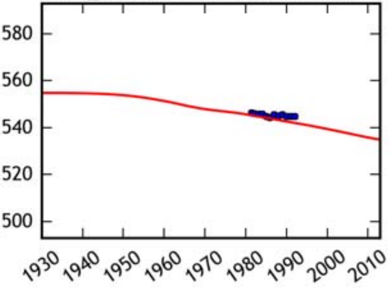

1016201 (Randall, TX)
HP_008933 LSD: 3861 TD: 194

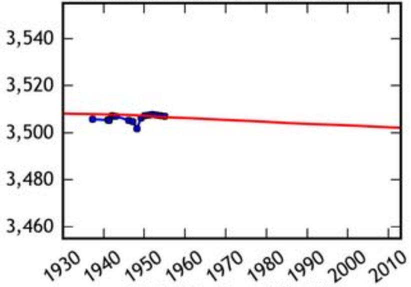

1016301 (Randall, TX)
HP_008935 LSD: 3813 TD: 200

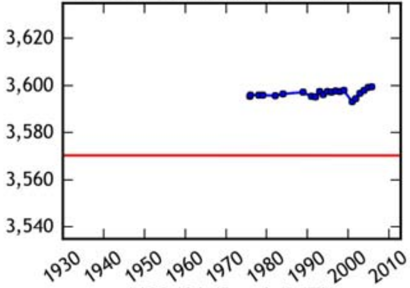

1016901 (Randall, TX)
HP_008950 LSD: 3745 TD: 203

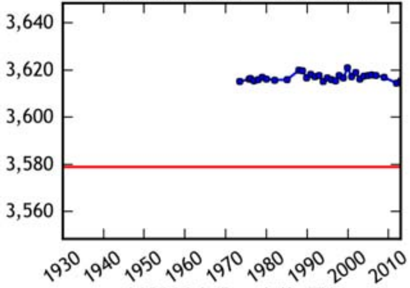

1101101 (Randall, TX)
HP_010641 LSD: 3619 TD: 87

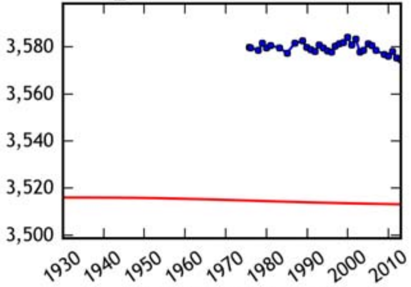

1101102 (Randall, TX)
HP_010642 LSD: 3554 TD: 25

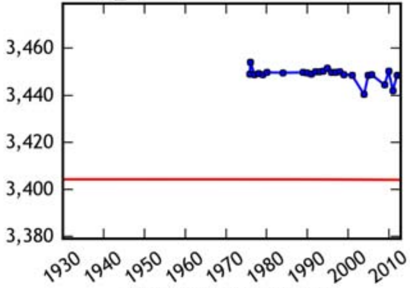

1101103 (Randall, TX)
HP_010643 LSD: 3631 TD: 127

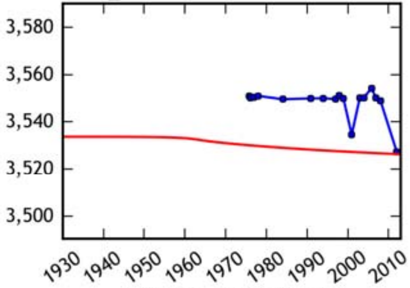

1101501 (Randall, TX)
HP_010668 LSD: 3560 TD: 75

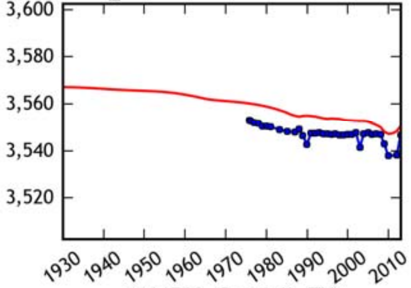

1101701 (Randall, TX)
HP_010681 LSD: 3713 TD: 145

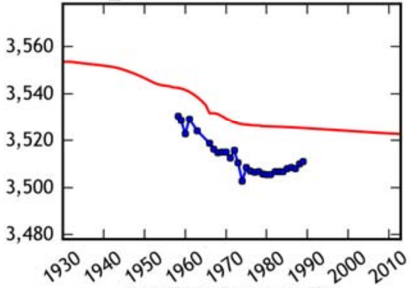

1101802 (Randall, TX)
HP_010683 LSD: 3650 TD: 58

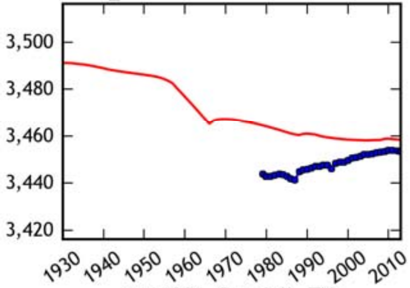

1101803 (Randall, TX)
HP_010684 LSD: 3613 TD: 60

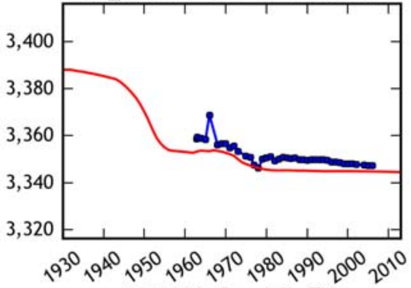

1103401 (Randall, TX)
HP_010701 LSD: 3510 TD: 88

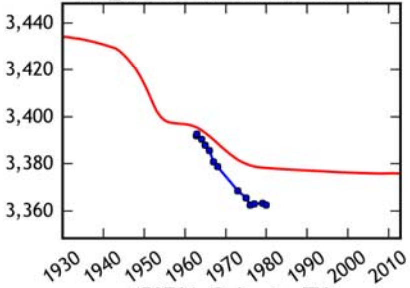

1109204 (Randall, TX)
HP_010786 LSD: 3723 TD: 200

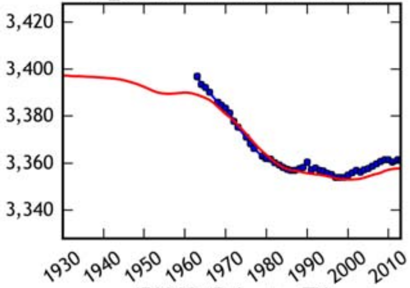

1109724 (Randall, TX)
HP_010867 LSD: 3716 TD: 200

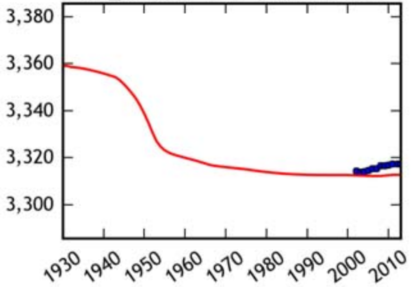

1109801 (Randall, TX)
HP_010868 LSD: 3707 TD: 230

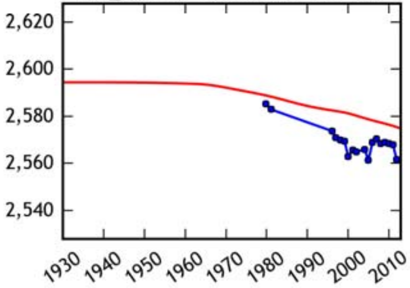

1110512 (Randall, TX)
HP_011011 LSD: 3623 TD: 203

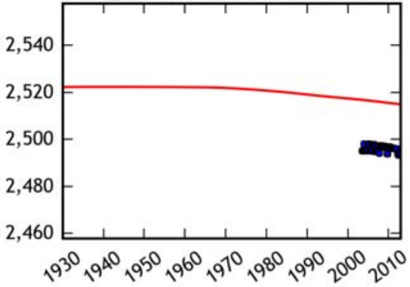

1111502 (Randall, TX)
HP_011124 LSD: 3518 TD: 205

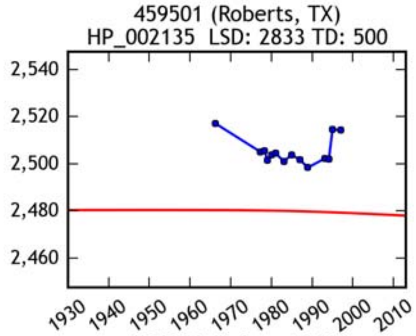

1111701 (Randall, TX)
HP_011165 LSD: 3544 TD: 212

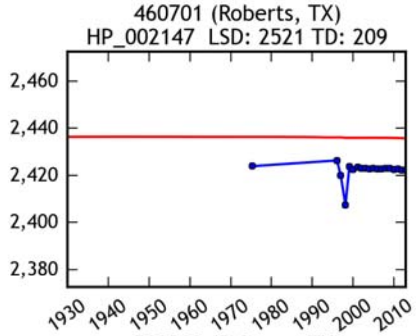

1111801 (Randall, TX)
HP_011202 LSD: 3495 TD: 178

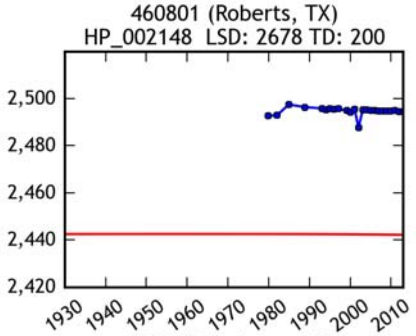

1111928 (Randall, TX)
HP_011246 LSD: 3462 TD: 176

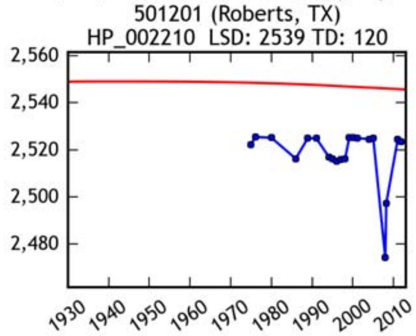

458701 (Roberts, TX)
HP_002127 LSD: 2658 TD: 125

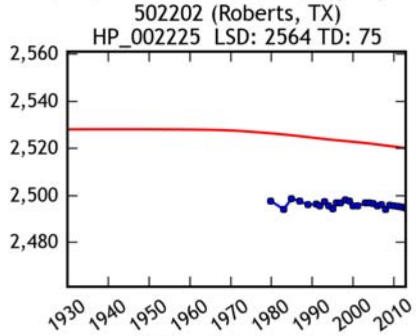

458902 (Roberts, TX)
HP_002130 LSD: 2614 TD: 410

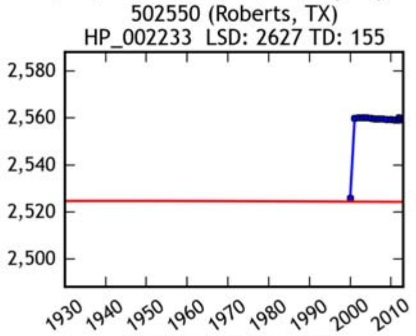

459501 (Roberts, TX)
HP_002135 LSD: 2833 TD: 500
2,540
2,520
2,500
2,480
2,460
1930
1940
1950
1960
1970
1980
1990
2000
2010

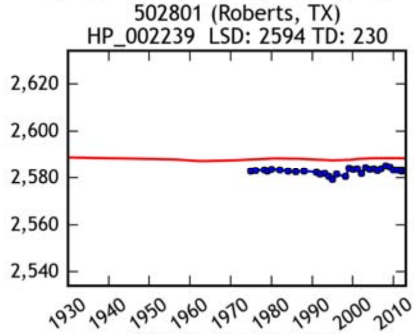

460701 (Roberts, TX)
HP_002147 LSD: 2521 TD: 209
2,460
2,440
2,420
2,400
2,380
1930
1940
1950
1960
1970
1980
1990
2000
2010

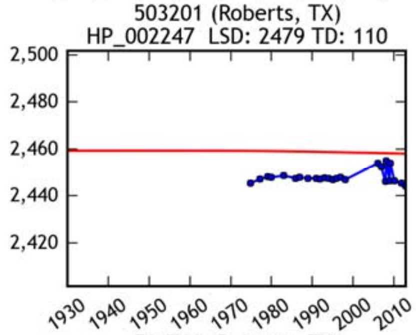

460801 (Roberts, TX)
HP_002148 LSD: 2678 TD: 200
2,500
2,480
2,460
2,440
2,420
1930
1940
1950
1960
1970
1980
1990
2000
2010

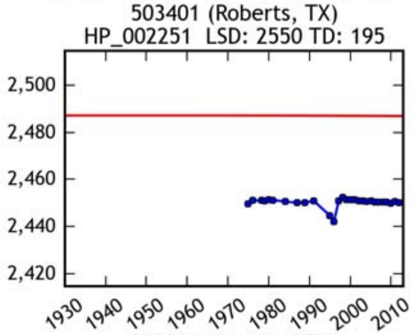

501201 (Roberts, TX)
HP_002210 LSD: 2539 TD: 120
2,560
2,540
2,520
2,500
2,480
1930
1940
1950
1960
1970
1980
1990
2000
2010

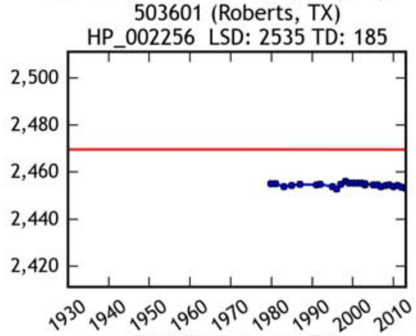

502202 (Roberts, TX)
HP_002225 LSD: 2564 TD: 75
2,560
2,540
2,520
2,500
2,480
1930
1940
1950
1960
1970
1980
1990
2000
2010

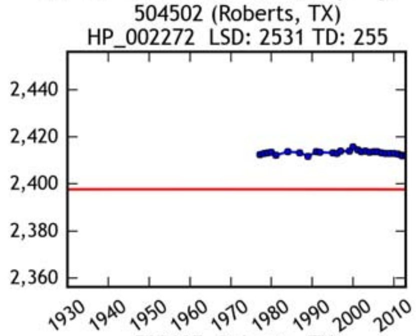

502550 (Roberts, TX)
HP_002233 LSD: 2627 TD: 155
2,580
2,560
2,540
2,520
2,500
1930
1940
1950
1960
1970
1980
1990
2000
2010

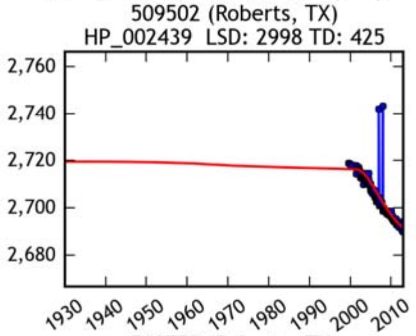

502801 (Roberts, TX)
HP_002239 LSD: 2594 TD: 230
2,620
2,600
2,580
2,560
2,540
1930
1940
1950
1960
1970
1980
1990
2000
2010

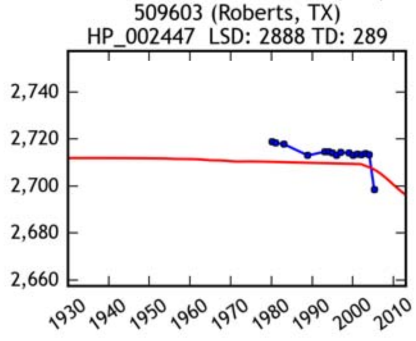

503201 (Roberts, TX)
HP_002247 LSD: 2479 TD: 110
2,500
2,480
2,460
2,440
2,420
1930
1940
1950
1960
1970
1980
1990
2000
2010

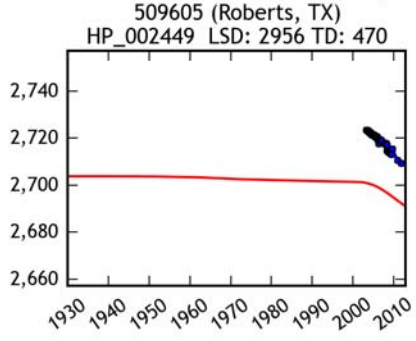

503401 (Roberts, TX)
HP_002251 LSD: 2550 TD: 195
2,500
2,480
2,460
2,440
2,420
1930
1940
1950
1960
1970
1980
1990
2000
2010

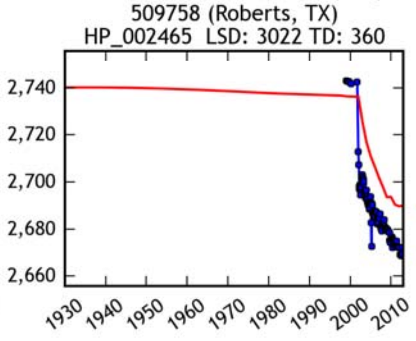

503601 (Roberts, TX)
HP_002256 LSD: 2535 TD: 185
2,500
2,480
2,460
2,440
2,420
1930
1940
1950
1960
1970
1980
1990
2000
2010


504502 (Roberts, TX)
HP_002272 LSD: 2531 TD: 255
2,440
2,420
2,400
2,380
2,360
1930
1940
1950
1960
1970
1980
1990
2000
2010

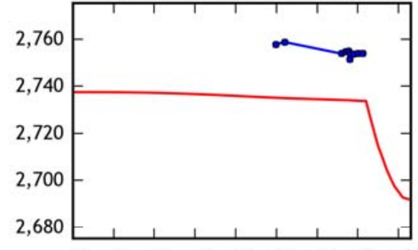

509502 (Roberts, TX)
HP_002439 LSD: 2998 TD: 425
2,760
2,740
2,720
2,700
2,680
1930
1940
1950
1960
1970
1980
1990
2000
2010


509603 (Roberts, TX)
HP_002447 LSD: 2888 TD: 289
2,740
2,720
2,700
2,680
2,660
1930
1940
1950
1960
1970
1980
1990
2000
2010

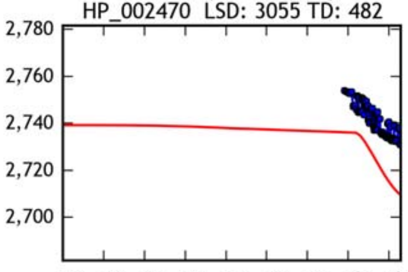

509605 (Roberts, TX)
HP_002449 LSD: 2956 TD: 470
2,740
2,720
2,700
2,680
2,660
1930
1940
1950
1960
1970
1980
1990
2000
2010


509758 (Roberts, TX)
HP_002465 LSD: 3022 TD: 360
2,740
2,720
2,700
2,680
2,660
1930
1940
1950
1960
1970
1980
1990
2000
2010

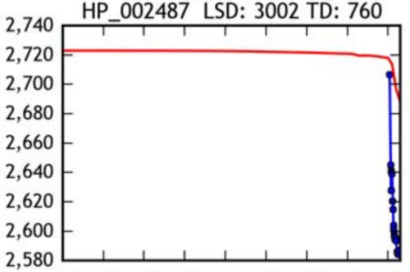
509801 (Roberts, TX)
HP_002466 LSD: 2896 TD: 153



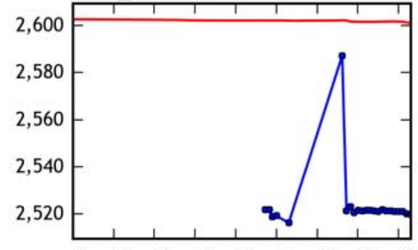
509805 (Roberts, TX)
HP_002470 LSD: 3055 TD: 482



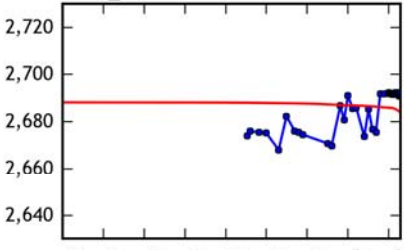
510808 (Roberts, TX)
HP_002487 LSD: 3002 TD: 760



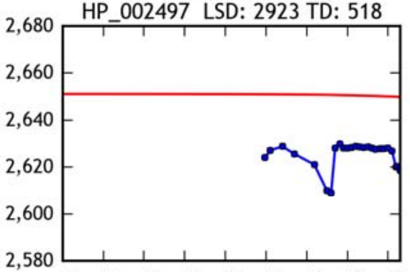
511201 (Roberts, TX)
HP_002493 LSD: 2864 TD: 485



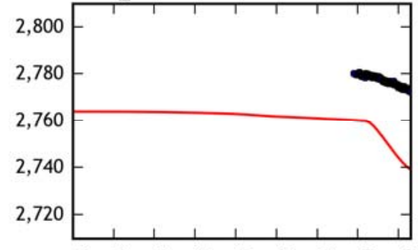
511401 (Roberts, TX)
HP_002495 LSD: 3021 TD: 380



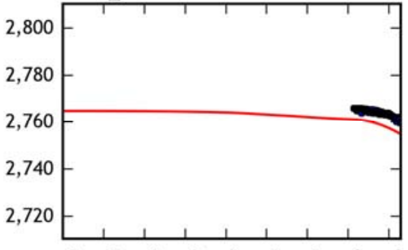
511501 (Roberts, TX)
HP_002497 LSD: 2923 TD: 518



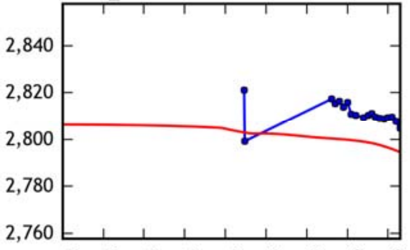
517203 (Roberts, TX)
HP_002666 LSD: 3102 TD: 466



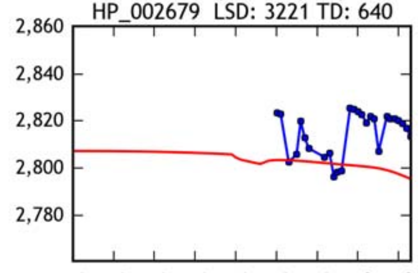
517350 (Roberts, TX)
HP_002668 LSD: 3112 TD: 510



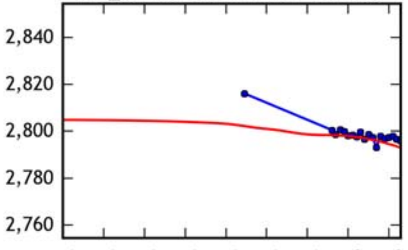
517802 (Roberts, TX)
HP_002677 LSD: 3209 TD: 630



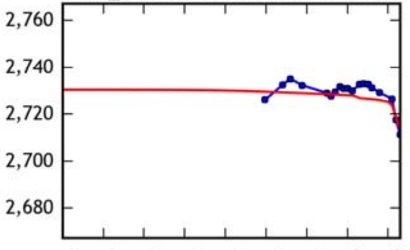
517804 (Roberts, TX)
HP_002679 LSD: 3221 TD: 640



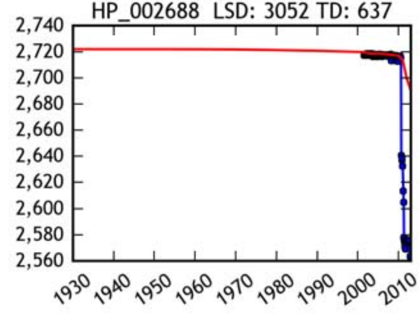
517901 (Roberts, TX)
HP_002682 LSD: 3192 TD: 650



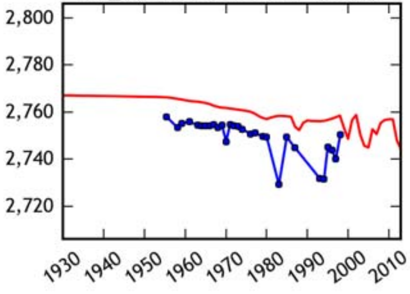
518101 (Roberts, TX)
HP_002685 LSD: 3072 TD: 350



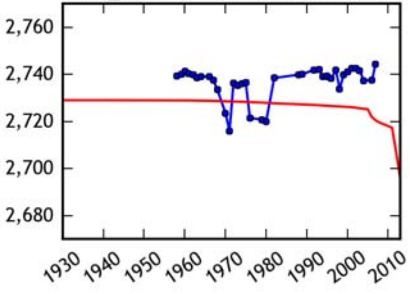
518250 (Roberts, TX)
HP_002688 LSD: 3052 TD: 637

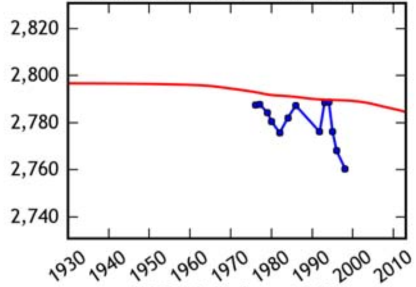


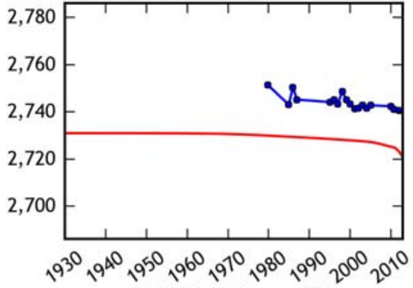
518504 (Roberts, TX)
HP_002695 LSD: 3116 TD: 660

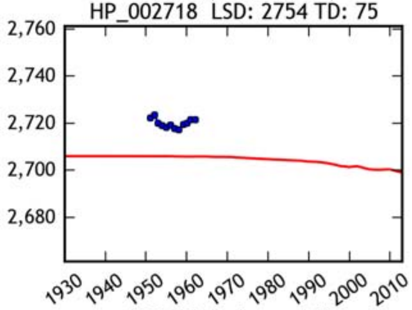


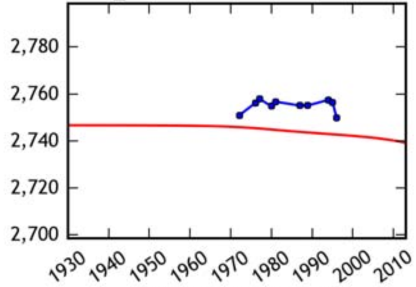
518601 (Roberts, TX)
HP_002696 LSD: 3106 TD: 600

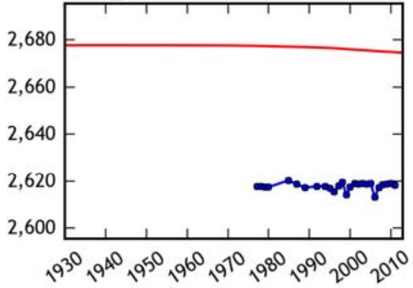


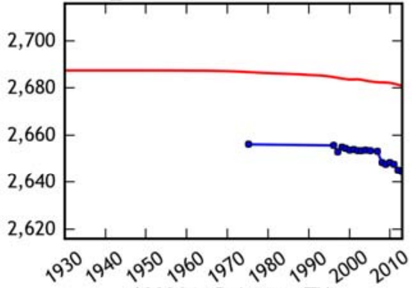

518701 (Roberts, TX)
HP_002698 LSD: 3164 TD: 630

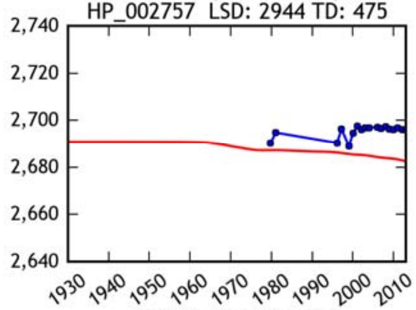

519401 (Roberts, TX)
HP_002712 LSD: 3074 TD: 350

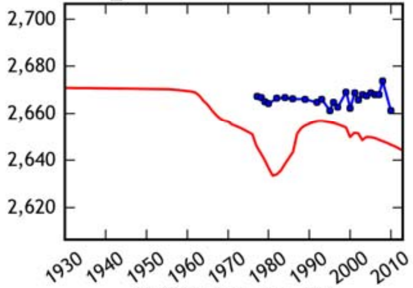

519602 (Roberts, TX)
HP_002718 LSD: 2754 TD: 75

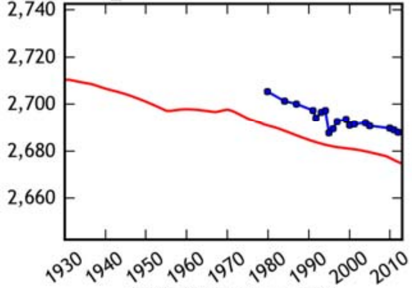

519701 (Roberts, TX)
HP_002726 LSD: 3019 TD: 313

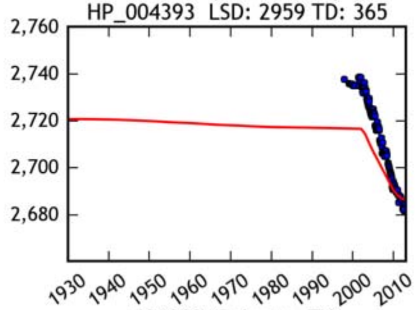

520104 (Roberts, TX)
HP_002736 LSD: 2759 TD: 340

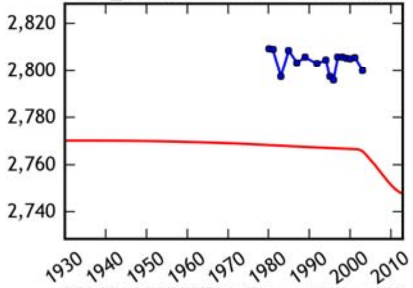

520402 (Roberts, TX)
HP_002749 LSD: 2936 TD: 360

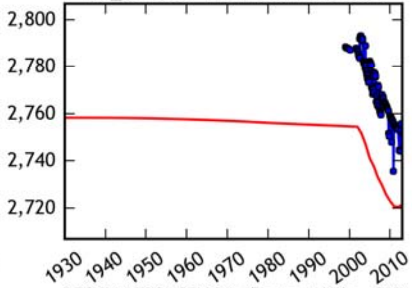

520802 (Roberts, TX)
HP_002757 LSD: 2944 TD: 475

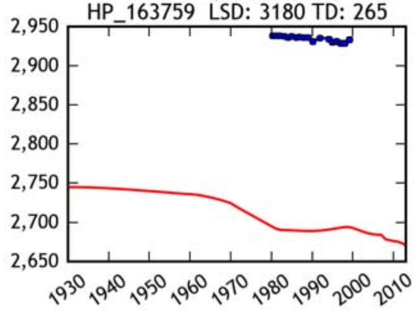

528204 (Roberts, TX)
HP_003111 LSD: 3017 TD: 714

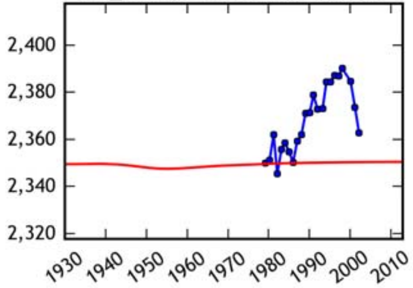

608201 (Roberts, TX)
HP_004273 LSD: 2862 TD: 180

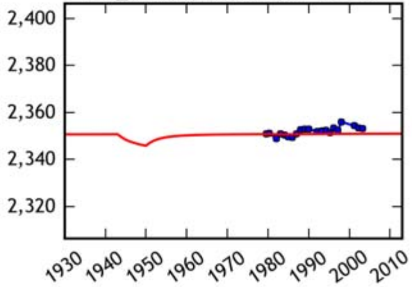

616601 (Roberts, TX)
HP_004393 LSD: 2959 TD: 365


624202 (Roberts, TX)
HP_004476 LSD: 3115 TD: 340

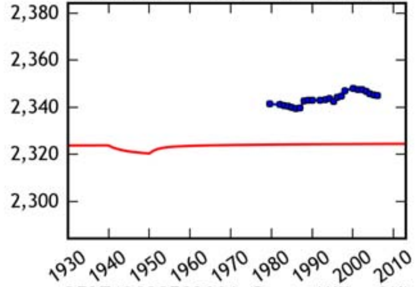

624358 (Roberts, TX)
HP_004489 LSD: 3081 TD: 395


631302 (Roberts, TX)
HP_163759 LSD: 3180 TD: 265

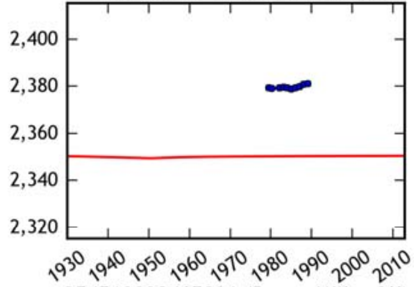

352834099533701 (Roger Mills, OK)
HP_114305 LSD: 2404 TD: unk


353044099492601 (Roger Mills, OK)
HP_114339 LSD: 2374 TD: 46

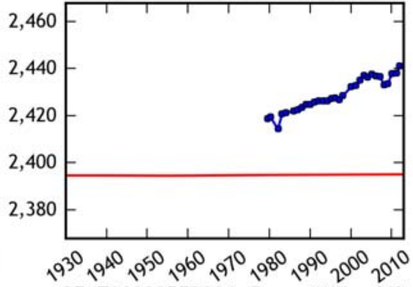
353242099471801 (Roger Mills, OK)
HP_114369 LSD: 2397 TD: 105



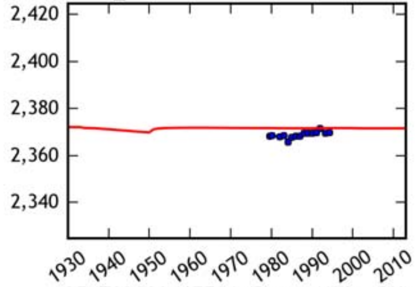
353440099534001 (Roger Mills, OK)
HP_114380 LSD: 2435 TD: 80



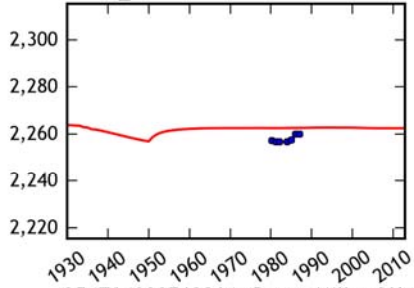
353440099575601 (Roger Mills, OK)
HP_114381 LSD: 2532 TD: 205



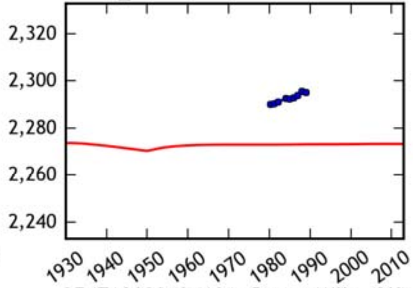
353712099582001 (Roger Mills, OK)
HP_114391 LSD: 2437 TD: 156



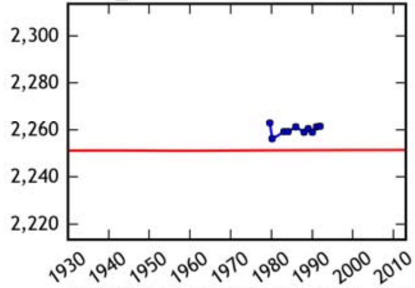
354519099465901 (Roger Mills, OK)
HP_114418 LSD: 2316 TD: 68



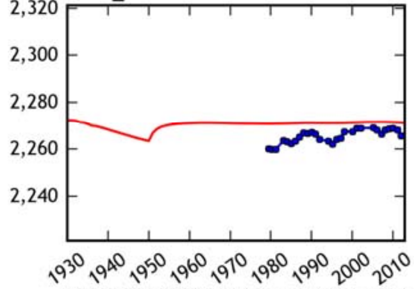
354700099552901 (Roger Mills, OK)
HP_114429 LSD: 2346 TD: 81



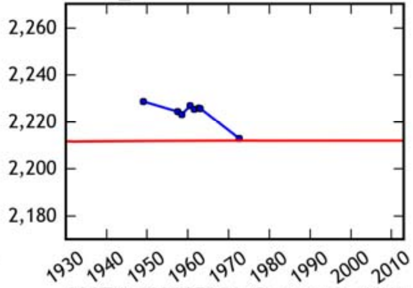
354702099465501 (Roger Mills, OK)
HP_114430 LSD: 2360 TD: 111



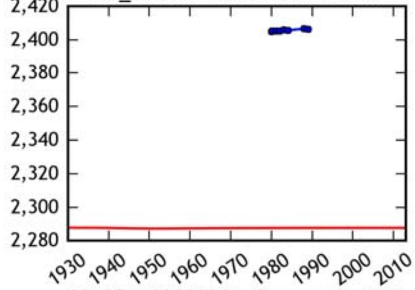
354704099563201 (Roger Mills, OK)
HP_114433 LSD: 2302 TD: unk



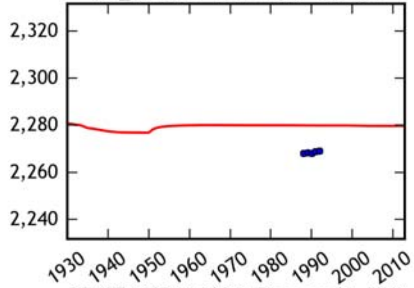
354718099424101 (Roger Mills, OK)
HP_114439 LSD: 2265 TD: 51



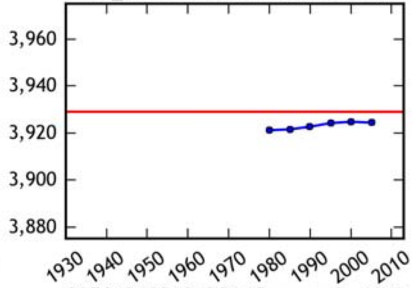
355047099540601 (Roger Mills, OK)
HP_114470 LSD: 2417 TD: 80



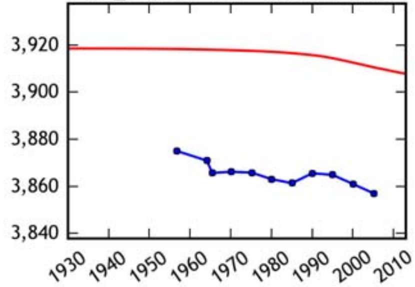
355122099551601 (Roger Mills, OK)
HP_114477 LSD: 2327 TD: 80



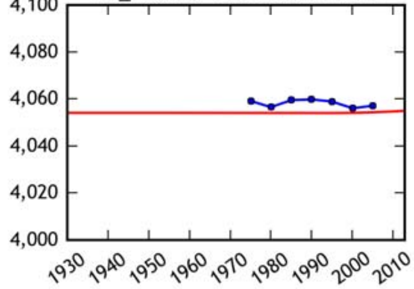
333741103085901 (Roosevelt, NM)
HP_122412 LSD: 4022 TD: 120



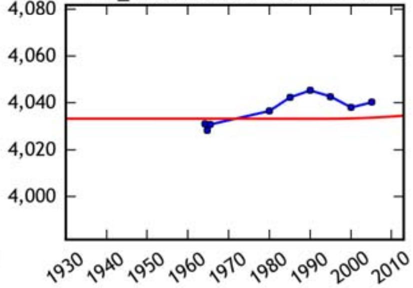
334954103032301 (Roosevelt, NM)
HP_122757 LSD: 3951 TD: 120

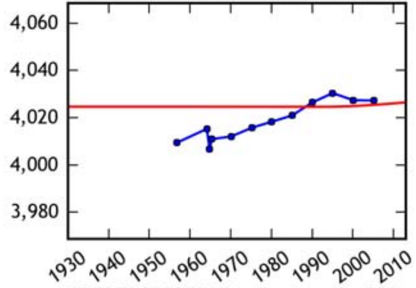


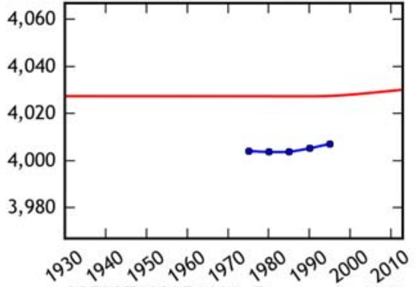
334954103114601 (Roosevelt, NM)
HP_122759 LSD: 4088 TD: 39

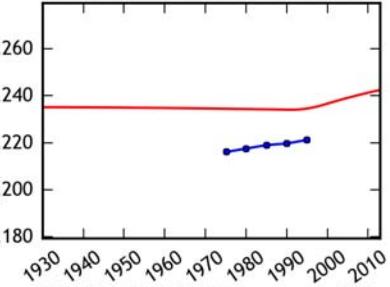


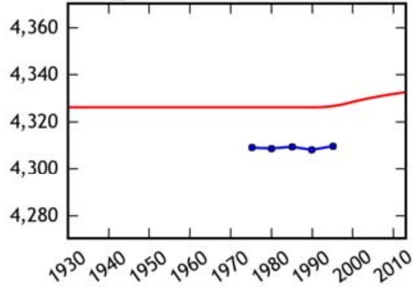
335013103104301 (Roosevelt, NM)
HP_122782 LSD: 4068 TD: 60

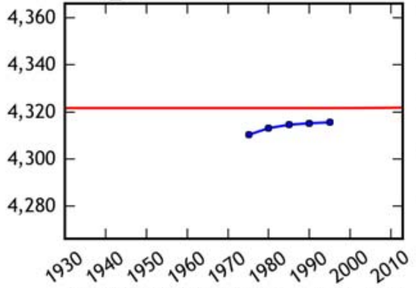


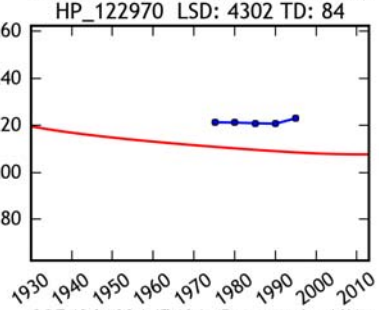

335048103093801 (Roosevelt, NM)
HP_122808 LSD: 4063 TD: 76

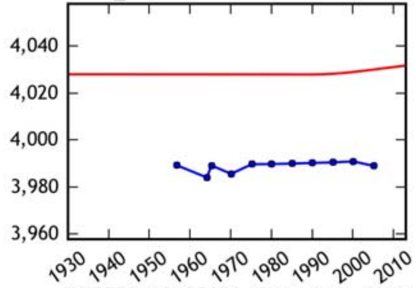

335204103084701 (Roosevelt, NM)
HP_122867 LSD: 4086 TD: 90

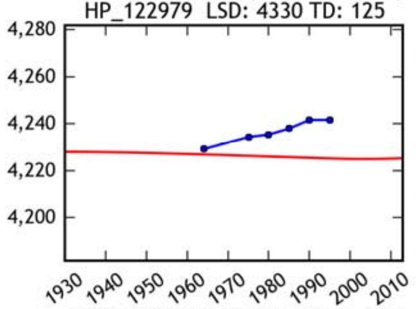

335247103221301 (Roosevelt, NM)
HP_122913 LSD: 4351 TD: 150

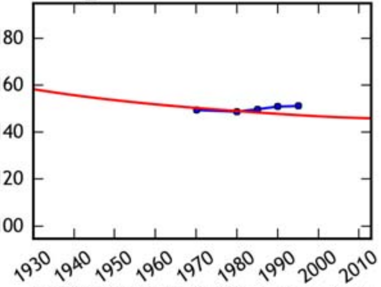

335259103252201 (Roosevelt, NM)
HP_122921 LSD: 4400 TD: unk

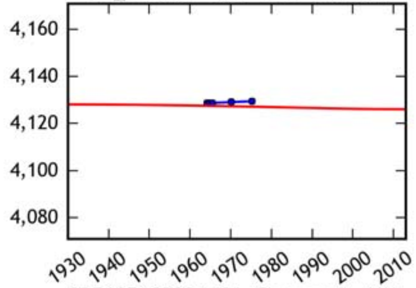

335337103251601 (Roosevelt, NM)
HP_122955 LSD: 4410 TD: unk

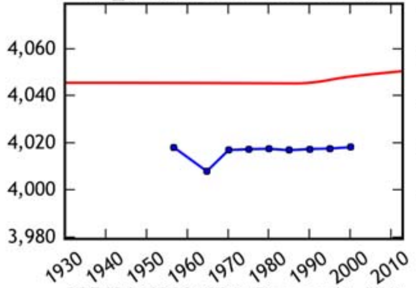

335407103190301 (Roosevelt, NM)
HP_122970 LSD: 4302 TD: 84

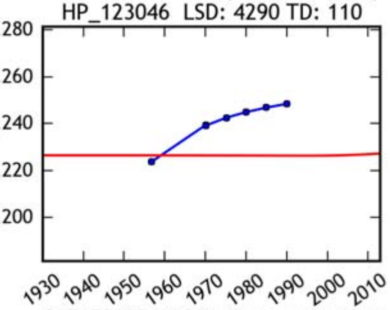

335416103073001 (Roosevelt, NM)
HP_122978 LSD: 4123 TD: 140

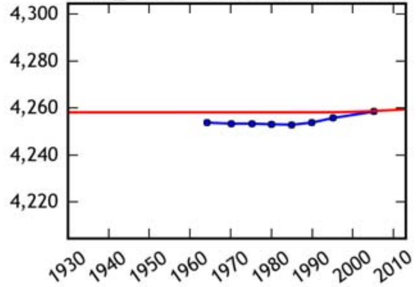

335420103203001 (Roosevelt, NM)
HP_122979 LSD: 4330 TD: 125

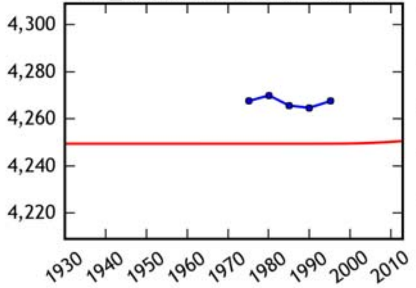

335436103145401 (Roosevelt, NM)
HP_122991 LSD: 4228 TD: 95

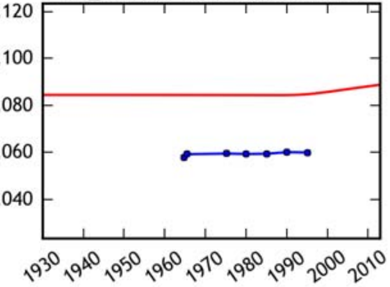

335550103135001 (Roosevelt, NM)
HP_123031 LSD: 4247 TD: 132

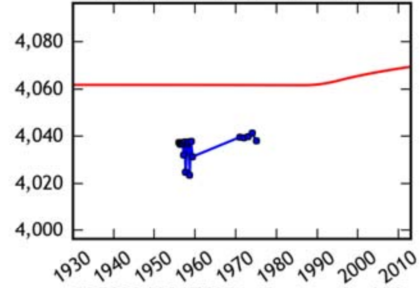

335604103084201 (Roosevelt, NM)
HP_123045 LSD: 4168 TD: 161

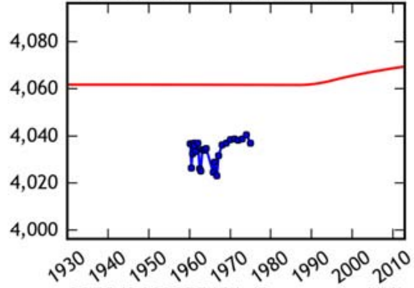

335605103195801 (Roosevelt, NM)
HP_123046 LSD: 4290 TD: 110

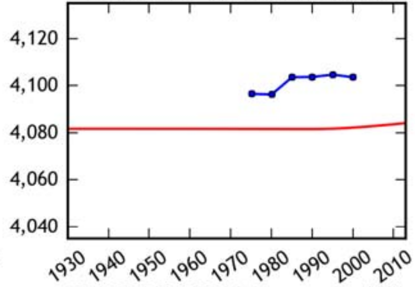

335605103224401 (Roosevelt, NM)
HP_123047 LSD: 4304 TD: unk

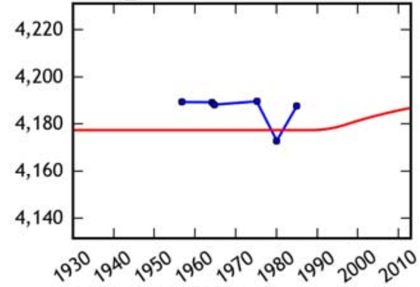

335636103231801 (Roosevelt, NM)
HP_123078 LSD: 4296 TD: unk

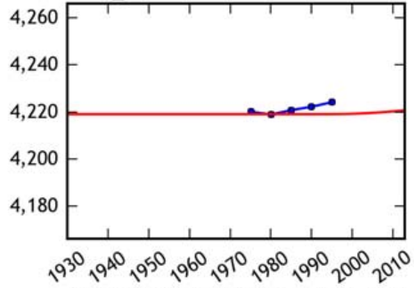

335653103111001 (Roosevelt, NM)
HP_123087 LSD: 4206 TD: 170

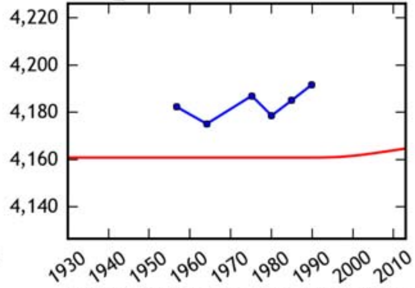

335744103095001 (Roosevelt, NM)
HP_123117 LSD: 4197 TD: 200

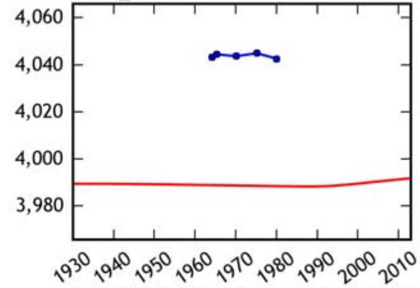

335745103095001 (Roosevelt, NM)
HP_123120 LSD: 4196 TD: 192

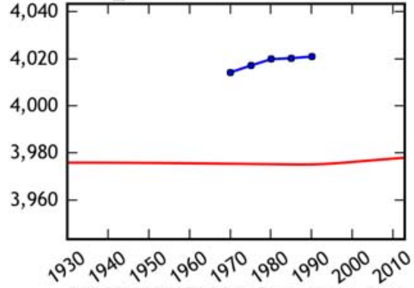

335759103112501 (Roosevelt, NM)
HP_123129 LSD: 4184 TD: 100

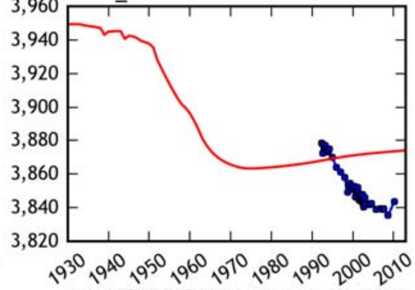

335822103175901 (Roosevelt, NM)
HP_123143 LSD: 4257 TD: 96

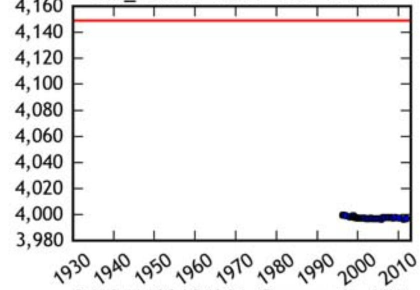

335842103255101 (Roosevelt, NM)
HP_123165 LSD: 4292 TD: unk

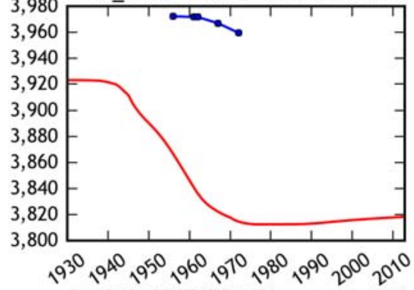

335925103175801 (Roosevelt, NM)
HP_123179 LSD: 4221 TD: unk

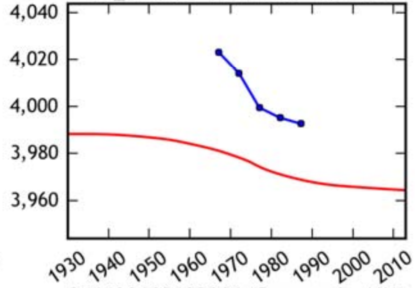

335946103052701 (Roosevelt, NM)
HP_123191 LSD: 4127 TD: 105

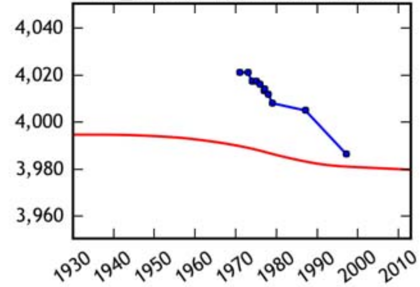

335957103035501 (Roosevelt, NM)
HP_123195 LSD: 4134 TD: 140

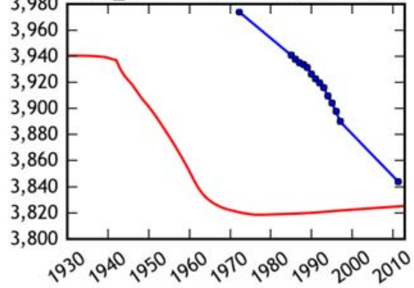

340844103055001 (Roosevelt, NM)
HP_123580 LSD: 4050 TD: 201

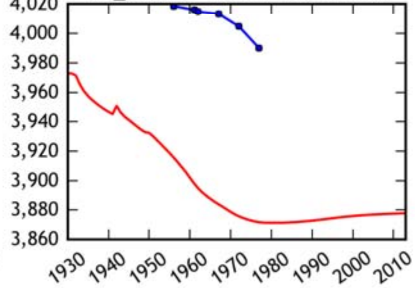

341014103264401 (Roosevelt, NM)
HP_123737 LSD: 4302 TD: 84


341024103053801 (Roosevelt, NM)
HP_123754 LSD: 4071 TD: unk

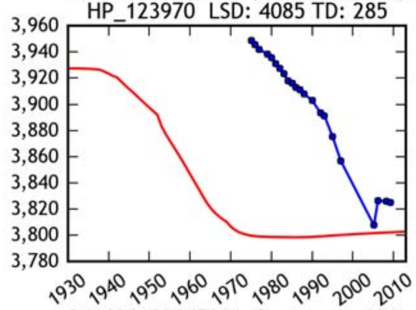

341027103173401 (Roosevelt, NM)
HP_123764 LSD: 4087 TD: 132


341041103184201 (Roosevelt, NM)
HP_123803 LSD: 4091 TD: 121

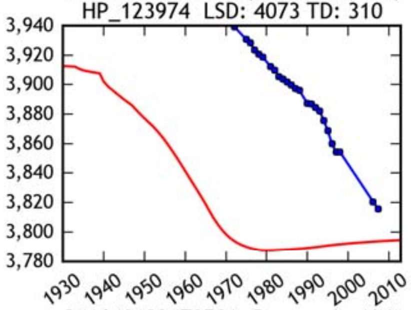

341042103074501 (Roosevelt, NM)
HP_123810 LSD: 4082 TD: 268


341139103122901 (Roosevelt, NM)
HP_123969 LSD: 4116 TD: 130

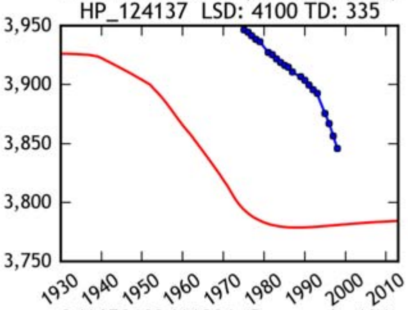
341140103053701 (Roosevelt, NM)
HP_123970 LSD: 4085 TD: 285



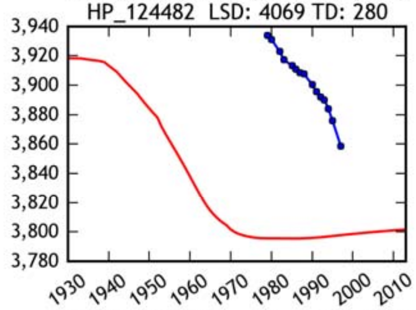
341143103032101 (Roosevelt, NM)
HP_123974 LSD: 4073 TD: 310



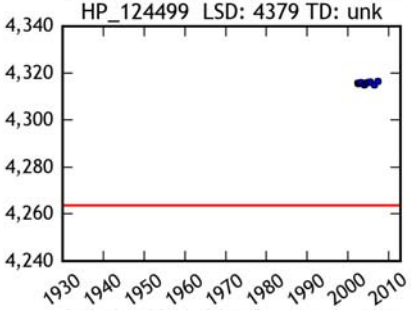
341232103051901 (Roosevelt, NM)
HP_124137 LSD: 4100 TD: 335



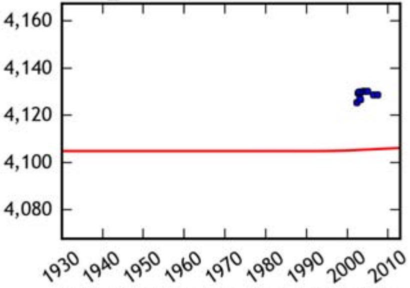
341626103045001 (Roosevelt, NM)
HP_124482 LSD: 4069 TD: 280



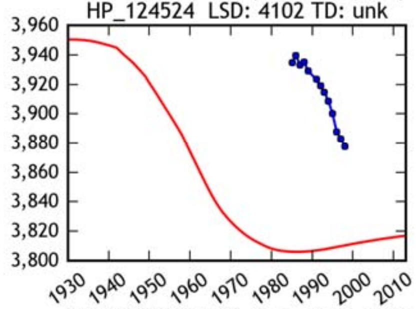
341640103470501 (Roosevelt, NM)
HP_124499 LSD: 4379 TD: unk



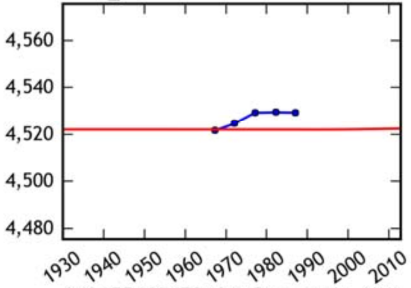
341658103411901 (Roosevelt, NM)
HP_124517 LSD: 4239 TD: 126



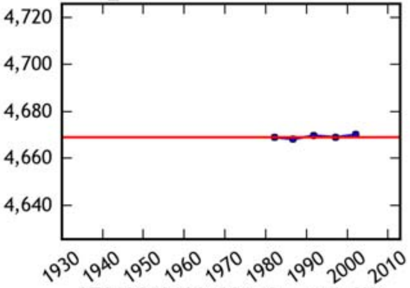
341705103084501 (Roosevelt, NM)
HP_124524 LSD: 4102 TD: unk



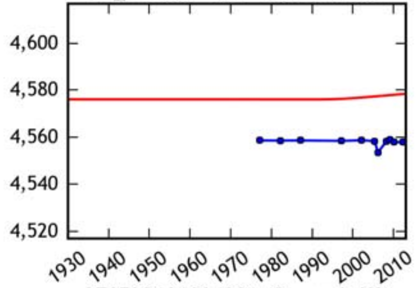
343401103464301 (Roosevelt, NM)
HP_125840 LSD: 4596 TD: unk



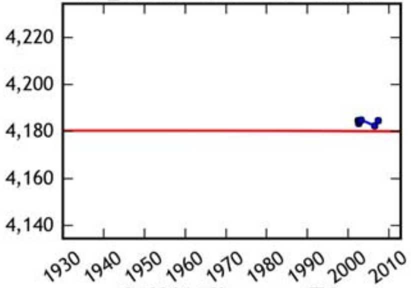
343511103555001 (Roosevelt, NM)
HP_125904 LSD: 4752 TD: 100



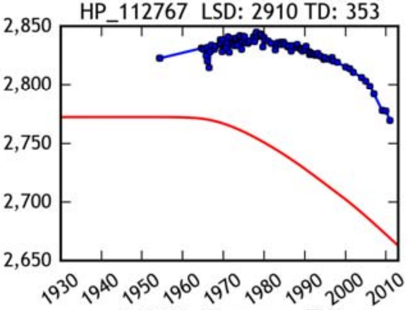
343627103490801 (Roosevelt, NM)
HP_125969 LSD: 4650 TD: 100



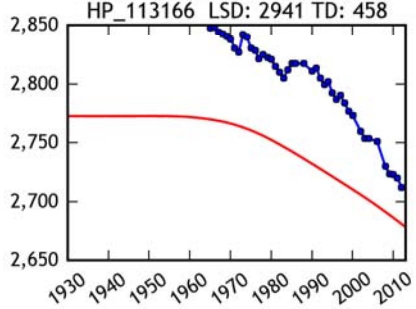
342155103453101 (Roosevelt, NM)
HP_163841 LSD: 4193 TD: unk



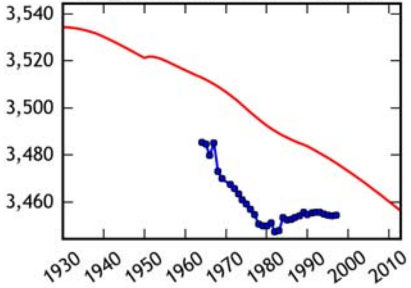
370128101004001 (Seward, KS)
HP_112767 LSD: 2910 TD: 353



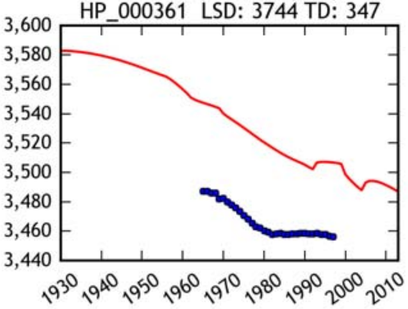
370523101004901 (Seward, KS)
HP_113166 LSD: 2941 TD: 458

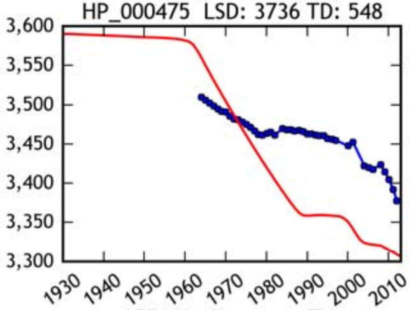


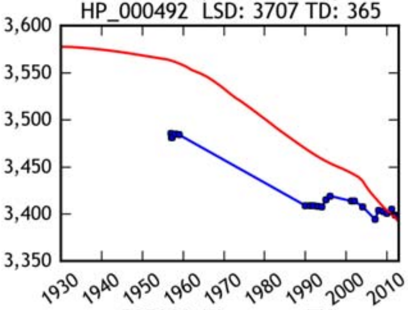
240201 (Sherman, TX)
HP_000356 LSD: 3717 TD: 374

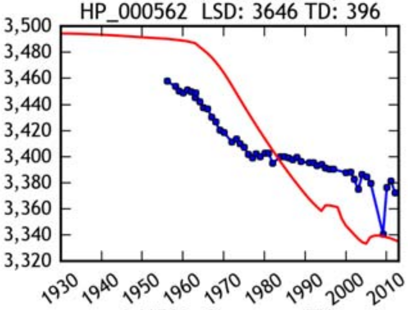


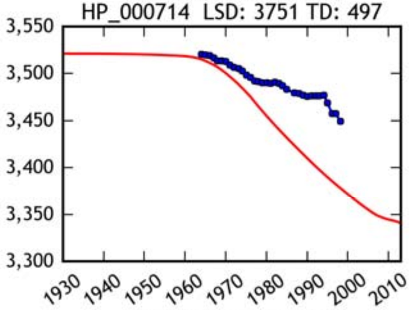
240402 (Sherman, TX)
HP_000361 LSD: 3744 TD: 347

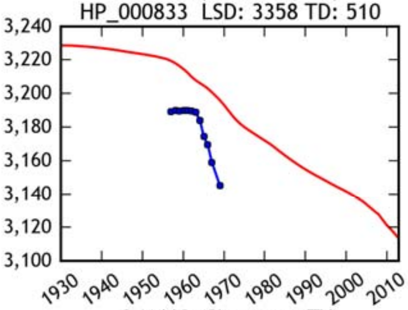


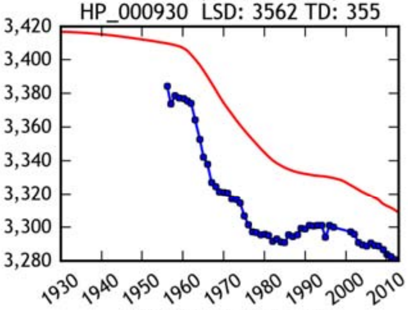

247603 (Sherman, TX)
HP_000475 LSD: 3736 TD: 548

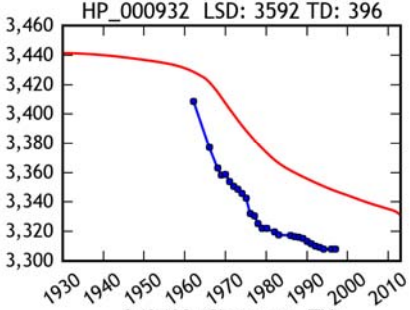

248102 (Sherman, TX)
HP_000492 LSD: 3707 TD: 365

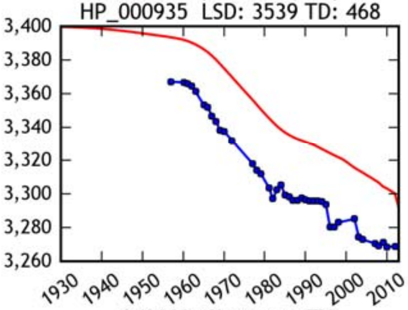

256201 (Sherman, TX)
HP_000562 LSD: 3646 TD: 396

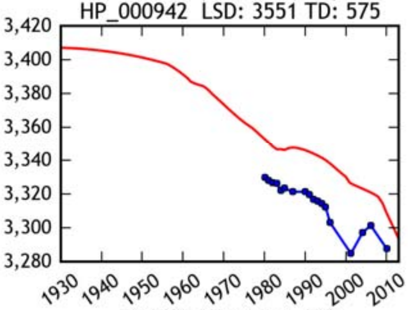

255602 (Sherman, TX)
HP_000714 LSD: 3751 TD: 497

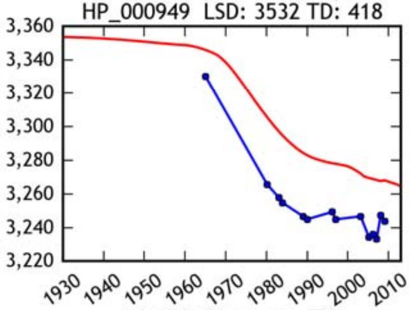

335902 (Sherman, TX)
HP_000833 LSD: 3358 TD: 510

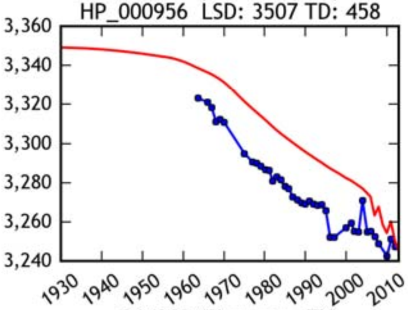

341502 (Sherman, TX)
HP_000930 LSD: 3562 TD: 355

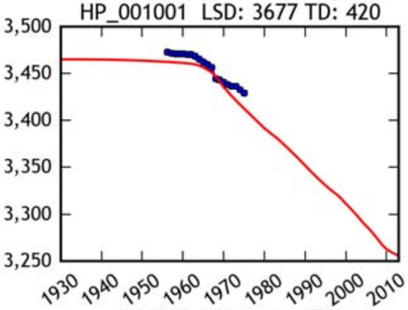

341504 (Sherman, TX)
HP_000932 LSD: 3592 TD: 396

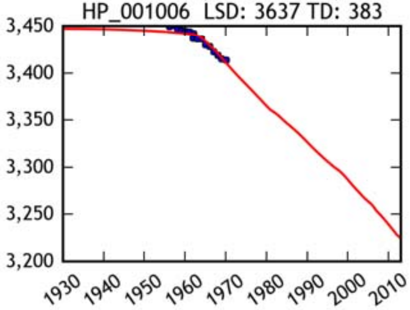

341602 (Sherman, TX)
HP_000935 LSD: 3539 TD: 468

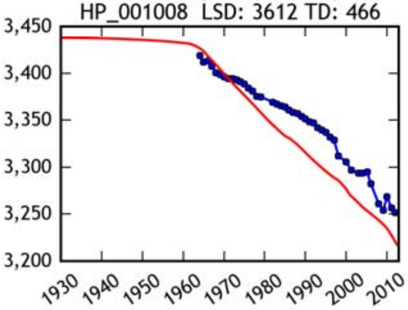

341901 (Sherman, TX)
HP_000942 LSD: 3551 TD: 575

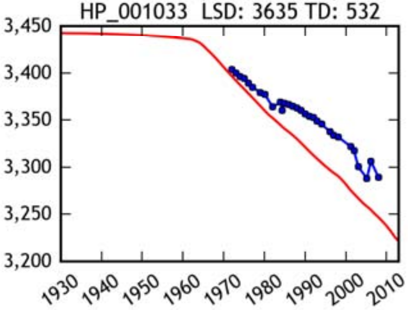

342402 (Sherman, TX)
HP_000949 LSD: 3532 TD: 418


342802 (Sherman, TX)
HP_000956 LSD: 3507 TD: 458

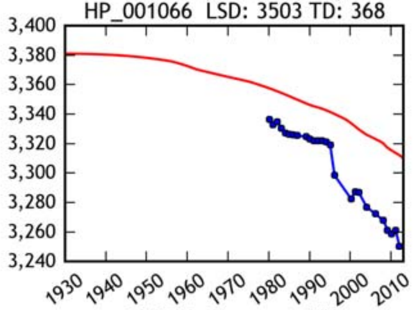

264201 (Sherman, TX)
HP_001001 LSD: 3677 TD: 420


264301 (Sherman, TX)
HP_001006 LSD: 3637 TD: 383

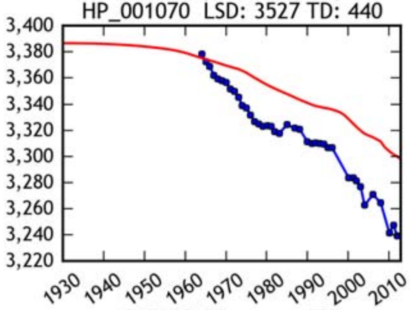

264303 (Sherman, TX)
HP_001008 LSD: 3612 TD: 466


264605 (Sherman, TX)
HP_001033 LSD: 3635 TD: 532

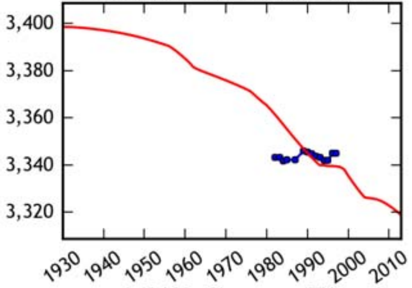
333302 (Sherman, TX)
HP_001066 LSD: 3503 TD: 368



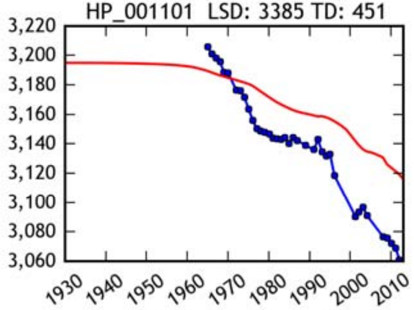
333501 (Sherman, TX)
HP_001070 LSD: 3527 TD: 440



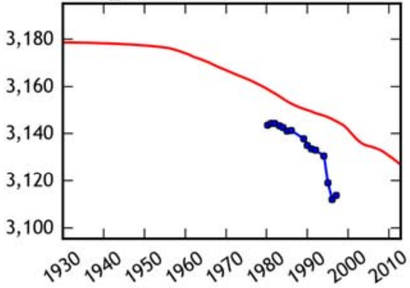
333902 (Sherman, TX)
HP_001085 LSD: 3522 TD: 355



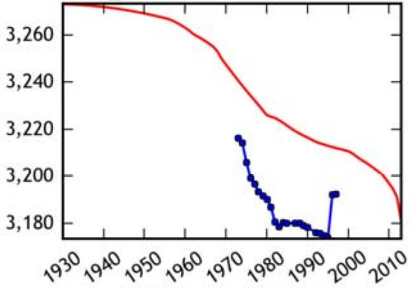
335201 (Sherman, TX)
HP_001101 LSD: 3385 TD: 451



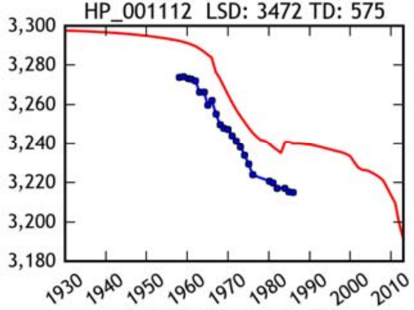
335203 (Sherman, TX)
HP_001103 LSD: 3362 TD: 533



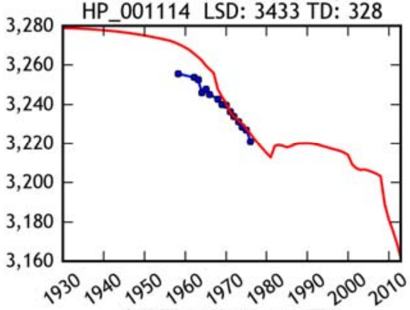
343103 (Sherman, TX)
HP_001108 LSD: 3430 TD: 525



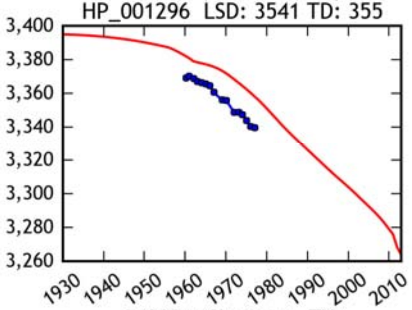
343401 (Sherman, TX)
HP_001112 LSD: 3472 TD: 575



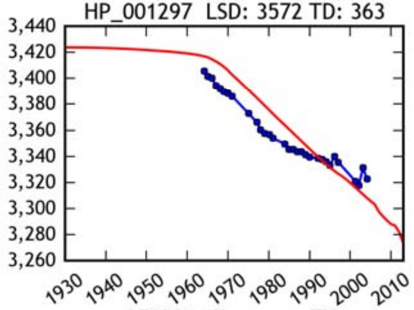
343403 (Sherman, TX)
HP_001114 LSD: 3433 TD: 328



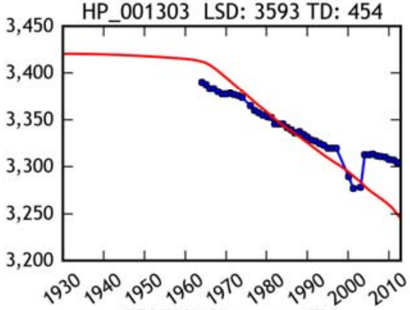
349301 (Sherman, TX)
HP_001296 LSD: 3541 TD: 355



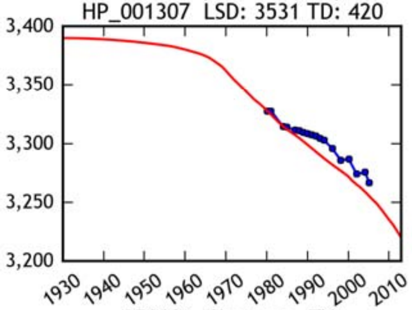
349401 (Sherman, TX)
HP_001297 LSD: 3572 TD: 363



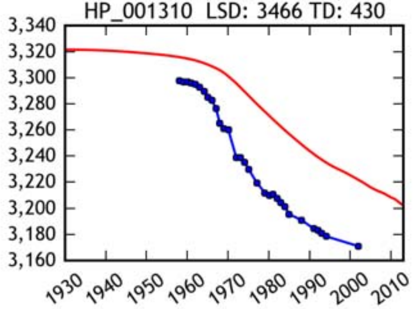
349701 (Sherman, TX)
HP_001303 LSD: 3593 TD: 454



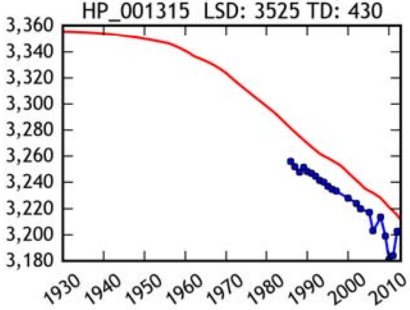
349901 (Sherman, TX)
HP_001307 LSD: 3531 TD: 420



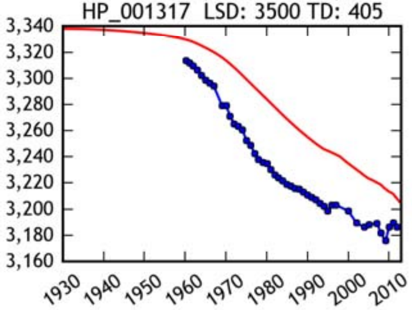
350301 (Sherman, TX)
HP_001310 LSD: 3466 TD: 430



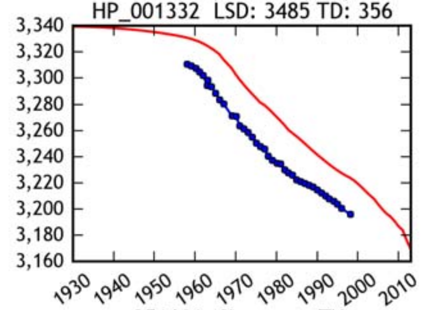
350503 (Sherman, TX)
HP_001315 LSD: 3525 TD: 430



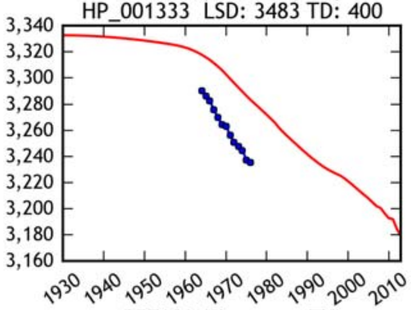
350601 (Sherman, TX)
HP_001317 LSD: 3500 TD: 405



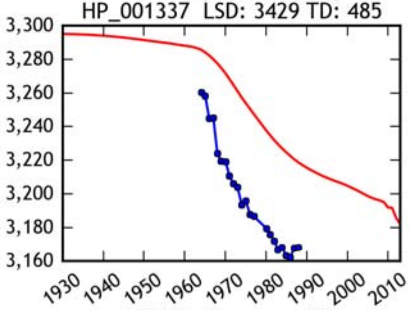
350901 (Sherman, TX)
HP_001332 LSD: 3485 TD: 356



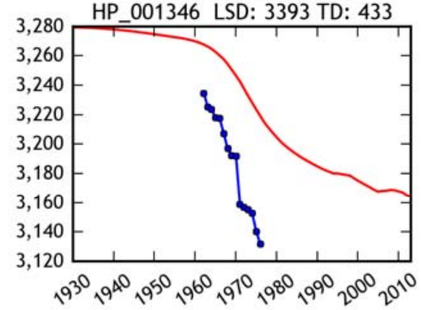
350902 (Sherman, TX)
HP_001333 LSD: 3483 TD: 400



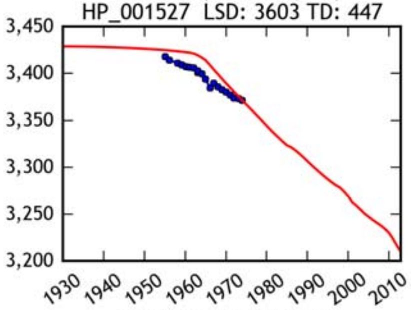
351202 (Sherman, TX)
HP_001337 LSD: 3429 TD: 485



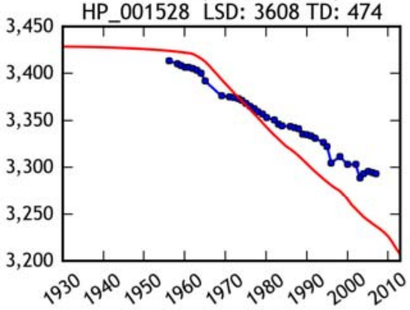
351601 (Sherman, TX)
HP_001346 LSD: 3393 TD: 433



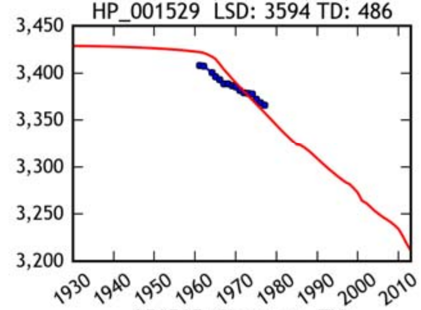
357101 (Sherman, TX)
HP_001527 LSD: 3603 TD: 447



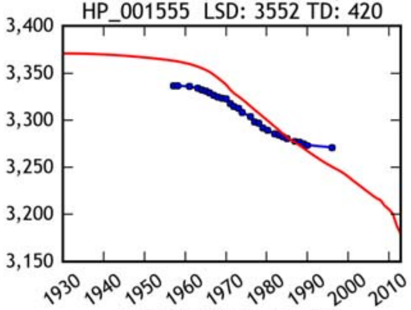
357102 (Sherman, TX)
HP_001528 LSD: 3608 TD: 474



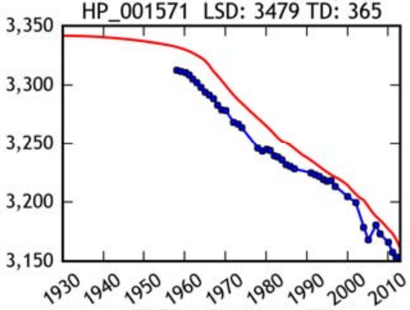
357103 (Sherman, TX)
HP_001529 LSD: 3594 TD: 486



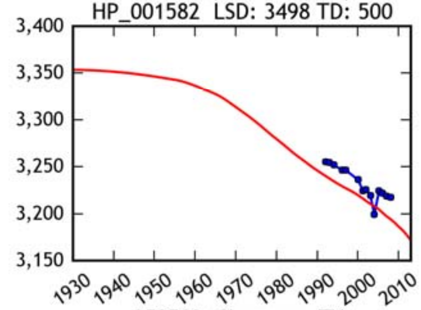
358101 (Sherman, TX)
HP_001555 LSD: 3552 TD: 420



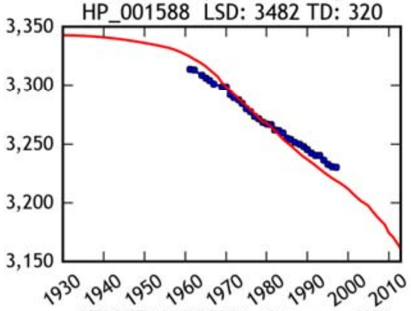
358302 (Sherman, TX)
HP_001571 LSD: 3479 TD: 365



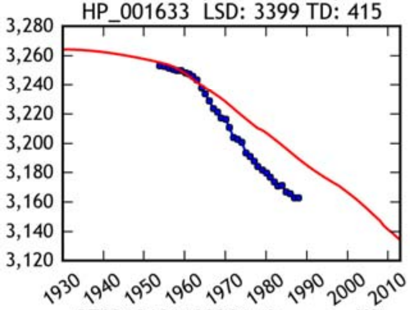
358505 (Sherman, TX)
HP_001582 LSD: 3498 TD: 500



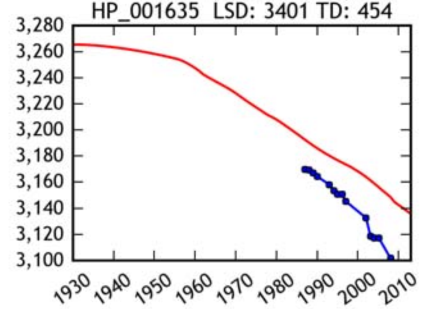
358603 (Sherman, TX)
HP_001588 LSD: 3482 TD: 320



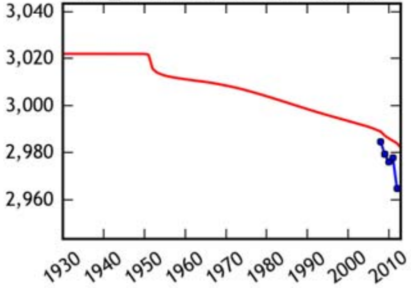
359501 (Sherman, TX)
HP_001633 LSD: 3399 TD: 415



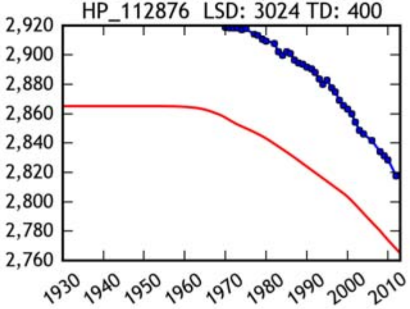
359503 (Sherman, TX)
HP_001635 LSD: 3401 TD: 454



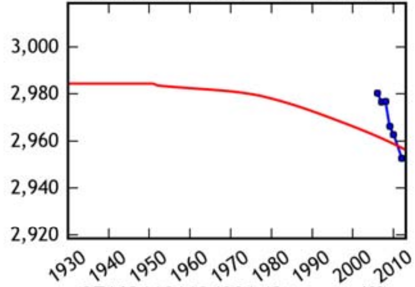
370037101300201 (Stevens, KS)
HP_112710 LSD: 3264 TD: 560



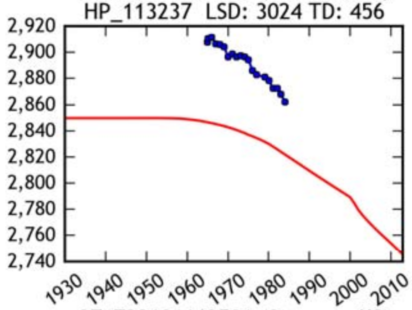
370218101103301 (Stevens, KS)
HP_112876 LSD: 3024 TD: 400



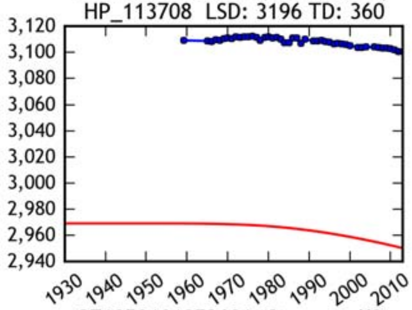
370410101272201 (Stevens, KS)
HP_113082 LSD: 3247 TD: 543



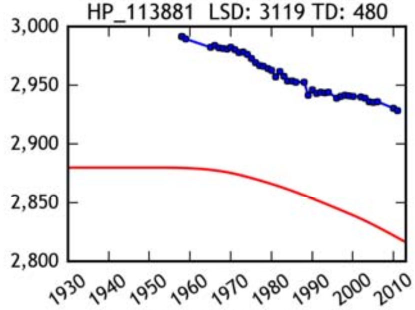
370619101102601 (Stevens, KS)
HP_113237 LSD: 3024 TD: 456



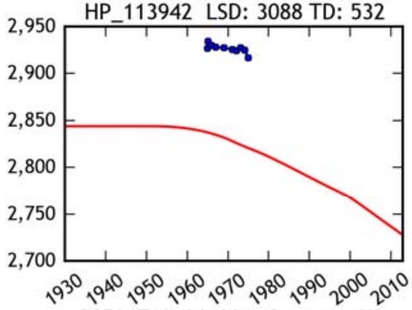
371246101290701 (Stevens, KS)
HP_113708 LSD: 3196 TD: 360



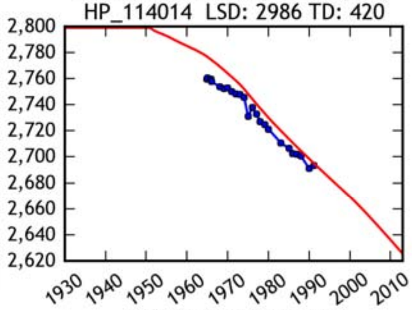
371621101194001 (Stevens, KS)
HP_113881 LSD: 3119 TD: 480



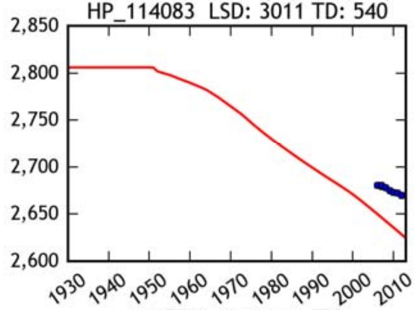
371733101162501 (Stevens, KS)
HP_113942 LSD: 3088 TD: 532



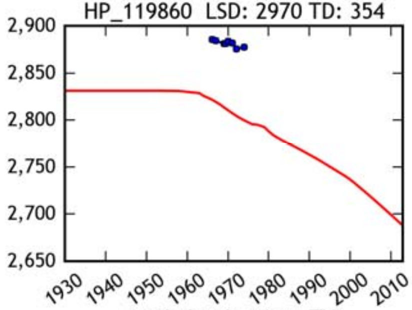
371858101053601 (Stevens, KS)
HP_114014 LSD: 2986 TD: 420



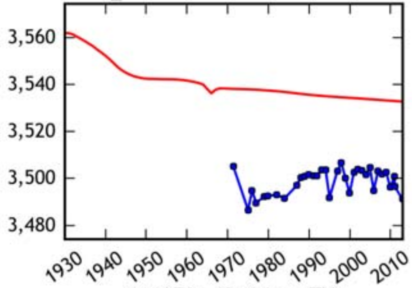
371947101082101 (Stevens, KS)
HP_114083 LSD: 3011 TD: 540



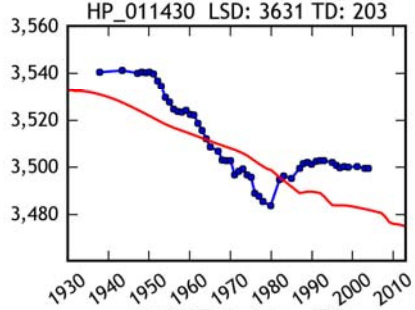
365947101064201 (Stevens, KS)
HP_119860 LSD: 2970 TD: 354



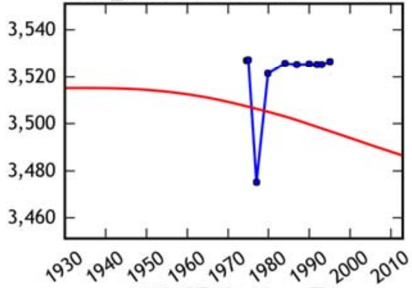
1117105 (Swisher, TX)
HP_011415 LSD: 3711 TD: 208



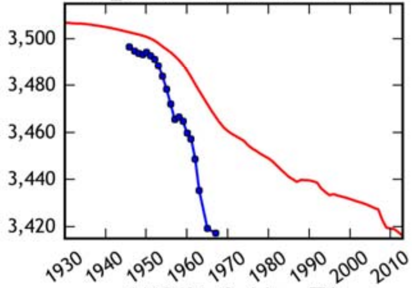
1117501 (Swisher, TX)
HP_011430 LSD: 3631 TD: 203



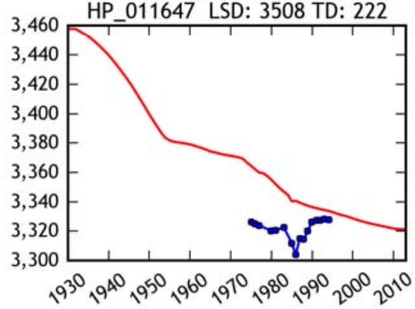
1118101 (Swisher, TX)
HP_011463 LSD: 3629 TD: 195



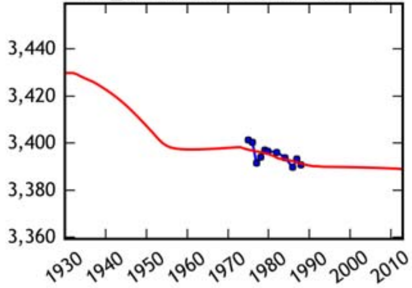
1118701 (Swisher, TX)
HP_011574 LSD: 3577 TD: 195



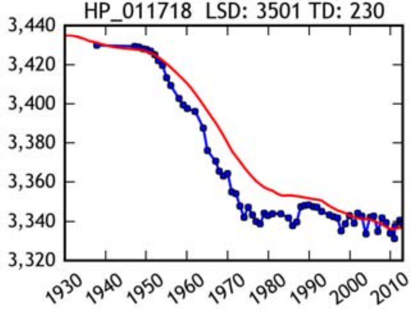
1118927 (Swisher, TX)
HP_011647 LSD: 3508 TD: 222



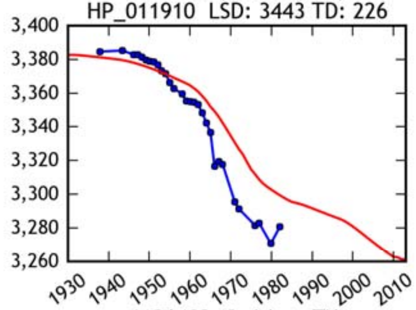
1119107 (Swisher, TX)
HP_011663 LSD: 3510 TD: 200



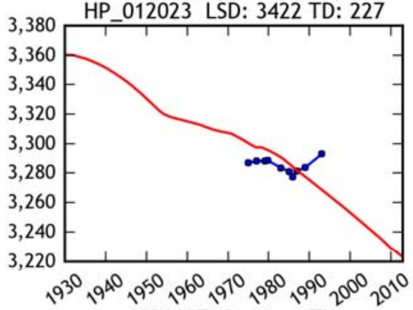
1119401 (Swisher, TX)
HP_011718 LSD: 3501 TD: 230



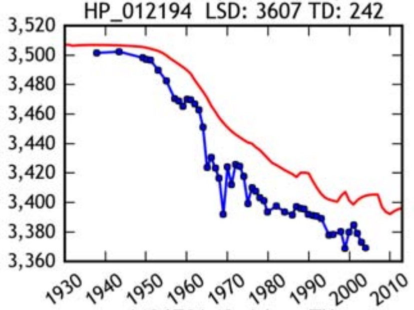
1119901 (Swisher, TX)
HP_011910 LSD: 3443 TD: 226



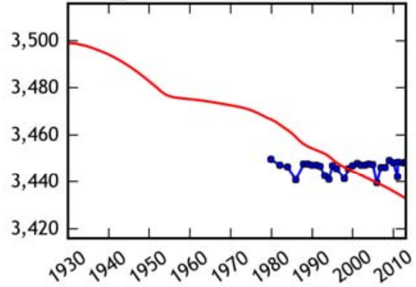
1120718 (Swisher, TX)
HP_012023 LSD: 3422 TD: 227



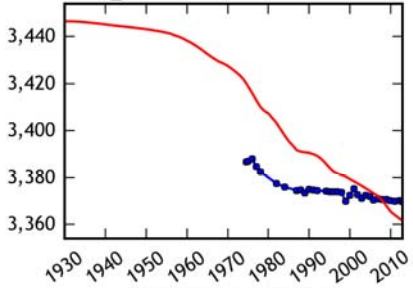
1125901 (Swisher, TX)
HP_012194 LSD: 3607 TD: 242



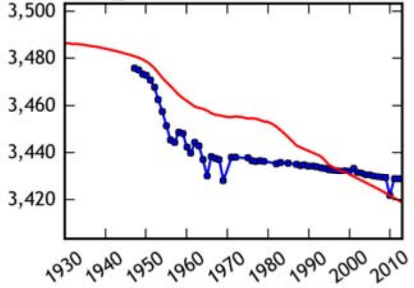
1126403 (Swisher, TX)
HP_012233 LSD: 3566 TD: 185



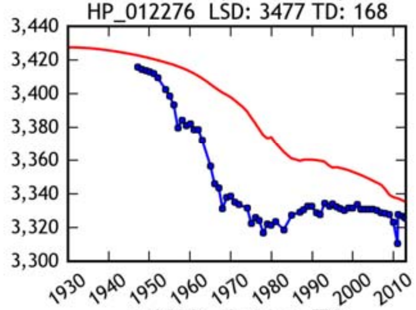
1126607 (Swisher, TX)
HP_012253 LSD: 3491 TD: 160



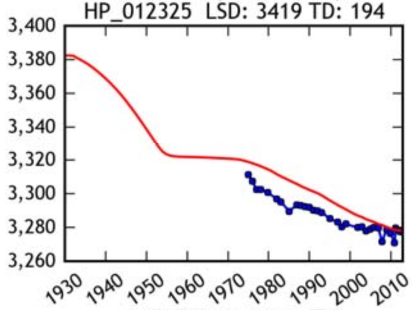
1126701 (Swisher, TX)
HP_012261 LSD: 3545 TD: 171



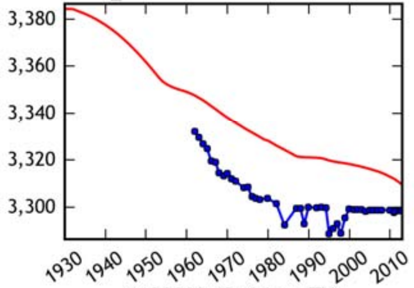
1126908 (Swisher, TX)
HP_012276 LSD: 3477 TD: 168



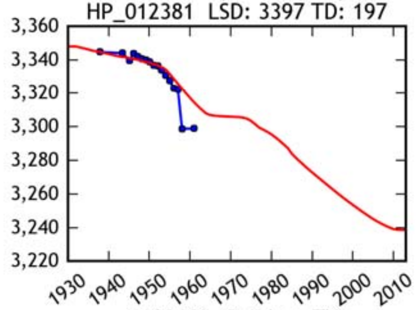
1127310 (Swisher, TX)
HP_012325 LSD: 3419 TD: 194



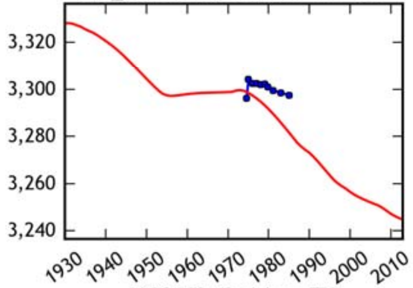
1127802 (Swisher, TX)
HP_012362 LSD: 3433 TD: 165



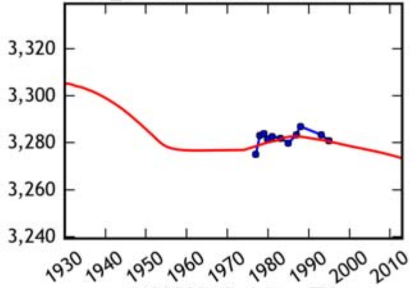
1128201 (Swisher, TX)
HP_012381 LSD: 3397 TD: 197



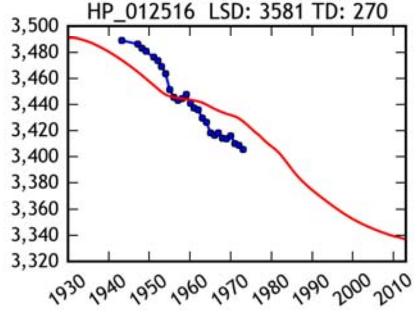
1128208 (Swisher, TX)
HP_012388 LSD: 3377 TD: 172



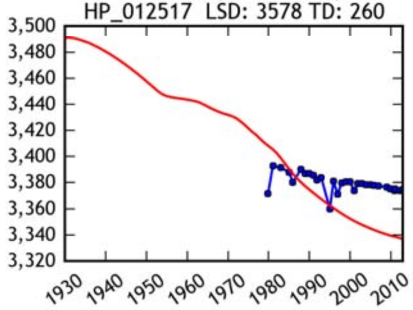
1128802 (Swisher, TX)
HP_012427 LSD: 3356 TD: 139



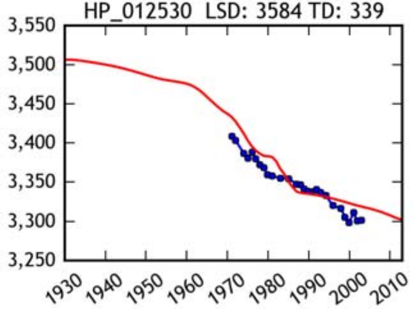
1133601 (Swisher, TX)
HP_012516 LSD: 3581 TD: 270

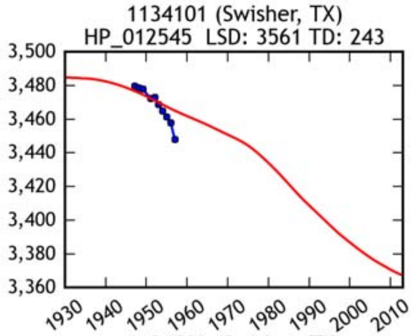


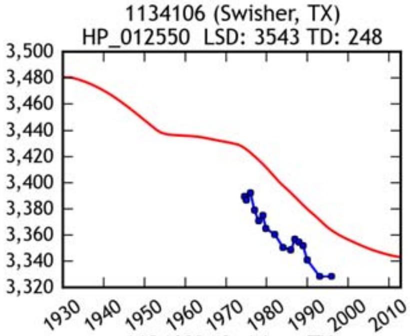
1133602 (Swisher, TX)
HP_012517 LSD: 3578 TD: 260

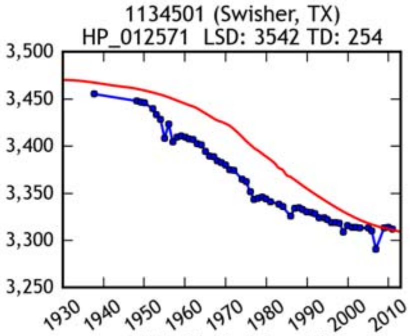


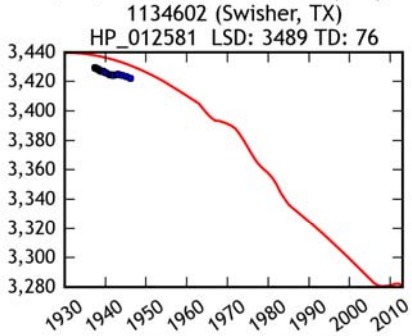
1133802 (Swisher, TX)
HP_012530 LSD: 3584 TD: 339

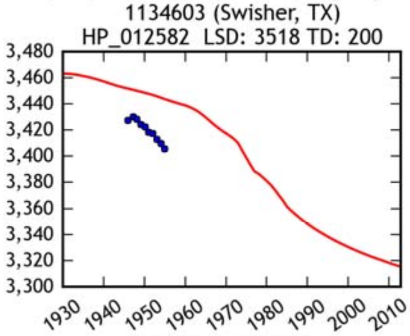


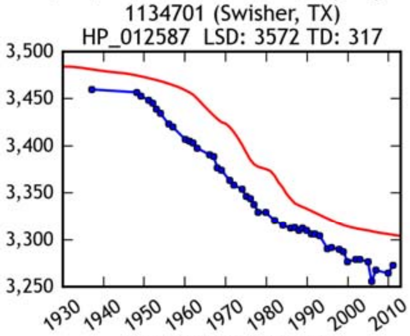

1134101 (Swisher, TX)
HP_012545 LSD: 3561 TD: 243

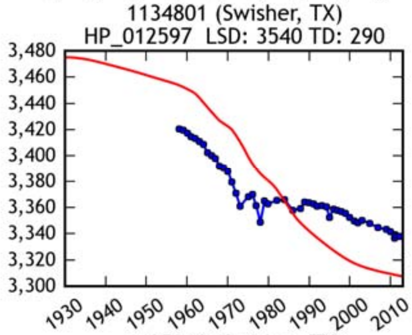

1134106 (Swisher, TX)
HP_012550 LSD: 3543 TD: 248

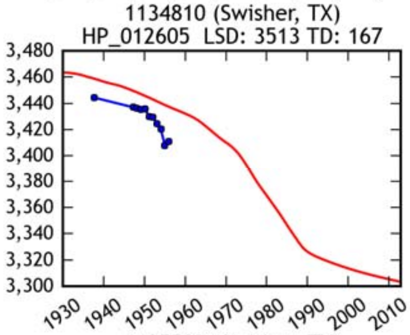

1134501 (Swisher, TX)
HP_012571 LSD: 3542 TD: 254

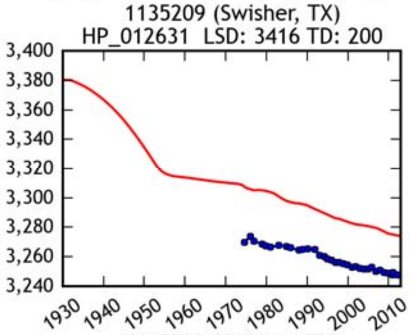

1134602 (Swisher, TX)
HP_012581 LSD: 3489 TD: 76

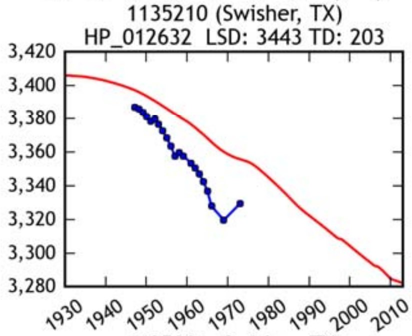

1134603 (Swisher, TX)
HP_012582 LSD: 3518 TD: 200

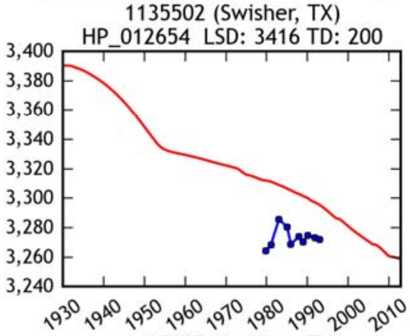

1134701 (Swisher, TX)
HP_012587 LSD: 3572 TD: 317

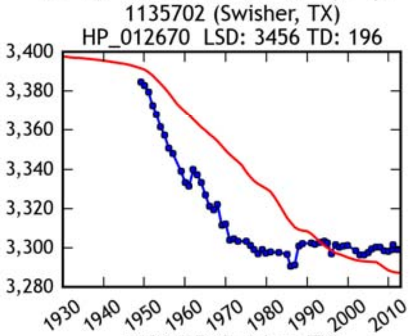

1134801 (Swisher, TX)
HP_012597 LSD: 3540 TD: 290

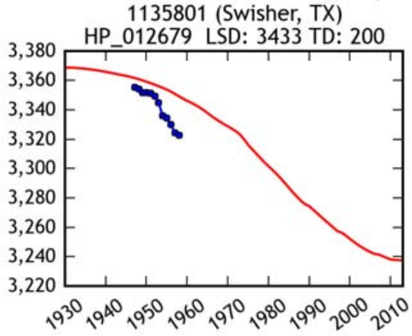

1134810 (Swisher, TX)
HP_012605 LSD: 3513 TD: 167

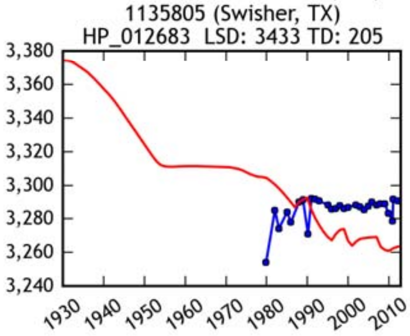

1135209 (Swisher, TX)
HP_012631 LSD: 3416 TD: 200

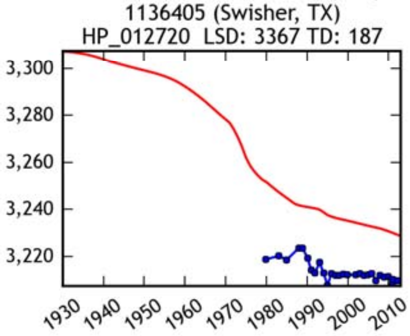

1135210 (Swisher, TX)
HP_012632 LSD: 3443 TD: 203

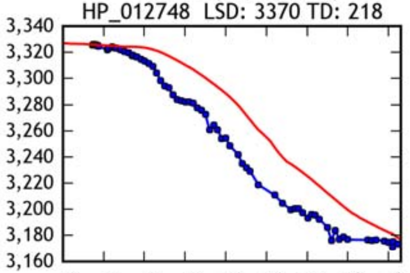

1135502 (Swisher, TX)
HP_012654 LSD: 3416 TD: 200

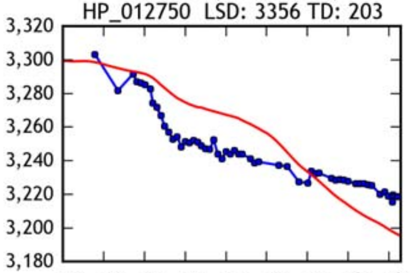

1135702 (Swisher, TX)
HP_012670 LSD: 3456 TD: 196

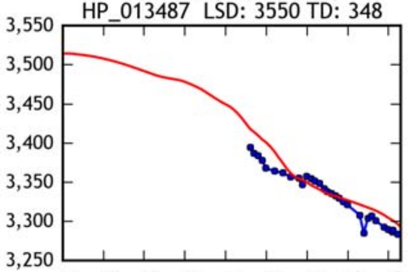

1135801 (Swisher, TX)
HP_012679 LSD: 3433 TD: 200

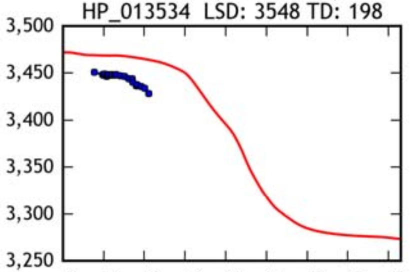

1135805 (Swisher, TX)
HP_012683 LSD: 3433 TD: 205

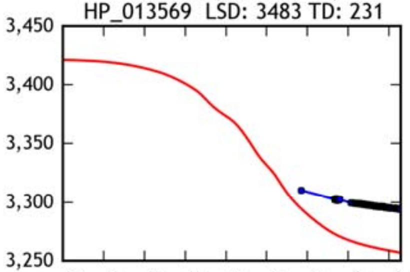

1136405 (Swisher, TX)
HP_012720 LSD: 3367 TD: 187

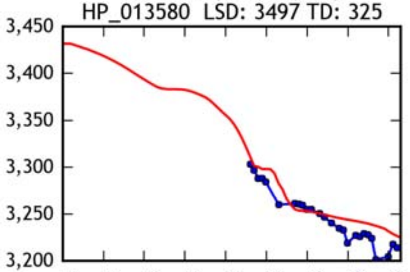

1136708 (Swisher, TX)
HP_012748 LSD: 3370 TD: 218

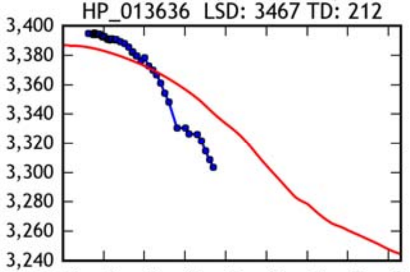

1136802 (Swisher, TX)
HP_012750 LSD: 3356 TD: 203

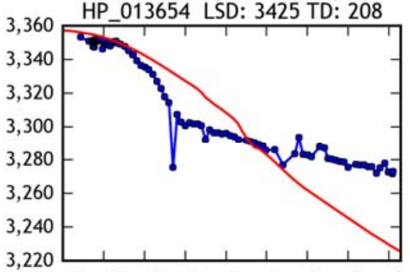

1141404 (Swisher, TX)
HP_013487 LSD: 3550 TD: 348

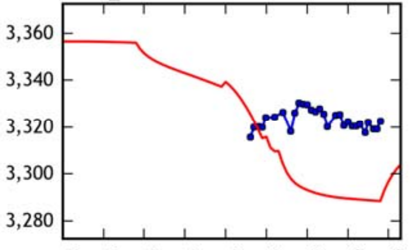

1142102 (Swisher, TX)
HP_013534 LSD: 3548 TD: 198

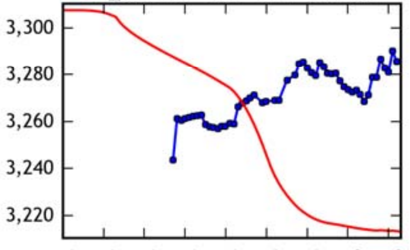

1142315 (Swisher, TX)
HP_013569 LSD: 3483 TD: 231

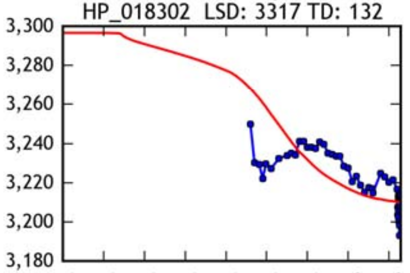

1142505 (Swisher, TX)
HP_013580 LSD: 3497 TD: 325

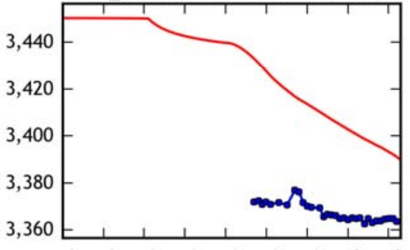

1143401 (Swisher, TX)
HP_013636 LSD: 3467 TD: 212

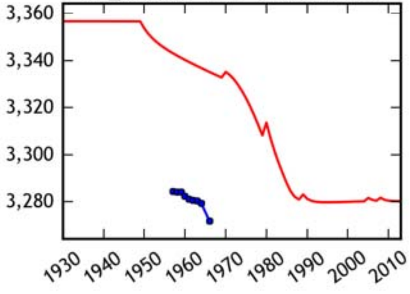

1143501 (Swisher, TX)
HP_013654 LSD: 3425 TD: 208

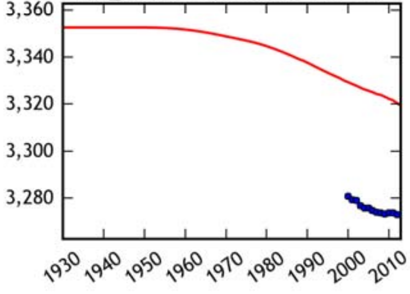

2438901 (Terry, TX)
HP_018240 LSD: 3410 TD: 142

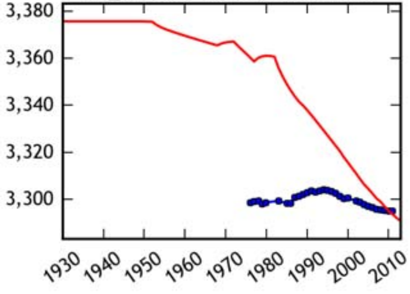

2439904 (Terry, TX)
HP_018259 LSD: 3327 TD: 150


2440701 (Terry, TX)
HP_018302 LSD: 3317 TD: 132

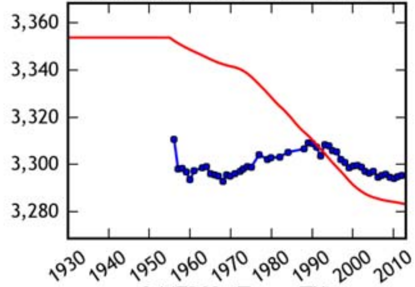

2444301 (Terry, TX)
HP_018343 LSD: 3537 TD: 200


2445601 (Terry, TX)
HP_018361 LSD: 3440 TD: 175

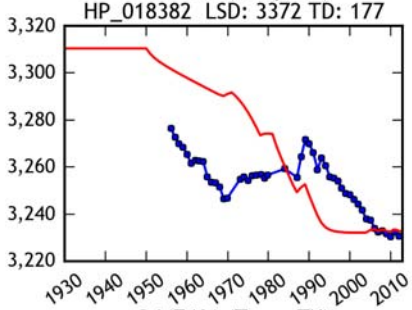

2445603 (Terry, TX)
HP_018363 LSD: 3435 TD: 185


2445801 (Terry, TX)
HP_018365 LSD: 3435 TD: 157

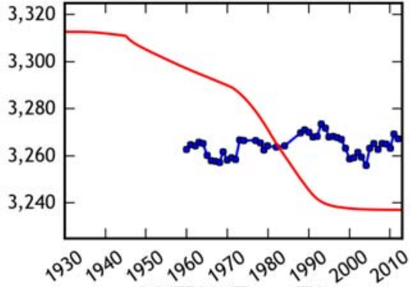
2445902 (Terry, TX)
HP_018368 LSD: 3418 TD: 160



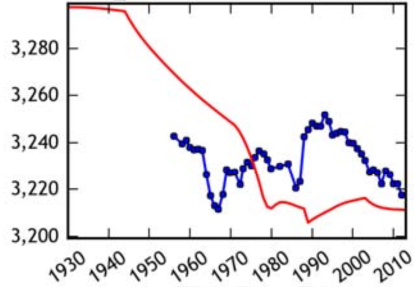
2446801 (Terry, TX)
HP_018382 LSD: 3372 TD: 177



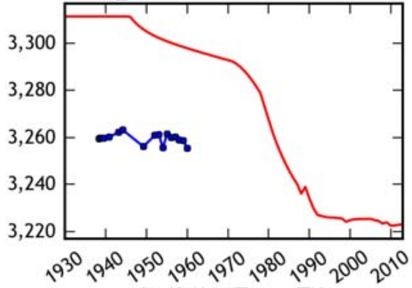
2447201 (Terry, TX)
HP_018390 LSD: 3336 TD: 88



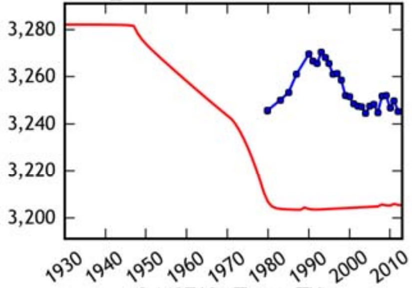
2447202 (Terry, TX)
HP_018391 LSD: 3326 TD: 149



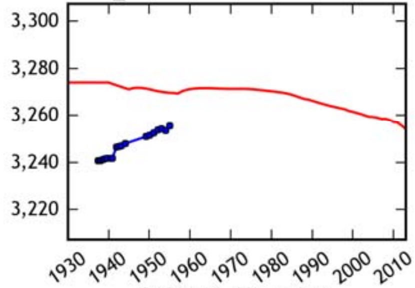
2447401 (Terry, TX)
HP_018397 LSD: 3340 TD: 90



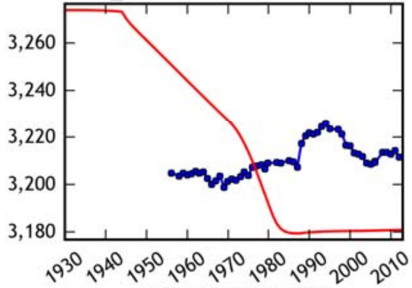
2447501 (Terry, TX)
HP_018399 LSD: 3313 TD: 132



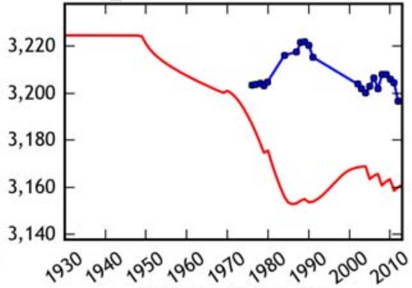
2447702 (Terry, TX)
HP_018401 LSD: 3339 TD: 114



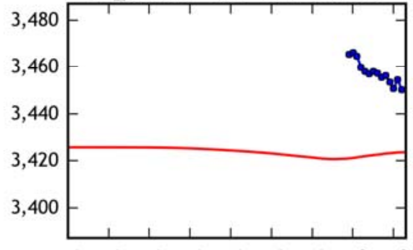
2448401 (Terry, TX)
HP_018415 LSD: 3295 TD: 140



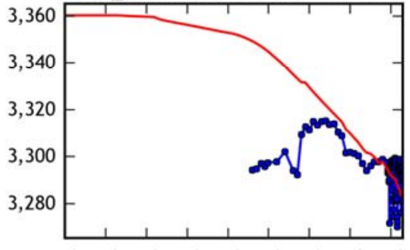
2448702 (Terry, TX)
HP_018420 LSD: 3228 TD: 105



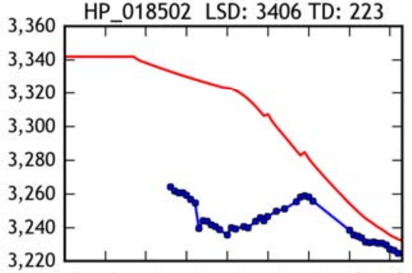
2452401 (Terry, TX)
HP_018481 LSD: 3510 TD: 123



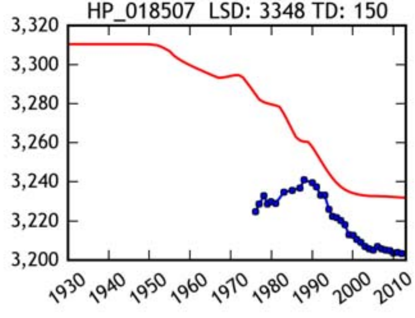
2453401 (Terry, TX)
HP_018500 LSD: 3405 TD: 143



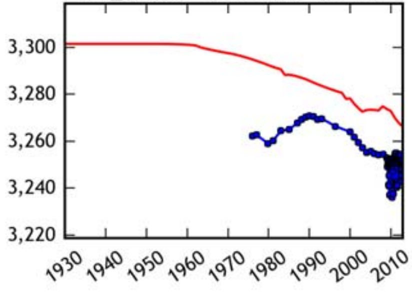
2453501 (Terry, TX)
HP_018502 LSD: 3406 TD: 223



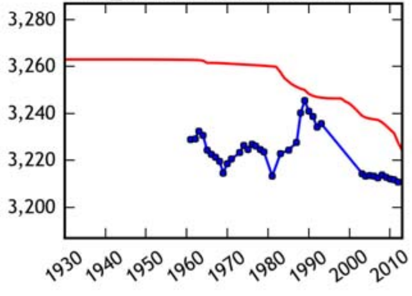
2453901 (Terry, TX)
HP_018507 LSD: 3348 TD: 150

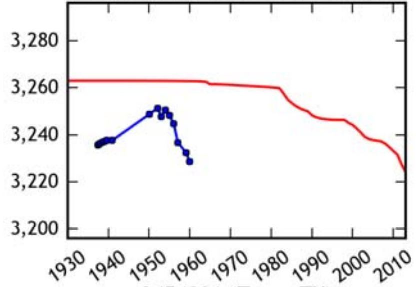


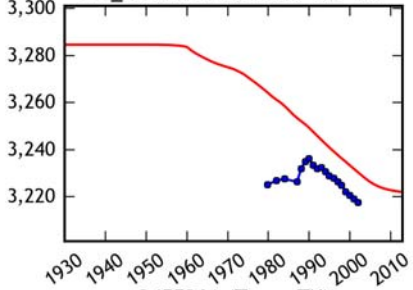
2454101 (Terry, TX)
HP_018509 LSD: 3365 TD: 129

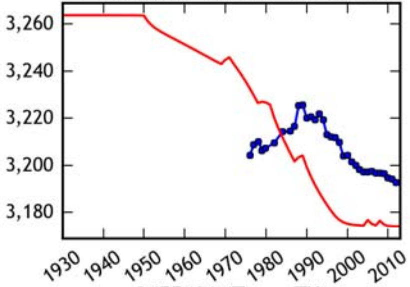


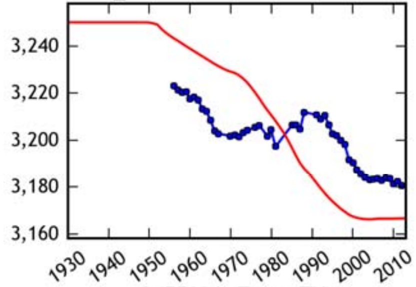
2454301 (Terry, TX)
HP_018514 LSD: 3330 TD: 137

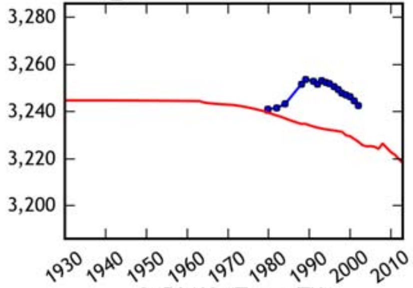


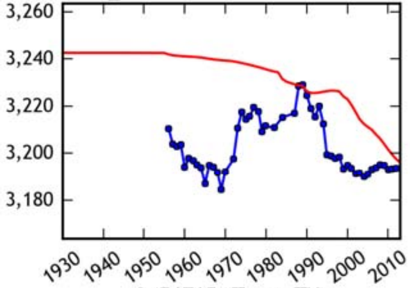

2454302 (Terry, TX)
HP_018515 LSD: 3324 TD: 102

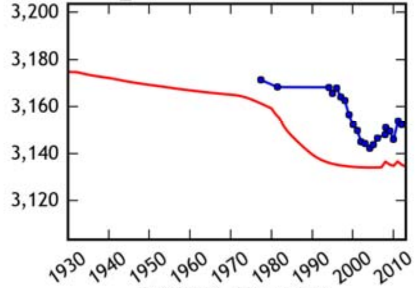

2454701 (Terry, TX)
HP_018532 LSD: 3349 TD: 153

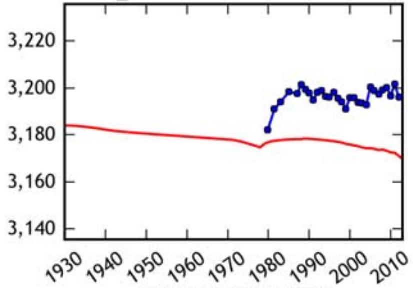

2454801 (Terry, TX)
HP_018534 LSD: 3314 TD: 166

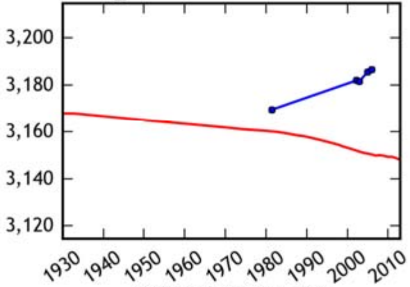

2454901 (Terry, TX)
HP_018535 LSD: 3303 TD: 160

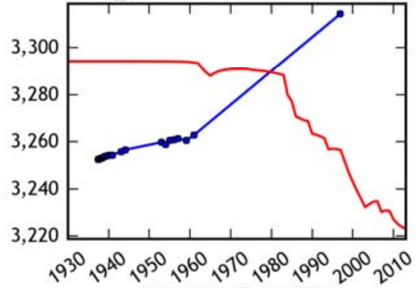

2455201 (Terry, TX)
HP_018549 LSD: 3297 TD: 104

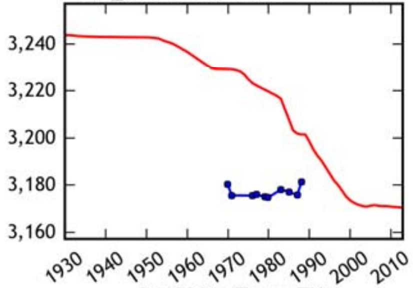

2455401 (Terry, TX)
HP_018555 LSD: 3285 TD: 110

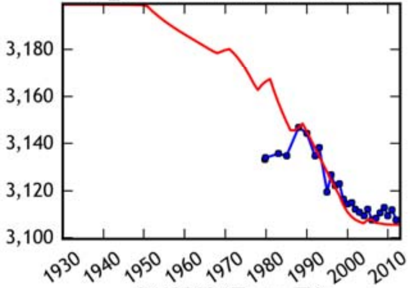

2455926 (Terry, TX)
HP_018608 LSD: 3176 TD: 63

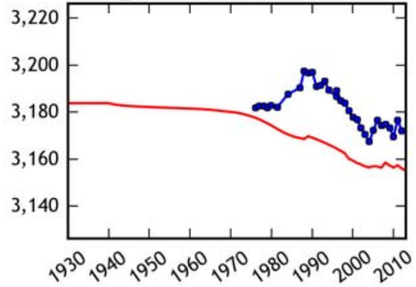

2456403 (Terry, TX)
HP_018625 LSD: 3203 TD: 55

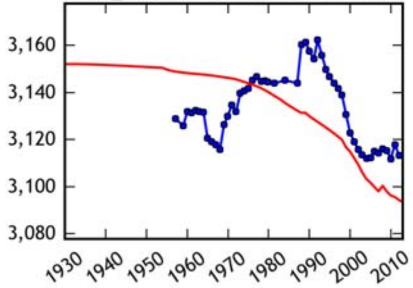

2456705 (Terry, TX)
HP_018642 LSD: 3201 TD: 36

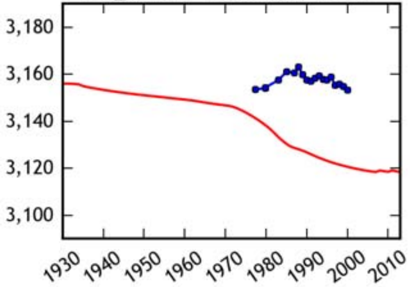

2461701 (Terry, TX)
HP_018728 LSD: 3359 TD: 120


2462401 (Terry, TX)
HP_018738 LSD: 3277 TD: 142

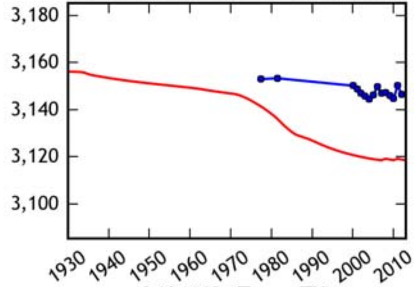

2462902 (Terry, TX)
HP_018747 LSD: 3234 TD: 130


2463201 (Terry, TX)
HP_018751 LSD: 3211 TD: 75

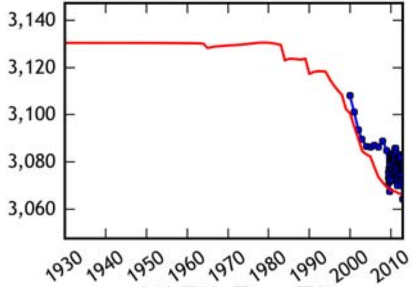

2463301 (Terry, TX)
HP_018756 LSD: 3187 TD: 105


2463302 (Terry, TX)
HP_018757 LSD: 3169 TD: 49

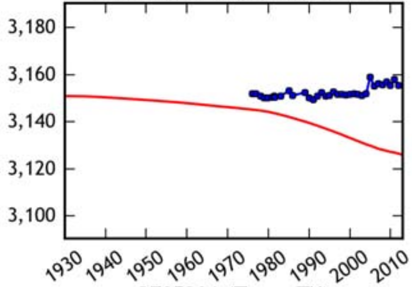
2463321 (Terry, TX)
HP_018776 LSD: 3171 TD: 58



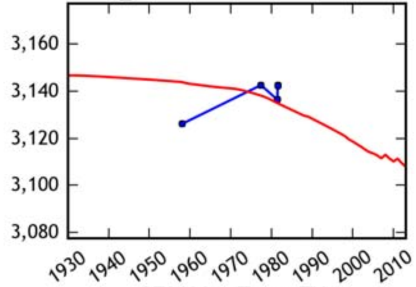
2463902 (Terry, TX)
HP_018793 LSD: 3156 TD: 116



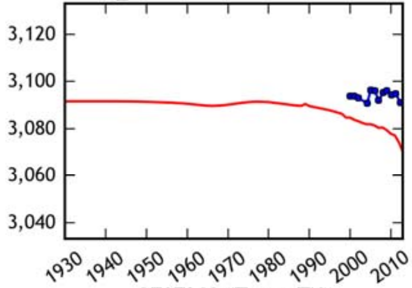
2464101 (Terry, TX)
HP_018794 LSD: 3160 TD: 31



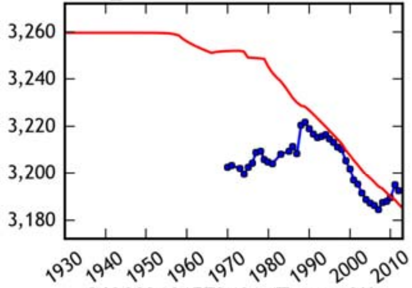
2464112 (Terry, TX)
HP_018805 LSD: 3150 TD: 48



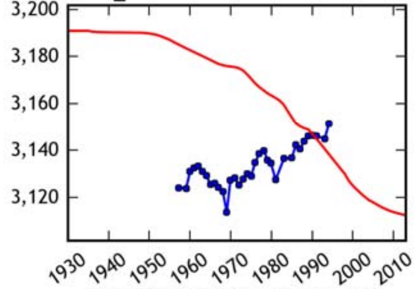
2464703 (Terry, TX)
HP_018843 LSD: 3108 TD: 55



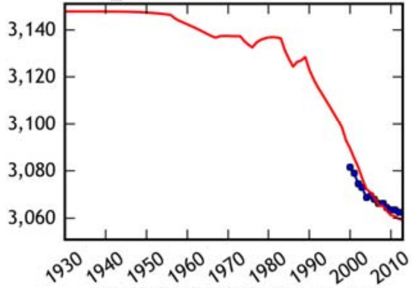
2705201 (Terry, TX)
HP_019480 LSD: 3297 TD: 155



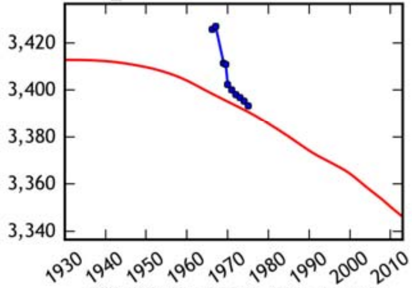
2706201 (Terry, TX)
HP_019610 LSD: 3226 TD: 113



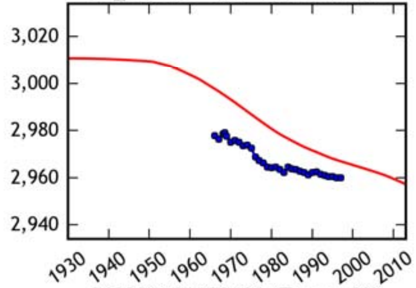
2707202 (Terry, TX)
HP_019667 LSD: 3180 TD: 140



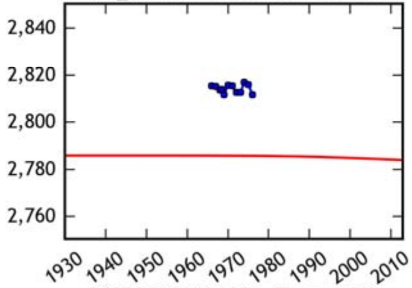
363002101573401 (Texas, OK)
HP_115354 LSD: 3564 TD: 168



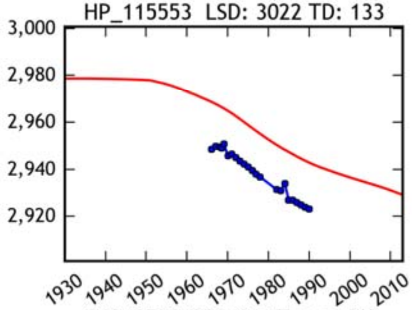
363027101282301 (Texas, OK)
HP_115423 LSD: 3175 TD: 333



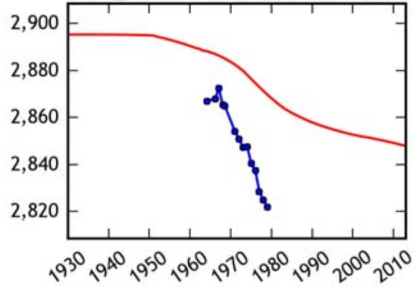
363059101023701 (Texas, OK)
HP_115517 LSD: 2857 TD: 66



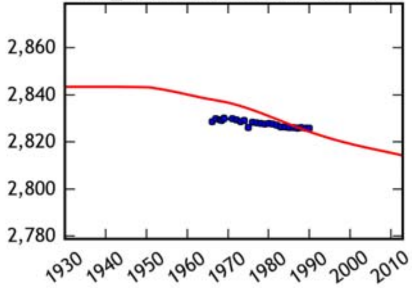
363107101261501 (Texas, OK)
HP_115553 LSD: 3022 TD: 133



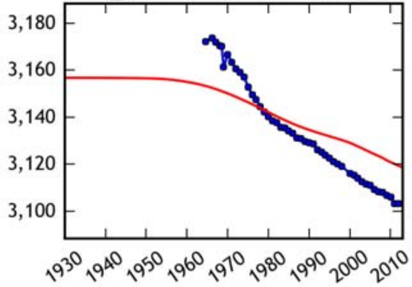
363231101180401 (Texas, OK)
HP_115801 LSD: 3057 TD: 425



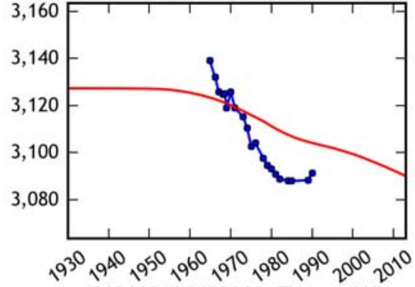
363338101131801 (Texas, OK)
HP_115983 LSD: 2965 TD: 180



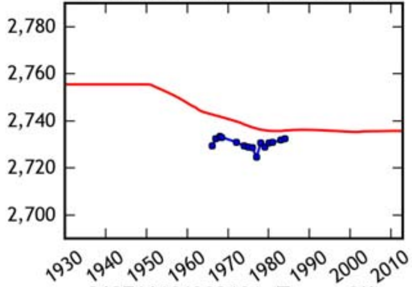
363405101390401 (Texas, OK)
HP_116062 LSD: 3327 TD: 402



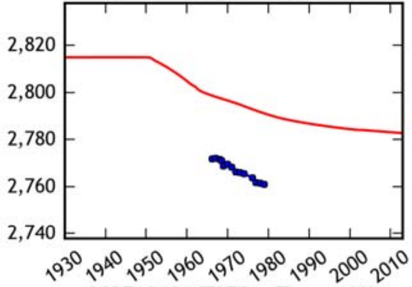
363459101370001 (Texas, OK)
HP_116242 LSD: 3280 TD: 310



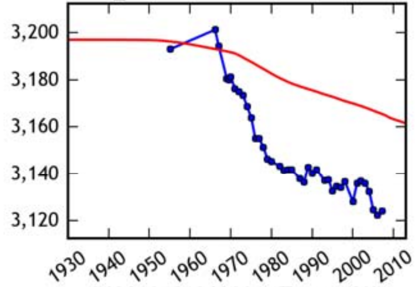
363539101064901 (Texas, OK)
HP_116366 LSD: 2834 TD: 118



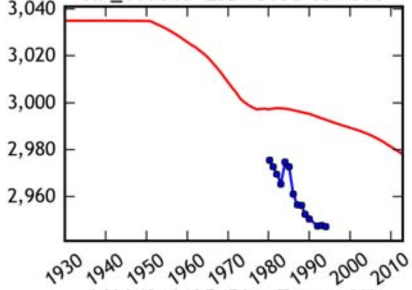
363559101121501 (Texas, OK)
HP_116417 LSD: 2940 TD: 280



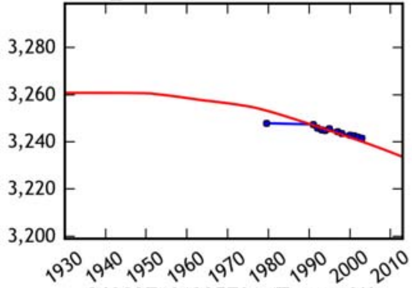
363632101423901 (Texas, OK)
HP_116508 LSD: 3416 TD: 332



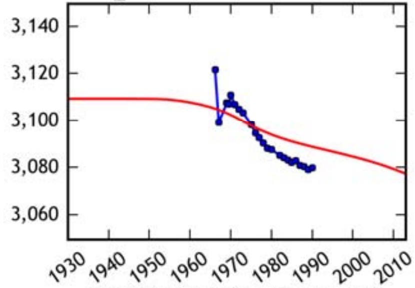
363716101303101 (Texas, OK)
HP_116648 LSD: 3138 TD: 360



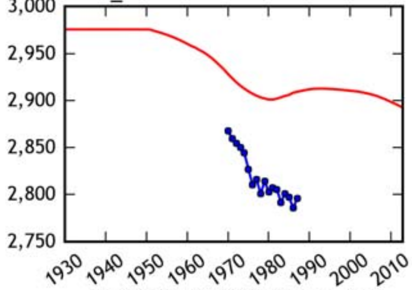
363718101473501 (Texas, OK)
HP_116652 LSD: 3380 TD: 280



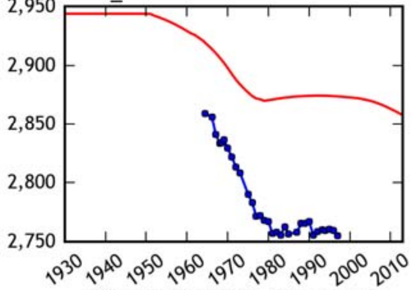
363819101363001 (Texas, OK)
HP_116837 LSD: 3276 TD: 300



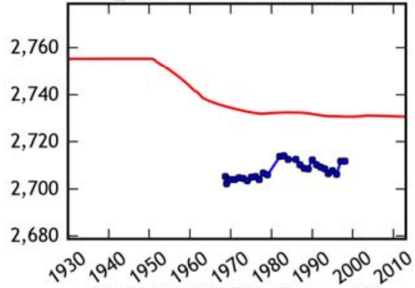
363843101254501 (Texas, OK)
HP_116895 LSD: 3078 TD: 410



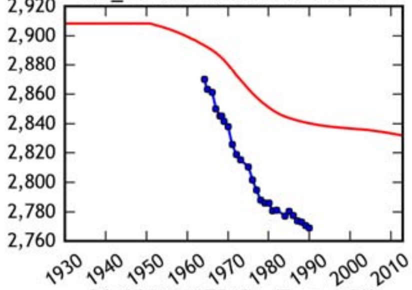
363927101225701 (Texas, OK)
HP_117010 LSD: 3061 TD: 480



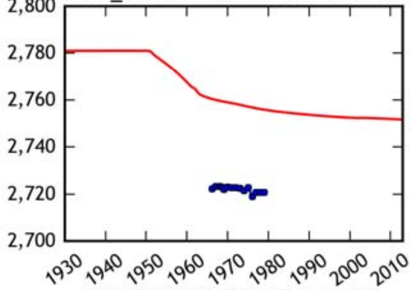
363938101090101 (Texas, OK)
HP_117049 LSD: 2789 TD: 117



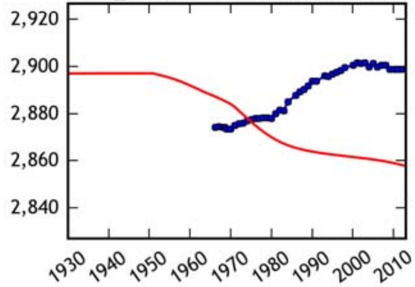
364003101201901 (Texas, OK)
HP_117125 LSD: 3021 TD: 435



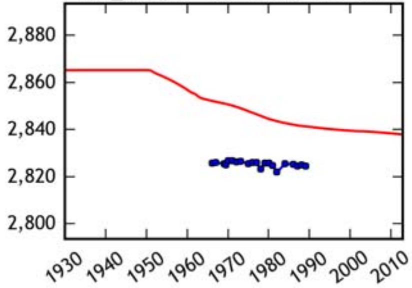
364045101105601 (Texas, OK)
HP_117237 LSD: 2815 TD: 108



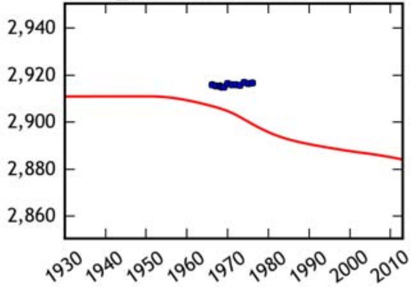
364202101195501 (Texas, OK)
HP_117395 LSD: 2990 TD: 148



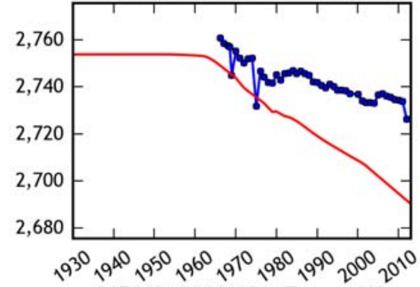
364301101175401 (Texas, OK)
HP_117529 LSD: 2830 TD: 122



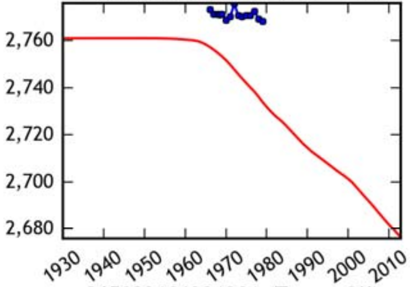
364531101194701 (Texas, OK)
HP_117919 LSD: 2996 TD: 99



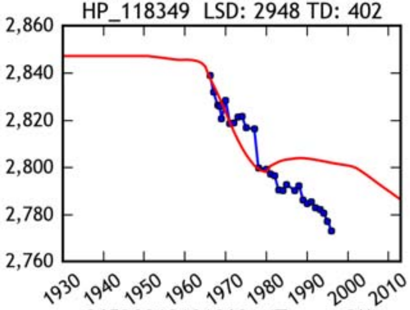
364658101044301 (Texas, OK)
HP_118131 LSD: 2855 TD: 355



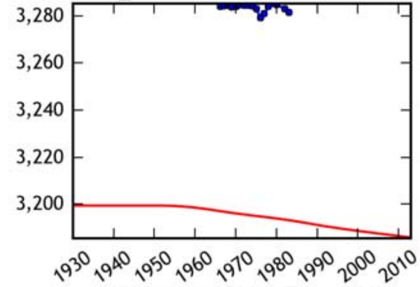
364822101043101 (Texas, OK)
HP_118348 LSD: 2888 TD: 141



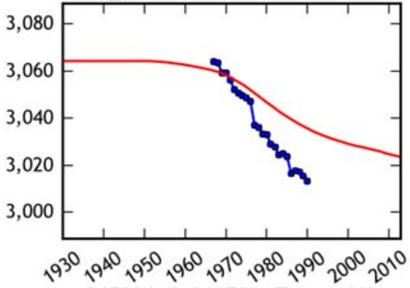
364822101121101 (Texas, OK)
HP_118349 LSD: 2948 TD: 402



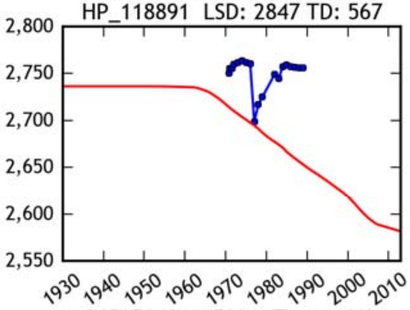
365009101444101 (Texas, OK)
HP_118614 LSD: 3415 TD: 175



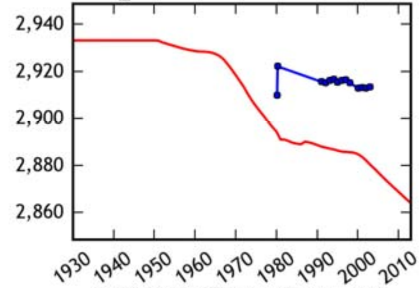
365032101321201 (Texas, OK)
HP_118668 LSD: 3248 TD: 363



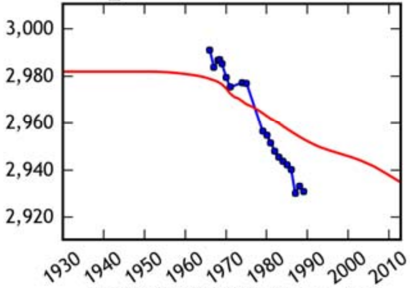
365208101010601 (Texas, OK)
HP_118891 LSD: 2847 TD: 567



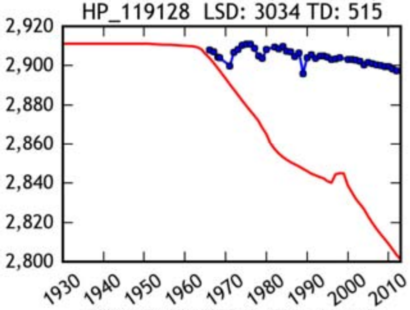
365224101165801 (Texas, OK)
HP_118930 LSD: 3046 TD: 360



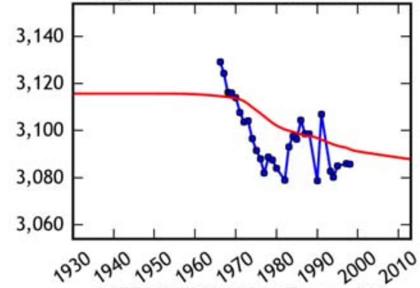
365336101214701 (Texas, OK)
HP_119086 LSD: 3116 TD: 197



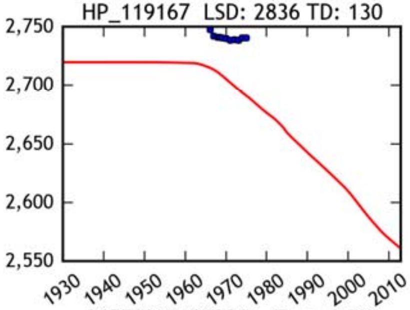
365358101145301 (Texas, OK)
HP_119128 LSD: 3034 TD: 515



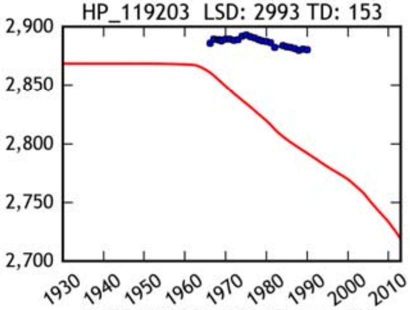
365358101371201 (Texas, OK)
HP_119131 LSD: 3335 TD: 350



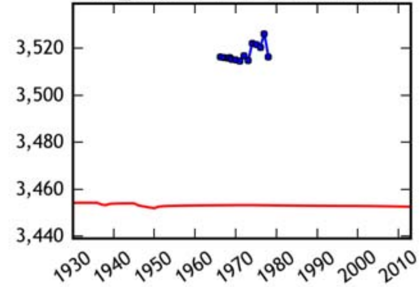
365421100584201 (Texas, OK)
HP_119167 LSD: 2836 TD: 130



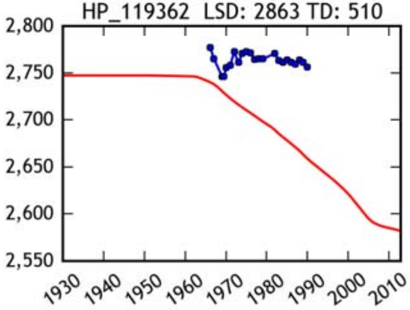
365427101111501 (Texas, OK)
HP_119203 LSD: 2993 TD: 153



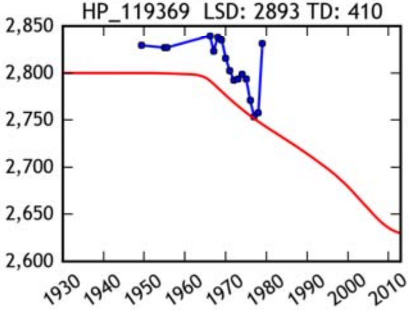
365500102013901 (Texas, OK)
HP_119271 LSD: 3732 TD: 249



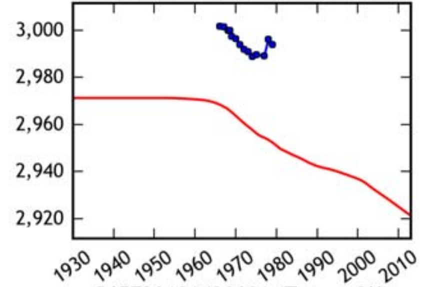
365539101002301 (Texas, OK)
HP_119362 LSD: 2863 TD: 510



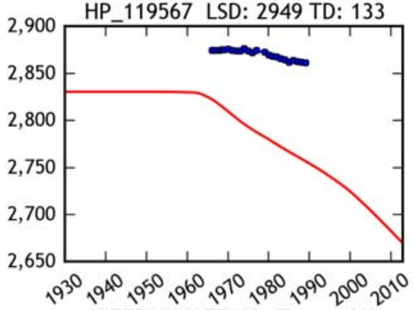
365541101044001 (Texas, OK)
HP_119369 LSD: 2893 TD: 410



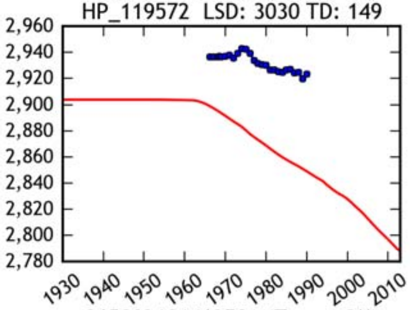
365605101203601 (Texas, OK)
HP_119434 LSD: 3131 TD: 165



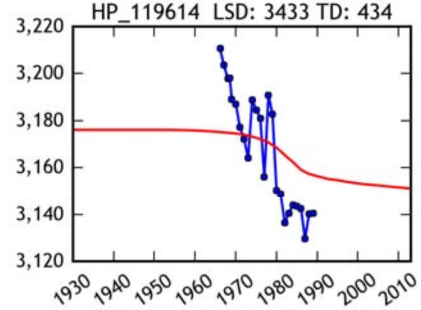
365704101070301 (Texas, OK)
HP_119567 LSD: 2949 TD: 133



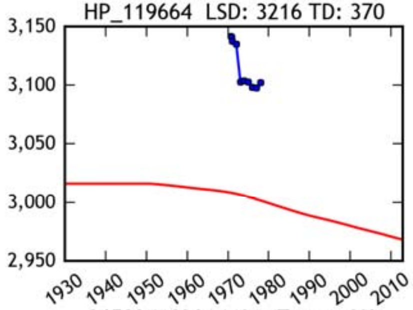
365706101134001 (Texas, OK)
HP_119572 LSD: 3030 TD: 149



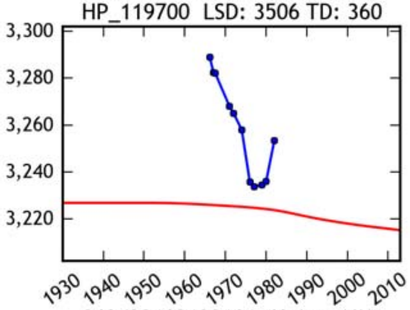
365730101420601 (Texas, OK)
HP_119614 LSD: 3433 TD: 434



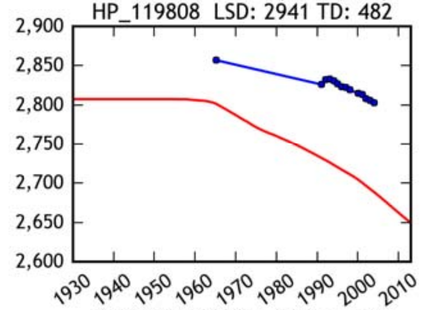
365751101275802 (Texas, OK)
HP_119664 LSD: 3216 TD: 370



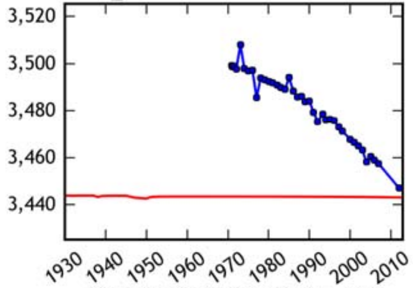
365802101462501 (Texas, OK)
HP_119700 LSD: 3506 TD: 360



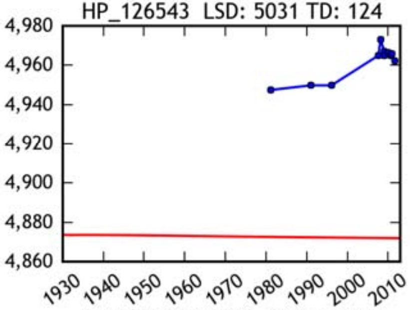
365911101042301 (Texas, OK)
HP_119808 LSD: 2941 TD: 482



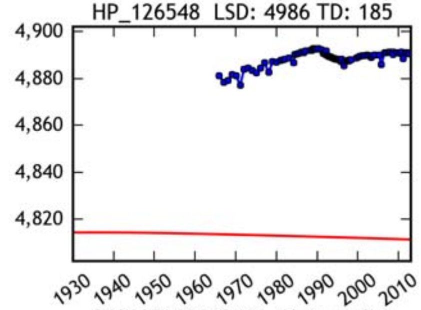
365934102014401 (Texas, OK)
HP_119843 LSD: 3694 TD: 272



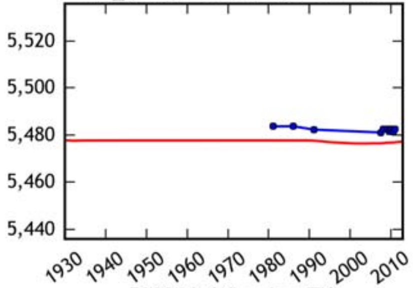
362422103123101 (Union, NM)
HP_126543 LSD: 5031 TD: 124



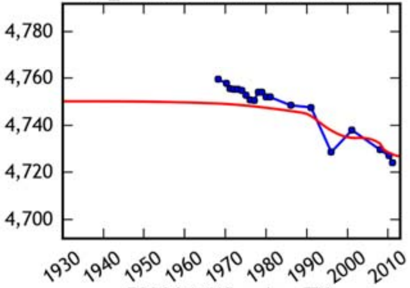
362540103095001 (Union, NM)
HP_126548 LSD: 4986 TD: 185



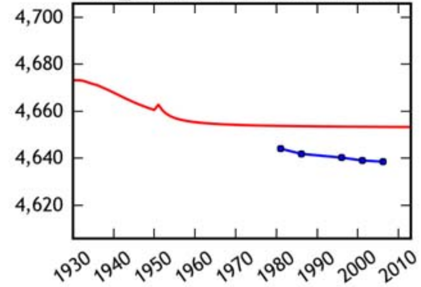
362919103282001 (Union, NM)
HP_126571 LSD: 5608 TD: 121



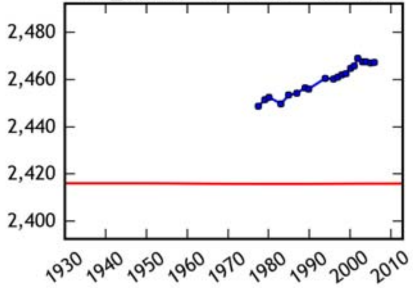
363320103062601 (Union, NM)
HP_126588 LSD: 4852 TD: 188



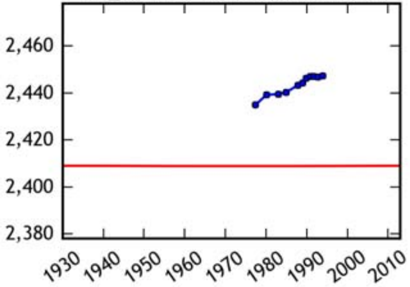
363808103013401 (Union, NM)
HP_126610 LSD: 4759 TD: 138



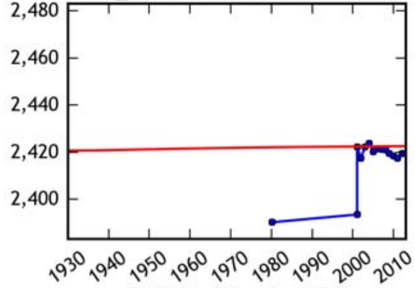
532206 (Wheeler, TX)
HP_002869 LSD: 2538 TD: 188



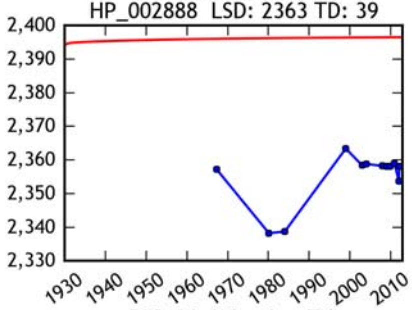
532304 (Wheeler, TX)
HP_002873 LSD: 2550 TD: 215



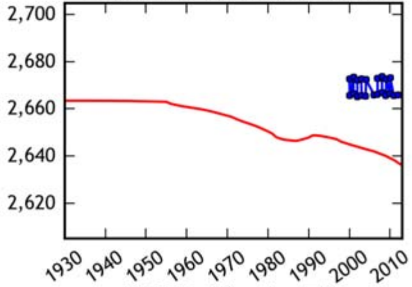
532601 (Wheeler, TX)
HP_002881 LSD: 2491 TD: 111



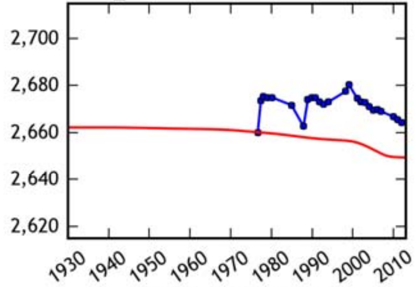
532801 (Wheeler, TX)
HP_002888 LSD: 2363 TD: 39



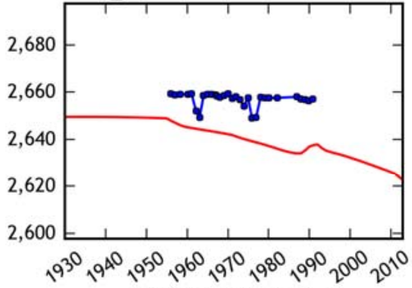
528303 (Wheeler, TX)
HP_003118 LSD: 2969 TD: 390



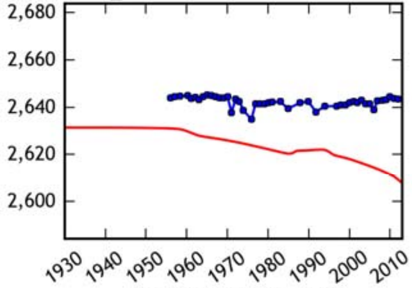
528902 (Wheeler, TX)
HP_003133 LSD: 2701 TD: 220



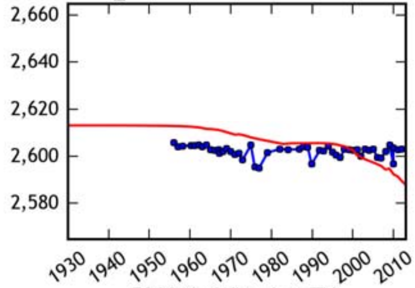
529101 (Wheeler, TX)
HP_003135 LSD: 2820 TD: 350



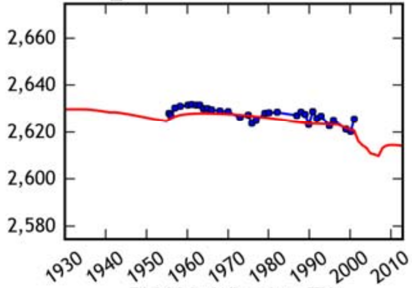
529201 (Wheeler, TX)
HP_003138 LSD: 2782 TD: 280



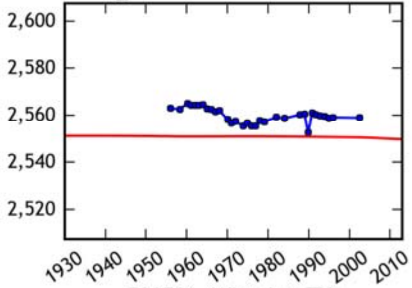
529301 (Wheeler, TX)
HP_003140 LSD: 2724 TD: 335



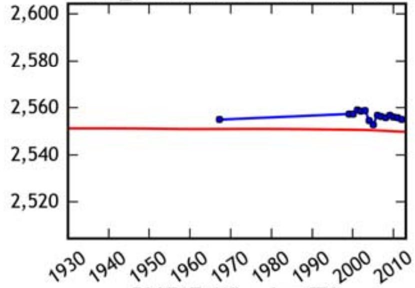
529502 (Wheeler, TX)
HP_003150 LSD: 2730 TD: 458



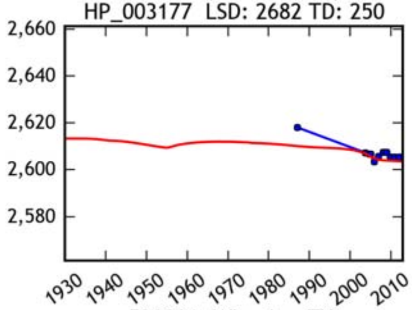
529802 (Wheeler, TX)
HP_003163 LSD: 2581 TD: 83



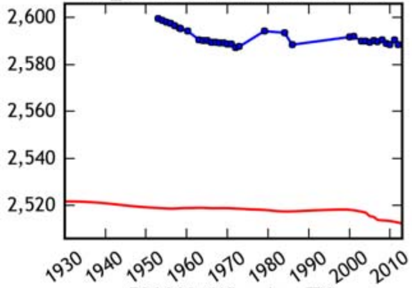
529812 (Wheeler, TX)
HP_003169 LSD: 2574 TD: 99



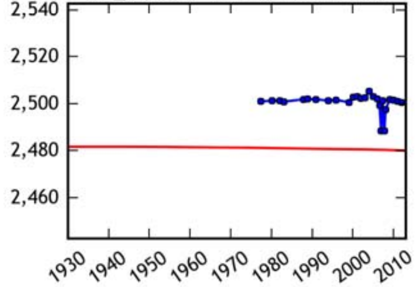
529820 (Wheeler, TX)
HP_003177 LSD: 2682 TD: 250



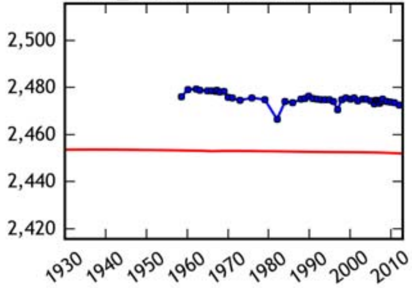
530501 (Wheeler, TX)
HP_003220 LSD: 2692 TD: 153



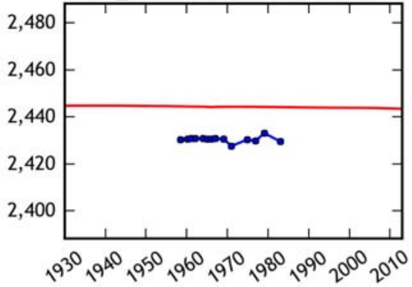
530707 (Wheeler, TX)
HP_003236 LSD: 2512 TD: 110

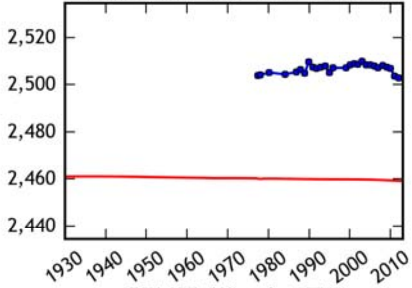


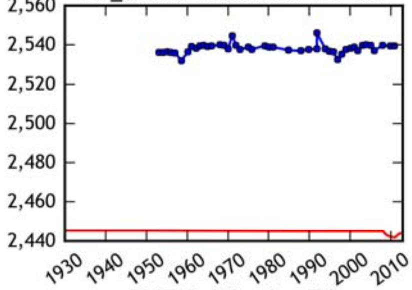
530801 (Wheeler, TX)
HP_003237 LSD: 2541 TD: 93

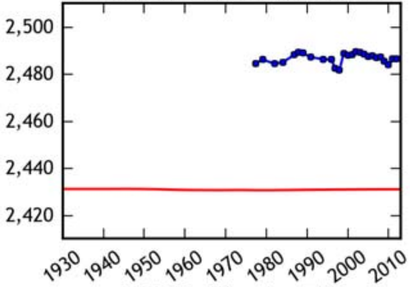


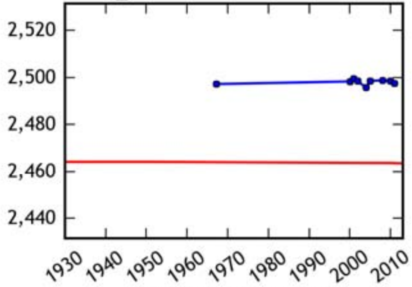
530802 (Wheeler, TX)
HP_003238 LSD: 2500 TD: 96

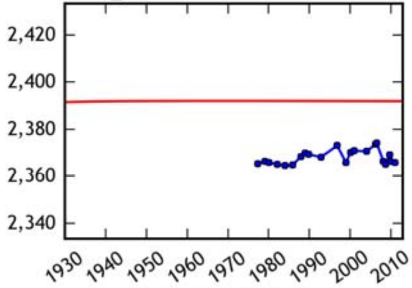


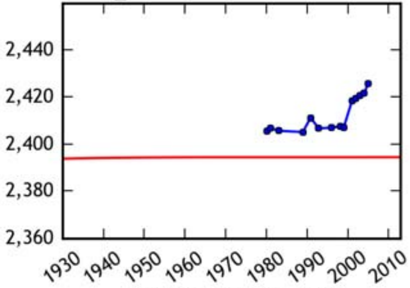

530903 (Wheeler, TX)
HP_003247 LSD: 2587 TD: 280

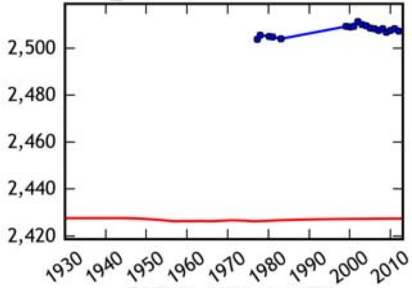

531201 (Wheeler, TX)
HP_003254 LSD: 2650 TD: 157

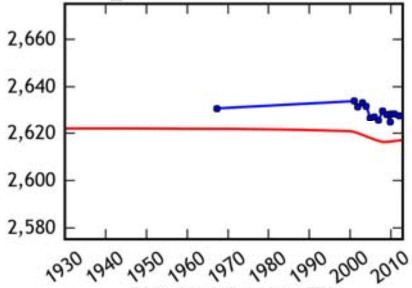

531307 (Wheeler, TX)
HP_003265 LSD: 2540 TD: 280

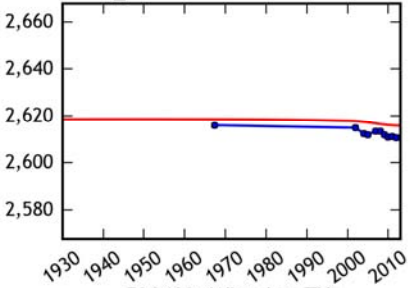

531405 (Wheeler, TX)
HP_003270 LSD: 2505 TD: 20

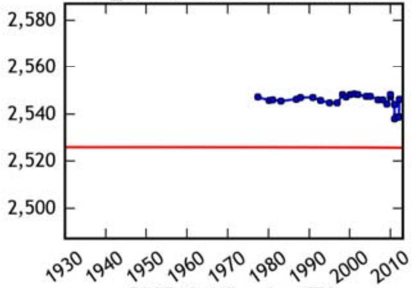

531703 (Wheeler, TX)
HP_003285 LSD: 2470 TD: 214

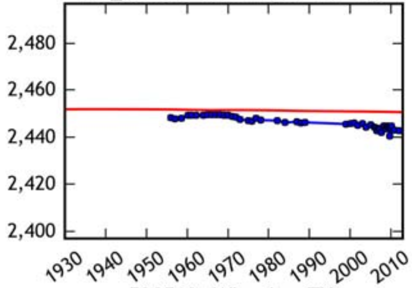

531902 (Wheeler, TX)
HP_003291 LSD: 2477 TD: 95

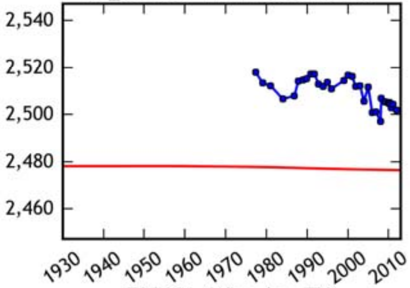

532107 (Wheeler, TX)
HP_003301 LSD: 2557 TD: 202

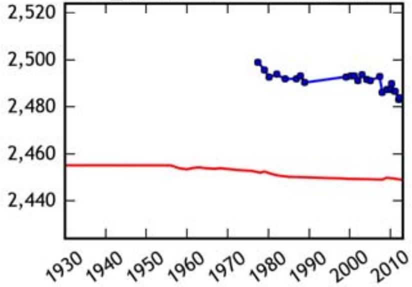

537101 (Wheeler, TX)
HP_003364 LSD: 2710 TD: 120

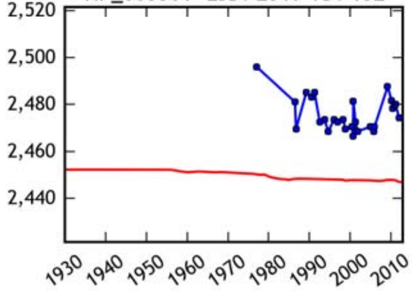

537102 (Wheeler, TX)
HP_003365 LSD: 2669 TD: 74

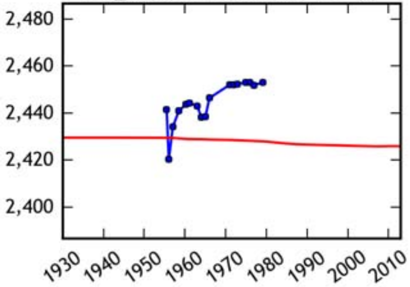

537311 (Wheeler, TX)
HP_003406 LSD: 2575 TD: 130

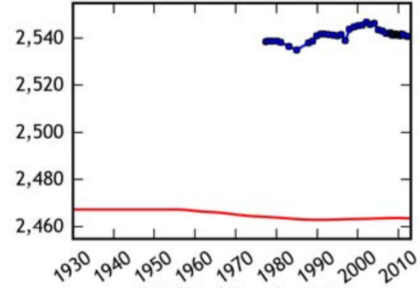

538101 (Wheeler, TX)
HP_003421 LSD: 2456 TD: 140

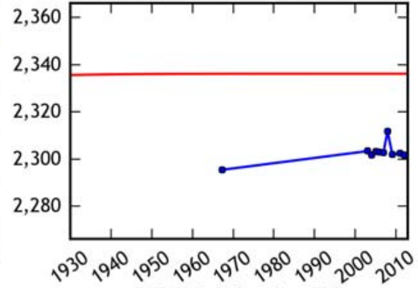

538409 (Wheeler, TX)
HP_003489 LSD: 2588 TD: 157

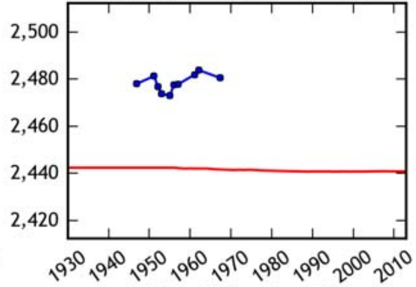

538510 (Wheeler, TX)
HP_003499 LSD: 2512 TD: 128

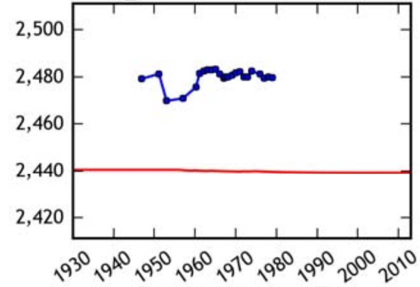

538512 (Wheeler, TX)
HP_003501 LSD: 2519 TD: 132

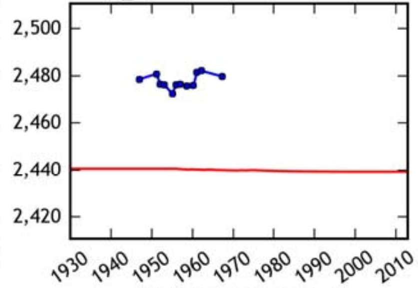

538601 (Wheeler, TX)
HP_003504 LSD: 2451 TD: 95

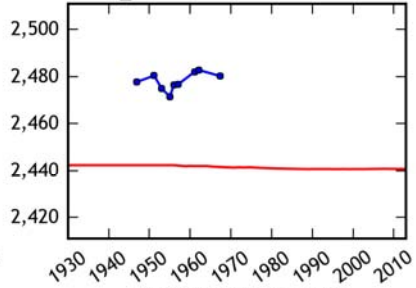

538610 (Wheeler, TX)
HP_003511 LSD: 2610 TD: 165

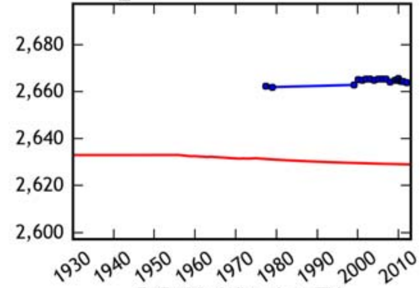

539302 (Wheeler, TX)
HP_003538 LSD: 2352 TD: 61

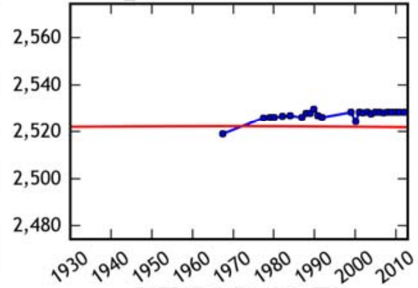

539701 (Wheeler, TX)
HP_003556 LSD: 2509 TD: 48

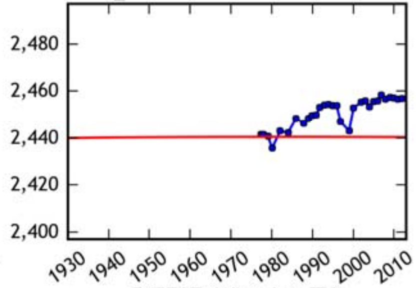

539702 (Wheeler, TX)
HP_003557 LSD: 2518 TD: 65

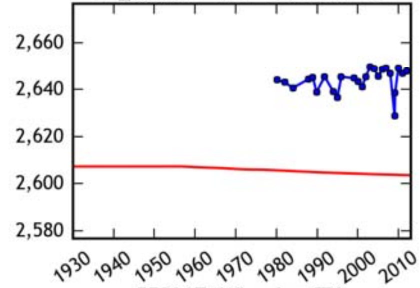

539703 (Wheeler, TX)
HP_003558 LSD: 2506 TD: 50

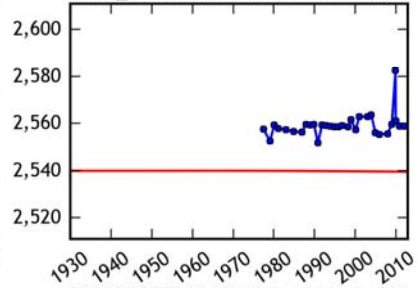

539704 (Wheeler, TX)
HP_003559 LSD: 2498 TD: 36

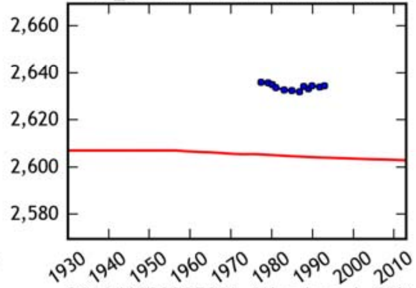

544906 (Wheeler, TX)
HP_003688 LSD: 2772 TD: 200

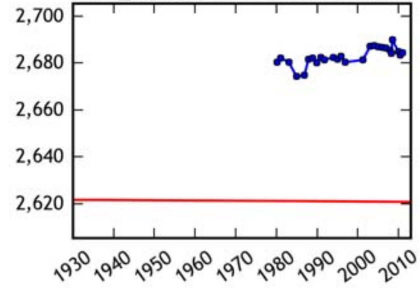

545103 (Wheeler, TX)
HP_003693 LSD: 2531 TD: 71

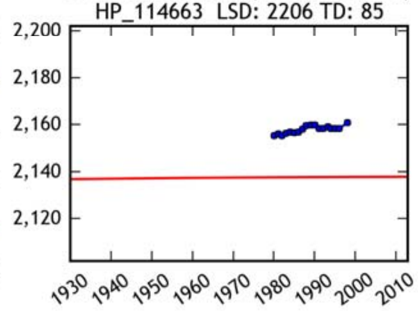

545204 (Wheeler, TX)
HP_003699 LSD: 2570 TD: 225

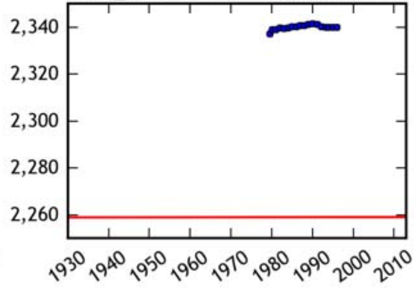

545408 (Wheeler, TX)
HP_003707 LSD: 2754 TD: 200


545505 (Wheeler, TX)
HP_003712 LSD: 2673 TD: 150

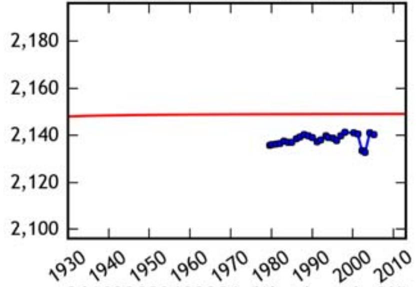

545707 (Wheeler, TX)
HP_003723 LSD: 2673 TD: 135


552307 (Wheeler, TX)
HP_003821 LSD: 2760 TD: 120

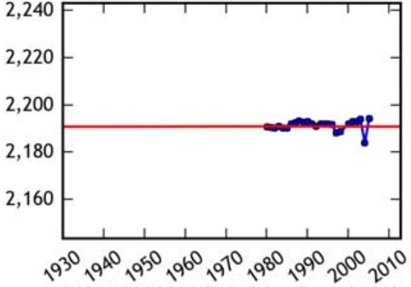

361128099210601 (Woodward, OK)
HP_114663 LSD: 2206 TD: 85


361146099395001 (Woodward, OK)
HP_114665 LSD: 2463 TD: 144

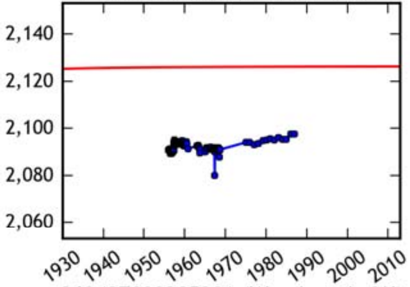
361605099253201 (Woodward, OK)
HP_114815 LSD: 2179 TD: unk



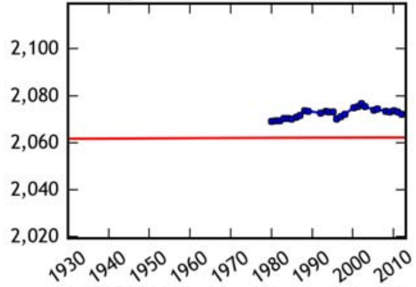
361748099334101 (Woodward, OK)
HP_114911 LSD: 2323 TD: unk



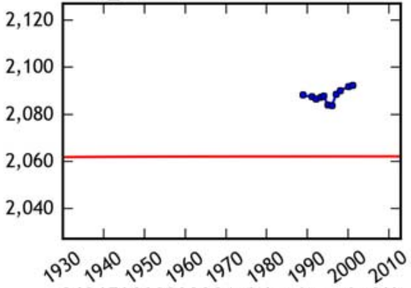
361810099242201 (Woodward, OK)
HP_114920 LSD: 2154 TD: 32



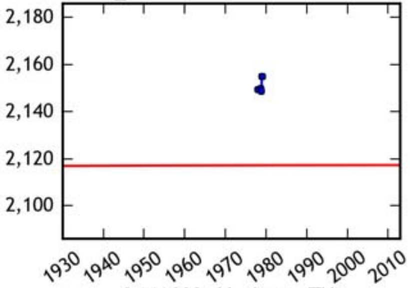
361833099192201 (Woodward, OK)
HP_114937 LSD: 2100 TD: 58



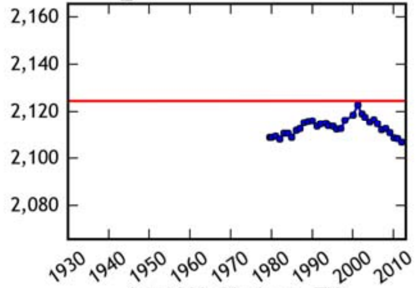
362216099223601 (Woodward, OK)
HP_115099 LSD: 2098 TD: unk



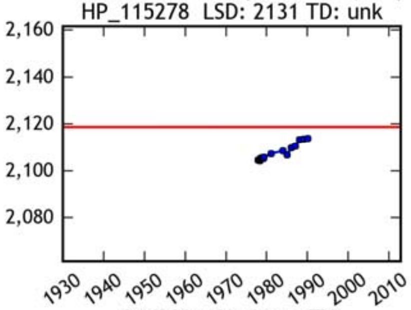
362437099285301 (Woodward, OK)
HP_115200 LSD: 2207 TD: 96



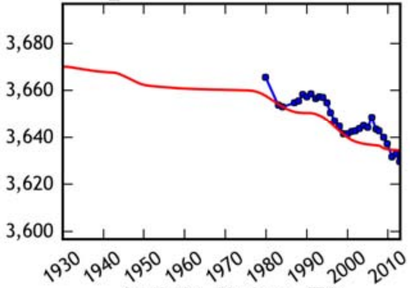
362658099321801 (Woodward, OK)
HP_115277 LSD: 2134 TD: 51



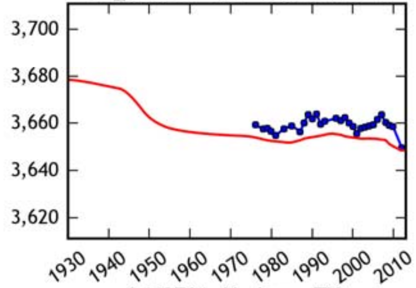
362659099322201 (Woodward, OK)
HP_115278 LSD: 2131 TD: unk



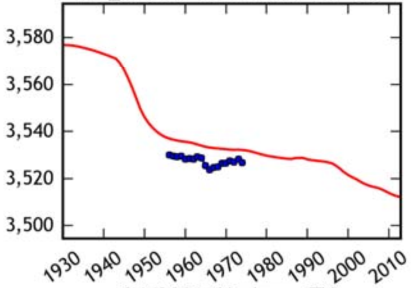
2441602 (Yoakum, TX)
HP_018317 LSD: 3748 TD: 155



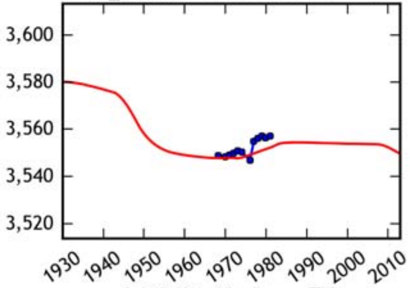
2441802 (Yoakum, TX)
HP_018320 LSD: 3731 TD: 118



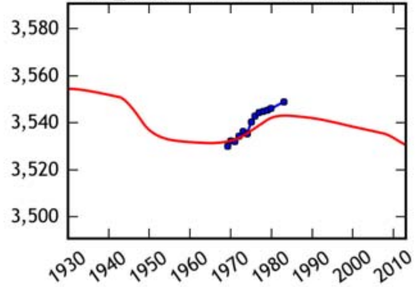
2442901 (Yoakum, TX)
HP_018329 LSD: 3646 TD: 178



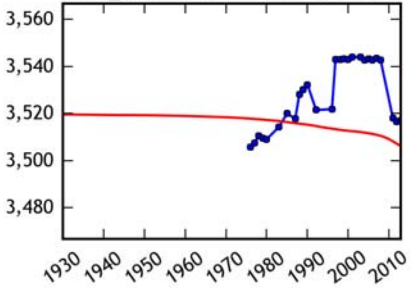
2443401 (Yoakum, TX)
HP_018332 LSD: 3661 TD: 145



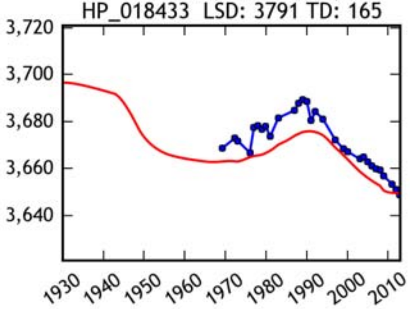
2443701 (Yoakum, TX)
HP_018336 LSD: 3628 TD: 150



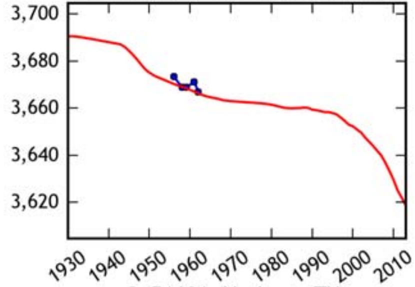
2443801 (Yoakum, TX)
HP_018337 LSD: 3601 TD: 140



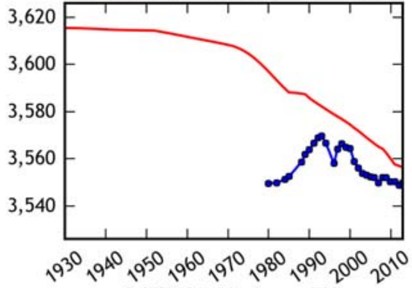
2449401 (Yoakum, TX)
HP_018433 LSD: 3791 TD: 165



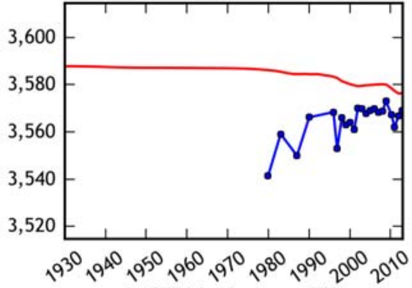
2449701 (Yoakum, TX)
HP_018436 LSD: 3776 TD: 167



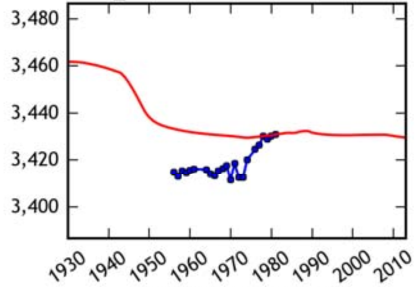
2450204 (Yoakum, TX)
HP_018448 LSD: 3705 TD: 190



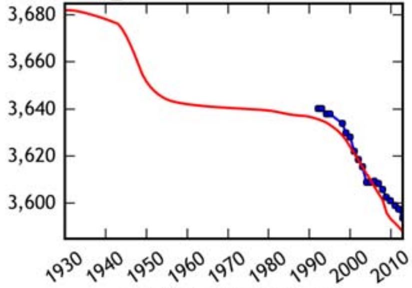
2450501 (Yoakum, TX)
HP_018456 LSD: 3611 TD: 80



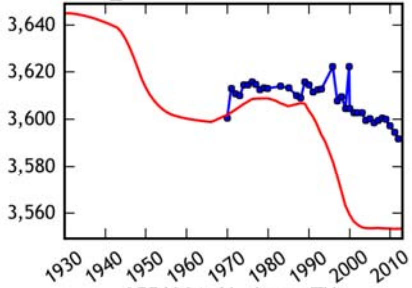
2451601 (Yoakum, TX)
HP_018469 LSD: 3570 TD: 185



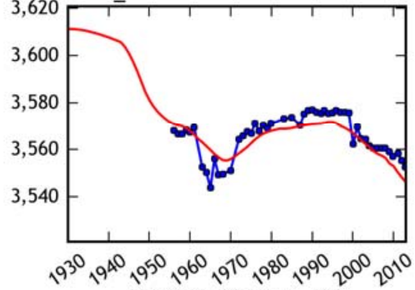
2457101 (Yoakum, TX)
HP_018649 LSD: 3737 TD: 186



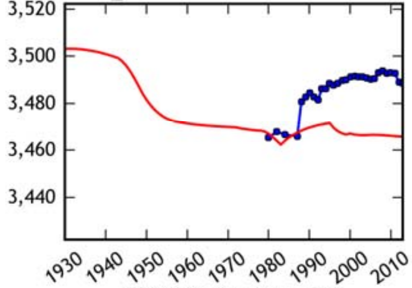
2457501 (Yoakum, TX)
HP_018655 LSD: 3662 TD: 112



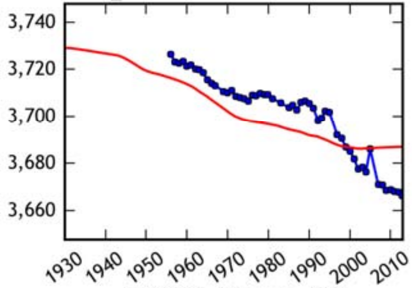
2458101 (Yoakum, TX)
HP_018666 LSD: 3661 TD: 148



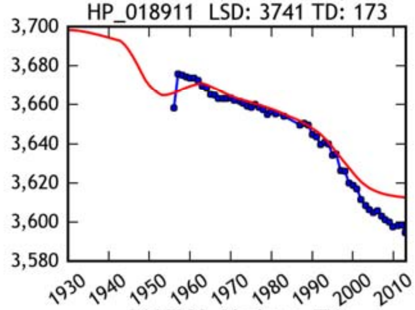
2459201 (Yoakum, TX)
HP_018683 LSD: 3547 TD: 132



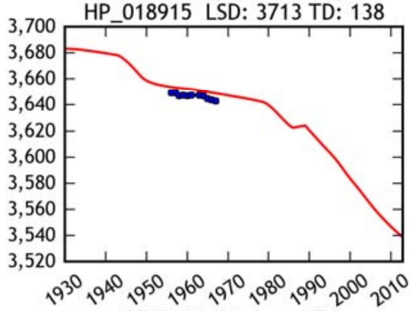
2556201 (Yoakum, TX)
HP_018902 LSD: 3792 TD: 136



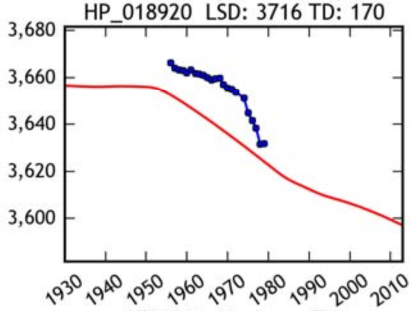
2564301 (Yoakum, TX)
HP_018911 LSD: 3741 TD: 173



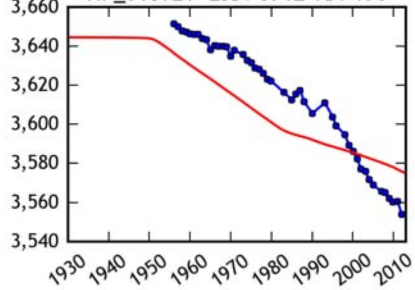
2564601 (Yoakum, TX)
HP_018915 LSD: 3713 TD: 138



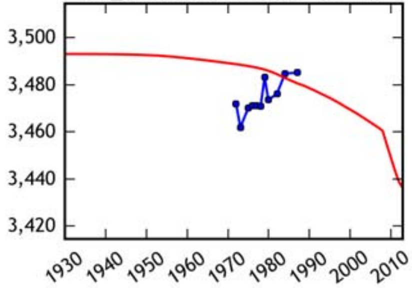
2608201 (Yoakum, TX)
HP_018920 LSD: 3716 TD: 170



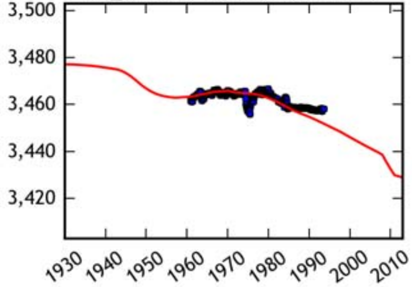
2608202 (Yoakum, TX)
HP_018921 LSD: 3712 TD: 170



2702201 (Yoakum, TX)
HP_019210 LSD: 3570 TD: 167



2702301 (Yoakum, TX)
HP_019217 LSD: 3530 TD: 137

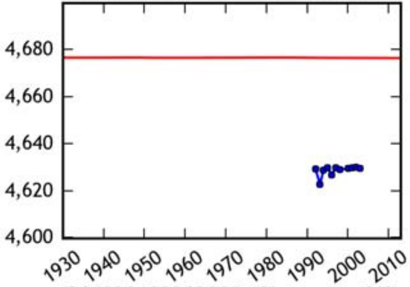


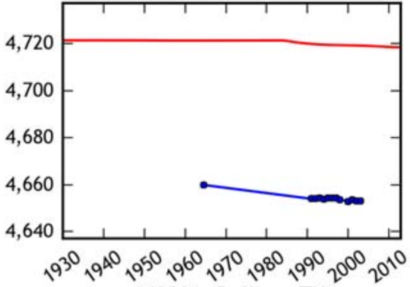
This page intentionally left blank.

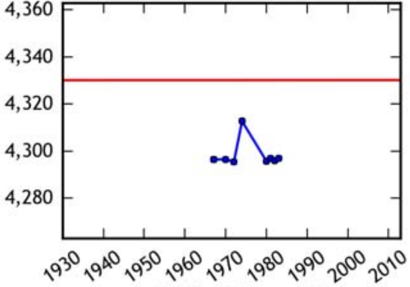
B.2 Rita Blanca Aquifer Hydrographs

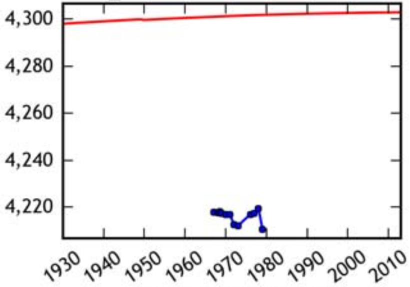
This section contains the observed and simulated hydrographs for the Rita Blanca Aquifer.

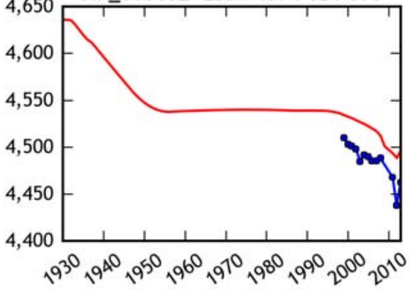
This page intentionally left blank.

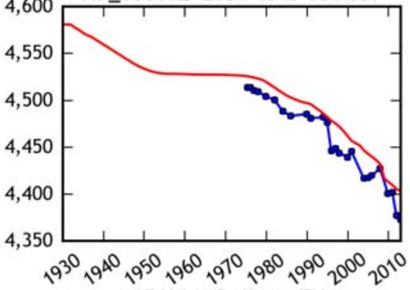

364215102564201 (Cimarron, OK)
HP_117439 LSD: 4751 TD: unk

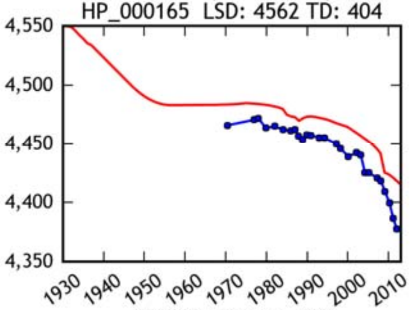

364241102591501 (Cimarron, OK)
HP_117492 LSD: 4820 TD: 327

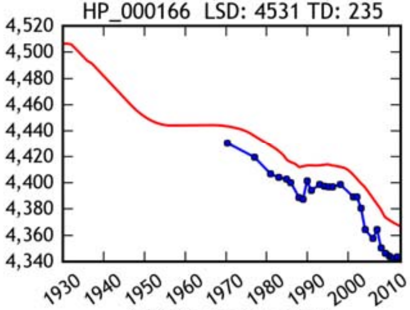

364745102435501 (Cimarron, OK)
HP_118264 LSD: 4323 TD: 66

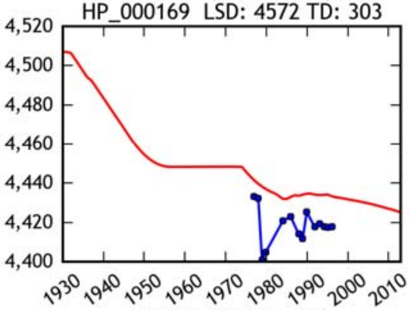

364820102362001 (Cimarron, OK)
HP_118344 LSD: 4311 TD: 116

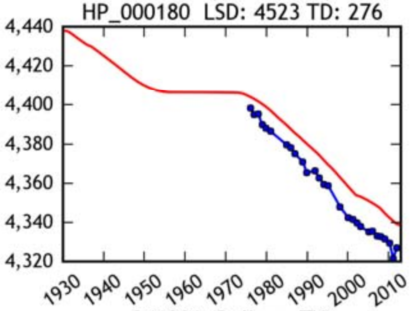

140601 (Dallam, TX)
HP_000152 LSD: 4694 TD: 390

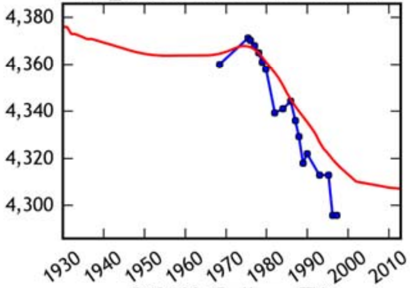

148303 (Dallam, TX)
HP_000162 LSD: 4640 TD: 357

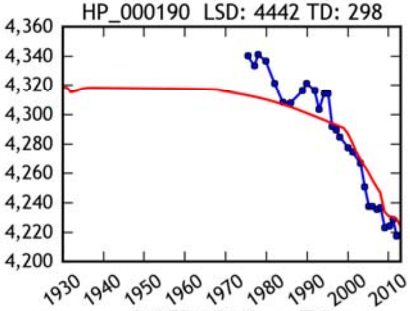

148901 (Dallam, TX)
HP_000165 LSD: 4562 TD: 404

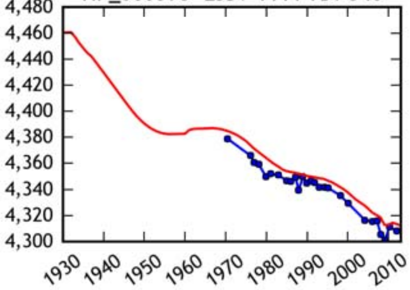

148902 (Dallam, TX)
HP_000166 LSD: 4531 TD: 235

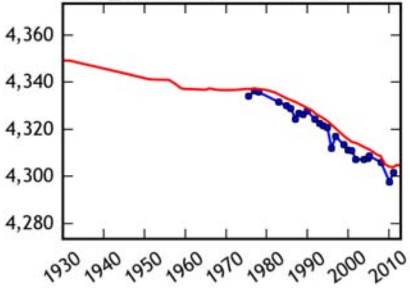

156301 (Dallam, TX)
HP_000169 LSD: 4572 TD: 303

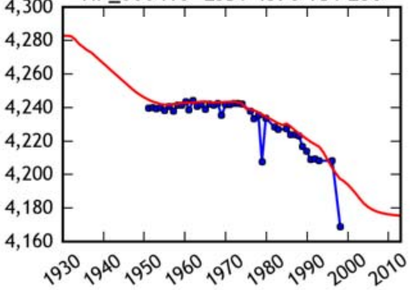

156602 (Dallam, TX)
HP_000180 LSD: 4523 TD: 276

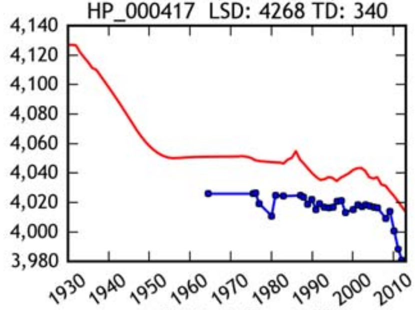

156902 (Dallam, TX)
HP_000185 LSD: 4497 TD: 315

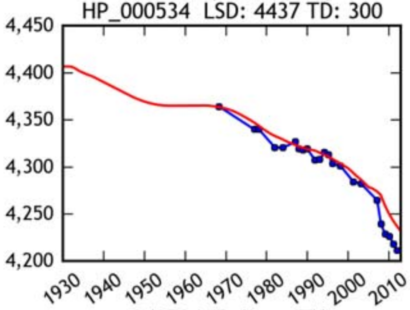

164301 (Dallam, TX)
HP_000190 LSD: 4442 TD: 298

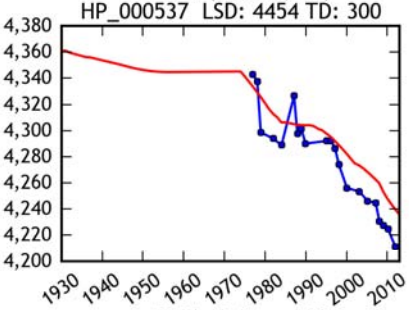

241801 (Dallam, TX)
HP_000398 LSD: 4444 TD: 340

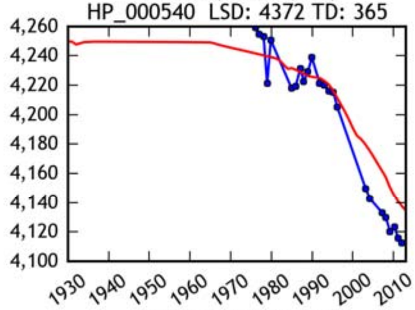

242103 (Dallam, TX)
HP_000403 LSD: 4380 TD: 268

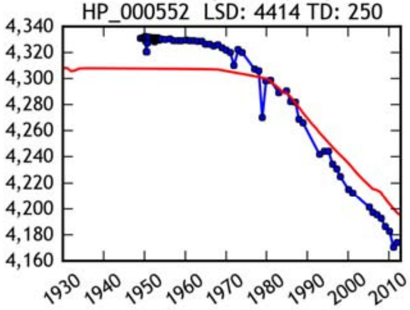

242701 (Dallam, TX)
HP_000410 LSD: 4376 TD: 250

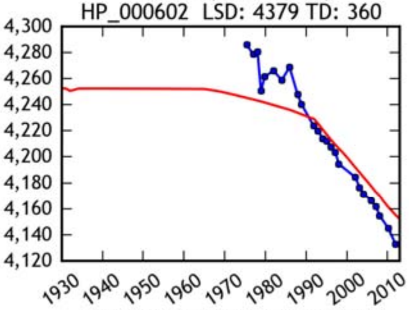

242903 (Dallam, TX)
HP_000417 LSD: 4268 TD: 340

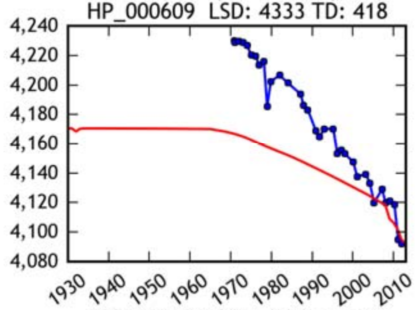

249201 (Dallam, TX)
HP_000534 LSD: 4437 TD: 300

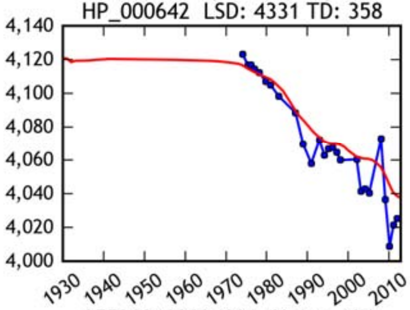

249401 (Dallam, TX)
HP_000537 LSD: 4454 TD: 300

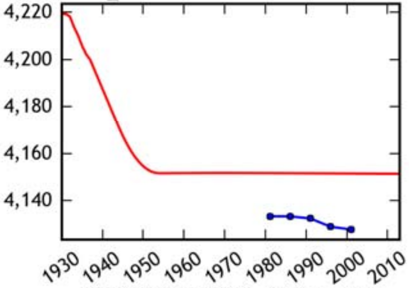

249503 (Dallam, TX)
HP_000540 LSD: 4372 TD: 365

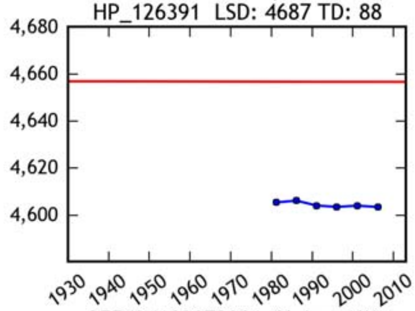

249704 (Dallam, TX)
HP_000552 LSD: 4414 TD: 250

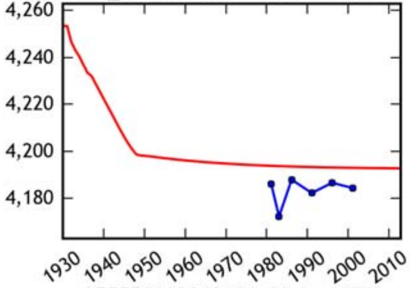

249801 (Dallam, TX)
HP_000602 LSD: 4379 TD: 360

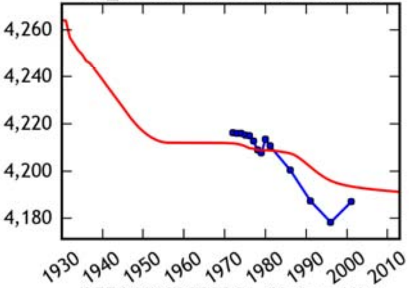

249901 (Dallam, TX)
HP_000609 LSD: 4333 TD: 418

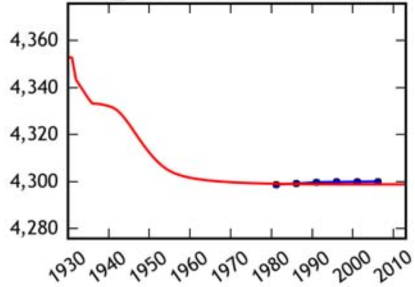

250701 (Dallam, TX)
HP_000642 LSD: 4331 TD: 358

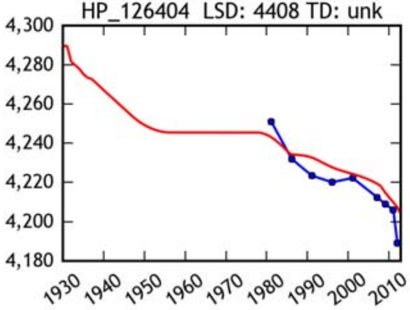

354930103031201 (Union, NM)
HP_126385 LSD: 4309 TD: unk

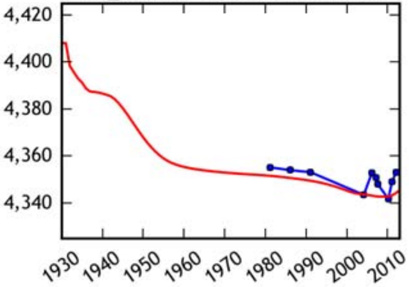

355143103162601 (Union, NM)
HP_126391 LSD: 4687 TD: 88


355302103034001 (Union, NM)
HP_126397 LSD: 4327 TD: unk

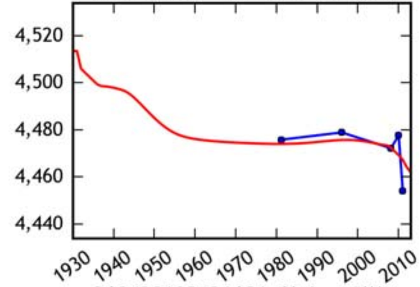

355407103035601 (Union, NM)
HP_126399 LSD: 4336 TD: unk


355434103073901 (Union, NM)
HP_126401 LSD: 4415 TD: 150

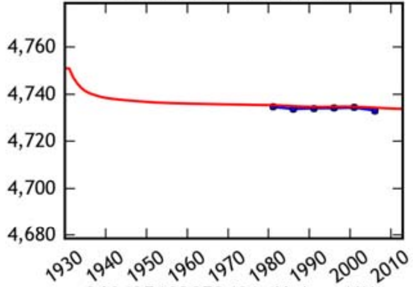

355550103043101 (Union, NM)
HP_126404 LSD: 4408 TD: unk


355641103083201 (Union, NM)
HP_126408 LSD: 4480 TD: 158

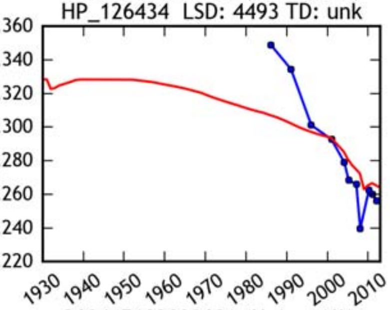
355805103114301 (Union, NM)
HP_126414 LSD: 4581 TD: unk



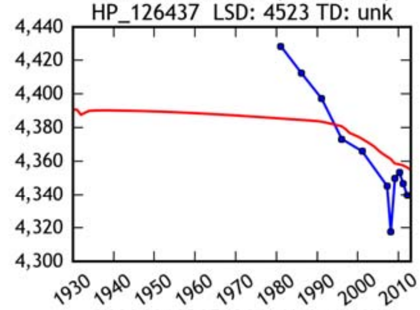
360116103174301 (Union, NM)
HP_126425 LSD: 4797 TD: 87



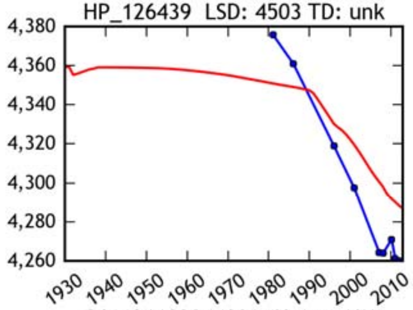
360336103043201 (Union, NM)
HP_126434 LSD: 4493 TD: unk



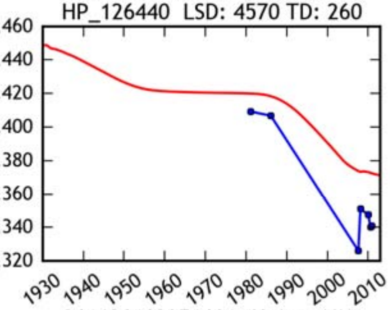
360420103131601 (Union, NM)
HP_126437 LSD: 4523 TD: unk



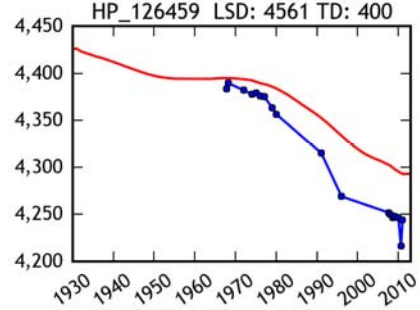
360435103053401 (Union, NM)
HP_126439 LSD: 4503 TD: unk



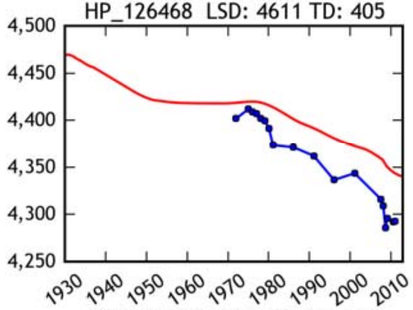
360445103090601 (Union, NM)
HP_126440 LSD: 4570 TD: 260



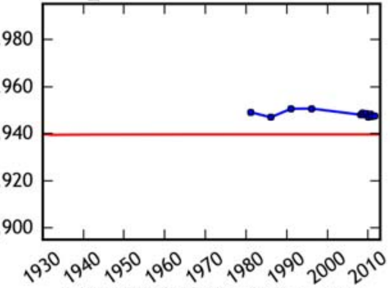
360910103051301 (Union, NM)
HP_126459 LSD: 4561 TD: 400



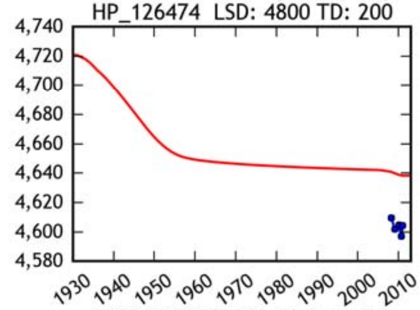
361121103044001 (Union, NM)
HP_126468 LSD: 4611 TD: 405



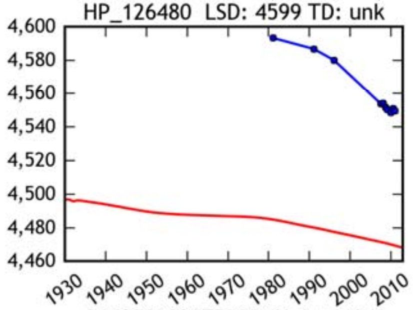
361130103251601 (Union, NM)
HP_126469 LSD: 5020 TD: unk



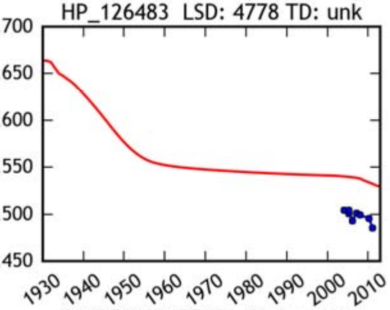
361207103135101 (Union, NM)
HP_126474 LSD: 4800 TD: 200



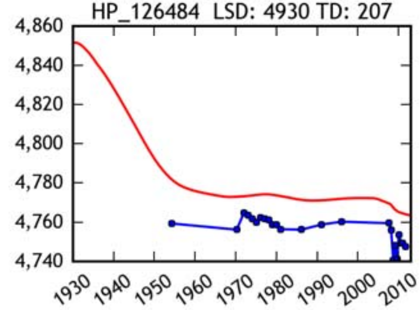
361226103042401 (Union, NM)
HP_126480 LSD: 4599 TD: unk



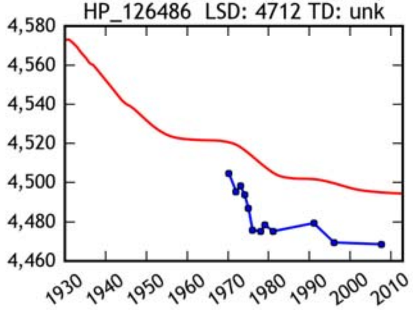
361311103103010 (Union, NM)
HP_126483 LSD: 4778 TD: unk



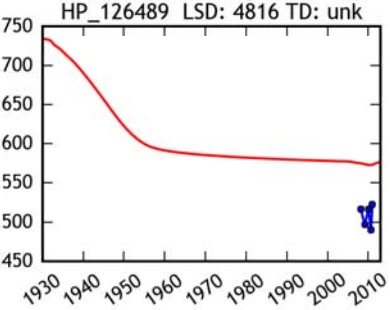
361314103183301 (Union, NM)
HP_126484 LSD: 4930 TD: 207

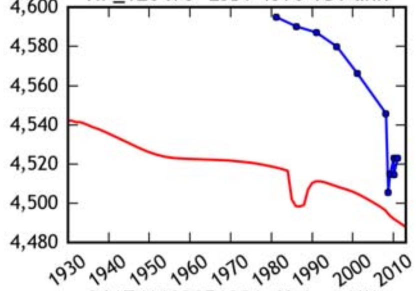


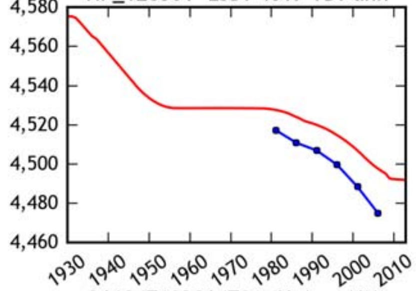
361320103075301 (Union, NM)
HP_126486 LSD: 4712 TD: unk

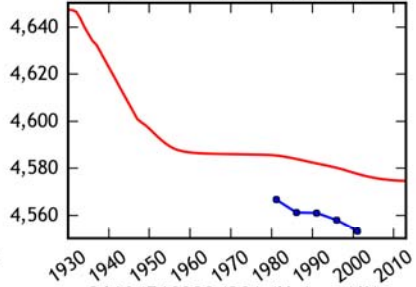


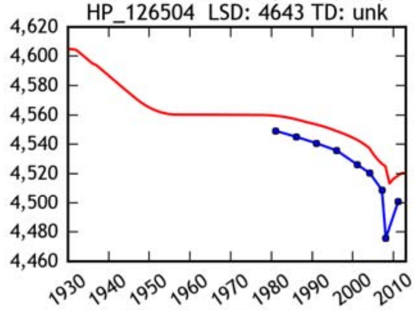
361351103125401 (Union, NM)
HP_126489 LSD: 4816 TD: unk

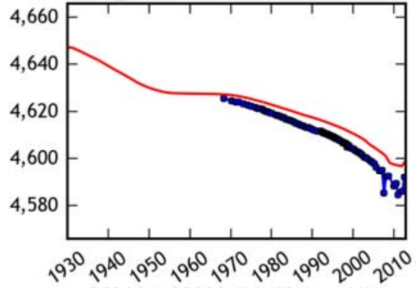


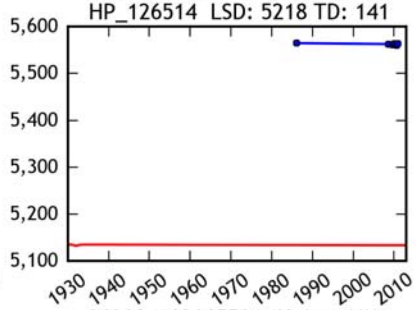

361556103024501 (Union, NM)
HP_126498 LSD: 4596 TD: unk

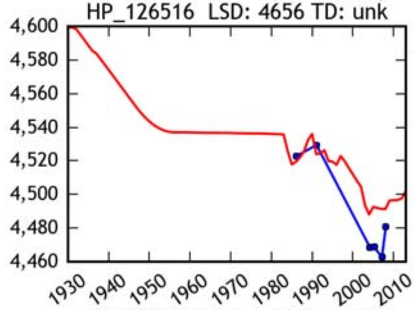

361701103040601 (Union, NM)
HP_126501 LSD: 4617 TD: unk

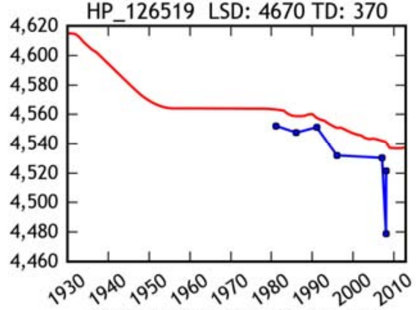

361715103075001 (Union, NM)
HP_126502 LSD: 4740 TD: 203

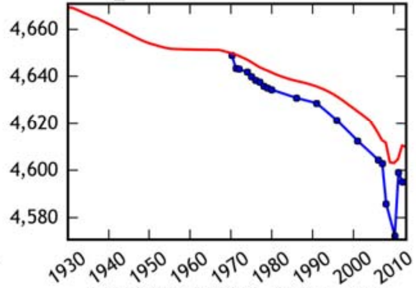

361741103051001 (Union, NM)
HP_126504 LSD: 4643 TD: unk

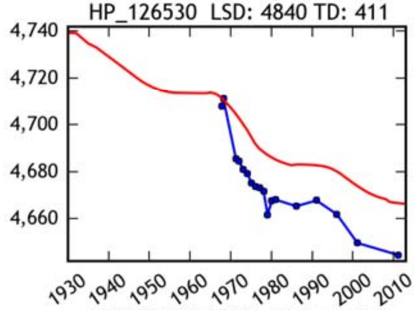

361847103064701 (Union, NM)
HP_126510 LSD: 4694 TD: 231

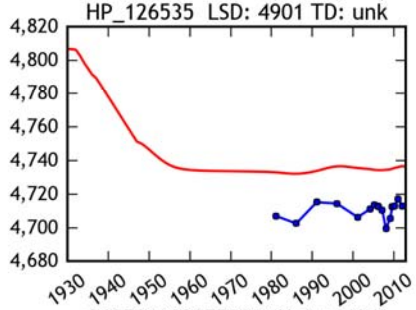

361945103224901 (Union, NM)
HP_126514 LSD: 5218 TD: 141

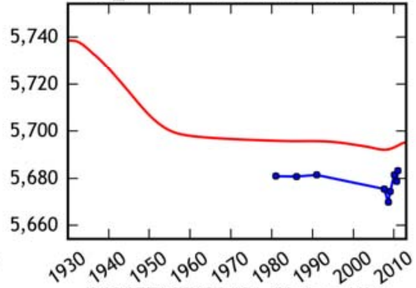

361952103024601 (Union, NM)
HP_126516 LSD: 4656 TD: unk

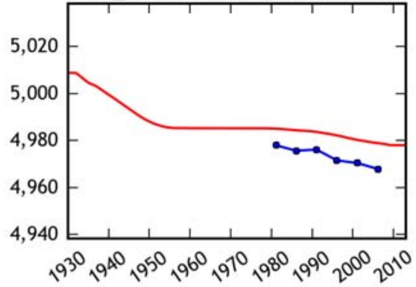

362004103033401 (Union, NM)
HP_126519 LSD: 4670 TD: 370

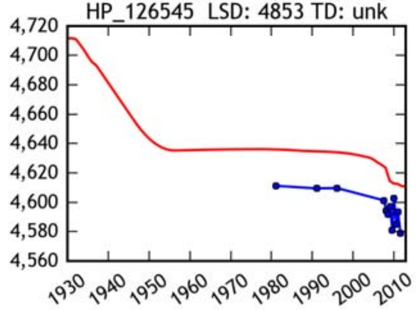

362004103065501 (Union, NM)
HP_126520 LSD: 4744 TD: 370

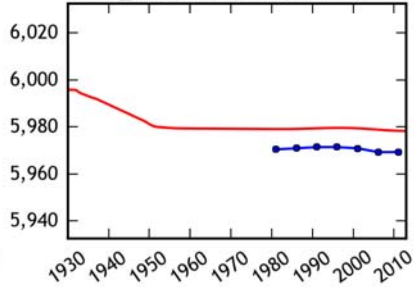

362206103083801 (Union, NM)
HP_126530 LSD: 4840 TD: 411

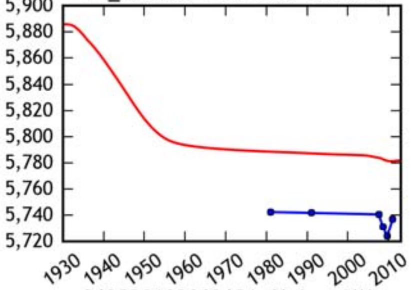

362251103103701 (Union, NM)
HP_126535 LSD: 4901 TD: unk

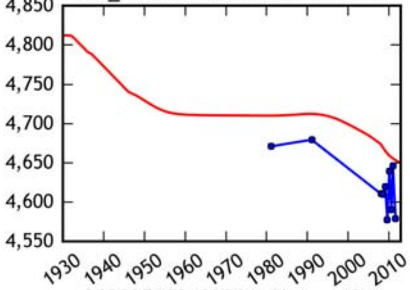

362338103385501 (Union, NM)
HP_126538 LSD: 5877 TD: unk

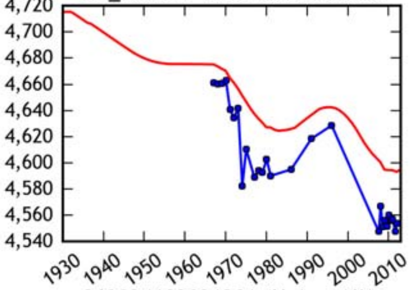

362407103165901 (Union, NM)
HP_126542 LSD: 5132 TD: unk

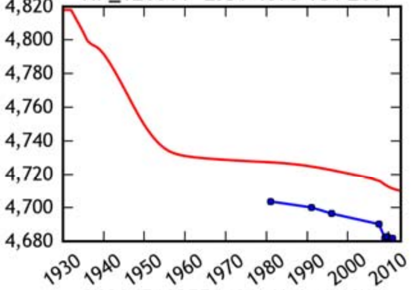

362501103055901 (Union, NM)
HP_126545 LSD: 4853 TD: unk

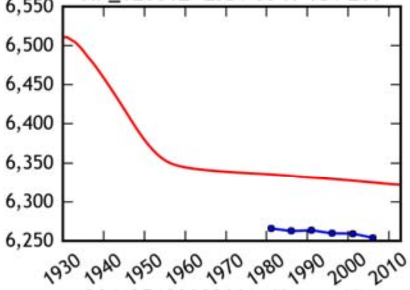

362657103432401 (Union, NM)
HP_126553 LSD: 6027 TD: 52

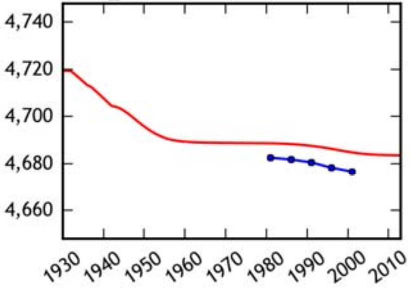

362839103381701 (Union, NM)
HP_126566 LSD: 6007 TD: unk

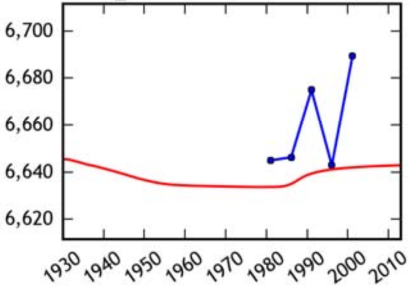

362921103092101 (Union, NM)
HP_126572 LSD: 4849 TD: unk

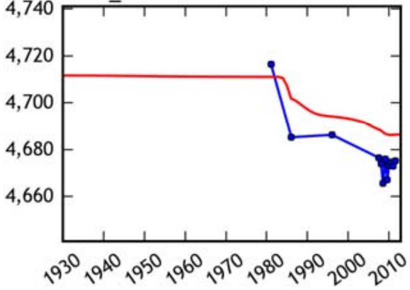

363041103054601 (Union, NM)
HP_126577 LSD: 4783 TD: 500


363820103062601 (Union, NM)
HP_126611 LSD: 4893 TD: 260


363825103492301 (Union, NM)
HP_126612 LSD: 6541 TD: 280


363924103031301 (Union, NM)
HP_126619 LSD: 4762 TD: 150


363945103550401 (Union, NM)
HP_126620 LSD: 6729 TD: 88


364135103003001 (Union, NM)
HP_126624 LSD: 4803 TD: 175

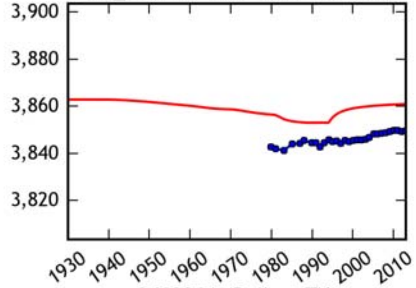
This page intentionally left blank.

B.3 Edwards-Trinity (High Plains) Aquifer Hydrographs

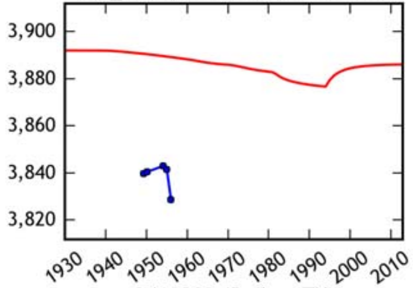
This section contains the observed and simulated hydrographs for the Edwards-Trinity (High Plains) Aquifer.

This page intentionally left blank.

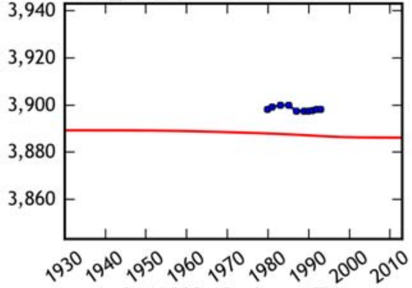
1057901 (Bailey, TX)
HP_010419 LSD: 3931 TD: unk



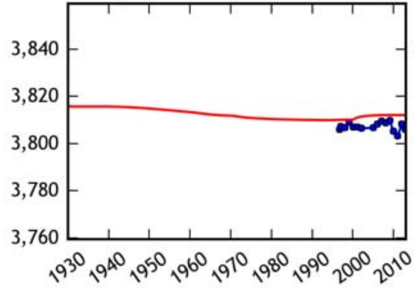
2401102 (Bailey, TX)
HP_017308 LSD: 4051 TD: unk



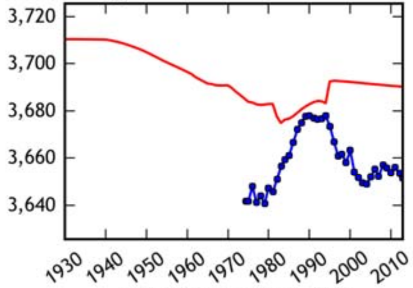
2401202 (Bailey, TX)
HP_017312 LSD: 4069 TD: unk



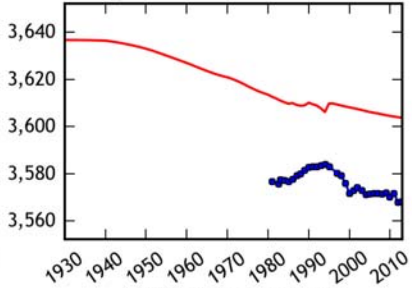
2402201 (Bailey, TX)
HP_017321 LSD: 3925 TD: unk



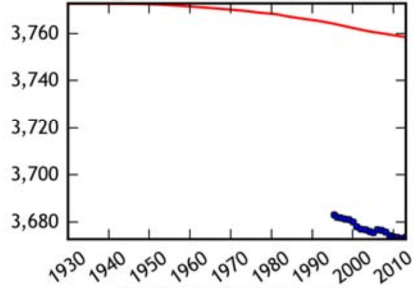
2410303 (Bailey, TX)
HP_017506 LSD: 3786 TD: 162



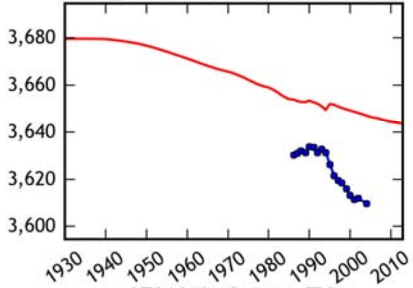
2411803 (Cochran, TX)
HP_017540 LSD: 3710 TD: 192



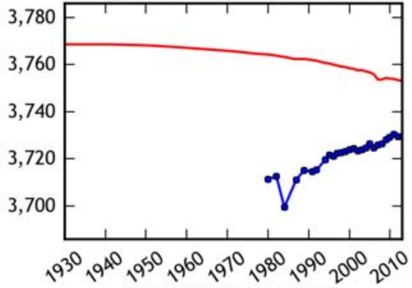
2417701 (Cochran, TX)
HP_017711 LSD: 3907 TD: unk



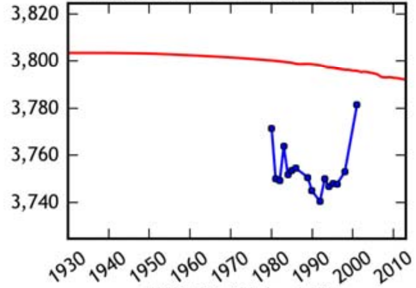
2418306 (Cochran, TX)
HP_017731 LSD: 3798 TD: unk



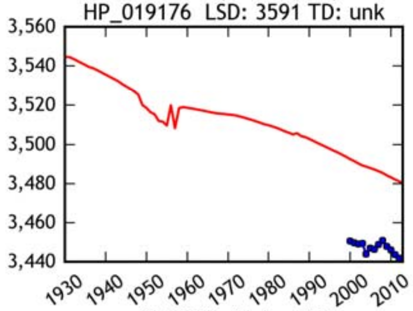
2425401 (Cochran, TX)
HP_017912 LSD: 3904 TD: unk



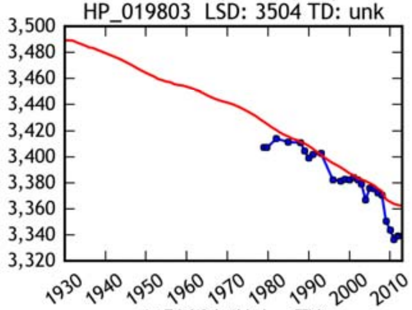
2532801 (Cochran, TX)
HP_018881 LSD: 3935 TD: 300



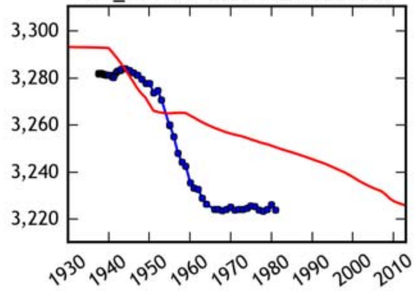
2701619 (Gaines, TX)
HP_019176 LSD: 3591 TD: unk



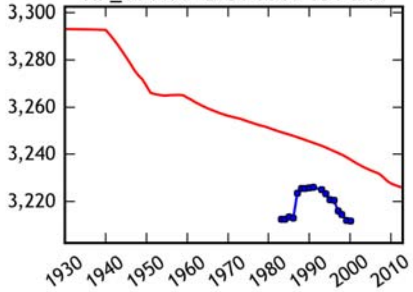
2709903 (Gaines, TX)
HP_019803 LSD: 3504 TD: unk



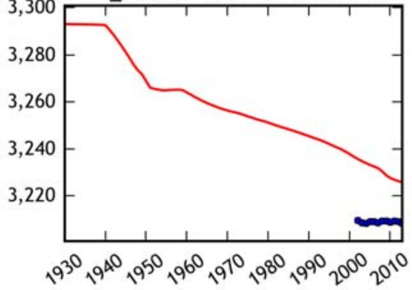
1159801 (Hale, TX)
HP_014495 LSD: 3323 TD: unk

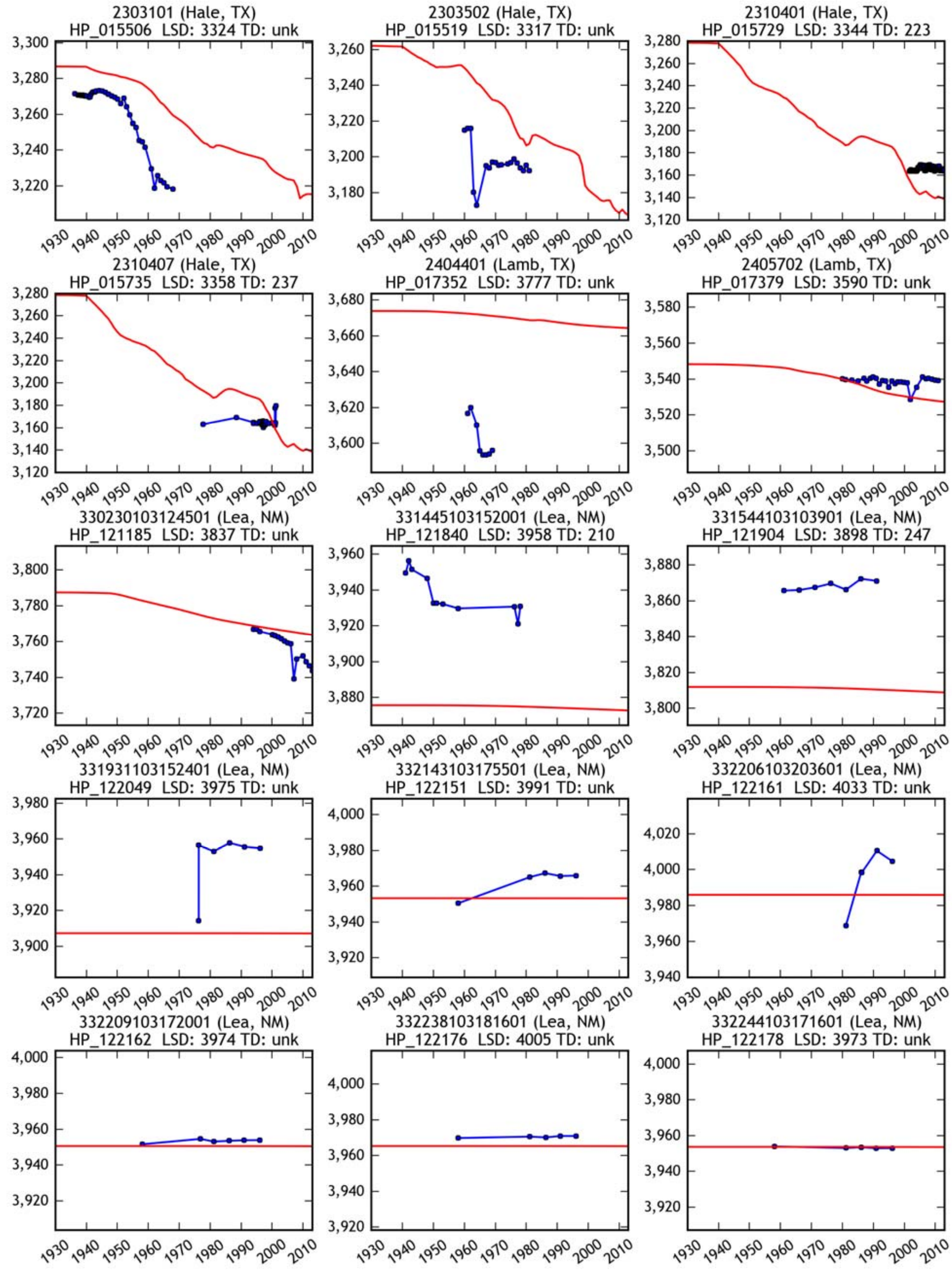


1159804 (Hale, TX)
HP_014498 LSD: 3318 TD: unk

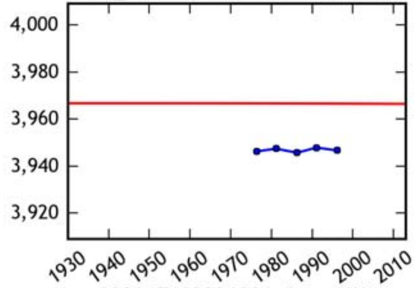


1159806 (Hale, TX)
HP_014500 LSD: 3315 TD: unk

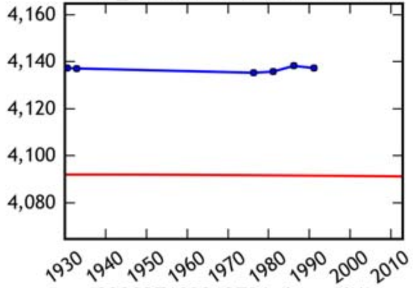



2303101 (Hale, TX)
HP_015506 LSD: 3324 TD: unk
3,300
3,280
3,260
3,240
3,220
2303502 (Hale, TX)
HP_015519 LSD: 3317 TD: unk
3,260
3,240
3,220
3,200
3,180
2310401 (Hale, TX)
HP_015729 LSD: 3344 TD: 223
3,280
3,260
3,240
3,220
3,200
3,180
3,160
3,140
3,120
2310407 (Hale, TX)
HP_015735 LSD: 3358 TD: 237
3,280
3,260
3,240
3,220
3,200
3,180
3,160
3,140
3,120
2404401 (Lamb, TX)
HP_017352 LSD: 3777 TD: unk
3,680
3,660
3,640
3,620
3,600
2405702 (Lamb, TX)
HP_017379 LSD: 3590 TD: unk
3,580
3,560
3,540
3,520
3,500
330230103124501 (Lea, NM)
HP_121185 LSD: 3837 TD: unk
3,800
3,780
3,760
3,740
3,720
331445103152001 (Lea, NM)
HP_121840 LSD: 3958 TD: 210
3,960
3,940
3,920
3,900
3,880
331544103103901 (Lea, NM)
HP_121904 LSD: 3898 TD: 247
3,880
3,860
3,840
3,820
3,800
331931103152401 (Lea, NM)
HP_122049 LSD: 3975 TD: unk
3,980
3,960
3,940
3,920
3,900
332143103175501 (Lea, NM)
HP_122151 LSD: 3991 TD: unk
4,000
3,980
3,960
3,940
3,920
332206103203601 (Lea, NM)
HP_122161 LSD: 4033 TD: unk
4,020
4,000
3,980
3,960
3,940
332209103172001 (Lea, NM)
HP_122162 LSD: 3974 TD: unk
4,000
3,980
3,960
3,940
3,920
332238103181601 (Lea, NM)
HP_122176 LSD: 4005 TD: unk
4,000
3,980
3,960
3,940
3,920
332244103171601 (Lea, NM)
HP_122178 LSD: 3973 TD: unk
4,000
3,980
3,960
3,940
3,920
1930
1940
1950
1960
1970
1980
1990
2000
2010

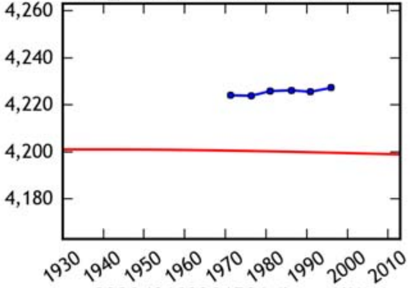
332456103171501 (Lea, NM)
HP_122208 LSD: 4034 TD: unk



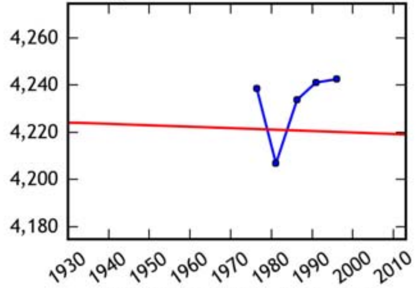
332501103270301 (Lea, NM)
HP_122212 LSD: 4190 TD: 59



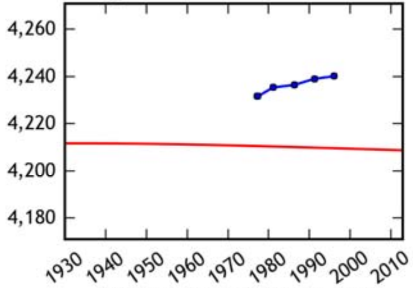
332917103303802 (Lea, NM)
HP_122293 LSD: 4291 TD: unk



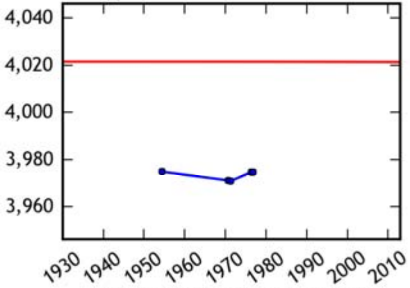
332917103331001 (Lea, NM)
HP_122294 LSD: 4276 TD: unk



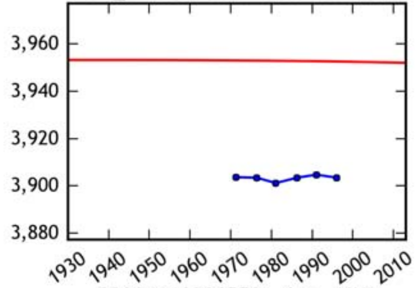
332927103312701 (Lea, NM)
HP_122295 LSD: 4285 TD: unk



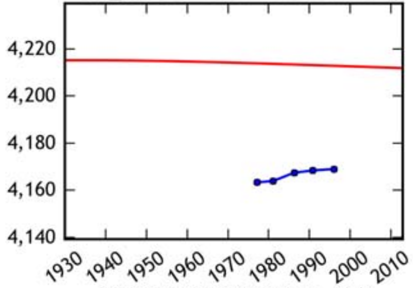
332940103201501 (Lea, NM)
HP_122298 LSD: 4114 TD: unk



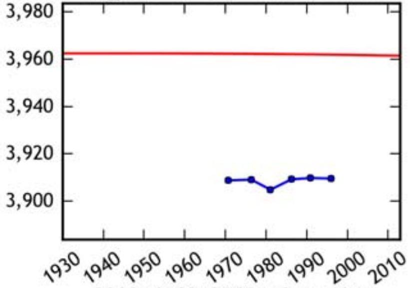
332947103143201 (Lea, NM)
HP_122300 LSD: 4027 TD: unk



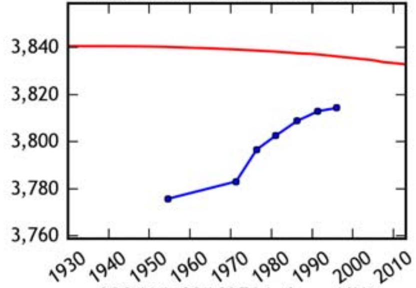
333012103313301 (Lea, NM)
HP_122305 LSD: 4313 TD: unk



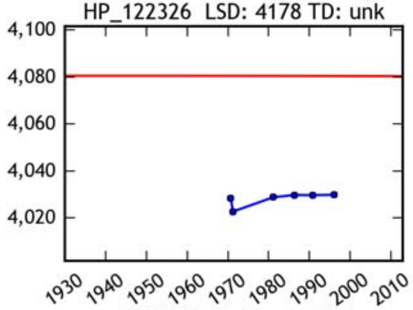
333023103150101 (Lea, NM)
HP_122310 LSD: 4038 TD: unk



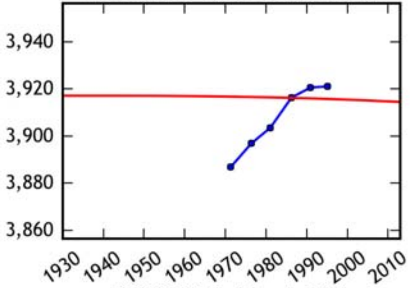
333041103065501 (Lea, NM)
HP_122322 LSD: 3962 TD: 230



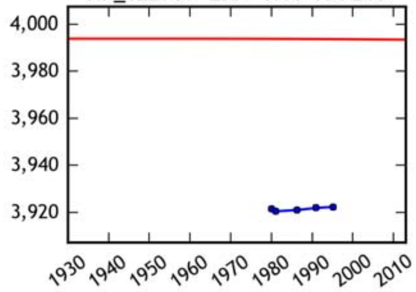
333057103232401 (Lea, NM)
HP_122326 LSD: 4178 TD: unk



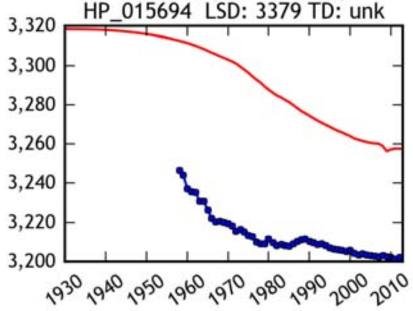
333216103120601 (Lea, NM)
HP_122352 LSD: 4032 TD: 233



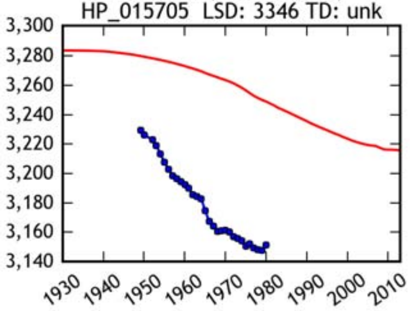
333414103163501 (Lea, NM)
HP_122366 LSD: 4099 TD: 209

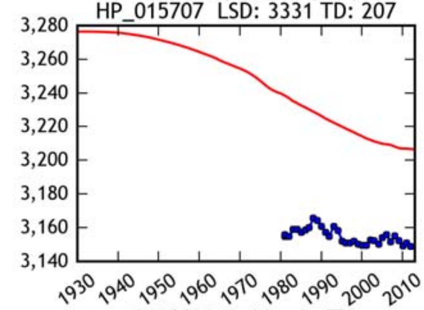


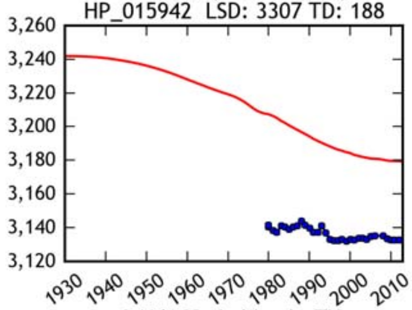
2309501 (Lubbock, TX)
HP_015694 LSD: 3379 TD: unk

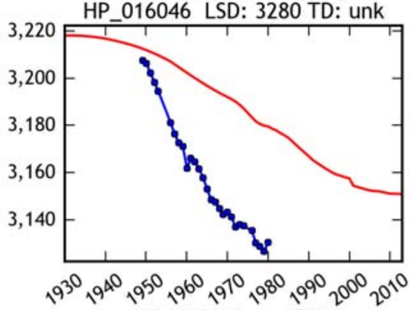


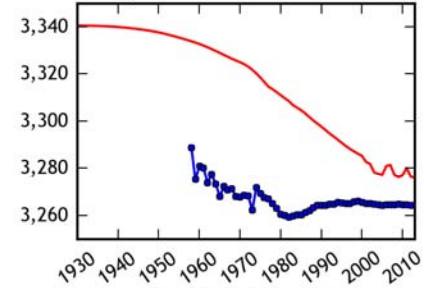
2309901 (Lubbock, TX)
HP_015705 LSD: 3346 TD: unk

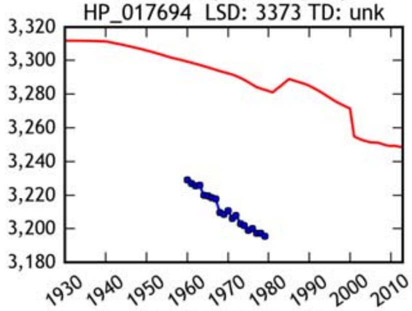


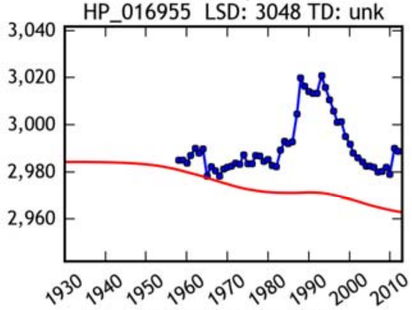

2309903 (Lubbock, TX)
HP_015707 LSD: 3331 TD: 207

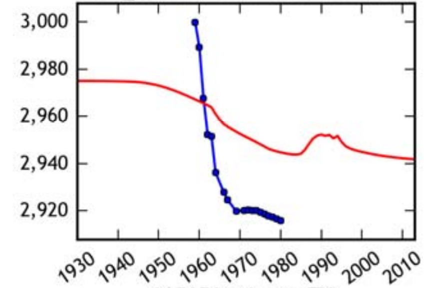

2317301 (Lubbock, TX)
HP_015942 LSD: 3307 TD: 188

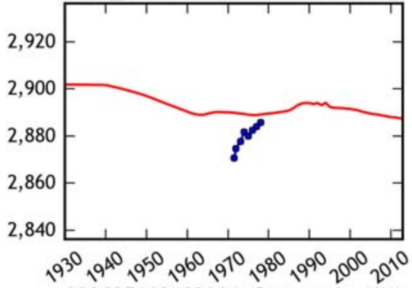

2318404 (Lubbock, TX)
HP_016046 LSD: 3280 TD: unk

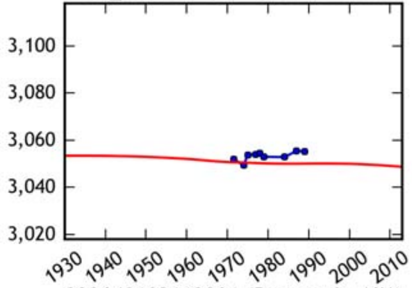

2416601 (Lubbock, TX)
HP_017682 LSD: 3399 TD: unk

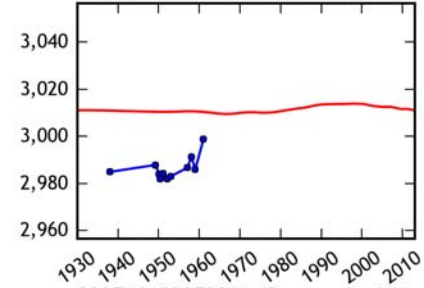

2416902 (Lubbock, TX)
HP_017694 LSD: 3373 TD: unk

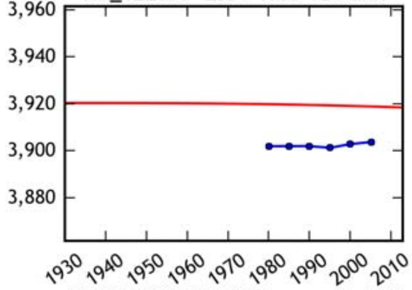

2344101 (Lynn, TX)
HP_016955 LSD: 3048 TD: unk

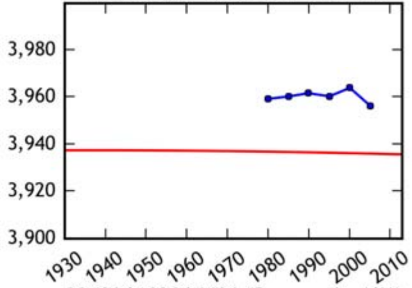

2344701 (Lynn, TX)
HP_016992 LSD: 3003 TD: unk

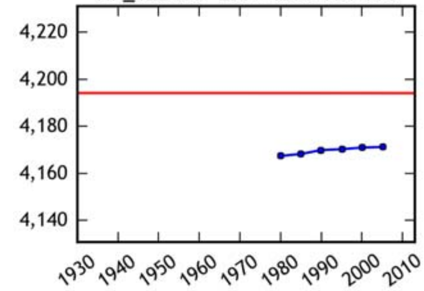

2352801 (Lynn, TX)
HP_017149 LSD: 2937 TD: 130

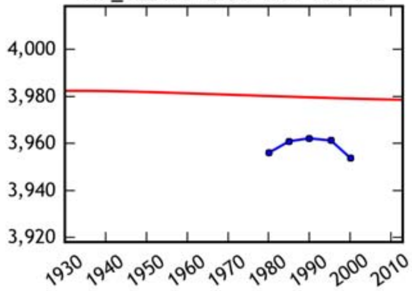

2357301 (Lynn, TX)
HP_017192 LSD: 3121 TD: unk

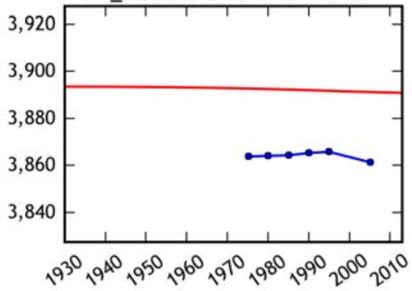

2358501 (Lynn, TX)
HP_017222 LSD: 3010 TD: unk

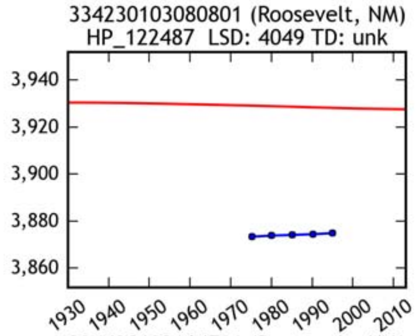

333635103102901 (Roosevelt, NM)
HP_122399 LSD: 4057 TD: unk

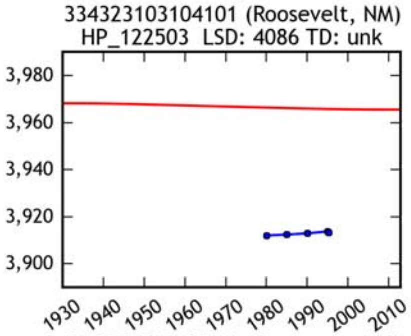

333648103113801 (Roosevelt, NM)
HP_122401 LSD: 4057 TD: 104

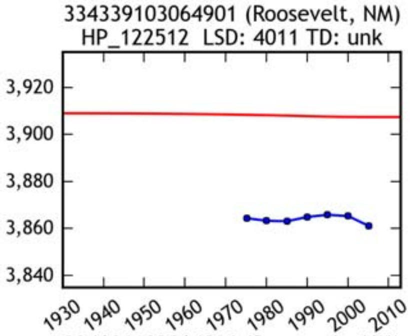

333716103252301 (Roosevelt, NM)
HP_122409 LSD: 4256 TD: 160

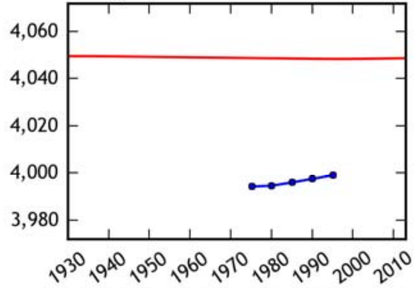

333840103140501 (Roosevelt, NM)
HP_122433 LSD: 4081 TD: 142

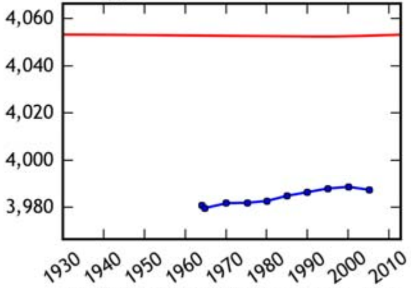

334226103064401 (Roosevelt, NM)
HP_122485 LSD: 4026 TD: 180

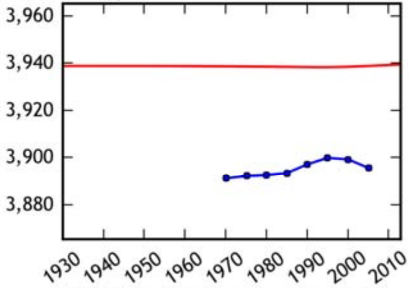

334230103080801 (Roosevelt, NM)
HP_122487 LSD: 4049 TD: unk

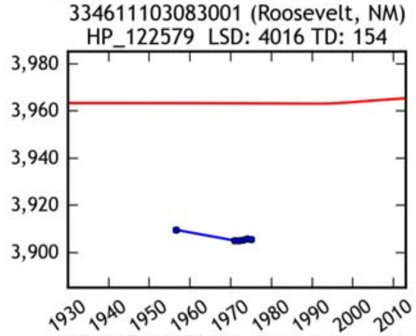

334323103104101 (Roosevelt, NM)
HP_122503 LSD: 4086 TD: unk

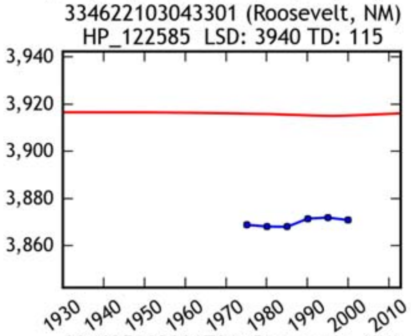

334339103064901 (Roosevelt, NM)
HP_122512 LSD: 4011 TD: unk

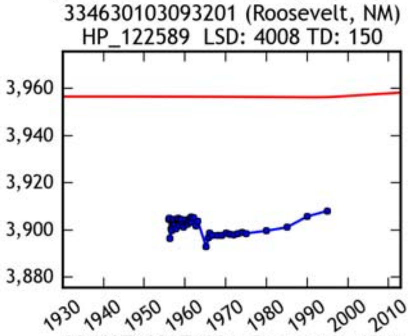

334428103164701 (Roosevelt, NM)
HP_122528 LSD: 4180 TD: unk

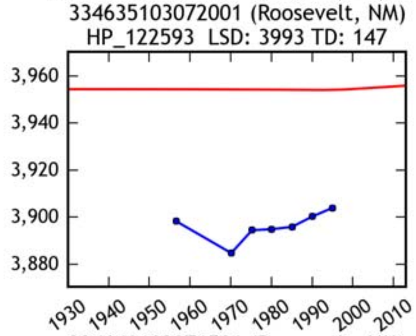

334539103153701 (Roosevelt, NM)
HP_122559 LSD: 4130 TD: 168

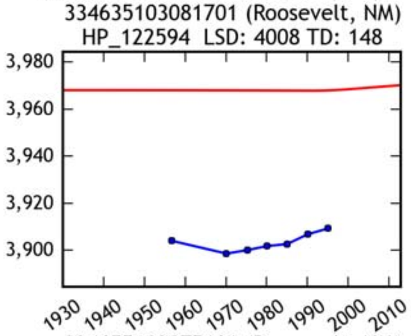

334601103064801 (Roosevelt, NM)
HP_122569 LSD: 4002 TD: unk

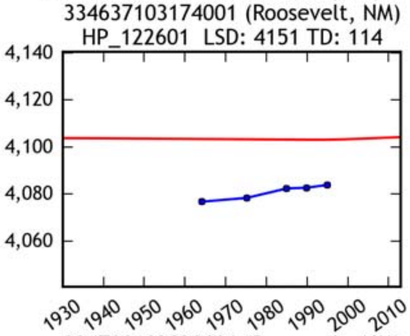

334611103083001 (Roosevelt, NM)
HP_122579 LSD: 4016 TD: 154

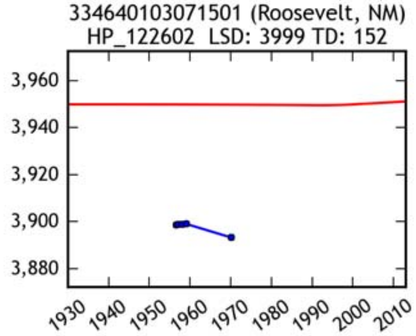

334622103043301 (Roosevelt, NM)
HP_122585 LSD: 3940 TD: 115

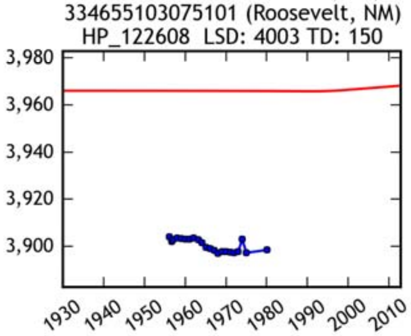

334630103093201 (Roosevelt, NM)
HP_122589 LSD: 4008 TD: 150

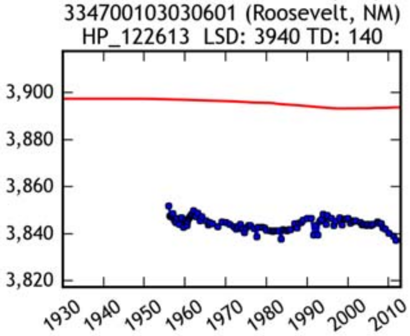

334635103072001 (Roosevelt, NM)
HP_122593 LSD: 3993 TD: 147


334635103081701 (Roosevelt, NM)
HP_122594 LSD: 4008 TD: 148

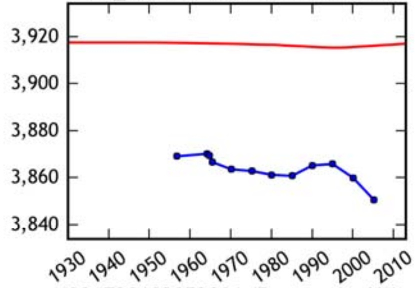

334637103174001 (Roosevelt, NM)
HP_122601 LSD: 4151 TD: 114


334640103071501 (Roosevelt, NM)
HP_122602 LSD: 3999 TD: 152

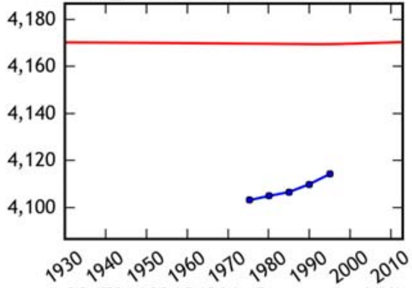

334655103075101 (Roosevelt, NM)
HP_122608 LSD: 4003 TD: 150


334700103030601 (Roosevelt, NM)
HP_122613 LSD: 3940 TD: 140

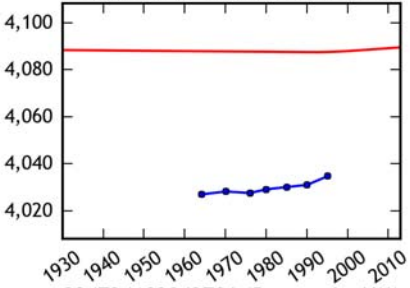
334704103041101 (Roosevelt, NM)
HP_122618 LSD: 3946 TD: 126



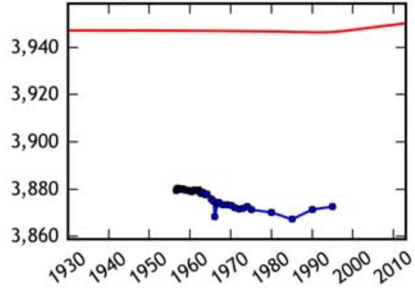
334705103194201 (Roosevelt, NM)
HP_122622 LSD: 4196 TD: unk



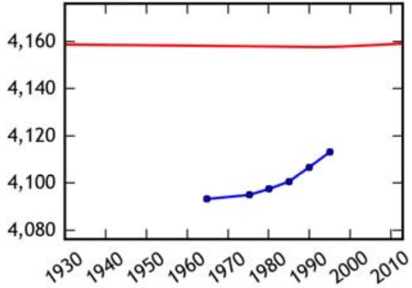
334708103162301 (Roosevelt, NM)
HP_122626 LSD: 4131 TD: unk



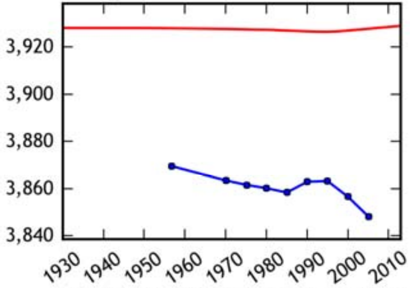
334720103052801 (Roosevelt, NM)
HP_122631 LSD: 3970 TD: 140



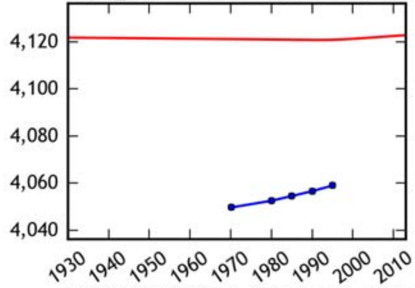
334731103184901 (Roosevelt, NM)
HP_122636 LSD: 4173 TD: 89



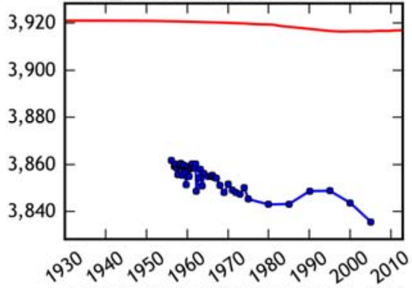
334734103043701 (Roosevelt, NM)
HP_122638 LSD: 3951 TD: 125



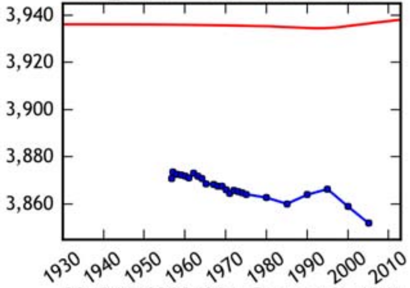
334739103165801 (Roosevelt, NM)
HP_122643 LSD: 4159 TD: 120



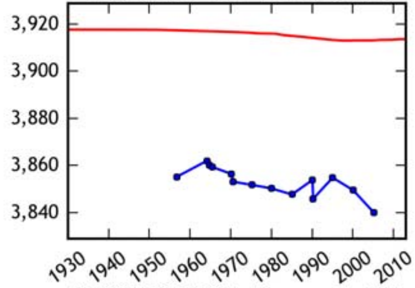
334745103033001 (Roosevelt, NM)
HP_122650 LSD: 3946 TD: 140



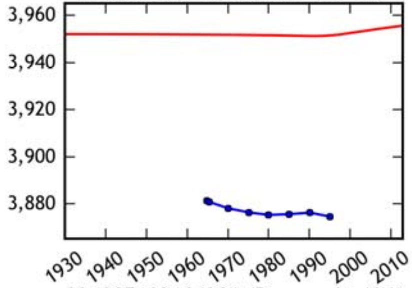
334745103043501 (Roosevelt, NM)
HP_122651 LSD: 3962 TD: 136



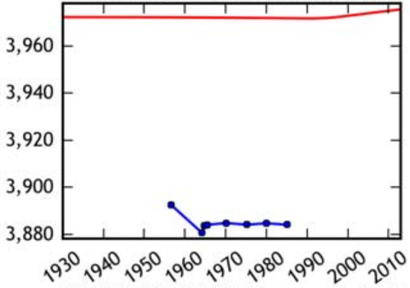
334754103033801 (Roosevelt, NM)
HP_122659 LSD: 3941 TD: 135



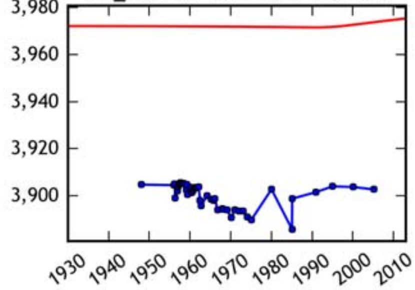
334831103055701 (Roosevelt, NM)
HP_122687 LSD: 3973 TD: 101



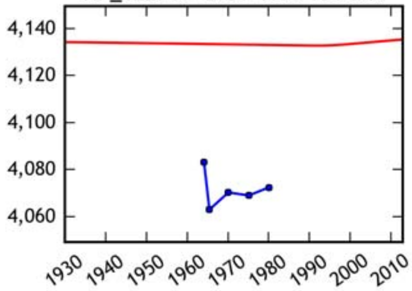
334844103064801 (Roosevelt, NM)
HP_122706 LSD: 3991 TD: 133



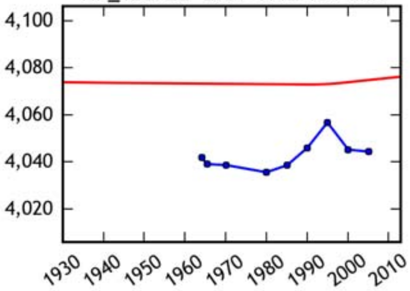
334905103071001 (Roosevelt, NM)
HP_122715 LSD: 3997 TD: 130



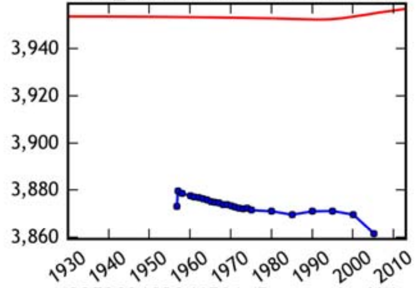
334905103164301 (Roosevelt, NM)
HP_122716 LSD: 4153 TD: unk



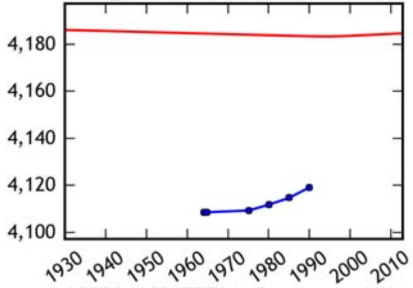
334914103131401 (Roosevelt, NM)
HP_122722 LSD: 4112 TD: unk



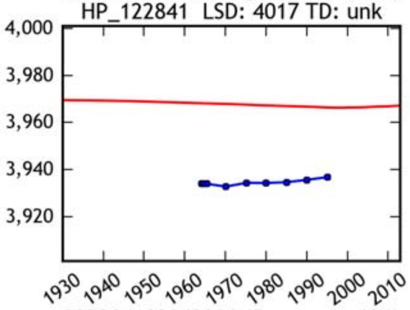
334945103051501 (Roosevelt, NM)
HP_122753 LSD: 3978 TD: 123



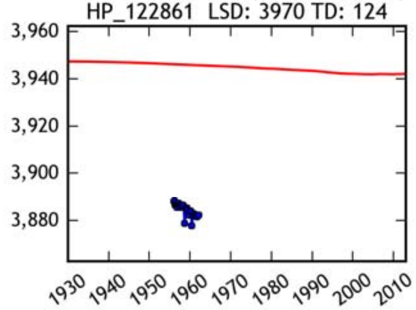
334957103185201 (Roosevelt, NM)
HP_122762 LSD: 4220 TD: unk



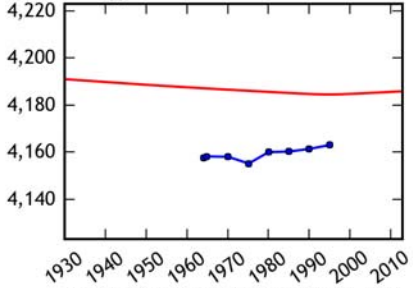
335136103052801 (Roosevelt, NM)
HP_122841 LSD: 4017 TD: unk



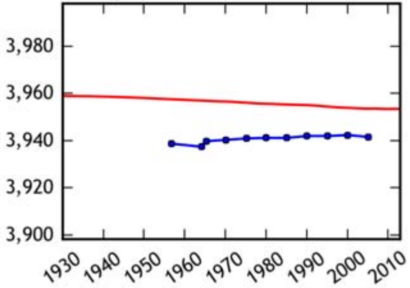
335203103041501 (Roosevelt, NM)
HP_122861 LSD: 3970 TD: 124



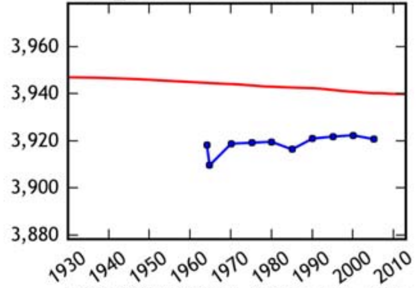
335204103175701 (Roosevelt, NM)
HP_122870 LSD: 4264 TD: 120



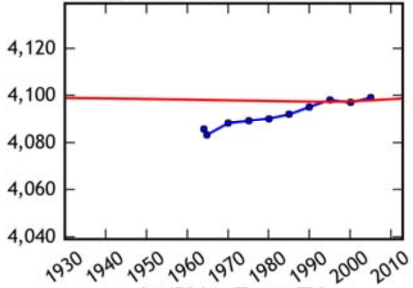
335304103042901 (Roosevelt, NM)
HP_122926 LSD: 4056 TD: 163



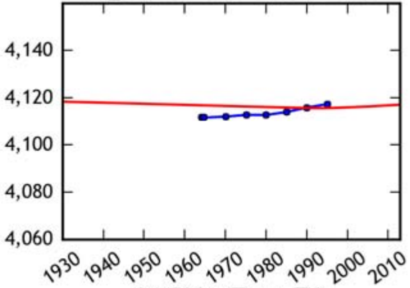
335325103031501 (Roosevelt, NM)
HP_122942 LSD: 4047 TD: 175



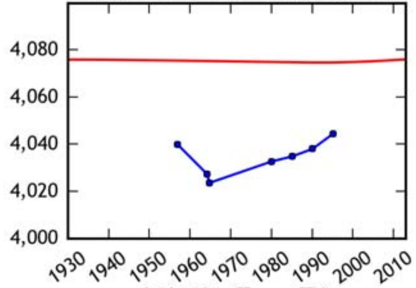
335411103121101 (Roosevelt, NM)
HP_122973 LSD: 4193 TD: unk



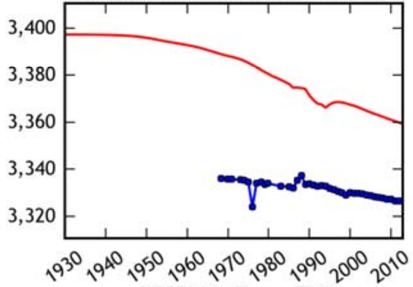
335435103131101 (Roosevelt, NM)
HP_122989 LSD: 4210 TD: 153



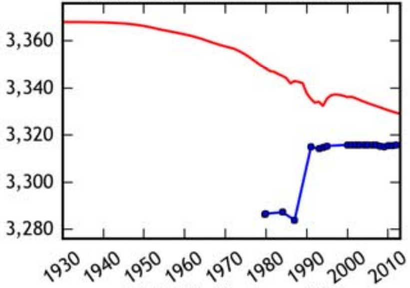
335529103104101 (Roosevelt, NM)
HP_123023 LSD: 4186 TD: 172



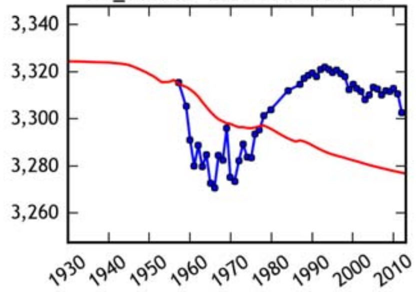
2445201 (Terry, TX)
HP_018356 LSD: 3481 TD: unk



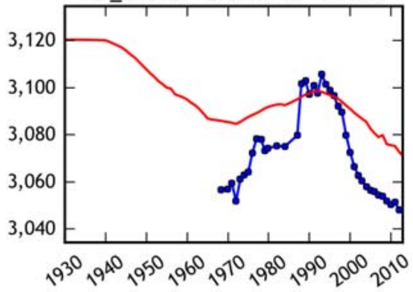
2445301 (Terry, TX)
HP_018357 LSD: 3458 TD: unk



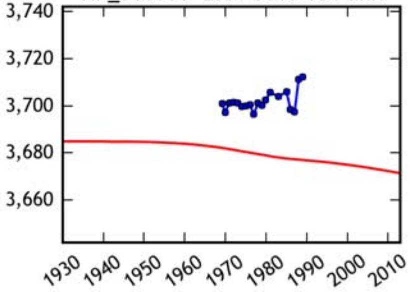
2461401 (Terry, TX)
HP_018715 LSD: 3338 TD: 117

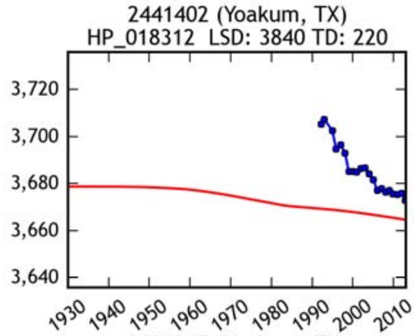


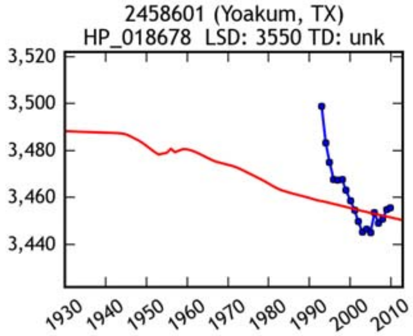
2707301 (Terry, TX)
HP_019668 LSD: 3142 TD: unk

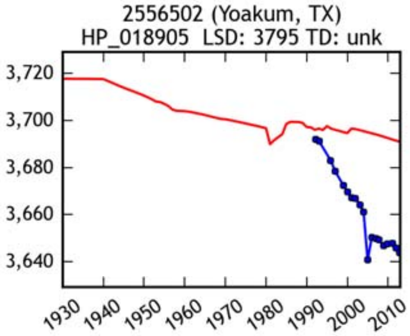


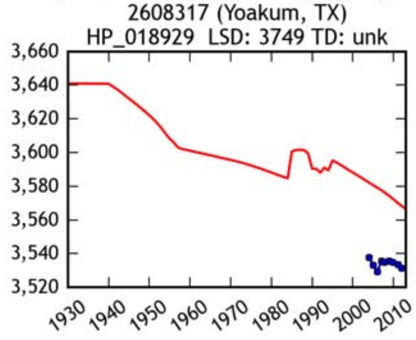
2441401 (Yoakum, TX)
HP_018311 LSD: 3819 TD: unk




2441402 (Yoakum, TX)
HP_018312 LSD: 3840 TD: 220


2458601 (Yoakum, TX)
HP_018678 LSD: 3550 TD: unk

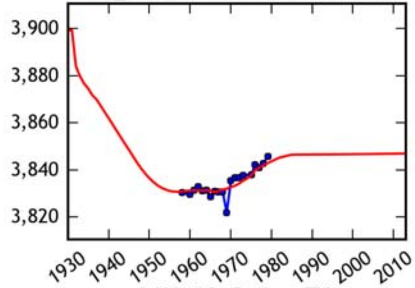

2556502 (Yoakum, TX)
HP_018905 LSD: 3795 TD: unk

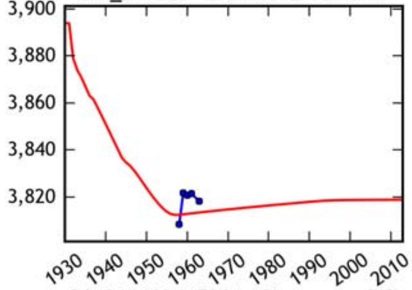

2608317 (Yoakum, TX)
HP_018929 LSD: 3749 TD: unk

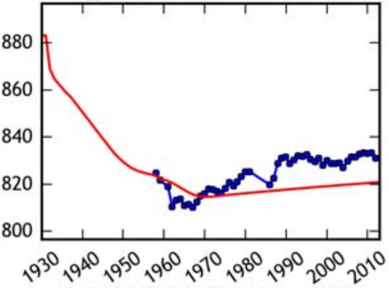
B.4 Upper Dockum Aquifer Hydrographs

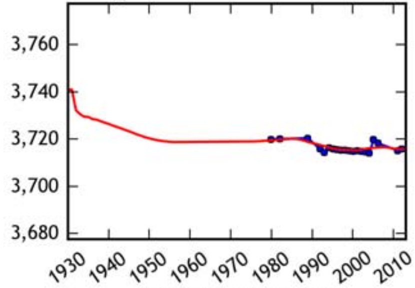
This section contains the observed and simulated hydrographs for the upper Dockum Aquifer.

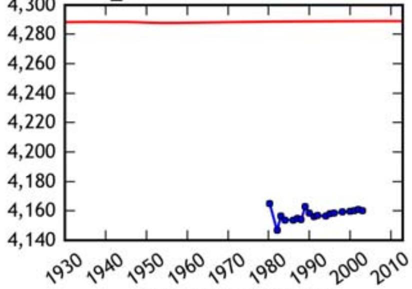
This page intentionally left blank.

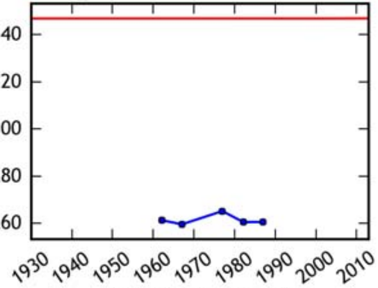

2401101 (Bailey, TX)
HP_017307 LSD: 4054 TD: unk

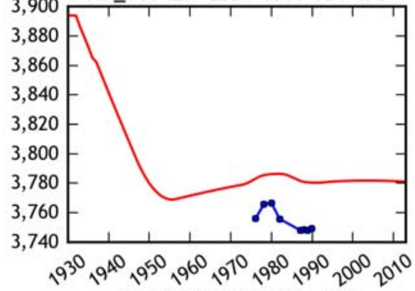

2401103 (Bailey, TX)
HP_017309 LSD: 4042 TD: unk

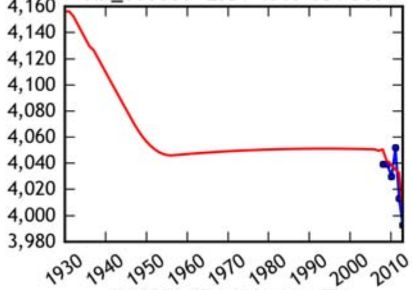

2401201 (Bailey, TX)
HP_017311 LSD: 4022 TD: unk

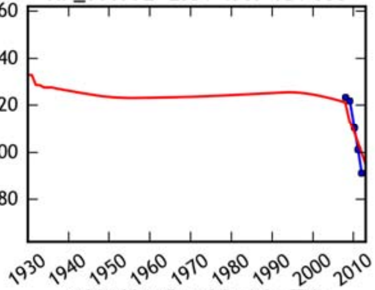

2403103 (Bailey, TX)
HP_017336 LSD: 3722 TD: 850

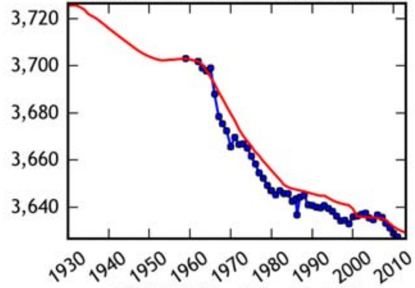

364918102415201 (Cimarron, OK)
HP_118488 LSD: 4265 TD: 247

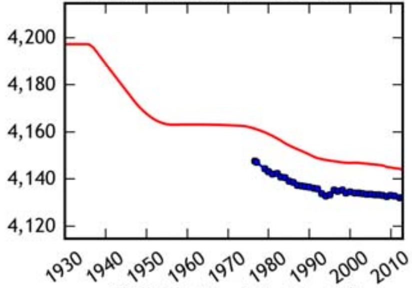

342928103364601 (Curry, NM)
HP_125641 LSD: 4480 TD: 400

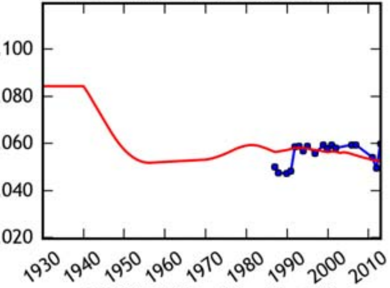

244301 (Dallam, TX)
HP_000427 LSD: 4116 TD: 475

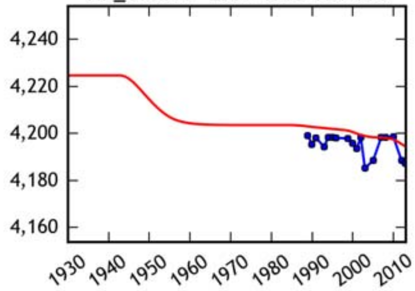

257307 (Dallam, TX)
HP_000600 LSD: 4315 TD: 565

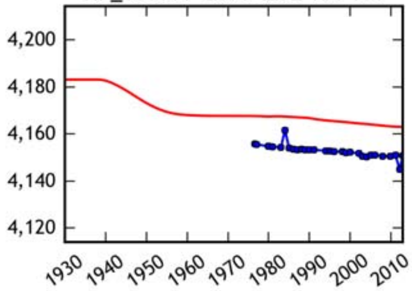

257501 (Dallam, TX)
HP_000772 LSD: 4387 TD: 535

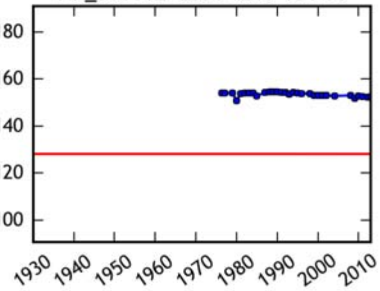

755701 (Deaf Smith, TX)
HP_007305 LSD: 3881 TD: 340

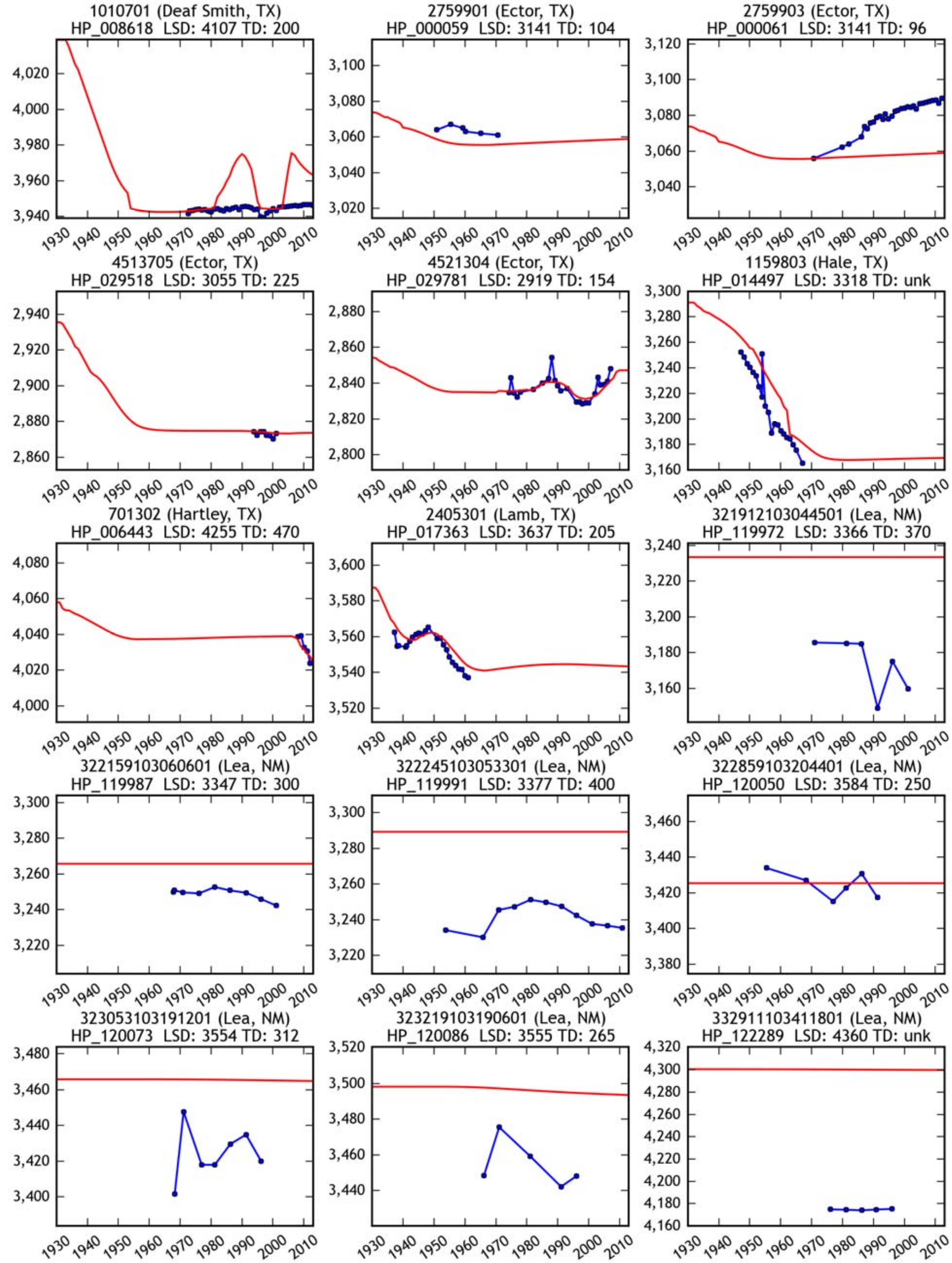

916901 (Deaf Smith, TX)
HP_008012 LSD: 4265 TD: 180


1001601 (Deaf Smith, TX)
HP_008095 LSD: 4276 TD: 260

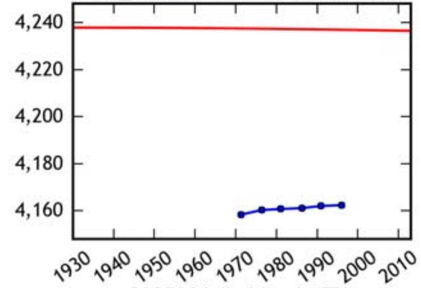

1001702 (Deaf Smith, TX)
HP_008097 LSD: 4333 TD: 160


1009701 (Deaf Smith, TX)
HP_008611 LSD: 4292 TD: 180

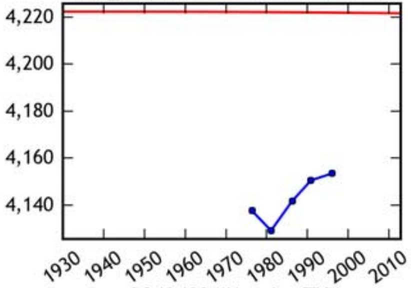

1009801 (Deaf Smith, TX)
HP_008612 LSD: 4209 TD: 68


1010701 (Deaf Smith, TX)
HP_008618 LSD: 4107 TD: 200
3,940
3,960
3,980
4,000
4,020
2759901 (Ector, TX)
HP_000059 LSD: 3141 TD: 104
3,020
3,040
3,060
3,080
3,100
2759903 (Ector, TX)
HP_000061 LSD: 3141 TD: 96
3,040
3,060
3,080
3,100
3,120
4513705 (Ector, TX)
HP_029518 LSD: 3055 TD: 225
2,860
2,880
2,900
2,920
2,940
4521304 (Ector, TX)
HP_029781 LSD: 2919 TD: 154
2,800
2,820
2,840
2,860
2,880
1159803 (Hale, TX)
HP_014497 LSD: 3318 TD: unk
3,160
3,180
3,200
3,220
3,240
3,260
3,280
3,300
701302 (Hartley, TX)
HP_006443 LSD: 4255 TD: 470
4,000
4,020
4,040
4,060
4,080
2405301 (Lamb, TX)
HP_017363 LSD: 3637 TD: 205
3,520
3,540
3,560
3,580
3,600
321912103044501 (Lea, NM)
HP_119972 LSD: 3366 TD: 370
3,160
3,180
3,200
3,220
3,240
322159103060601 (Lea, NM)
HP_119987 LSD: 3347 TD: 300
3,220
3,240
3,260
3,280
3,300
322245103053301 (Lea, NM)
HP_119991 LSD: 3377 TD: 400
3,220
3,240
3,260
3,280
3,300
322859103204401 (Lea, NM)
HP_120050 LSD: 3584 TD: 250
3,380
3,400
3,420
3,440
3,460
323053103191201 (Lea, NM)
HP_120073 LSD: 3554 TD: 312
3,400
3,420
3,440
3,460
3,480
323219103190601 (Lea, NM)
HP_120086 LSD: 3555 TD: 265
3,440
3,460
3,480
3,500
3,520
332911103411801 (Lea, NM)
HP_122289 LSD: 4360 TD: unk
4,160
4,180
4,200
4,220
4,240
4,260
4,280
4,300
4,320
1930
1940
1950
1960
1970
1980
1990
2000
2010

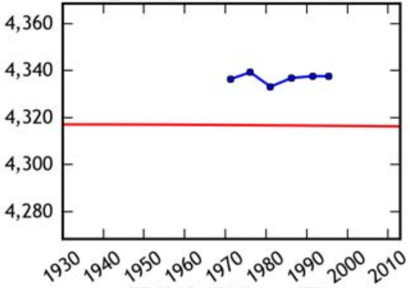
333039103334801 (Lea, NM)
HP_122320 LSD: 4348 TD: unk



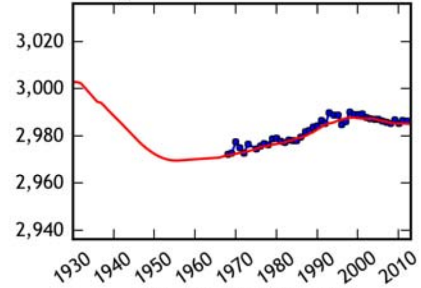
333043103320601 (Lea, NM)
HP_122323 LSD: 4331 TD: unk



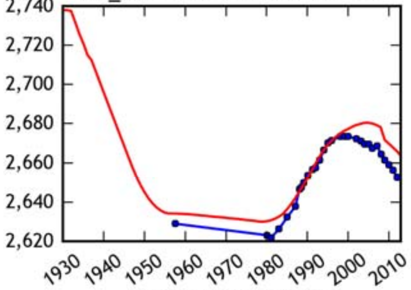
333121103401401 (Lea, NM)
HP_122332 LSD: 4380 TD: 139



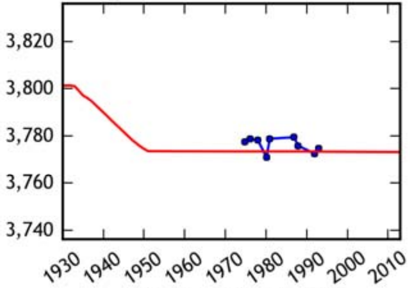
2335301 (Lubbock, TX)
HP_016750 LSD: 3090 TD: 203



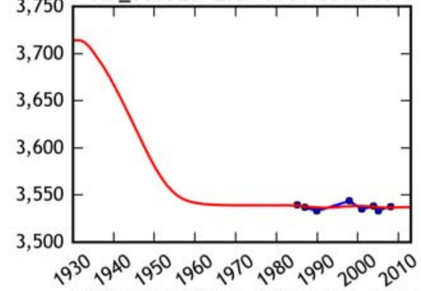
2849402 (Martin, TX)
HP_022894 LSD: 2775 TD: 190



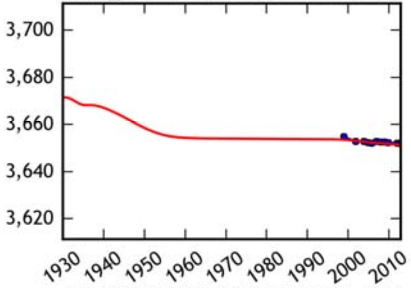
754202 (Oldham, TX)
HP_007195 LSD: 3980 TD: 232



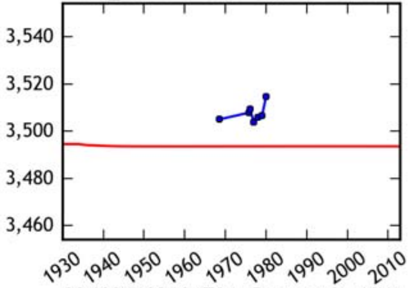
1015901 (Randall, TX)
HP_008928 LSD: 3861 TD: 340



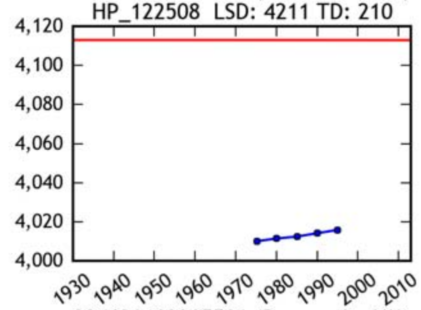
1016702 (Randall, TX)
HP_008940 LSD: 3812 TD: 390



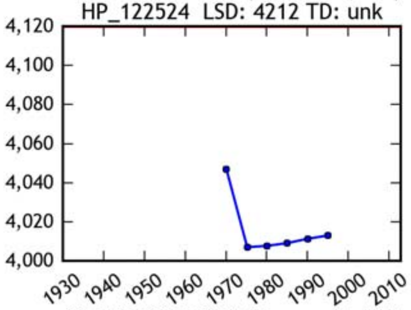
1102701 (Randall, TX)
HP_010695 LSD: 3651 TD: 220



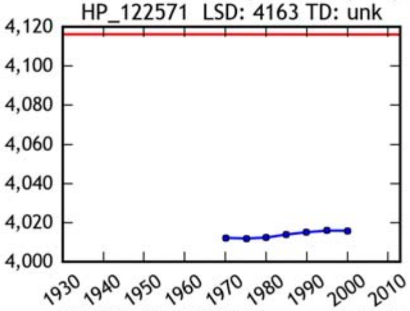
334331103191401 (Roosevelt, NM)
HP_122508 LSD: 4211 TD: 210



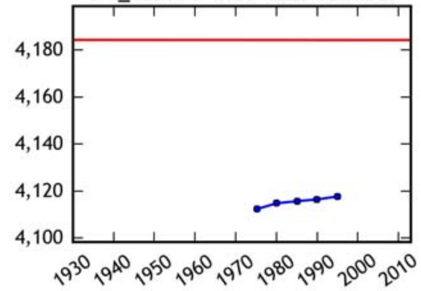
334419103190201 (Roosevelt, NM)
HP_122524 LSD: 4212 TD: unk



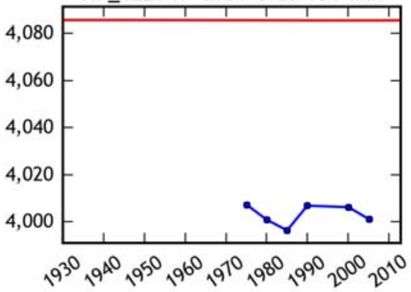
334604103181701 (Roosevelt, NM)
HP_122571 LSD: 4163 TD: unk



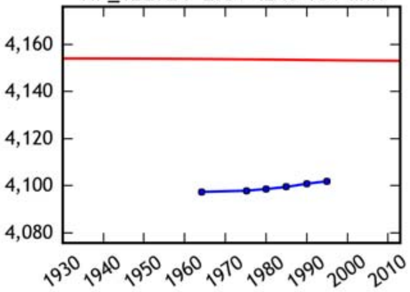
334620103205501 (Roosevelt, NM)
HP_122584 LSD: 4226 TD: unk



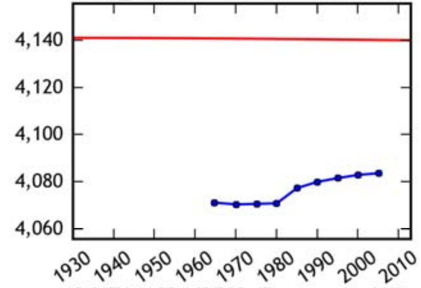
334740103151301 (Roosevelt, NM)
HP_122646 LSD: 4129 TD: unk



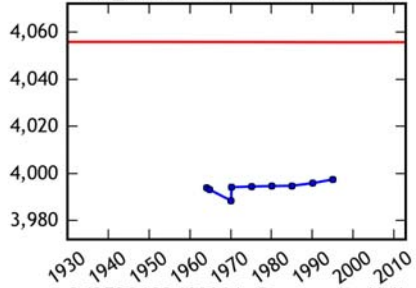
335301103155301 (Roosevelt, NM)
HP_122924 LSD: 4245 TD: unk



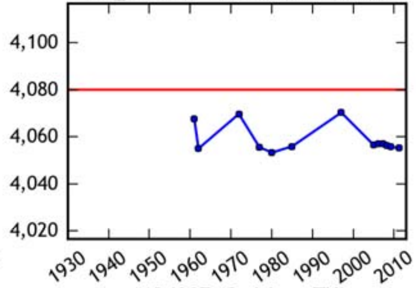
335525103145201 (Roosevelt, NM)
HP_123021 LSD: 4260 TD: unk



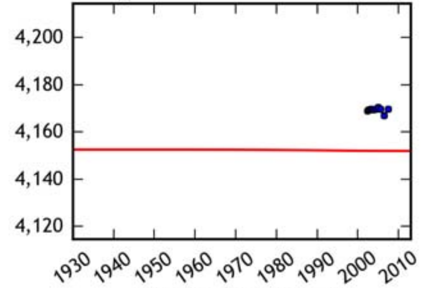
335559103094001 (Roosevelt, NM)
HP_123038 LSD: 4175 TD: unk



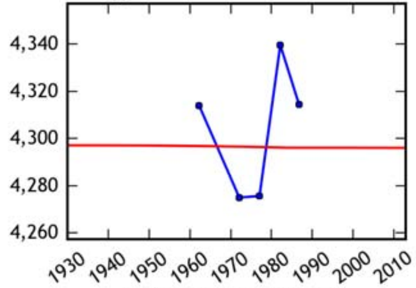
340138103165601 (Roosevelt, NM)
HP_123212 LSD: 4126 TD: 100



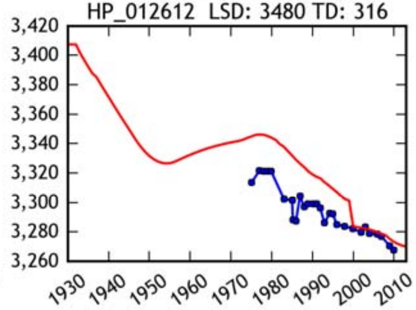
341714103442502 (Roosevelt, NM)
HP_124530 LSD: 4293 TD: 245



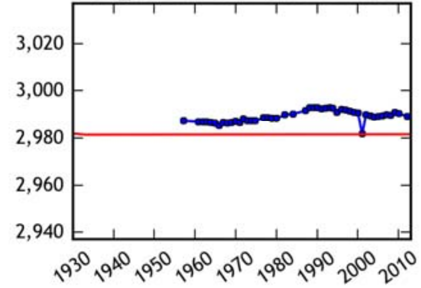
342539103460001 (Roosevelt, NM)
HP_125390 LSD: 4384 TD: 120



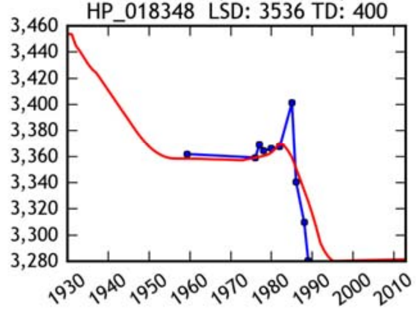
1134907 (Swisher, TX)
HP_012612 LSD: 3480 TD: 316



4501901 (Winkler, TX)
HP_028865 LSD: 3051 TD: 108



2444701 (Yoakum, TX)
HP_018348 LSD: 3536 TD: 400

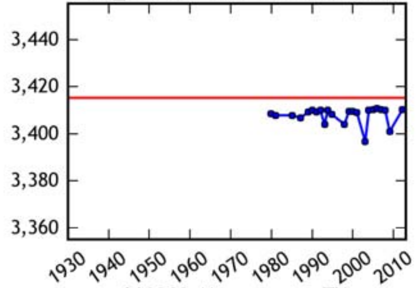


B.5 Lower Dockum Aquifer Hydrographs

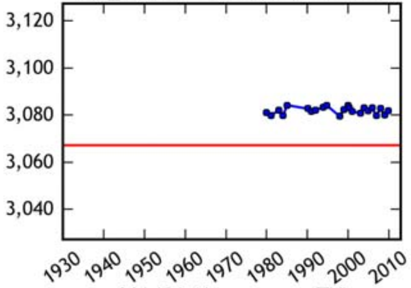
This section contains the observed and simulated hydrographs for the lower Dockum Aquifer.

This page is intentionally left blank.

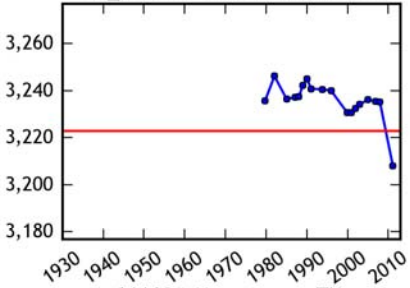
2640201 (Andrews, TX)
HP_019093 LSD: 3490 TD: unk



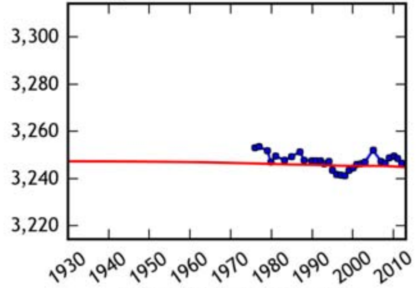
2656601 (Andrews, TX)
HP_019099 LSD: 3192 TD: unk



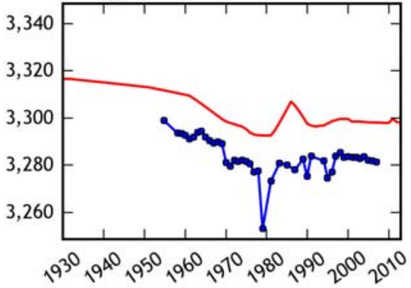
2750501 (Andrews, TX)
HP_021261 LSD: 3316 TD: unk



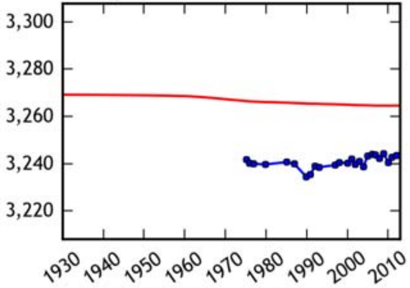
660902 (Armstrong, TX)
HP_006272 LSD: 3461 TD: 294



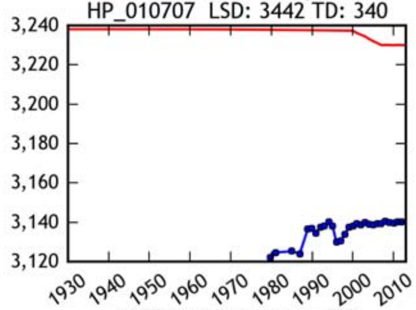
661401 (Armstrong, TX)
HP_006302 LSD: 3444 TD: 268



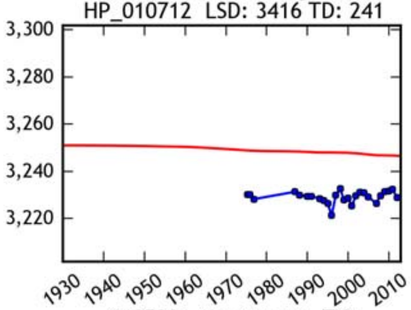
661608 (Armstrong, TX)
HP_006316 LSD: 3407 TD: 230



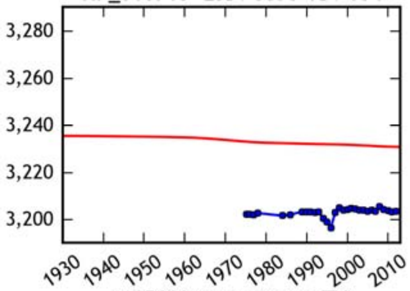
1104301 (Armstrong, TX)
HP_010707 LSD: 3442 TD: 340



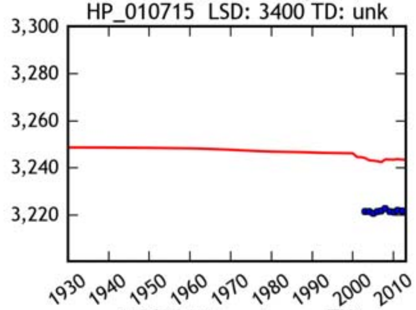
1105101 (Armstrong, TX)
HP_010712 LSD: 3416 TD: 241



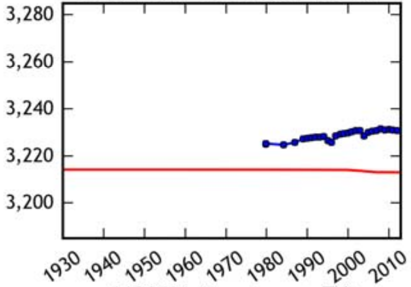
1105102 (Armstrong, TX)
HP_010713 LSD: 3373 TD: 184



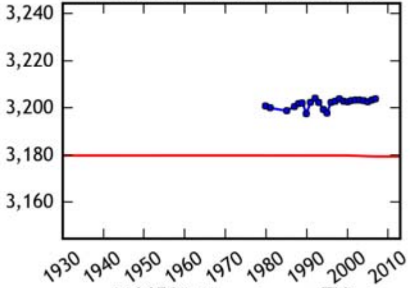
1105104 (Armstrong, TX)
HP_010715 LSD: 3400 TD: unk



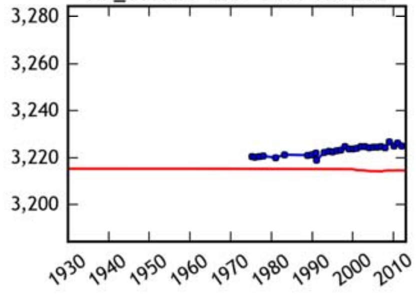
1105301 (Armstrong, TX)
HP_010717 LSD: 3386 TD: 190



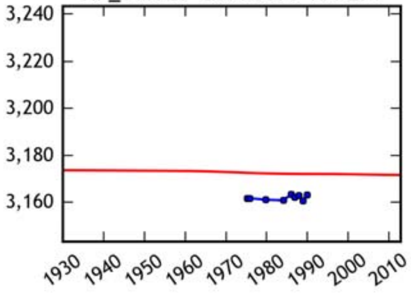
1105602 (Armstrong, TX)
HP_010723 LSD: 3372 TD: 235



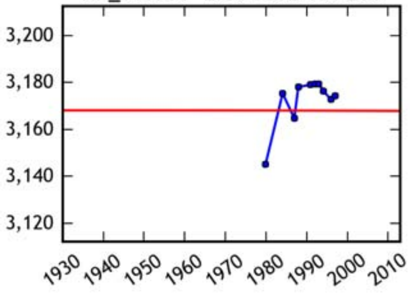
1106101 (Armstrong, TX)
HP_010724 LSD: 3401 TD: 252

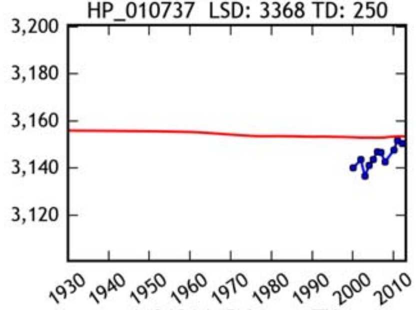


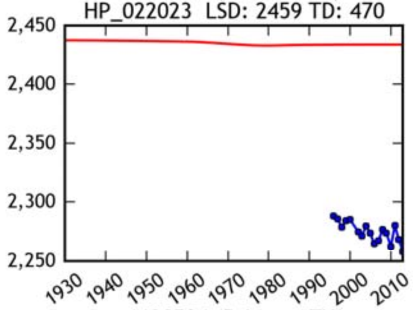
1106401 (Armstrong, TX)
HP_010729 LSD: 3373 TD: 270

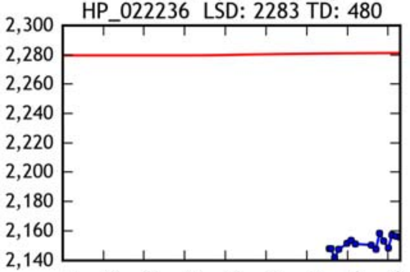


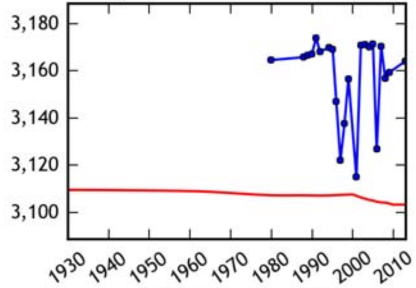
1106501 (Armstrong, TX)
HP_010731 LSD: 3352 TD: 280

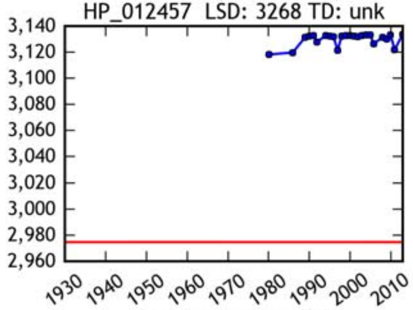


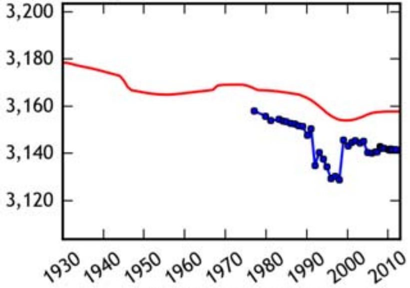

1106804 (Armstrong, TX)
HP_010737 LSD: 3368 TD: 250

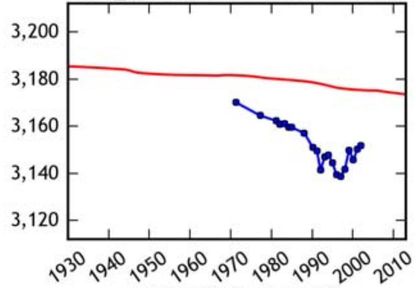

2813901 (Borden, TX)
HP_022023 LSD: 2459 TD: 470

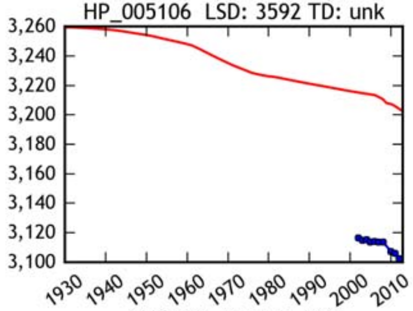

2831401 (Borden, TX)
HP_022236 LSD: 2283 TD: 480

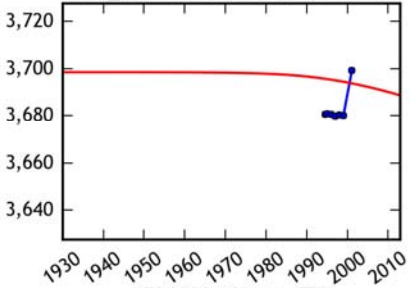

1121214 (Briscoe, TX)
HP_012058 LSD: 3321 TD: unk

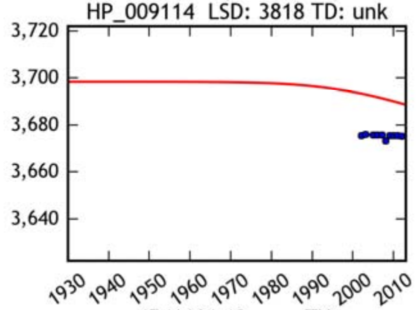

1130504 (Briscoe, TX)
HP_012457 LSD: 3268 TD: unk

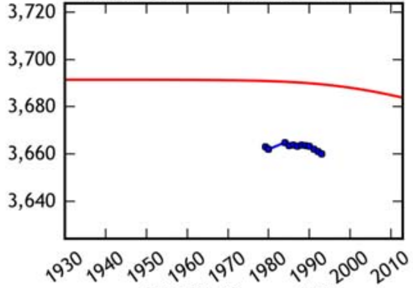

628701 (Carson, TX)
HP_004541 LSD: 3409 TD: 468

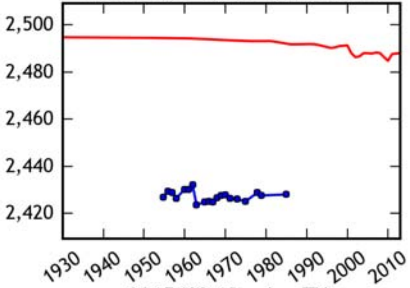

636101 (Carson, TX)
HP_004665 LSD: 3429 TD: 325

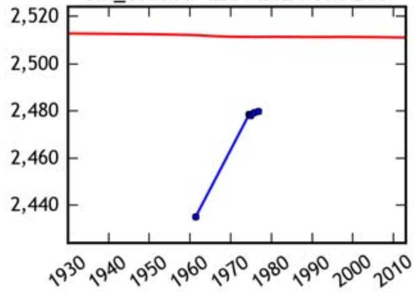

644162 (Carson, TX)
HP_005106 LSD: 3592 TD: unk

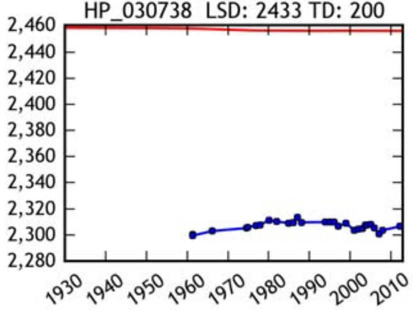

1023401 (Castro, TX)
HP_009110 LSD: 3813 TD: unk

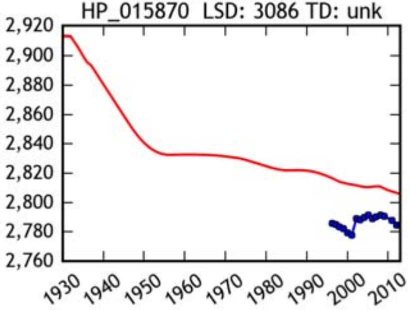

1023702 (Castro, TX)
HP_009114 LSD: 3818 TD: unk


1023802 (Castro, TX)
HP_009117 LSD: 3805 TD: unk

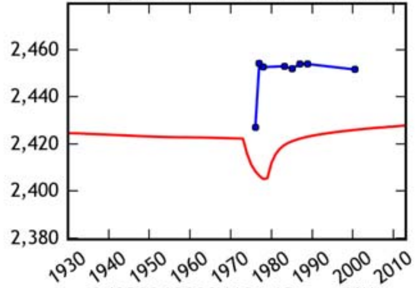

4536802 (Crane, TX)
HP_030429 LSD: 2491 TD: 234


4546101 (Crane, TX)
HP_030599 LSD: 2624 TD: 210

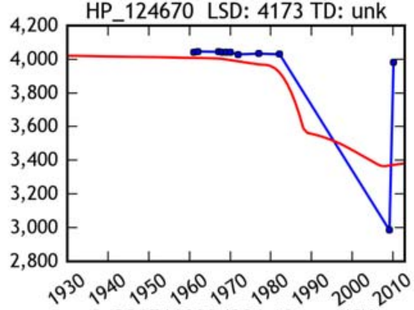

4554501 (Crane, TX)
HP_030738 LSD: 2433 TD: 200


2315403 (Crosby, TX)
HP_015870 LSD: 3086 TD: unk

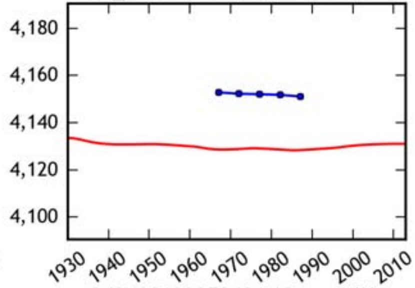
2339501 (Crosby, TX)
HP_016840 LSD: 2461 TD: 50



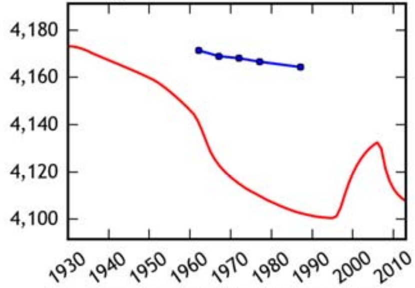
341851103194101 (Curry, NM)
HP_124670 LSD: 4173 TD: unk



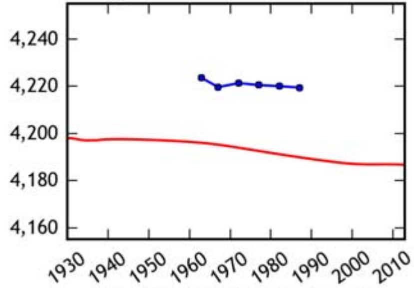
342116103285301 (Curry, NM)
HP_124943 LSD: 4266 TD: unk



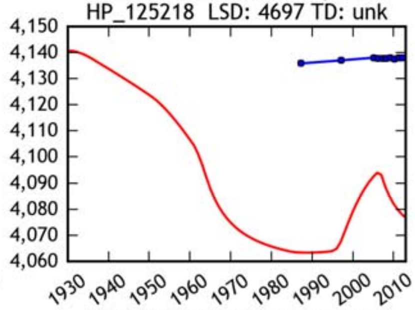
342202103324101 (Curry, NM)
HP_125038 LSD: 4251 TD: unk



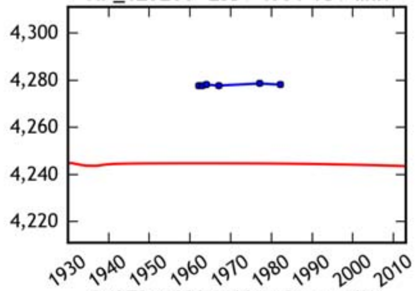
342305103324301 (Curry, NM)
HP_125134 LSD: 4304 TD: unk



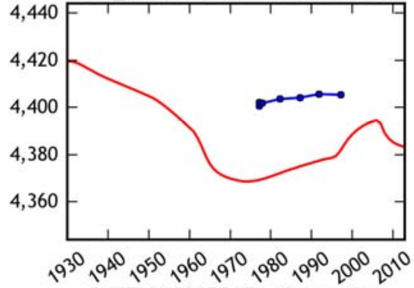
342400103270401 (Curry, NM)
HP_125218 LSD: 4697 TD: unk



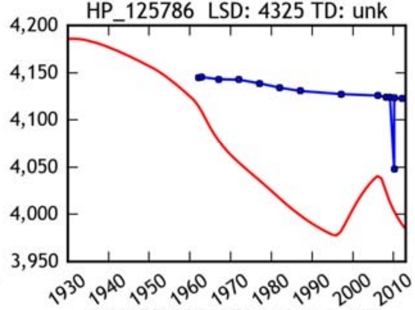
342432103365601 (Curry, NM)
HP_125280 LSD: 4351 TD: unk



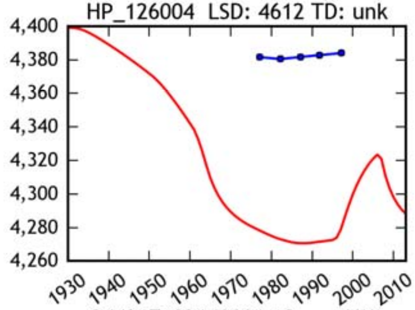
343231103410601 (Curry, NM)
HP_125759 LSD: 4597 TD: 203



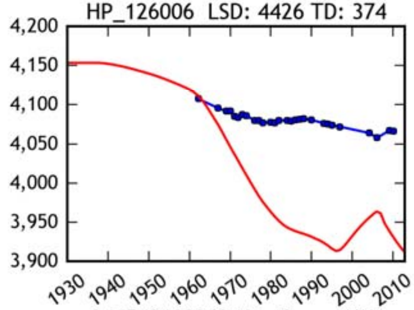
343257103174901 (Curry, NM)
HP_125786 LSD: 4325 TD: unk



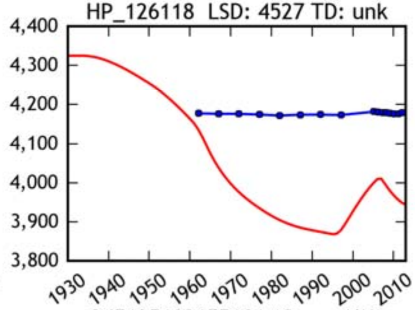
343724103344601 (Curry, NM)
HP_126004 LSD: 4612 TD: unk



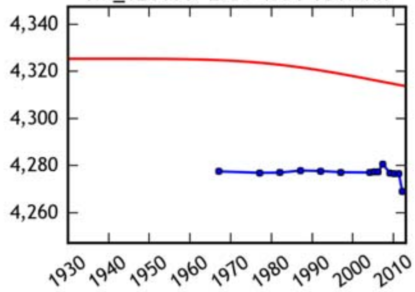
343730103055601 (Curry, NM)
HP_126006 LSD: 4426 TD: 374



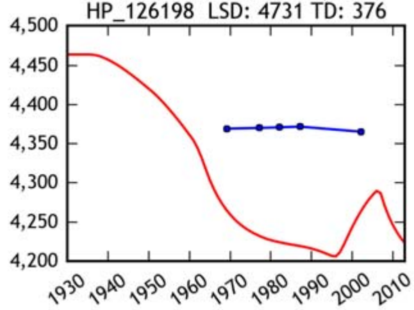
344158103083501 (Curry, NM)
HP_126118 LSD: 4527 TD: unk



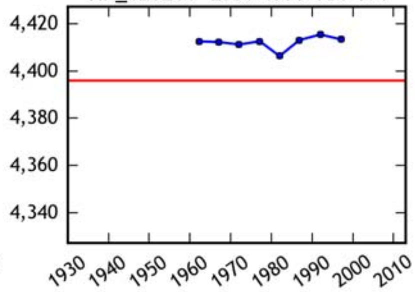
344317103140901 (Curry, NM)
HP_126150 LSD: 4551 TD: unk

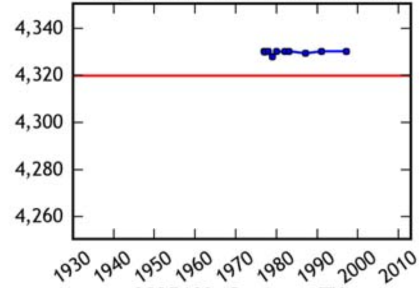


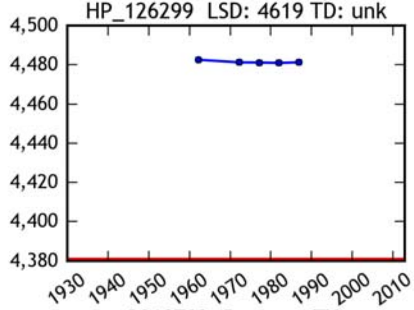
344543103262401 (Curry, NM)
HP_126198 LSD: 4731 TD: 376

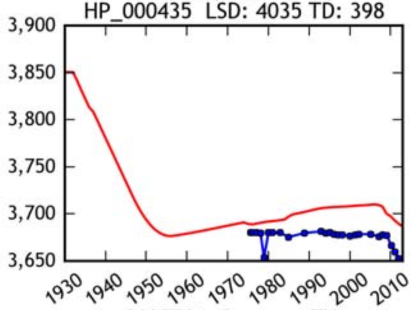


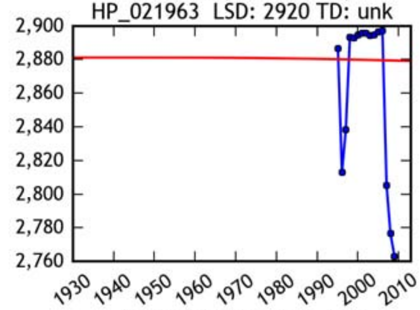
345125103155101 (Curry, NM)
HP_126280 LSD: 4599 TD: 191

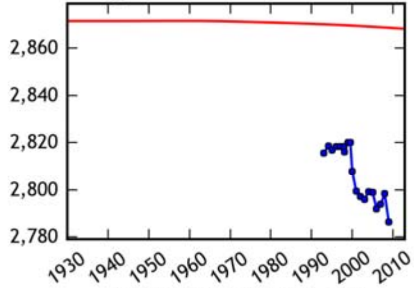


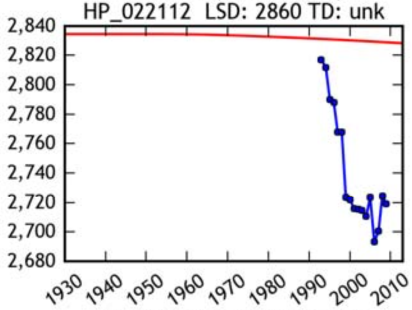

345134103100301 (Curry, NM)
HP_126283 LSD: 4550 TD: unk

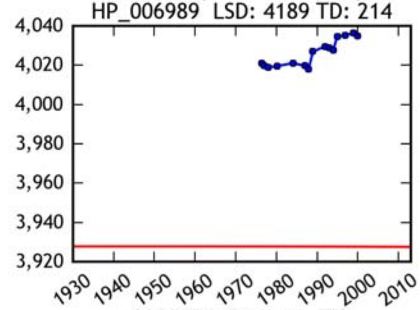

345322103154201 (Curry, NM)
HP_126299 LSD: 4619 TD: unk

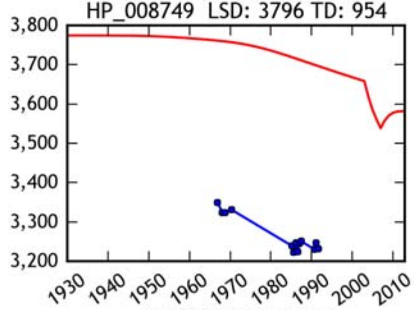

245101 (Dallam, TX)
HP_000435 LSD: 4035 TD: 398

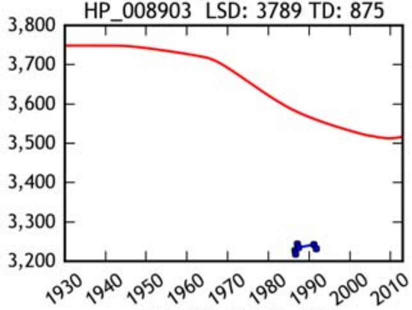

2825102 (Dawson, TX)
HP_021963 LSD: 2920 TD: unk

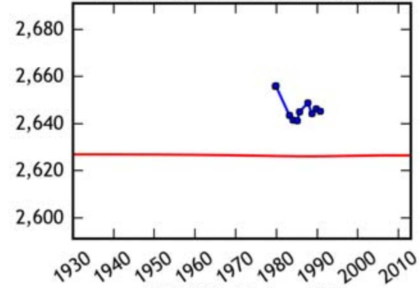

2810703 (Dawson, TX)
HP_021995 LSD: 2941 TD: unk

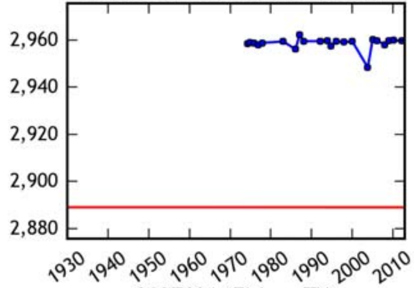

2825704 (Dawson, TX)
HP_022112 LSD: 2860 TD: unk

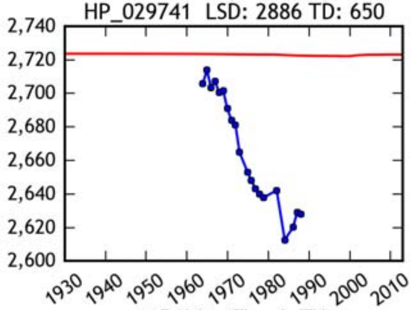

750901 (Deaf Smith, TX)
HP_006989 LSD: 4189 TD: 214

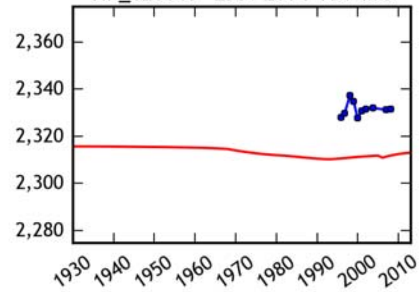

1013503 (Deaf Smith, TX)
HP_008749 LSD: 3796 TD: 954

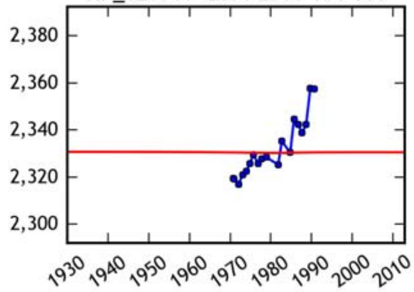

1014443 (Deaf Smith, TX)
HP_008903 LSD: 3789 TD: 875

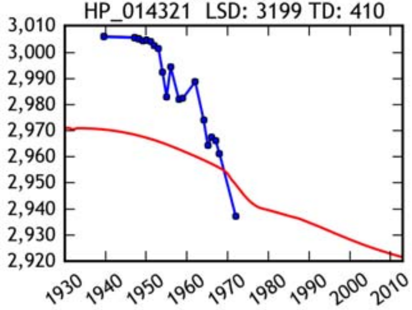

2209604 (Dickens, TX)
HP_015338 LSD: 2735 TD: unk


4512104 (Ector, TX)
HP_029416 LSD: 3137 TD: 200

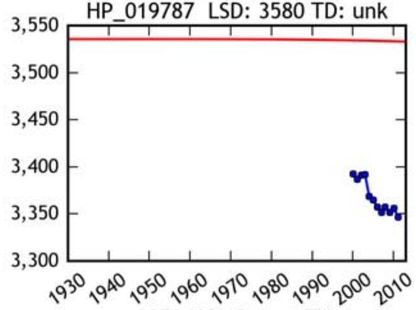

4519101 (Ector, TX)
HP_029741 LSD: 2886 TD: 650


2927302 (Fisher, TX)
HP_023907 LSD: 2391 TD: 150

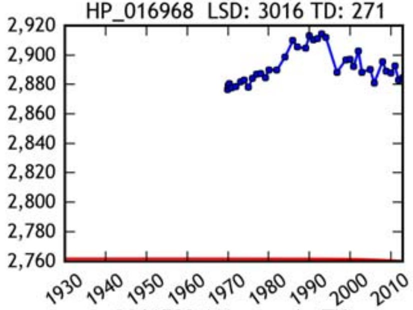

2927601 (Fisher, TX)
HP_023910 LSD: 2388 TD: 116


1154301 (Floyd, TX)
HP_014321 LSD: 3199 TD: 410

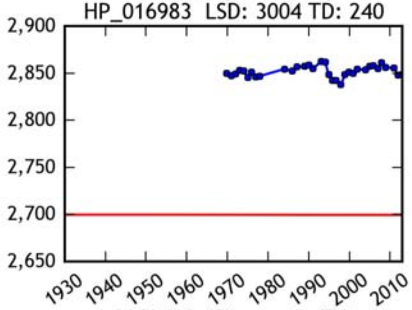
2709702 (Gaines, TX)
HP_019787 LSD: 3580 TD: unk



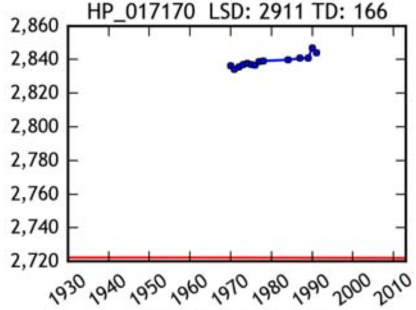
2344208 (Garza, TX)
HP_016968 LSD: 3016 TD: 271



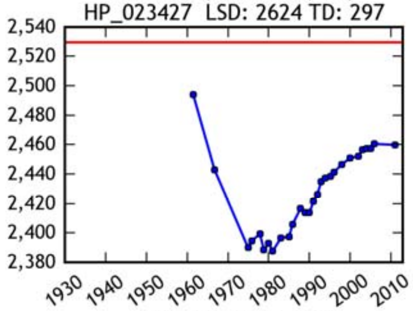
2344608 (Garza, TX)
HP_016983 LSD: 3004 TD: 240



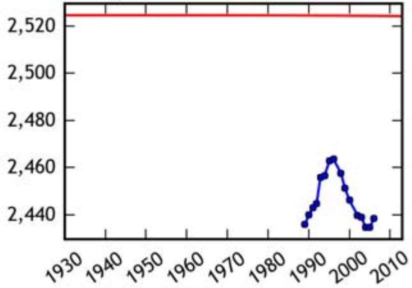
2353402 (Garza, TX)
HP_017170 LSD: 2911 TD: 166



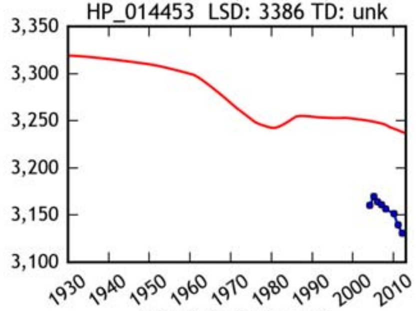
2861502 (Glasscock, TX)
HP_023427 LSD: 2624 TD: 297



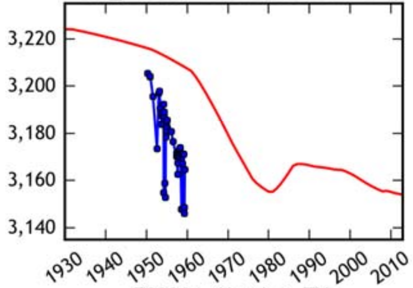
2862418 (Glasscock, TX)
HP_023540 LSD: 2603 TD: 310



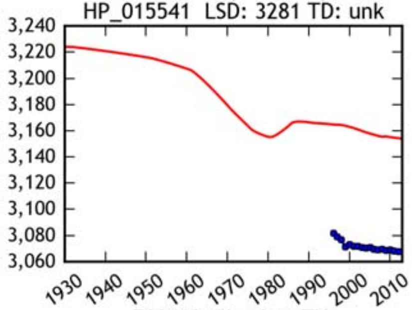
1158605 (Hale, TX)
HP_014453 LSD: 3386 TD: unk



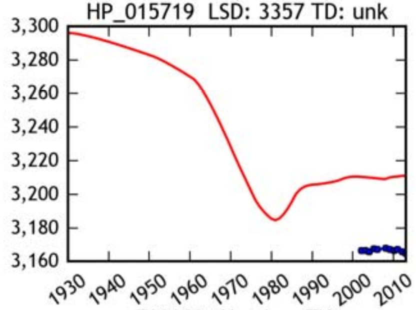
2303901 (Hale, TX)
HP_015539 LSD: 3282 TD: unk



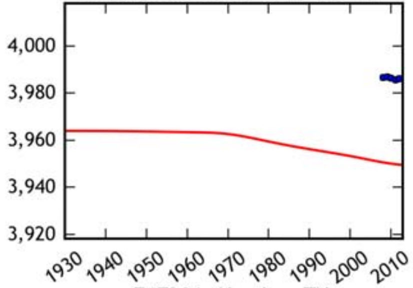
2303903 (Hale, TX)
HP_015541 LSD: 3281 TD: unk



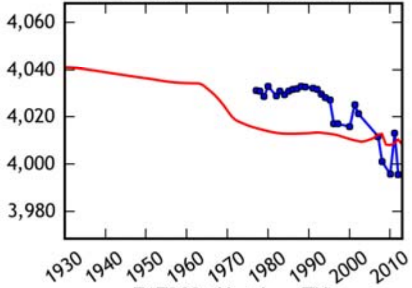
2310112 (Hale, TX)
HP_015719 LSD: 3357 TD: unk



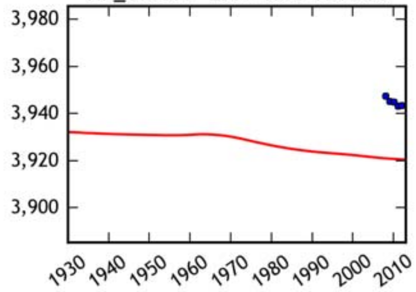
709301 (Hartley, TX)
HP_006590 LSD: 4146 TD: 420



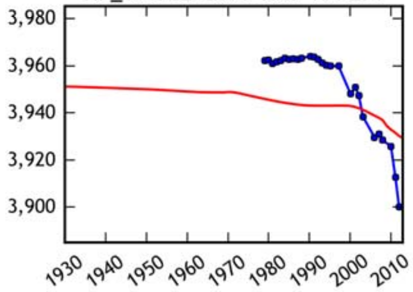
709403 (Hartley, TX)
HP_006593 LSD: 4185 TD: 420



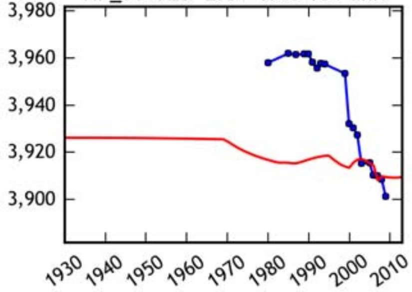
709902 (Hartley, TX)
HP_006597 LSD: 4085 TD: 380



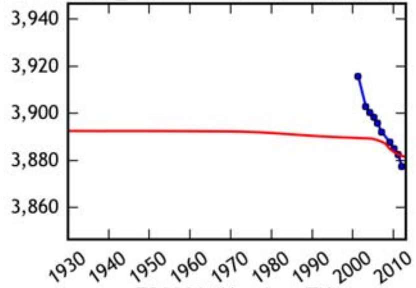
717201 (Hartley, TX)
HP_006722 LSD: 4047 TD: 270



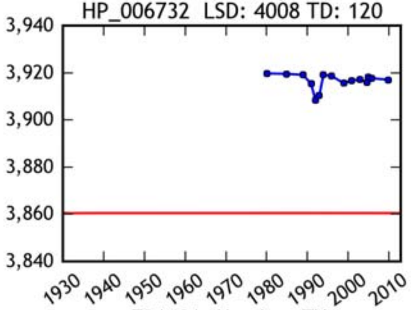
717302 (Hartley, TX)
HP_006725 LSD: 4063 TD: unk



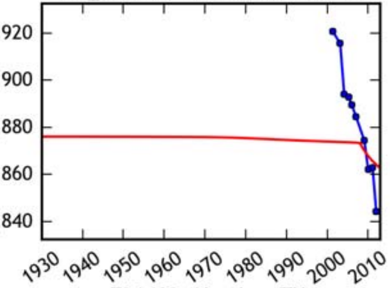
717304 (Hartley, TX)
HP_006727 LSD: 4030 TD: 311



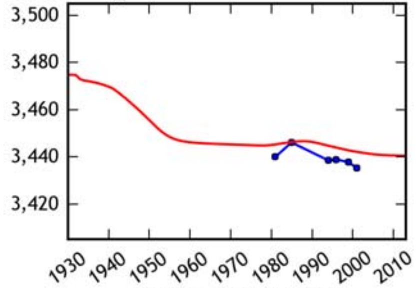
717901 (Hartley, TX)
HP_006732 LSD: 4008 TD: 120



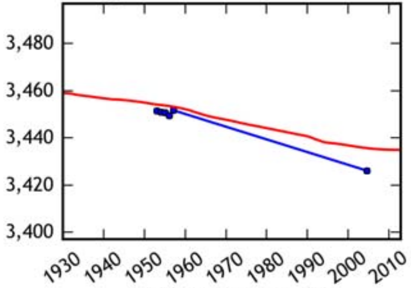
718101 (Hartley, TX)
HP_006733 LSD: 4009 TD: 304



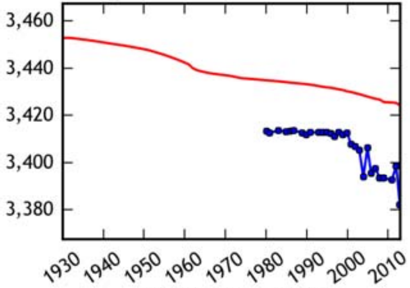
720801 (Hartley, TX)
HP_006745 LSD: 3667 TD: 300



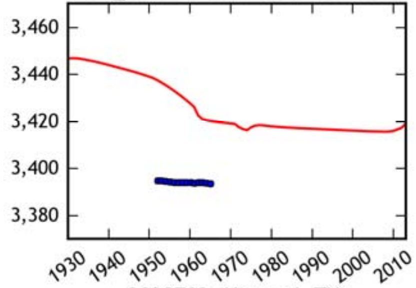
721401 (Hartley, TX)
HP_006749 LSD: 3500 TD: unk



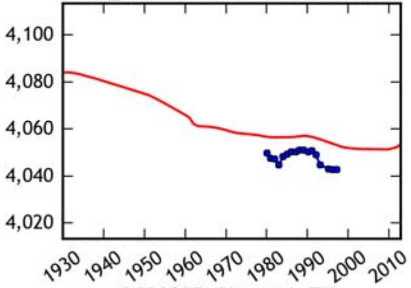
721402 (Hartley, TX)
HP_006750 LSD: 3436 TD: 304



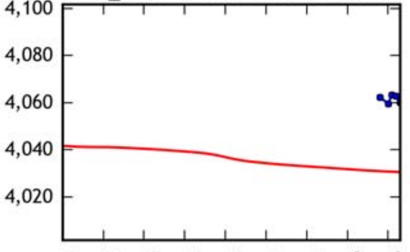
721701 (Hartley, TX)
HP_006752 LSD: 3429 TD: 124



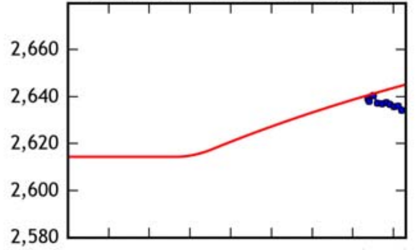
816602 (Hartley, TX)
HP_007997 LSD: 4248 TD: 358



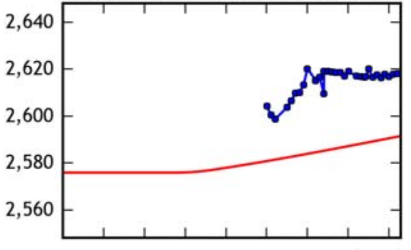
816901 (Hartley, TX)
HP_007998 LSD: 4242 TD: 378



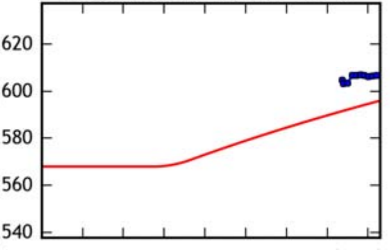
2828702 (Howard, TX)
HP_022200 LSD: 2677 TD: unk



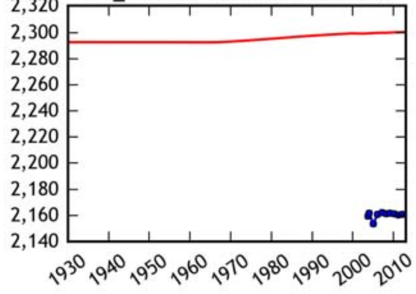
2828805 (Howard, TX)
HP_022205 LSD: 2686 TD: 139



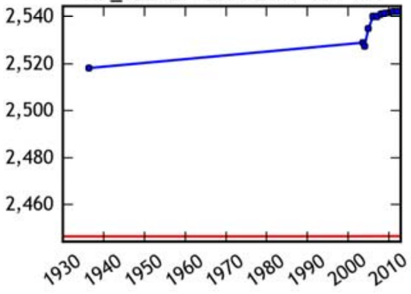
2828806 (Howard, TX)
HP_022206 LSD: 2641 TD: 90



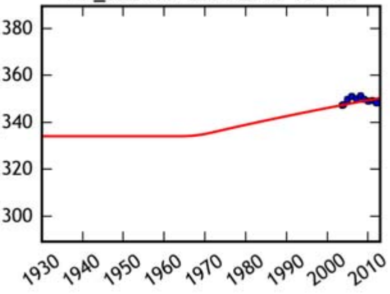
2831703 (Howard, TX)
HP_022245 LSD: 2329 TD: unk



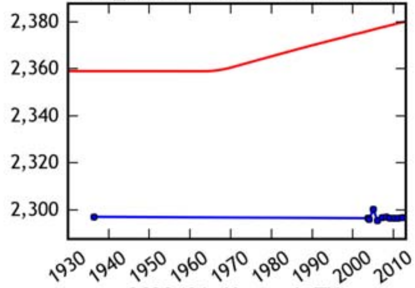
2837303 (Howard, TX)
HP_022429 LSD: 2609 TD: 101



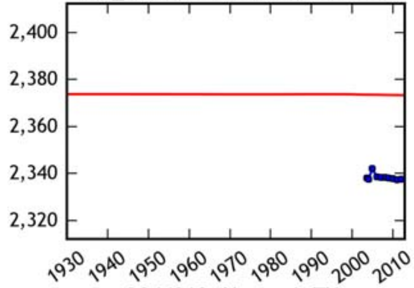
2838302 (Howard, TX)
HP_022468 LSD: 2363 TD: 65



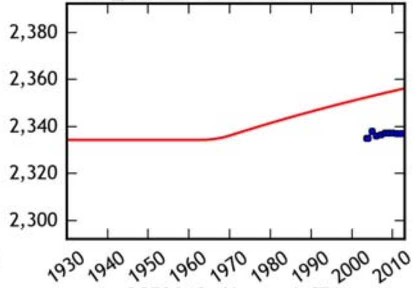
2838303 (Howard, TX)
HP_022469 LSD: 2389 TD: 129



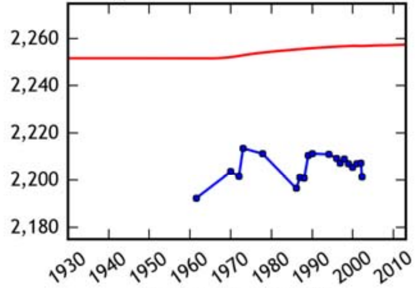
2838703 (Howard, TX)
HP_022484 LSD: 2412 TD: unk



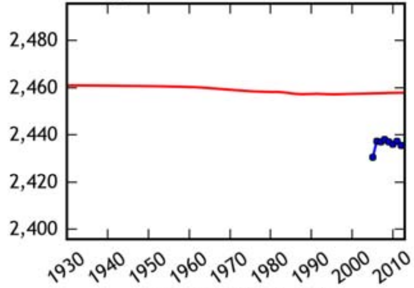
2839108 (Howard, TX)
HP_022496 LSD: 2371 TD: unk



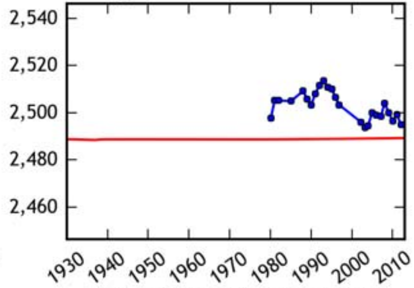
2839401 (Howard, TX)
HP_022503 LSD: 2288 TD: 110



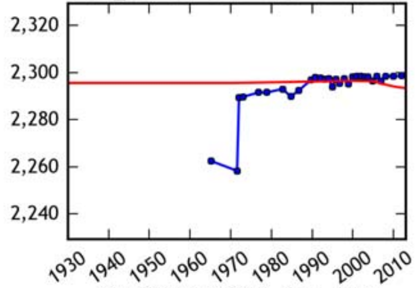
2844910 (Howard, TX)
HP_022708 LSD: 2494 TD: unk



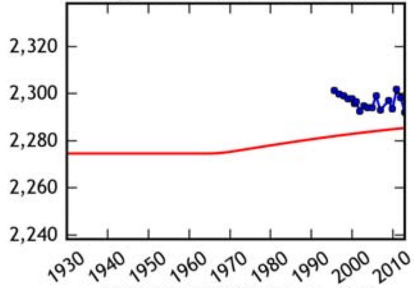
2852913 (Howard, TX)
HP_023046 LSD: 2521 TD: 30



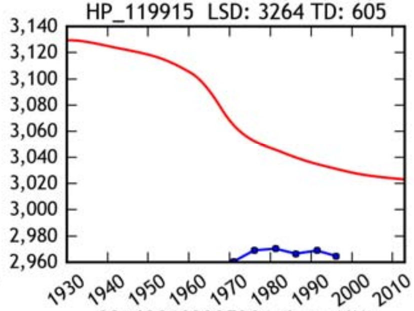
2257701 (Kent, TX)
HP_015429 LSD: 2365 TD: 126



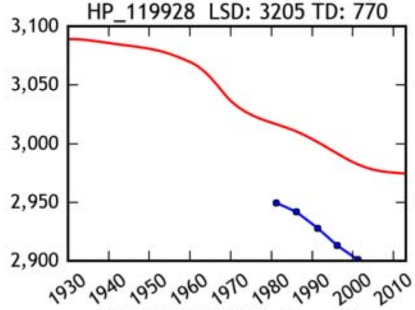
2364901 (Kent, TX)
HP_017302 LSD: 2329 TD: 59



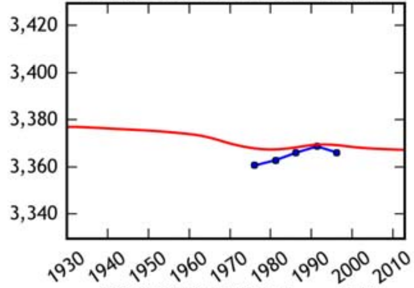
320916103182501 (Lea, NM)
HP_119915 LSD: 3264 TD: 605



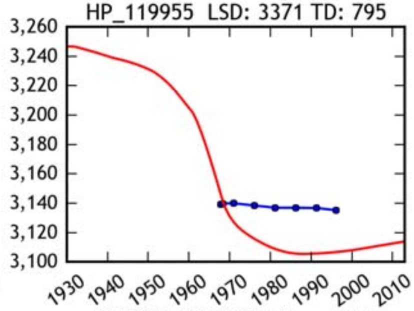
321125103093001 (Lea, NM)
HP_119928 LSD: 3205 TD: 770



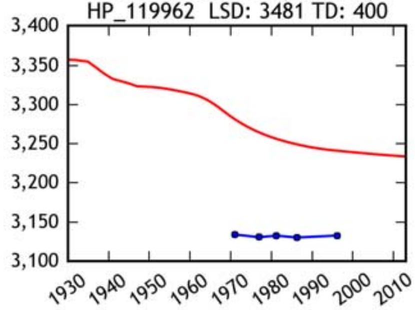
321510103290801 (Lea, NM)
HP_119943 LSD: 3574 TD: 550



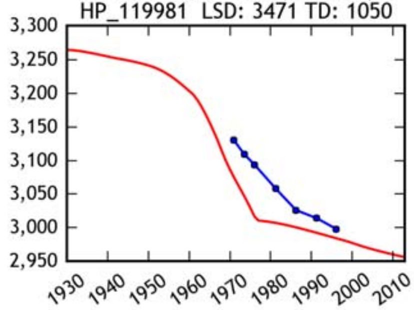
321638103225201 (Lea, NM)
HP_119955 LSD: 3371 TD: 795



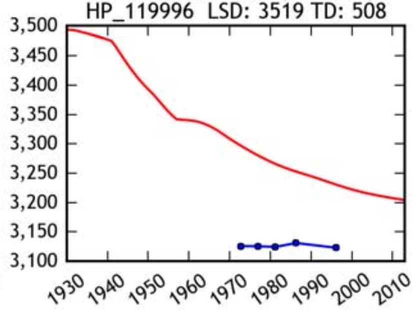
321734103290001 (Lea, NM)
HP_119962 LSD: 3481 TD: 400



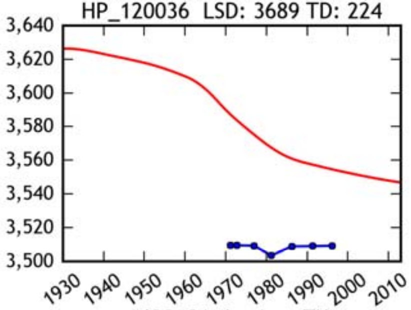
322049103155901 (Lea, NM)
HP_119981 LSD: 3471 TD: 1050



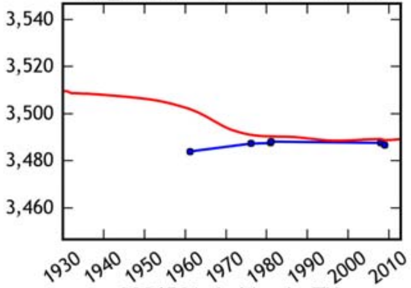
322325103313301 (Lea, NM)
HP_119996 LSD: 3519 TD: 508



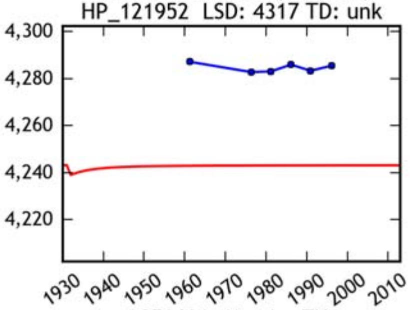
322702103344001 (Lea, NM)
HP_120036 LSD: 3689 TD: 224



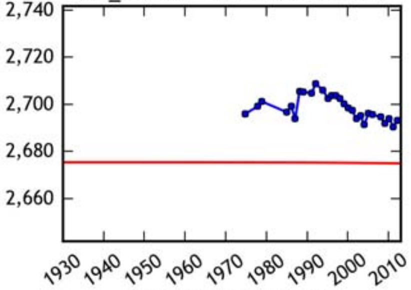
323307103044701 (Lea, NM)
HP_120089 LSD: 3541 TD: unk



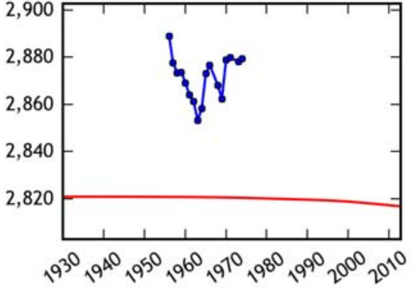
331644103404101 (Lea, NM)
HP_121952 LSD: 4317 TD: unk



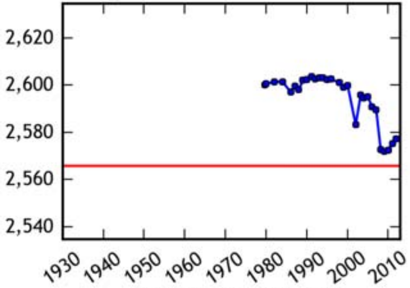
4622401 (Loving, TX)
HP_031365 LSD: 2792 TD: 212



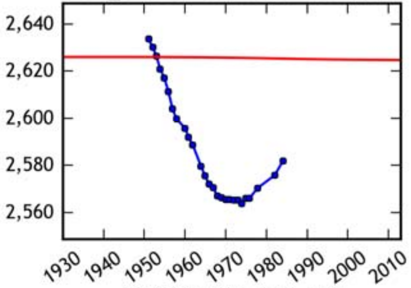
2336501 (Lubbock, TX)
HP_016819 LSD: 3050 TD: unk



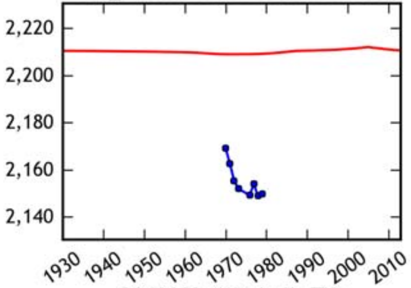
2850601 (Martin, TX)
HP_022930 LSD: 2658 TD: 128



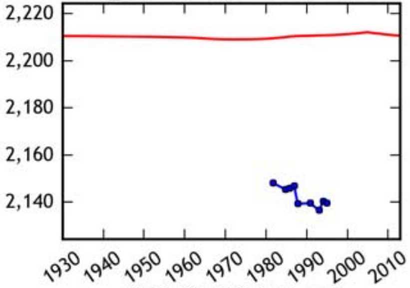
2858105 (Martin, TX)
HP_023269 LSD: 2709 TD: unk



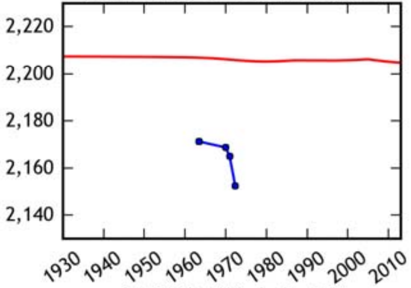
2839802 (Mitchell, TX)
HP_022512 LSD: 2266 TD: 215



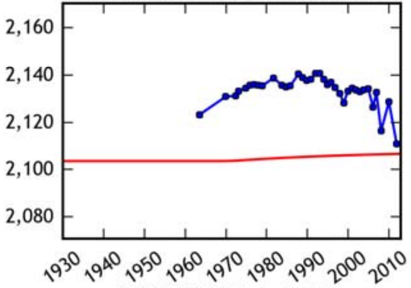
2839803 (Mitchell, TX)
HP_022513 LSD: 2266 TD: 202



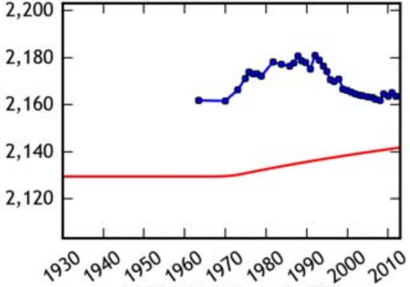
2840104 (Mitchell, TX)
HP_022519 LSD: 2232 TD: 284



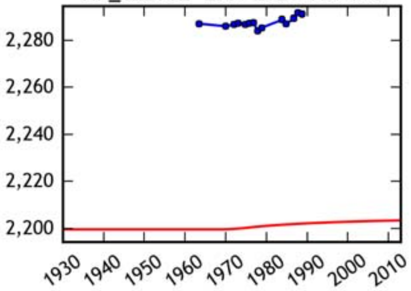
2840602 (Mitchell, TX)
HP_022548 LSD: 2151 TD: 65



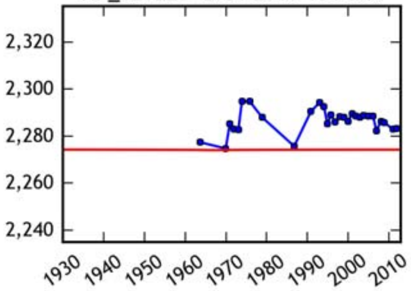
2848303 (Mitchell, TX)
HP_022862 LSD: 2192 TD: 61



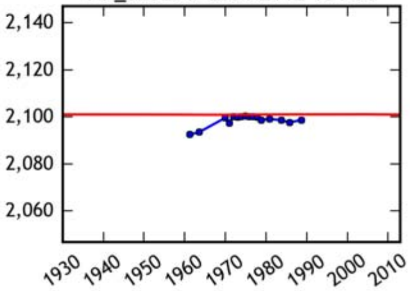
2848702 (Mitchell, TX)
HP_022882 LSD: 2328 TD: 100



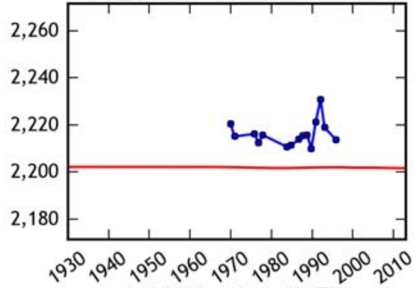
2855903 (Mitchell, TX)
HP_023225 LSD: 2368 TD: unk



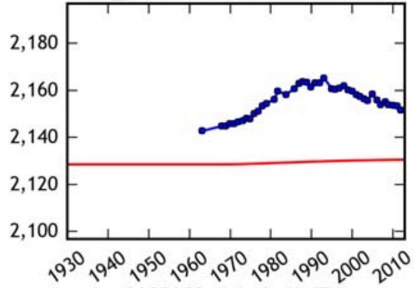
2856601 (Mitchell, TX)
HP_023236 LSD: 2112 TD: 36



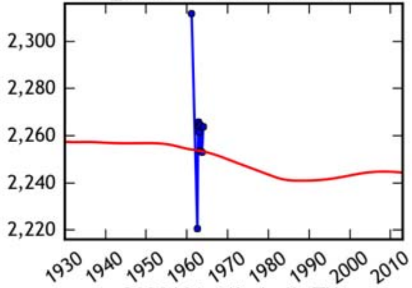
2864302 (Mitchell, TX)
HP_023631 LSD: 2280 TD: 90



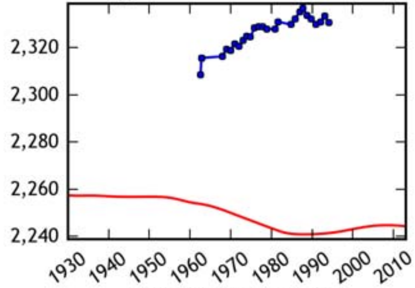
2925901 (Mitchell, TX)
HP_023881 LSD: 2224 TD: 100



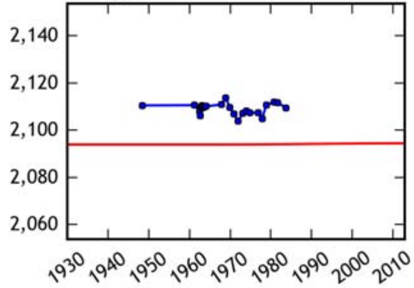
2926801 (Mitchell, TX)
HP_023894 LSD: 2352 TD: 332



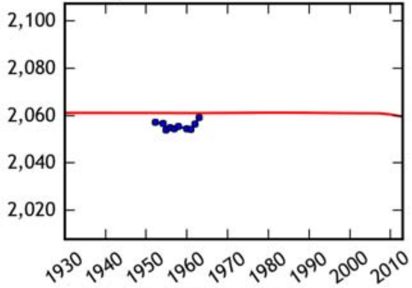
2926803 (Mitchell, TX)
HP_023896 LSD: 2326 TD: 90



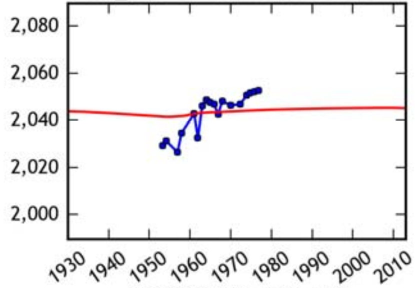
2933202 (Mitchell, TX)
HP_023935 LSD: 2206 TD: 100



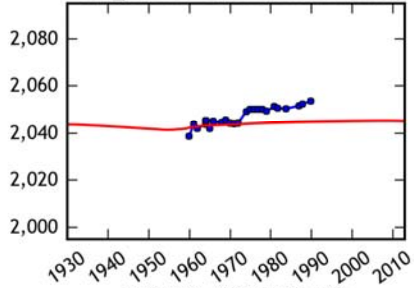
2933601 (Mitchell, TX)
HP_023964 LSD: 2110 TD: 170



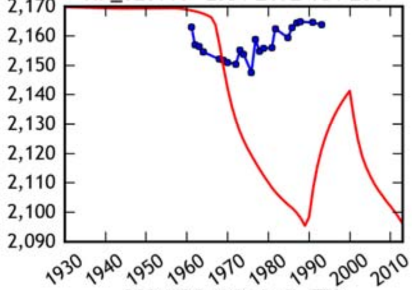
2933906 (Mitchell, TX)
HP_023983 LSD: 2075 TD: 131



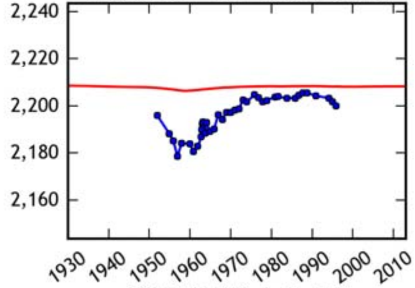
2933907 (Mitchell, TX)
HP_023984 LSD: 2072 TD: 158



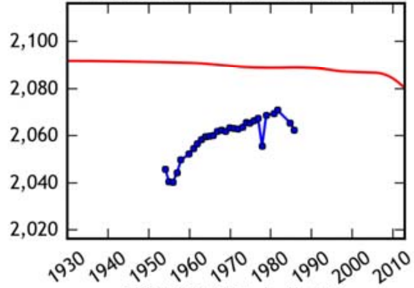
2934101 (Mitchell, TX)
HP_023997 LSD: 2192 TD: 250



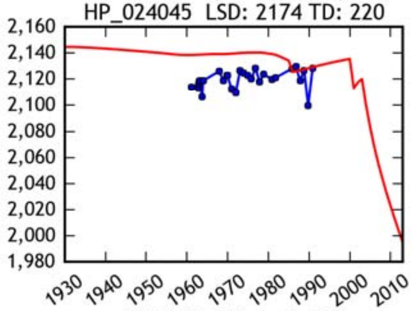
2934301 (Mitchell, TX)
HP_024017 LSD: 2212 TD: 230



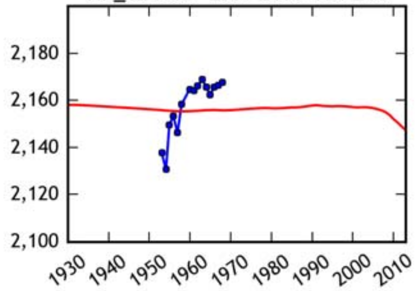
2934401 (Mitchell, TX)
HP_024023 LSD: 2188 TD: 250



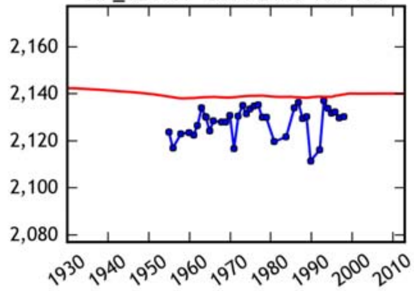
2934426 (Mitchell, TX)
HP_024045 LSD: 2174 TD: 220



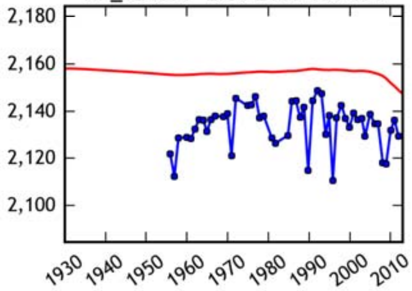
2934502 (Mitchell, TX)
HP_024056 LSD: 2199 TD: 210

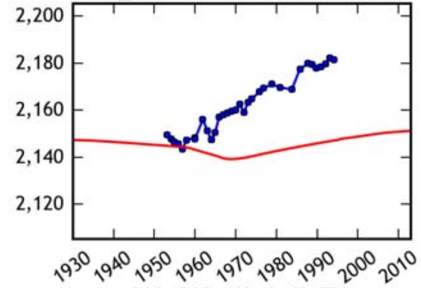


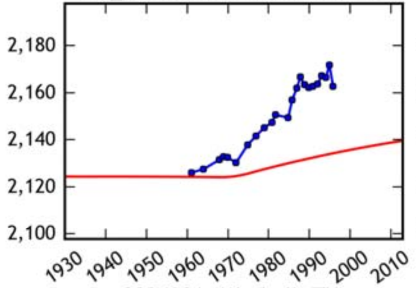
2934503 (Mitchell, TX)
HP_024057 LSD: 2145 TD: 190

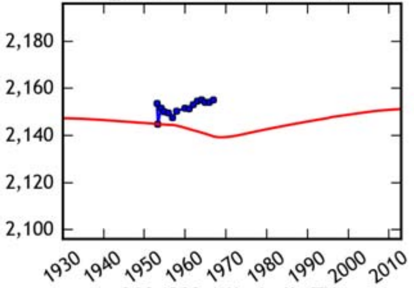


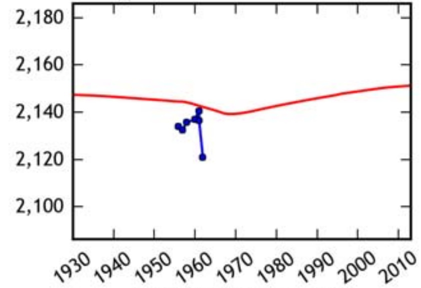
2934507 (Mitchell, TX)
HP_024061 LSD: 2165 TD: 155

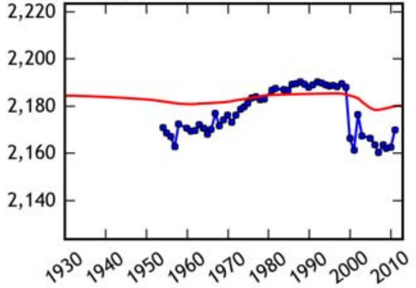


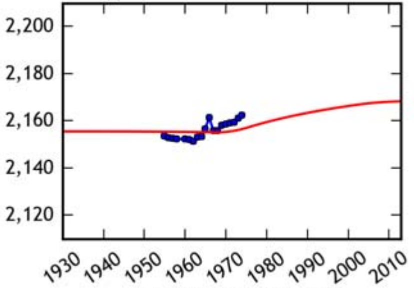

2934803 (Mitchell, TX)
HP_024112 LSD: 2180 TD: 188

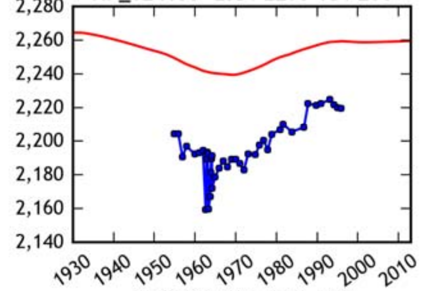

2934805 (Mitchell, TX)
HP_024114 LSD: 2192 TD: 190

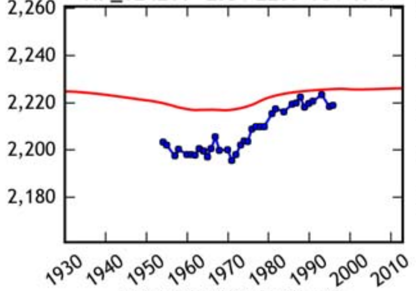

2934807 (Mitchell, TX)
HP_024116 LSD: 2206 TD: 184

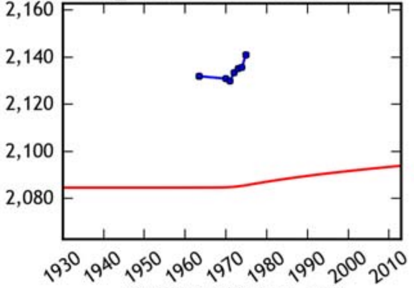

2934808 (Mitchell, TX)
HP_024117 LSD: 2178 TD: 206

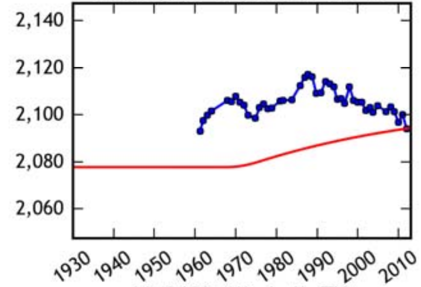

2934901 (Mitchell, TX)
HP_024127 LSD: 2194 TD: 165

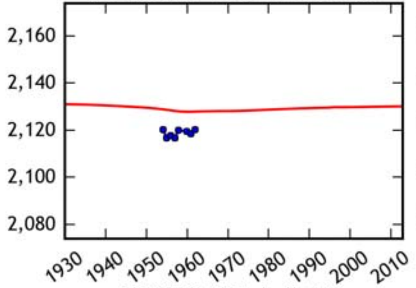

2934903 (Mitchell, TX)
HP_024129 LSD: 2209 TD: unk

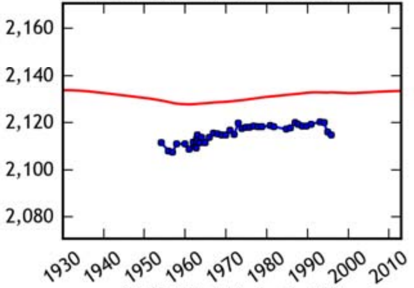

2935102 (Mitchell, TX)
HP_024153 LSD: 2293 TD: 206

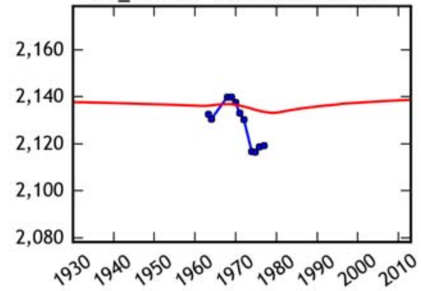

2935707 (Mitchell, TX)
HP_024263 LSD: 2237 TD: 174

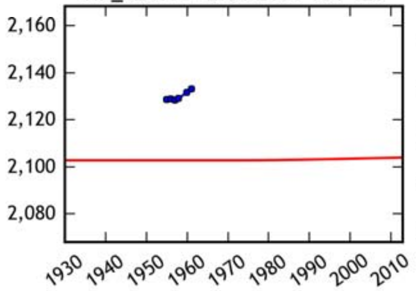

2941401 (Mitchell, TX)
HP_024459 LSD: 2145 TD: 25

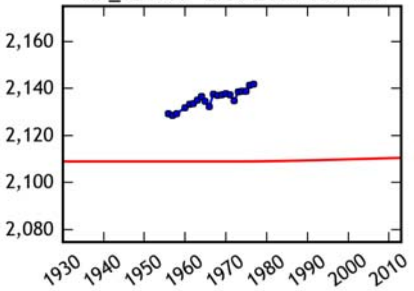

2942208 (Mitchell, TX)
HP_024491 LSD: 2176 TD: 95

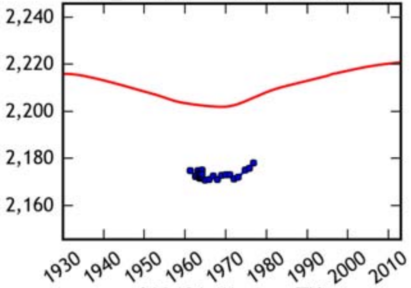

2942303 (Mitchell, TX)
HP_024502 LSD: 2143 TD: 92

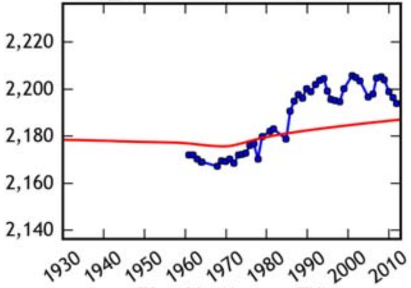

2942311 (Mitchell, TX)
HP_024509 LSD: 2149 TD: 115

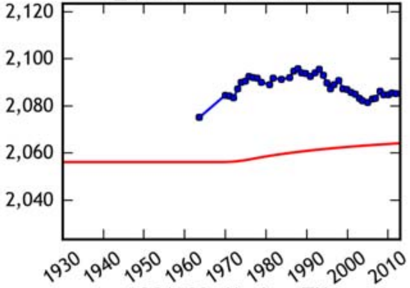

2942603 (Mitchell, TX)
HP_024528 LSD: 2222 TD: 187

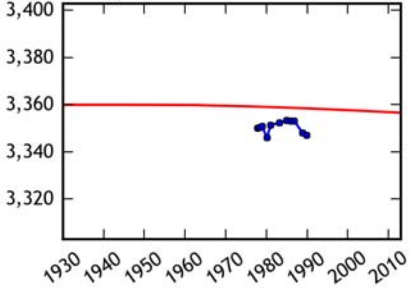

2942802 (Mitchell, TX)
HP_024535 LSD: 2181 TD: 125

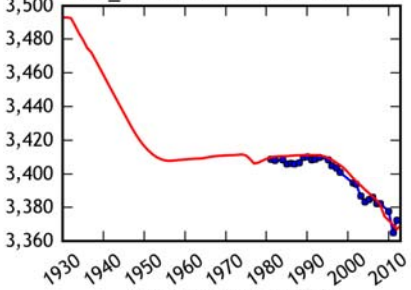

2942804 (Mitchell, TX)
HP_024537 LSD: 2183 TD: 120

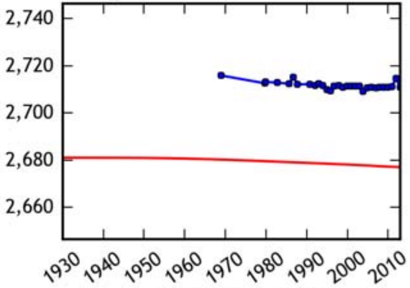

2943111 (Mitchell, TX)
HP_024559 LSD: 2260 TD: 151

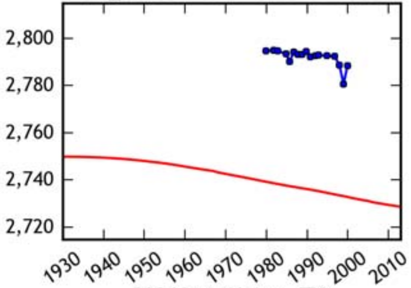

2943801 (Mitchell, TX)
HP_024653 LSD: 2299 TD: 200

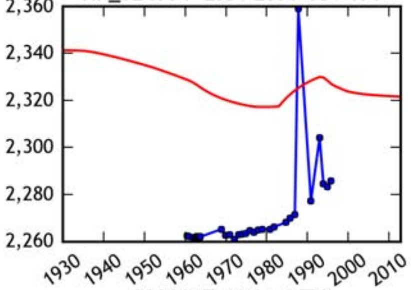

2949201 (Mitchell, TX)
HP_024781 LSD: 2110 TD: 56

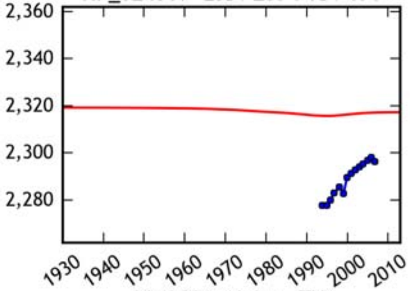

618401 (Moore, TX)
HP_004418 LSD: 3497 TD: 155

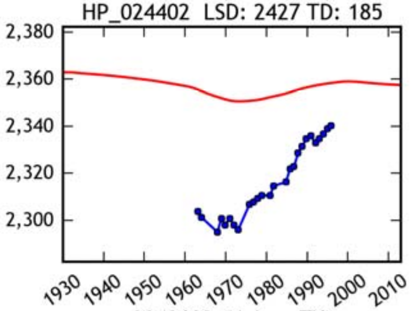

724403 (Moore, TX)
HP_006774 LSD: 3782 TD: 510

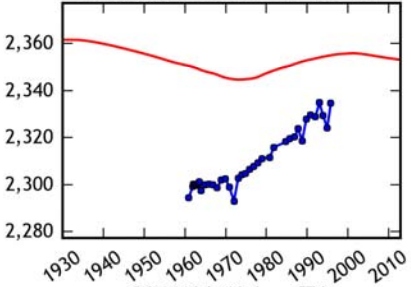

2201203 (Motley, TX)
HP_015288 LSD: 2799 TD: 136

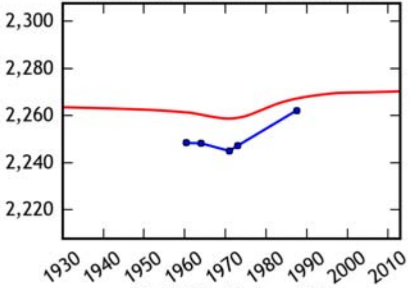

2308303 (Motley, TX)
HP_015658 LSD: 3070 TD: 360

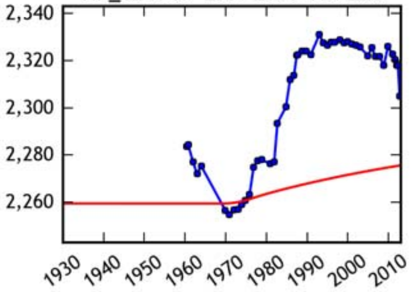

2936102 (Nolan, TX)
HP_024304 LSD: 2379 TD: 170

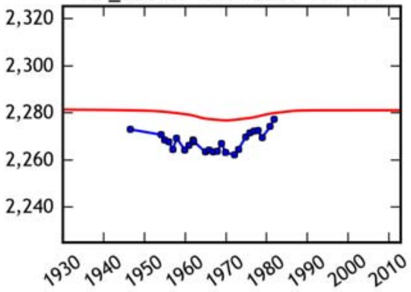

2936109 (Nolan, TX)
HP_024309 LSD: 2374 TD: 170

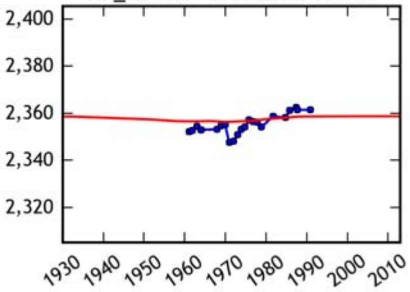

2936814 (Nolan, TX)
HP_024402 LSD: 2427 TD: 185

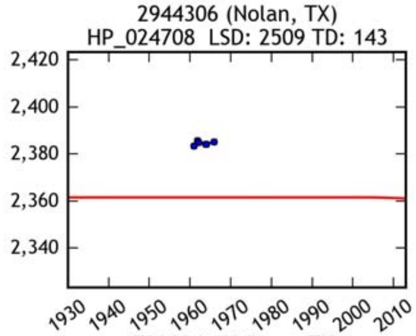

2936917 (Nolan, TX)
HP_024423 LSD: 2405 TD: 170

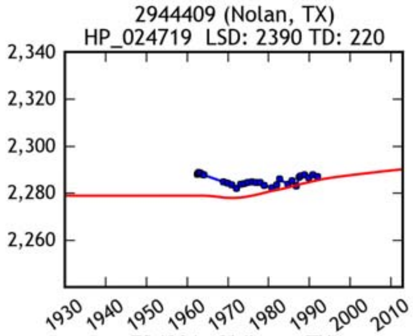

2943601 (Nolan, TX)
HP_024639 LSD: 2300 TD: 150

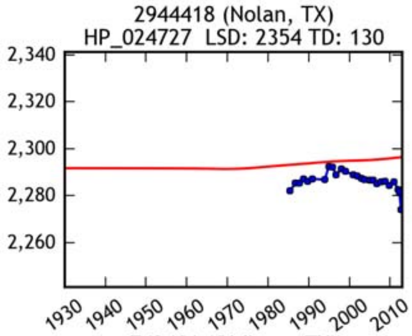

2943602 (Nolan, TX)
HP_024640 LSD: 2369 TD: 220

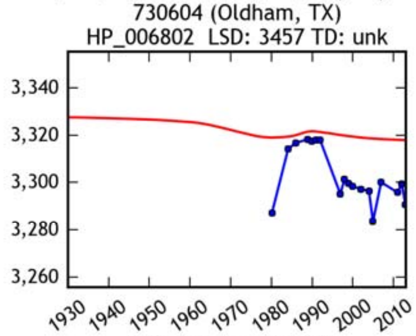

2944106 (Nolan, TX)
HP_024667 LSD: 2299 TD: 110

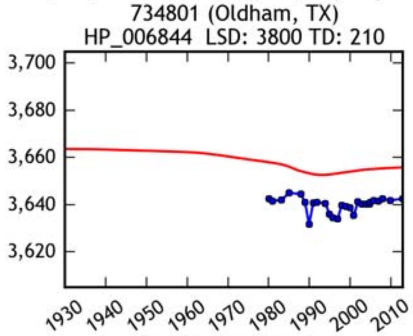

2944205 (Nolan, TX)
HP_024697 LSD: 2372 TD: 64

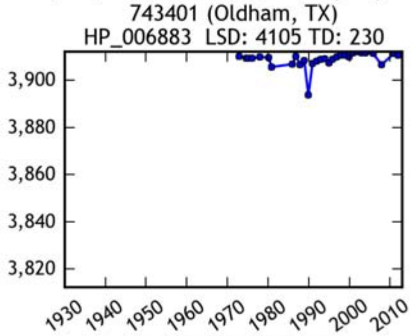

2944306 (Nolan, TX)
HP_024708 LSD: 2509 TD: 143

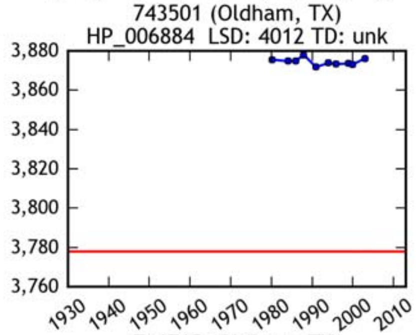

2944409 (Nolan, TX)
HP_024719 LSD: 2390 TD: 220

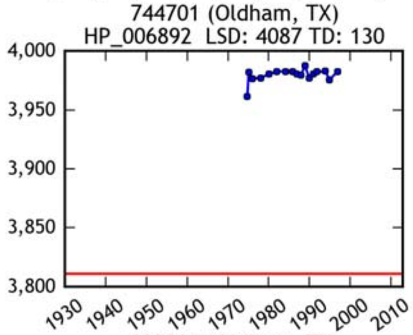

2944418 (Nolan, TX)
HP_024727 LSD: 2354 TD: 130

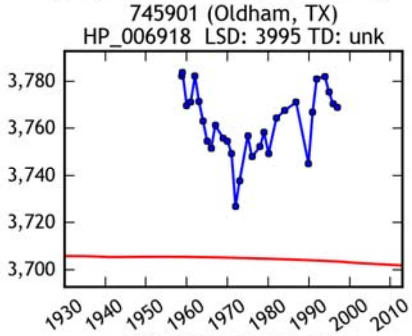

730604 (Oldham, TX)
HP_006802 LSD: 3457 TD: unk

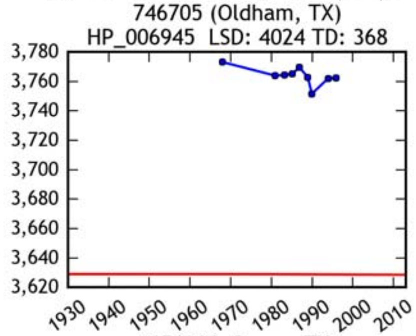

734801 (Oldham, TX)
HP_006844 LSD: 3800 TD: 210

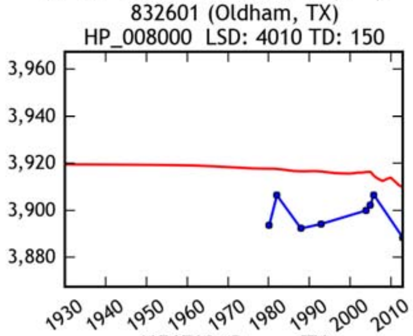

743401 (Oldham, TX)
HP_006883 LSD: 4105 TD: 230

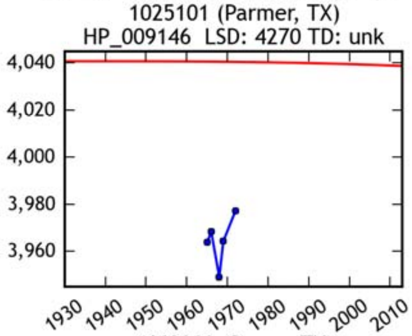

743501 (Oldham, TX)
HP_006884 LSD: 4012 TD: unk

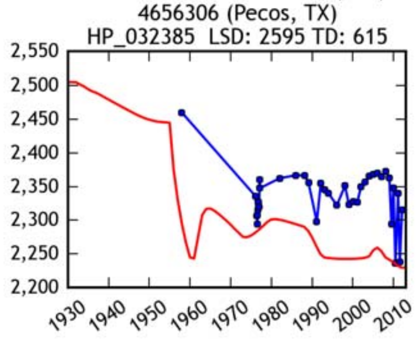

744701 (Oldham, TX)
HP_006892 LSD: 4087 TD: 130

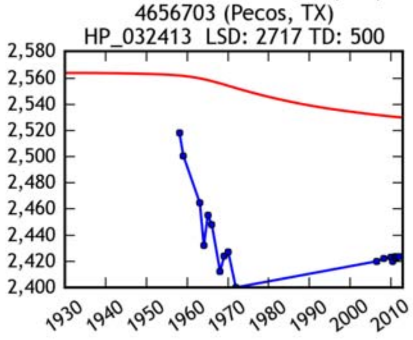

745901 (Oldham, TX)
HP_006918 LSD: 3995 TD: unk

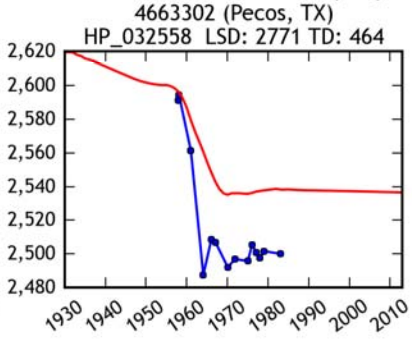

746705 (Oldham, TX)
HP_006945 LSD: 4024 TD: 368


832601 (Oldham, TX)
HP_008000 LSD: 4010 TD: 150

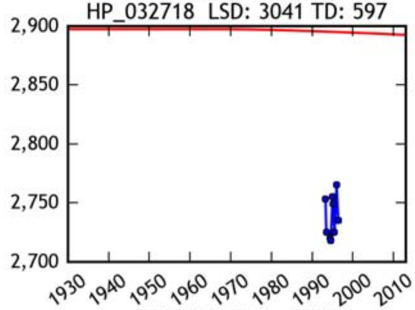

1025101 (Parmer, TX)
HP_009146 LSD: 4270 TD: unk


4656306 (Pecos, TX)
HP_032385 LSD: 2595 TD: 615

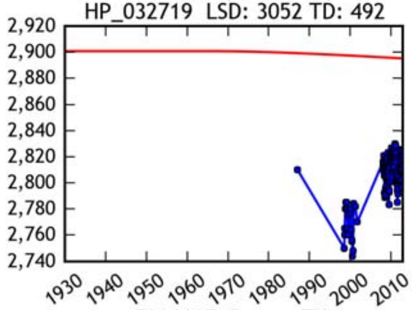

4656703 (Pecos, TX)
HP_032413 LSD: 2717 TD: 500


4663302 (Pecos, TX)
HP_032558 LSD: 2771 TD: 464

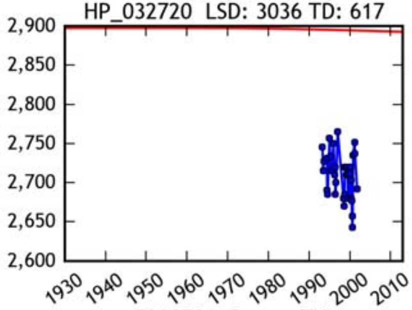
5206603 (Pecos, TX)
HP_032718 LSD: 3041 TD: 597



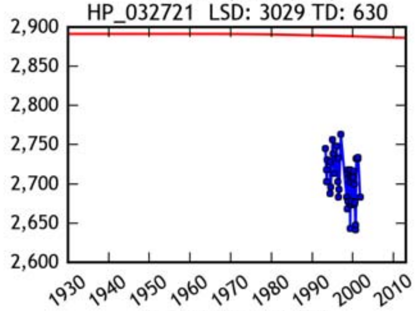
5206604 (Pecos, TX)
HP_032719 LSD: 3052 TD: 492



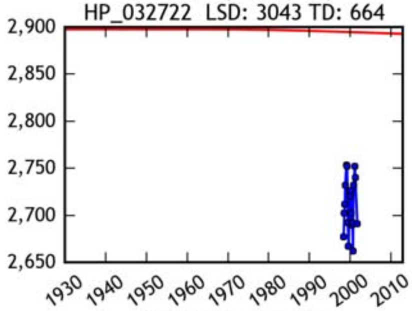
5206605 (Pecos, TX)
HP_032720 LSD: 3036 TD: 617



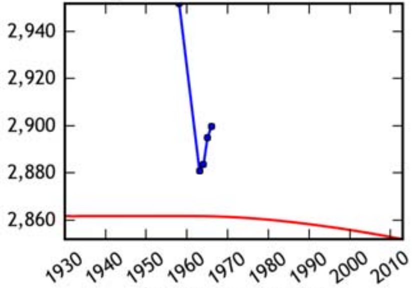
5206606 (Pecos, TX)
HP_032721 LSD: 3029 TD: 630



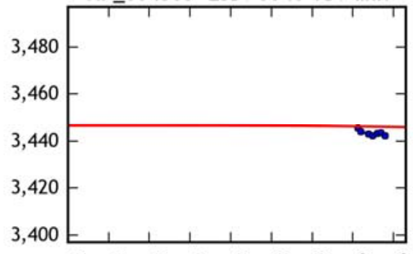
5206607 (Pecos, TX)
HP_032722 LSD: 3043 TD: 664



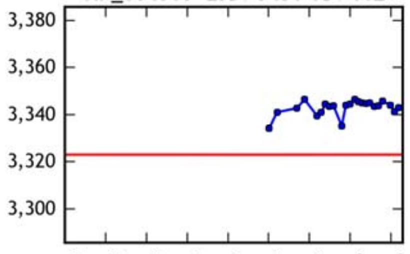
5208701 (Pecos, TX)
HP_032751 LSD: 3052 TD: 658



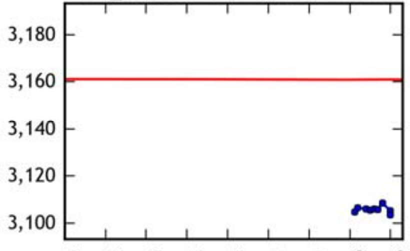
625302 (Potter, TX)
HP_004503 LSD: 3540 TD: unk



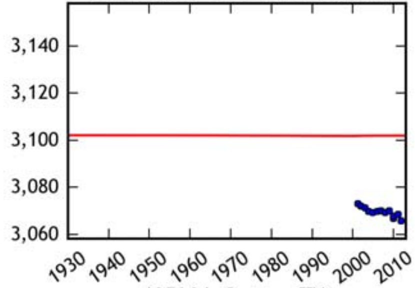
625801 (Potter, TX)
HP_004510 LSD: 3431 TD: 112



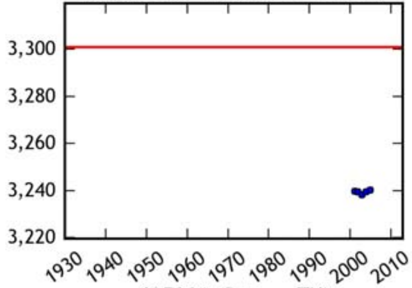
633201 (Potter, TX)
HP_004627 LSD: 3192 TD: unk



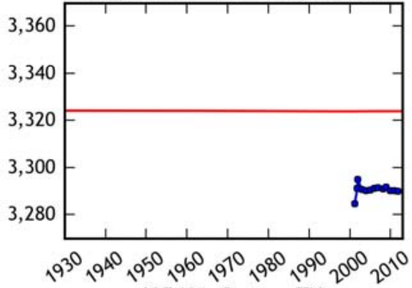
633301 (Potter, TX)
HP_004628 LSD: 3134 TD: unk



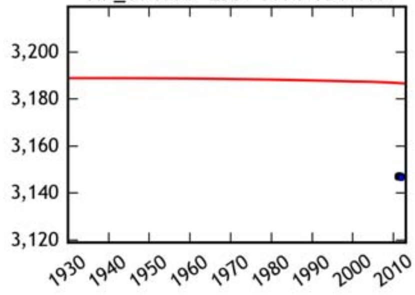
633701 (Potter, TX)
HP_004629 LSD: 3296 TD: unk



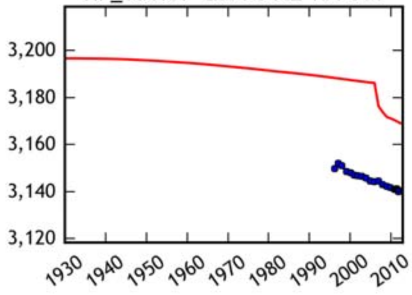
633702 (Potter, TX)
HP_004630 LSD: 3393 TD: unk



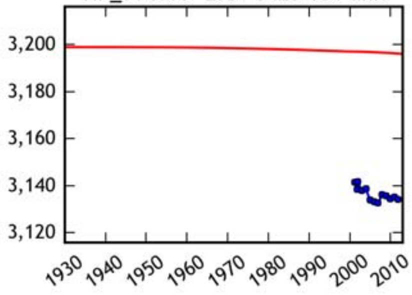
635206 (Potter, TX)
HP_004633 LSD: 3376 TD: 415



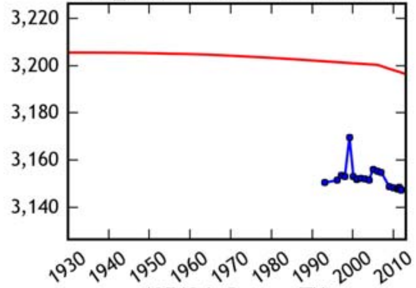
635301 (Potter, TX)
HP_004637 LSD: 3442 TD: 580



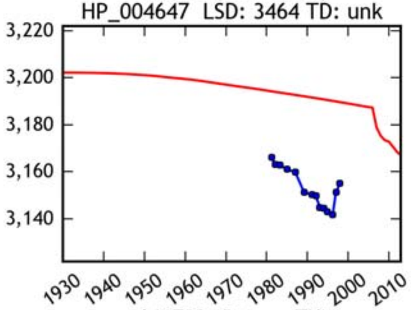
635401 (Potter, TX)
HP_004639 LSD: 3425 TD: unk



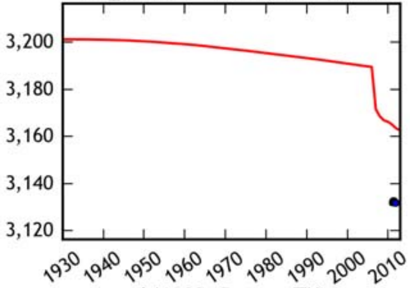
635501 (Potter, TX)
HP_004640 LSD: 3461 TD: 520



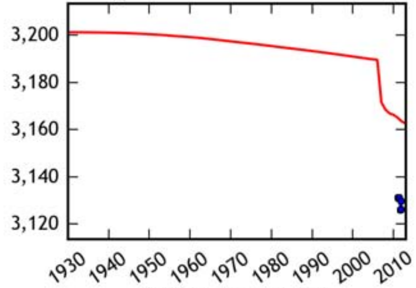
635602 (Potter, TX)
HP_004647 LSD: 3464 TD: unk



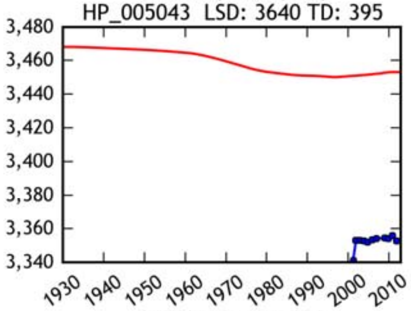
635623 (Potter, TX)
HP_004649 LSD: 3361 TD: 345



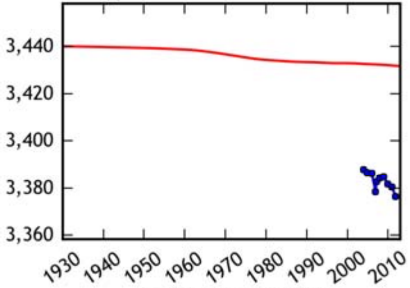
635624 (Potter, TX)
HP_004650 LSD: 3361 TD: 445



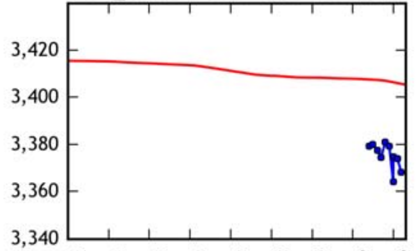
641703 (Potter, TX)
HP_005043 LSD: 3640 TD: 395



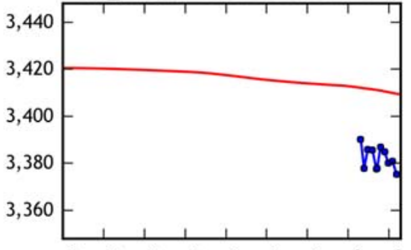
641803 (Potter, TX)
HP_005046 LSD: 3517 TD: unk



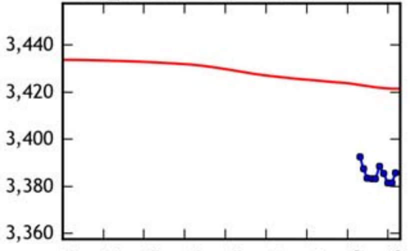
641931 (Potter, TX)
HP_005056 LSD: 3438 TD: unk



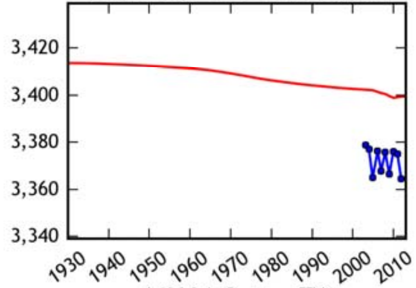
642703 (Potter, TX)
HP_005068 LSD: 3476 TD: unk



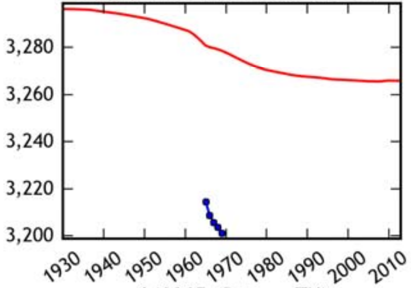
642714 (Potter, TX)
HP_005069 LSD: 3462 TD: unk



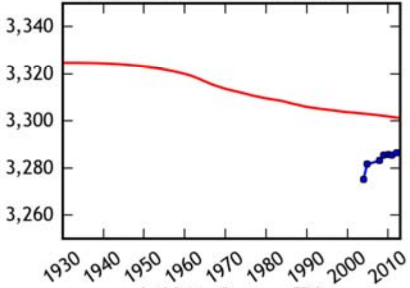
642719 (Potter, TX)
HP_005070 LSD: 3502 TD: unk



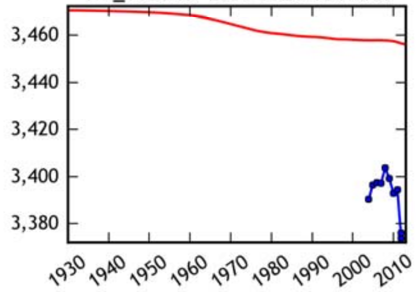
643601 (Potter, TX)
HP_005084 LSD: 3591 TD: 565



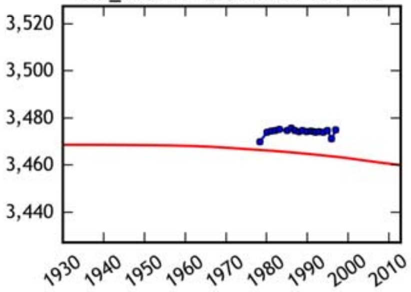
643606 (Potter, TX)
HP_005088 LSD: 3554 TD: unk



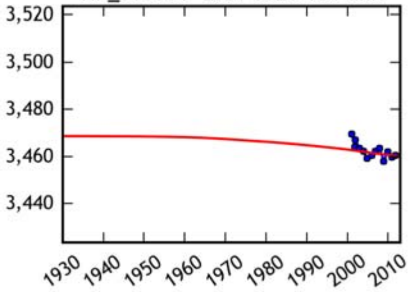
649204 (Potter, TX)
HP_005540 LSD: 3528 TD: unk

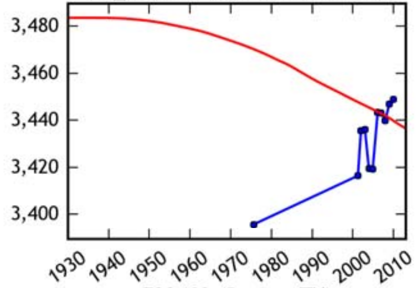


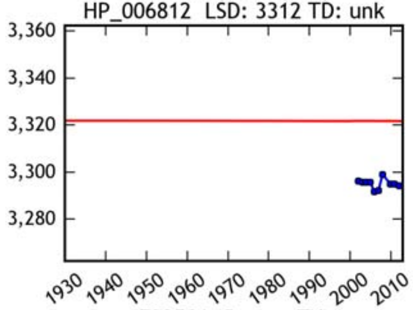
649305 (Potter, TX)
HP_005545 LSD: 3534 TD: 112

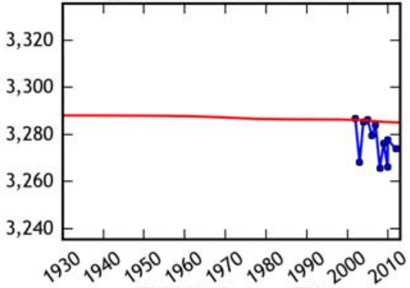


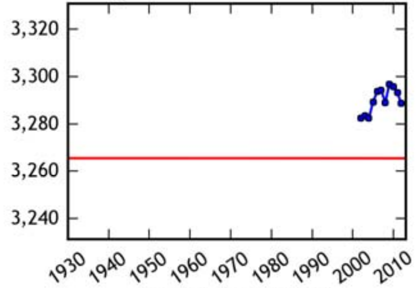
649311 (Potter, TX)
HP_005551 LSD: 3520 TD: unk

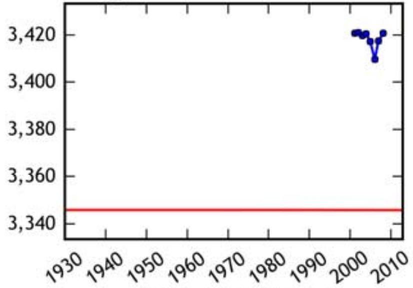


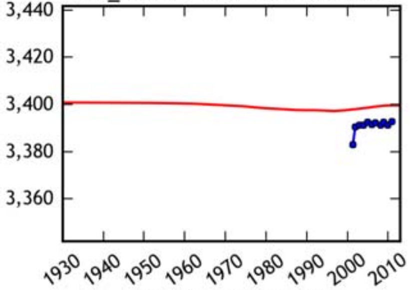

650209 (Potter, TX)
HP_005640 LSD: 3653 TD: 312

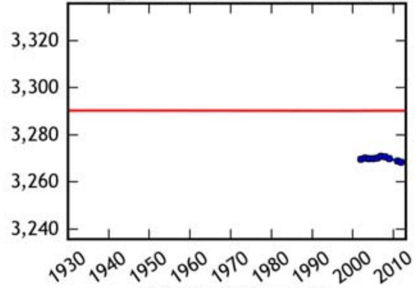

731301 (Potter, TX)
HP_006812 LSD: 3312 TD: unk

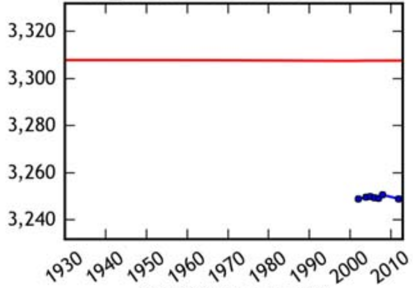

732401 (Potter, TX)
HP_006835 LSD: 3314 TD: unk

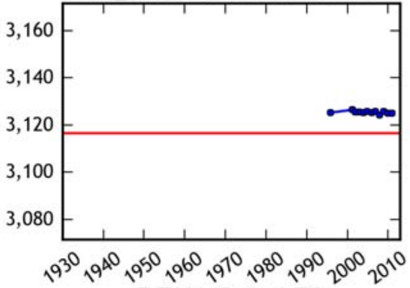

732402 (Potter, TX)
HP_006836 LSD: 3301 TD: unk

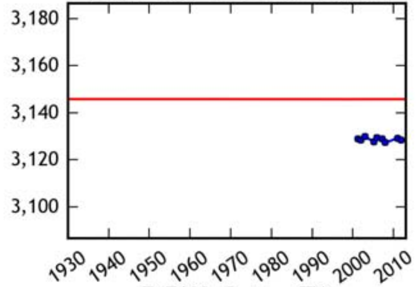

732501 (Potter, TX)
HP_006837 LSD: 3482 TD: unk

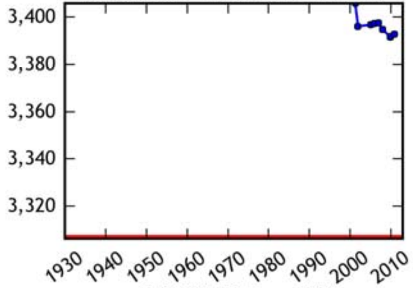

732602 (Potter, TX)
HP_006838 LSD: 3428 TD: unk

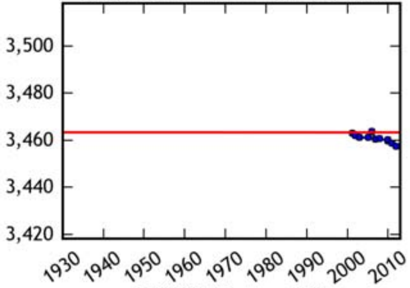

732801 (Potter, TX)
HP_006840 LSD: 3409 TD: unk

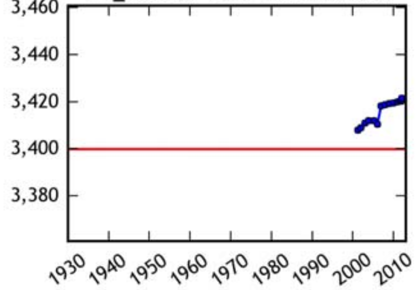

732901 (Potter, TX)
HP_006841 LSD: 3421 TD: unk

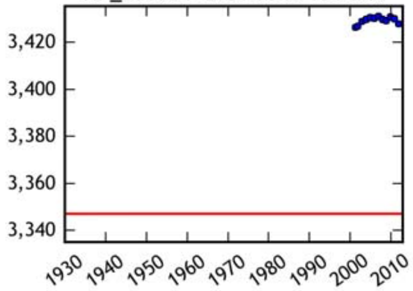

739301 (Potter, TX)
HP_006863 LSD: 3132 TD: 22

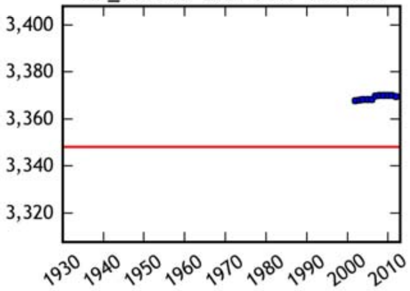

739302 (Potter, TX)
HP_006864 LSD: 3225 TD: unk


747301 (Potter, TX)
HP_006959 LSD: 3438 TD: unk

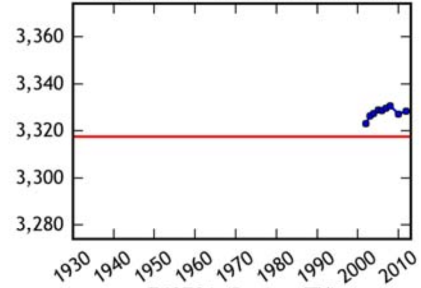

747601 (Potter, TX)
HP_006961 LSD: 3502 TD: unk


747602 (Potter, TX)
HP_006962 LSD: 3508 TD: unk

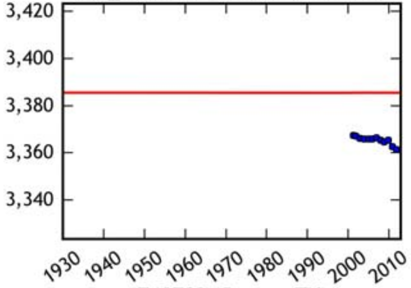

748101 (Potter, TX)
HP_006964 LSD: 3543 TD: unk


748103 (Potter, TX)
HP_006965 LSD: 3407 TD: unk

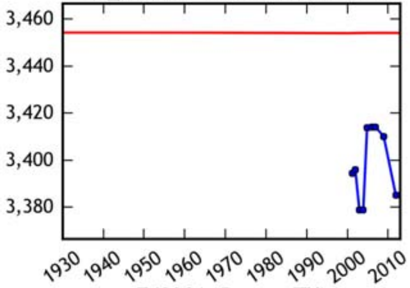
748202 (Potter, TX)
HP_006967 LSD: 3335 TD: unk



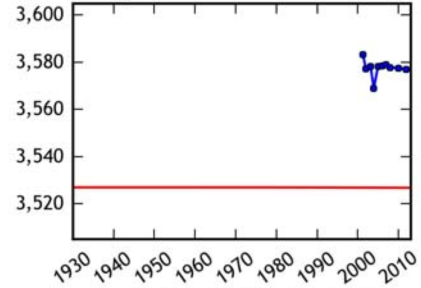
748402 (Potter, TX)
HP_006970 LSD: 3392 TD: unk



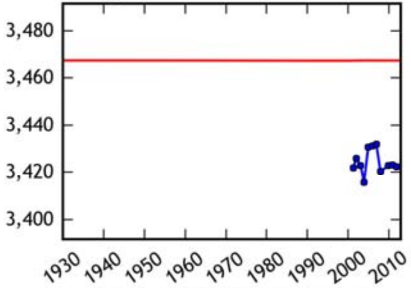
748501 (Potter, TX)
HP_006971 LSD: 3438 TD: unk



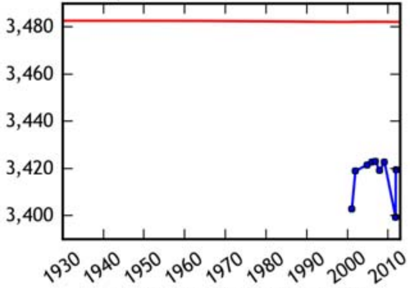
748701 (Potter, TX)
HP_006974 LSD: 3667 TD: unk



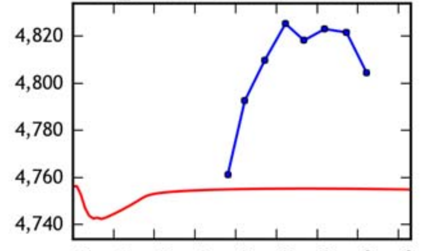
748702 (Potter, TX)
HP_006975 LSD: 3465 TD: unk



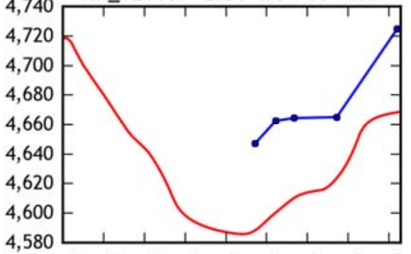
748901 (Potter, TX)
HP_006977 LSD: 3501 TD: unk



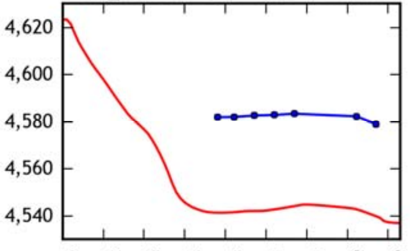
343944104012801 (Quay, NM)
HP_126083 LSD: 4923 TD: unk



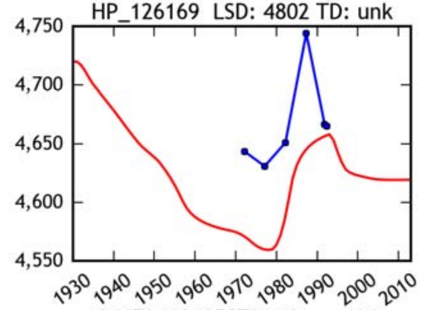
344339103530001 (Quay, NM)
HP_126157 LSD: 4774 TD: unk



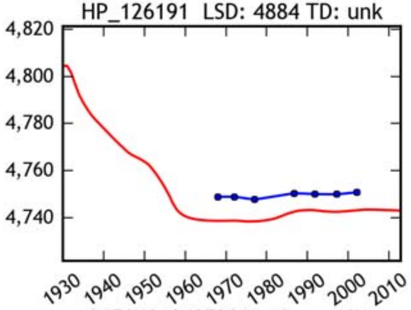
344405103445801 (Quay, NM)
HP_126165 LSD: 4760 TD: unk



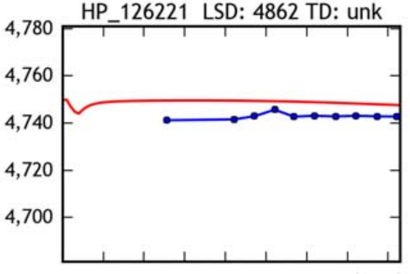
344407103523901 (Quay, NM)
HP_126169 LSD: 4802 TD: unk



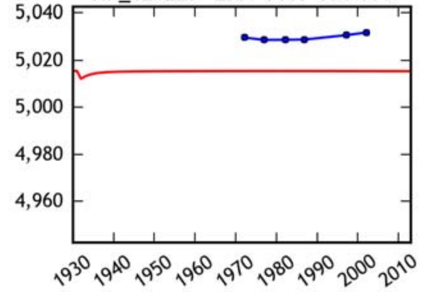
344524103580801 (Quay, NM)
HP_126191 LSD: 4884 TD: unk



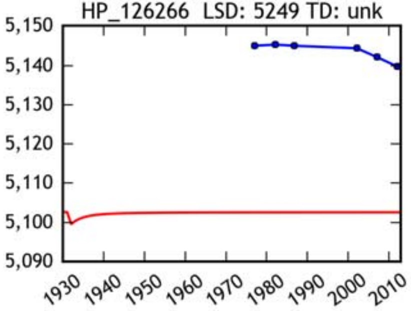
344729103494001 (Quay, NM)
HP_126221 LSD: 4862 TD: unk



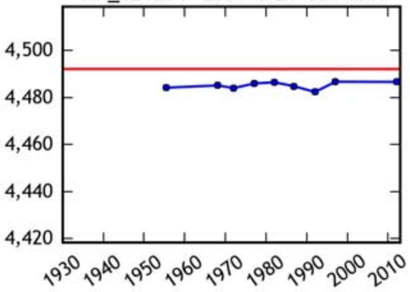
344734104050701 (Quay, NM)
HP_126227 LSD: 5157 TD: 130

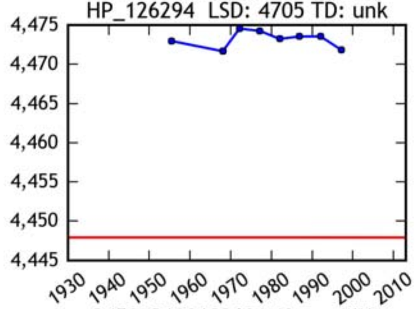


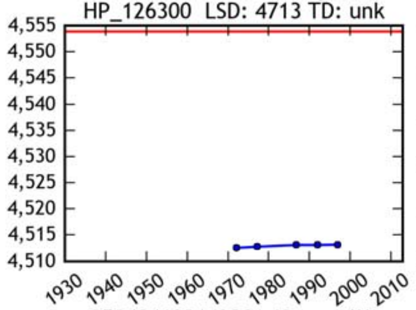
345040104053901 (Quay, NM)
HP_126266 LSD: 5249 TD: unk

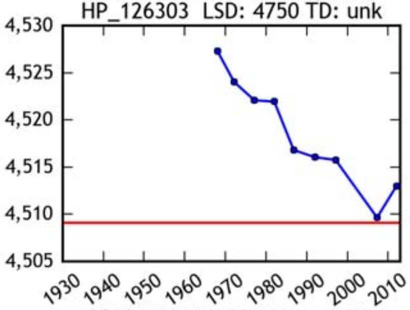


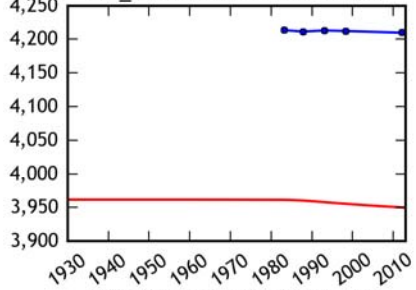
345046103233501 (Quay, NM)
HP_126270 LSD: 4629 TD: unk

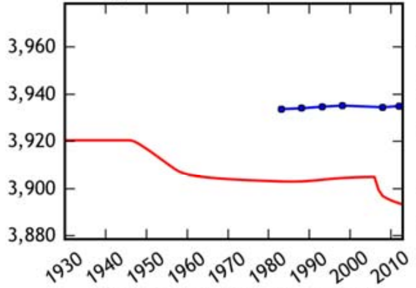


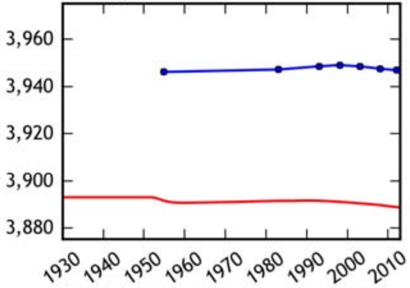

345257103185001 (Quay, NM)
HP_126294 LSD: 4705 TD: unk

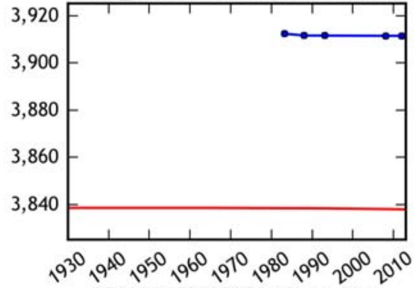

345323103245301 (Quay, NM)
HP_126300 LSD: 4713 TD: unk

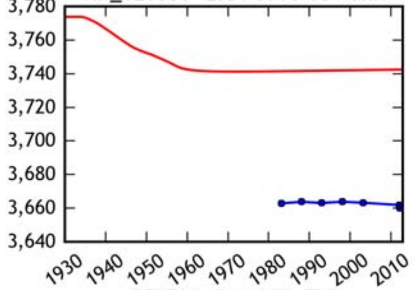

345350103220701 (Quay, NM)
HP_126303 LSD: 4750 TD: unk

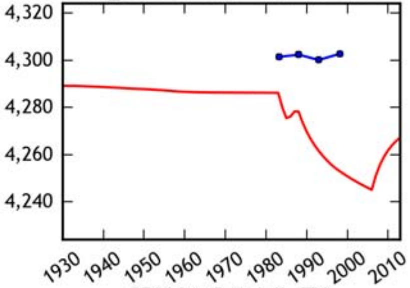

345942103182601 (Quay, NM)
HP_126326 LSD: 4275 TD: 85

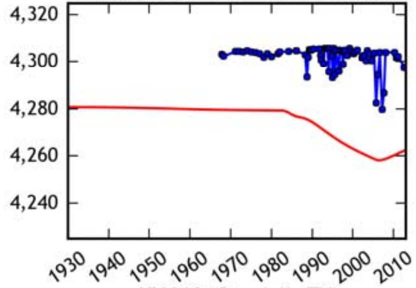

350404103142801 (Quay, NM)
HP_126331 LSD: 3993 TD: 225

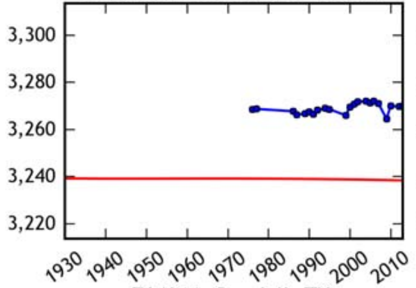

350648103111901 (Quay, NM)
HP_126333 LSD: 3985 TD: 69

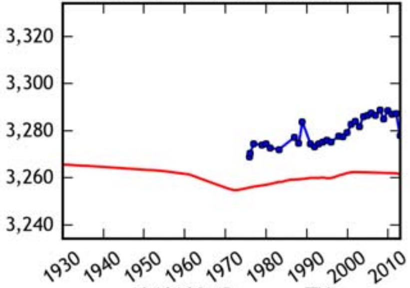

350824103031101 (Quay, NM)
HP_126336 LSD: 3946 TD: 63

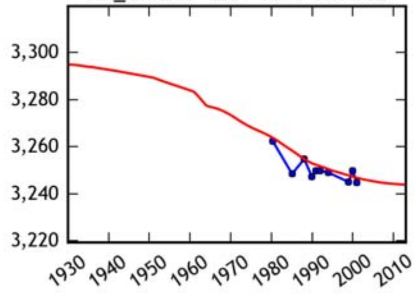

351233103040501 (Quay, NM)
HP_126338 LSD: 3795 TD: unk

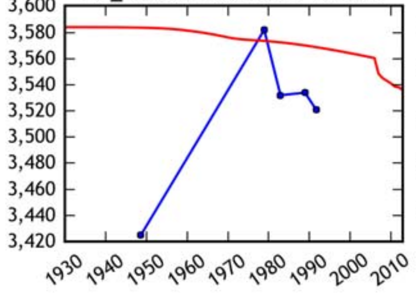

354234103133501 (Quay, NM)
HP_126368 LSD: 4479 TD: 240

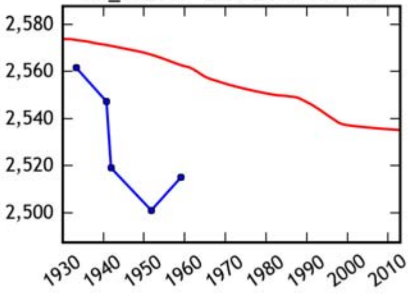

354238103132301 (Quay, NM)
HP_126369 LSD: 4465 TD: 250


659504 (Randall, TX)
HP_005736 LSD: 3499 TD: 349

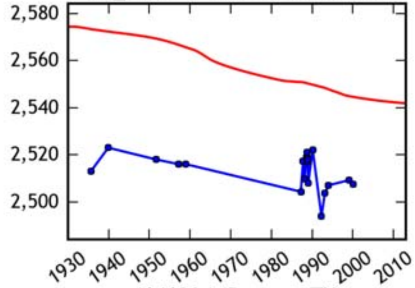

659901 (Randall, TX)
HP_005740 LSD: 3485 TD: 390


658902 (Randall, TX)
HP_006261 LSD: 3551 TD: 362

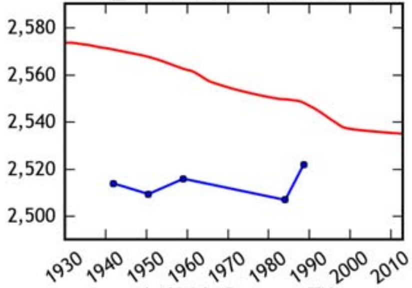

764911 (Randall, TX)
HP_007972 LSD: 3610 TD: 200


4646103 (Reeves, TX)
HP_032113 LSD: 2635 TD: 187

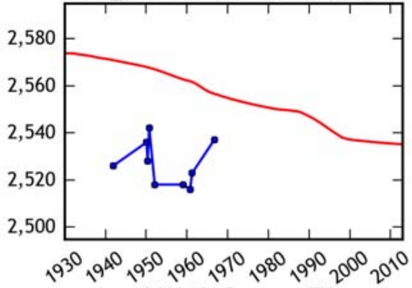
4646201 (Reeves, TX)
HP_032114 LSD: 2640 TD: 187



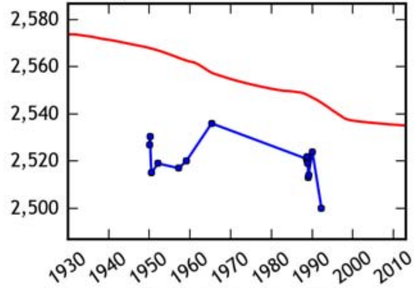
4646202 (Reeves, TX)
HP_032115 LSD: 2623 TD: 191



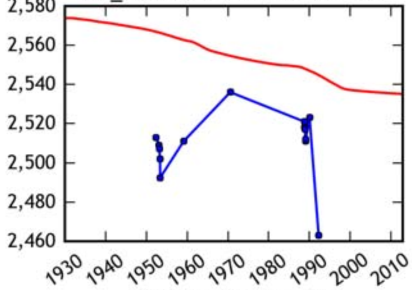
4646203 (Reeves, TX)
HP_032116 LSD: 2628 TD: 170



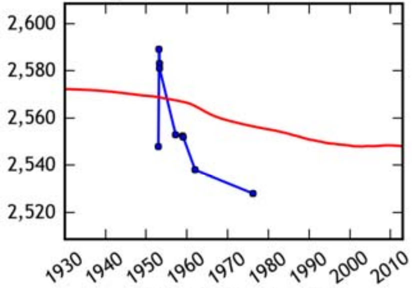
4646204 (Reeves, TX)
HP_032117 LSD: 2622 TD: 200



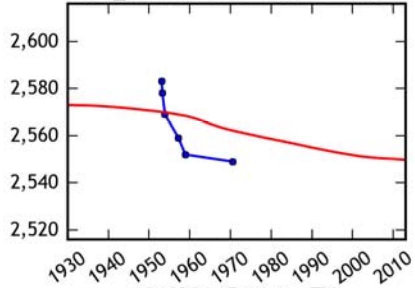
4646206 (Reeves, TX)
HP_032119 LSD: 2616 TD: 198



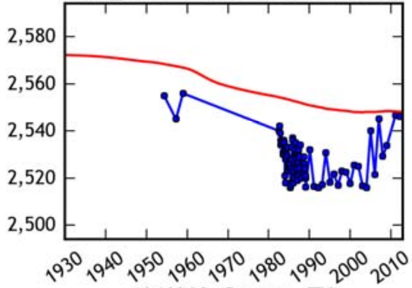
4646208 (Reeves, TX)
HP_032121 LSD: 2639 TD: 160



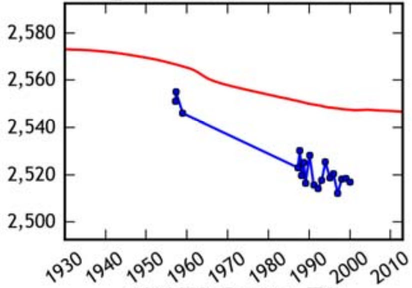
4646209 (Reeves, TX)
HP_032122 LSD: 2655 TD: 176



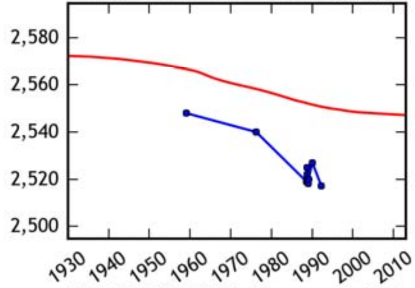
4646211 (Reeves, TX)
HP_032124 LSD: 2634 TD: 160



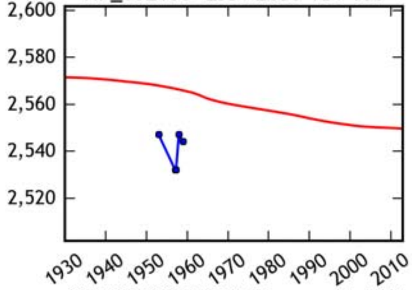
4646215 (Reeves, TX)
HP_032128 LSD: 2663 TD: 250



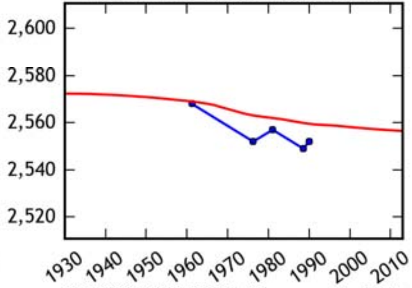
4646301 (Reeves, TX)
HP_032132 LSD: 2661 TD: 223



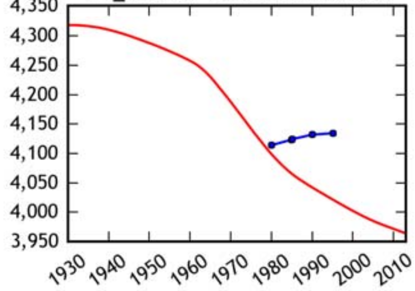
4646302 (Reeves, TX)
HP_032133 LSD: 2635 TD: 160



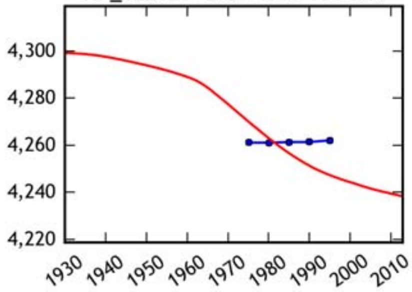
4646602 (Reeves, TX)
HP_032137 LSD: 2662 TD: 208



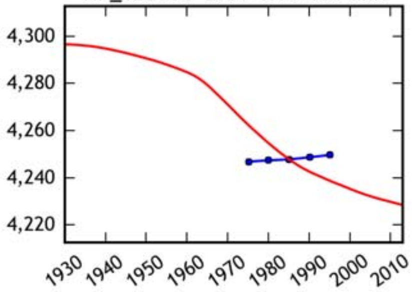
334253103310301 (Roosevelt, NM)
HP_122492 LSD: 4342 TD: unk



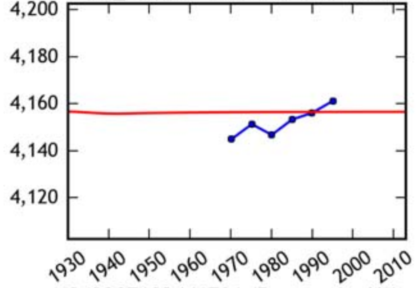
335109103255801 (Roosevelt, NM)
HP_122825 LSD: 4363 TD: unk



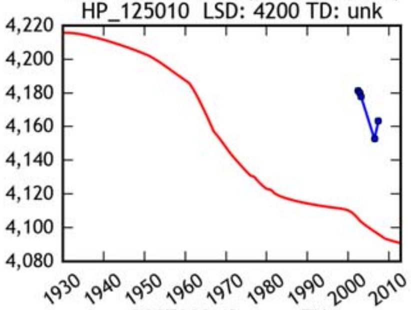
335203103252201 (Roosevelt, NM)
HP_122864 LSD: 4379 TD: unk



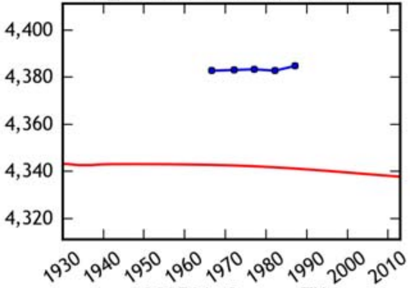
335928103214101 (Roosevelt, NM)
HP_123182 LSD: 4195 TD: unk



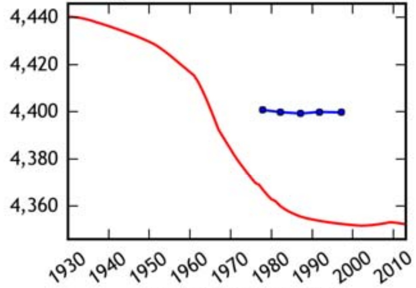
342152103444201 (Roosevelt, NM)
HP_125010 LSD: 4200 TD: unk



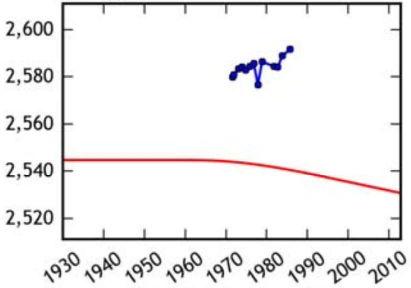
342739103441901 (Roosevelt, NM)
HP_125528 LSD: 4448 TD: unk



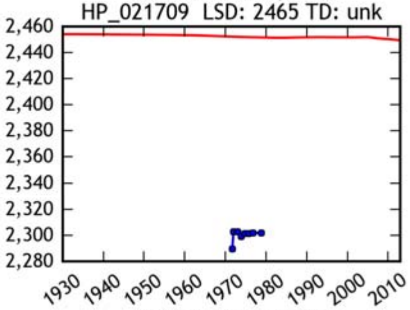
343207103441701 (Roosevelt, NM)
HP_125747 LSD: 4547 TD: unk



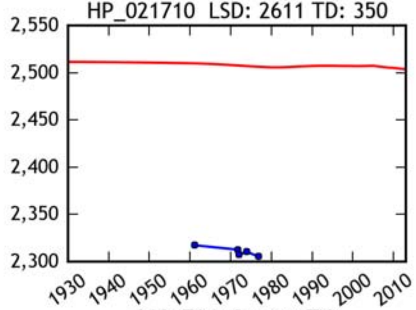
2807903 (Scurry, TX)
HP_021706 LSD: 2675 TD: 110



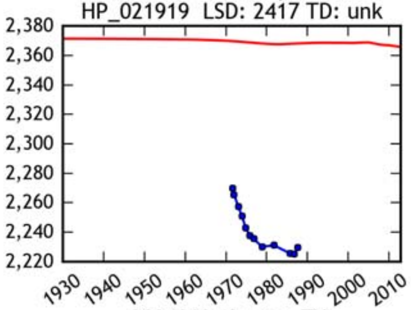
2808501 (Scurry, TX)
HP_021709 LSD: 2465 TD: unk



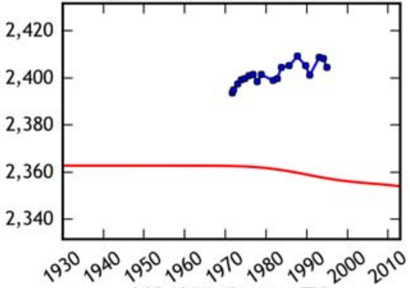
2808801 (Scurry, TX)
HP_021710 LSD: 2611 TD: 350



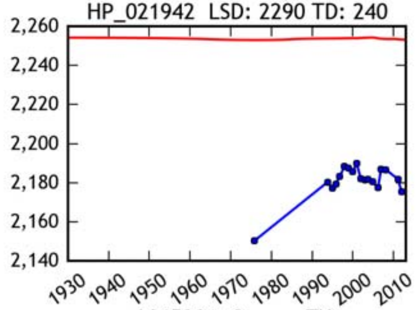
2824101 (Scurry, TX)
HP_021919 LSD: 2417 TD: unk



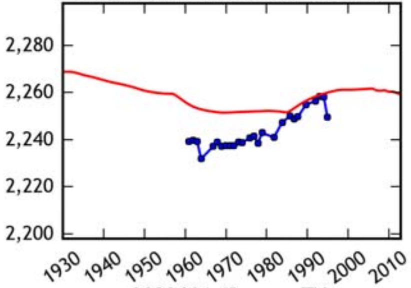
2824302 (Scurry, TX)
HP_021923 LSD: 2453 TD: unk



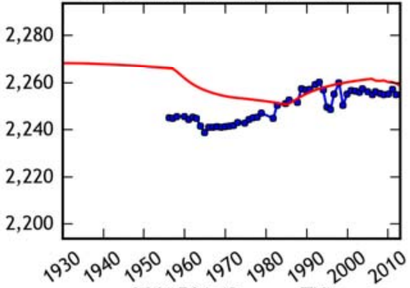
2824704 (Scurry, TX)
HP_021942 LSD: 2290 TD: 240



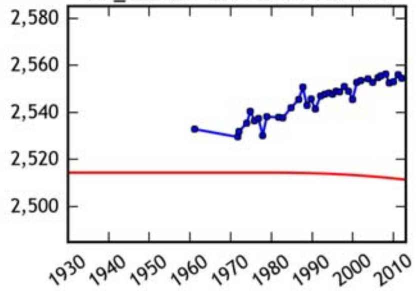
2824903 (Scurry, TX)
HP_021958 LSD: 2318 TD: 272



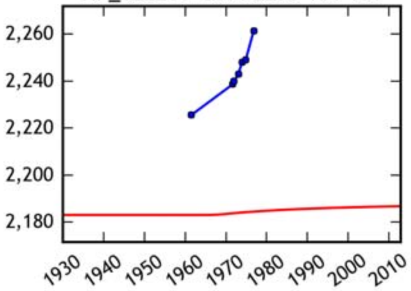
2824904 (Scurry, TX)
HP_021959 LSD: 2295 TD: 80



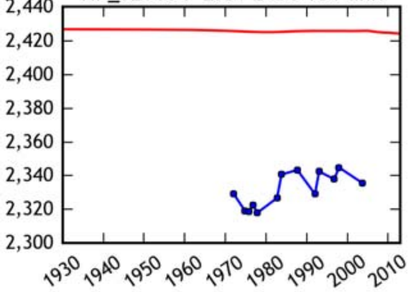
2815301 (Scurry, TX)
HP_022026 LSD: 2664 TD: 170

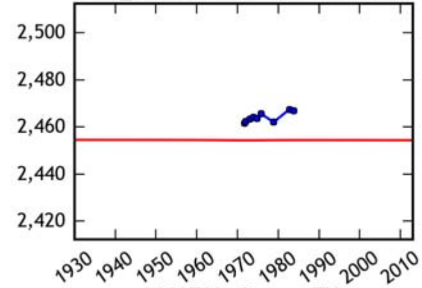


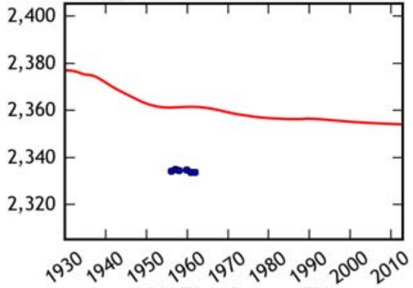
2832601 (Scurry, TX)
HP_022266 LSD: 2293 TD: 150

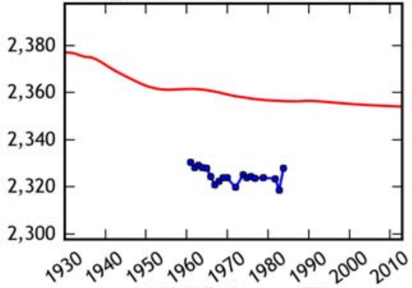


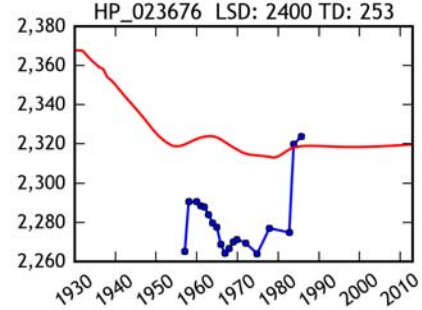
2901501 (Scurry, TX)
HP_023654 LSD: 2458 TD: unk

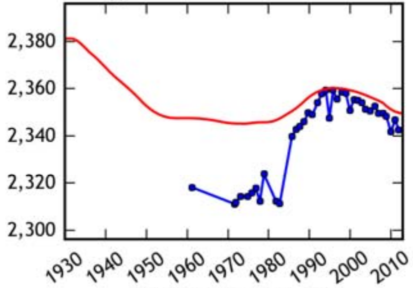


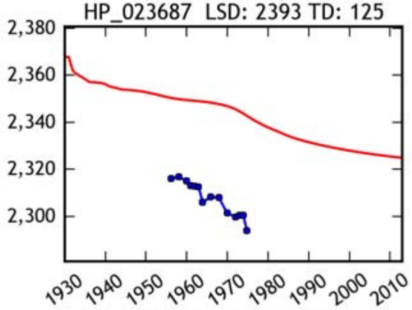

2909101 (Scurry, TX)
HP_023656 LSD: 2482 TD: unk

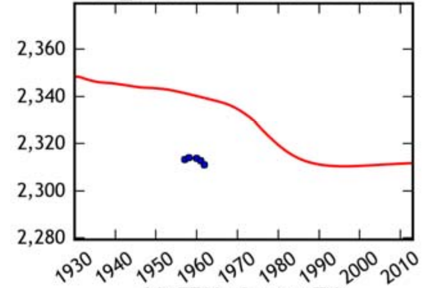

2909501 (Scurry, TX)
HP_023664 LSD: 2466 TD: 244

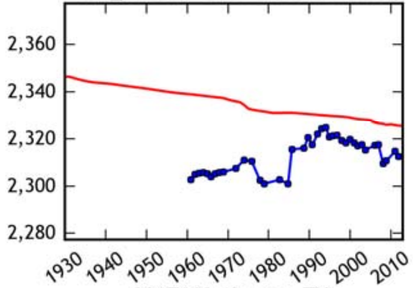

2909502 (Scurry, TX)
HP_023665 LSD: 2452 TD: 280

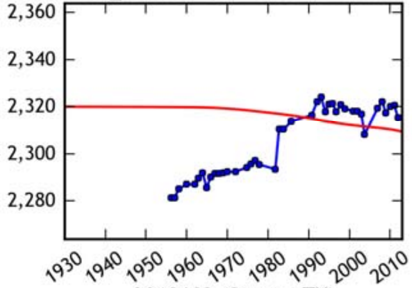

2909702 (Scurry, TX)
HP_023676 LSD: 2400 TD: 253

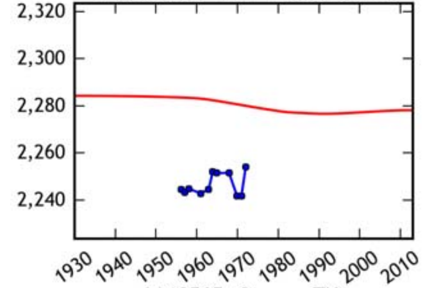

2909704 (Scurry, TX)
HP_023678 LSD: 2441 TD: 360

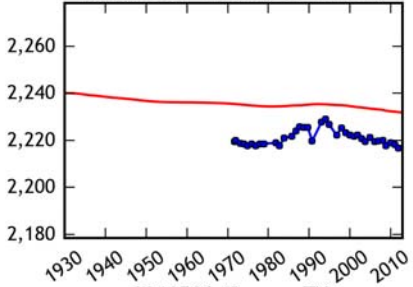

2909805 (Scurry, TX)
HP_023687 LSD: 2393 TD: 125

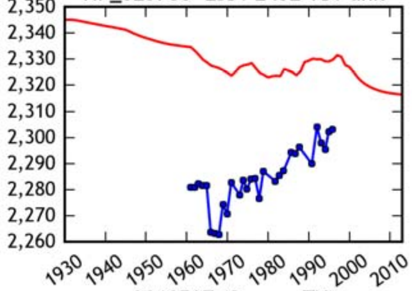

2917204 (Scurry, TX)
HP_023731 LSD: 2387 TD: 273

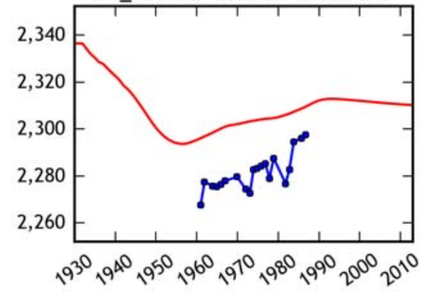

2917302 (Scurry, TX)
HP_023747 LSD: 2370 TD: 150

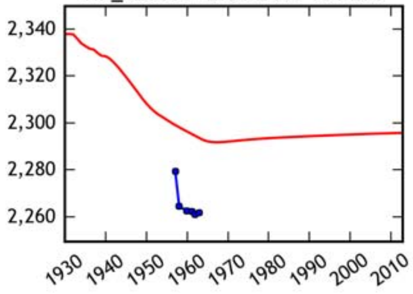

2917402 (Scurry, TX)
HP_023762 LSD: 2428 TD: unk

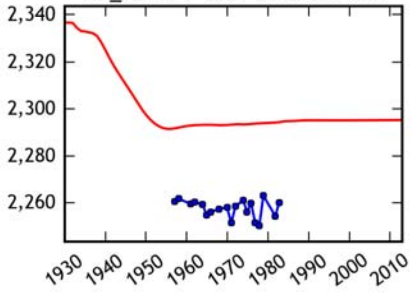

2917702 (Scurry, TX)
HP_023773 LSD: 2336 TD: 165


2917802 (Scurry, TX)
HP_023780 LSD: 2294 TD: unk

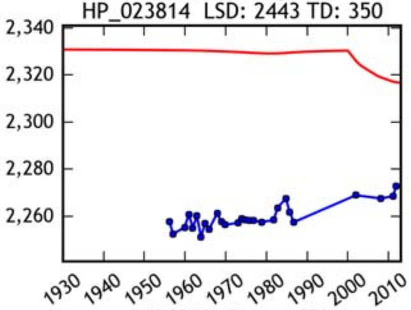

2918102 (Scurry, TX)
HP_023786 LSD: 2452 TD: unk


2918505 (Scurry, TX)
HP_023802 LSD: 2449 TD: 267

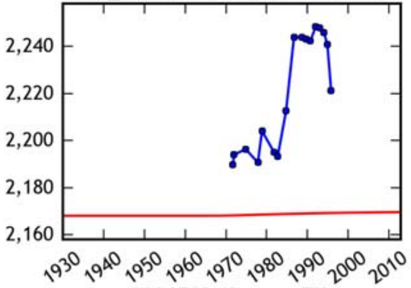

2918506 (Scurry, TX)
HP_023803 LSD: 2440 TD: 275


2918507 (Scurry, TX)
HP_023804 LSD: 2442 TD: unk

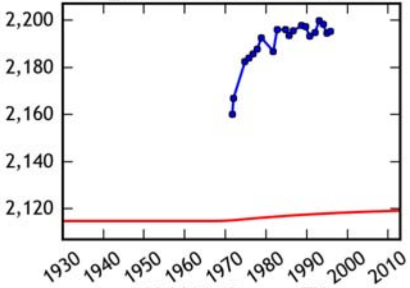
2918902 (Scurry, TX)
HP_023814 LSD: 2443 TD: 350



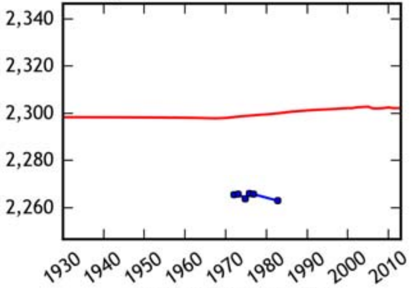
2925501 (Scurry, TX)
HP_023858 LSD: 2268 TD: unk



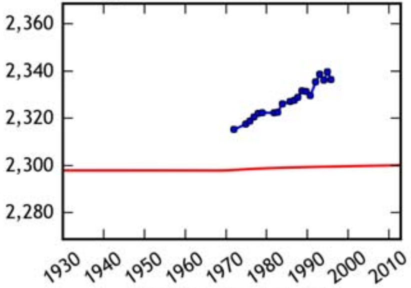
2925707 (Scurry, TX)
HP_023868 LSD: 2228 TD: 140



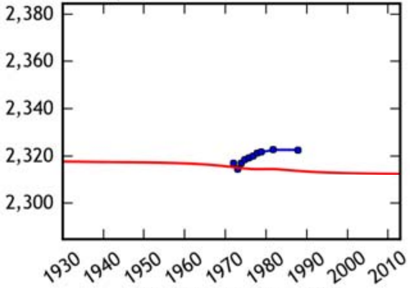
2926202 (Scurry, TX)
HP_023886 LSD: 2292 TD: unk



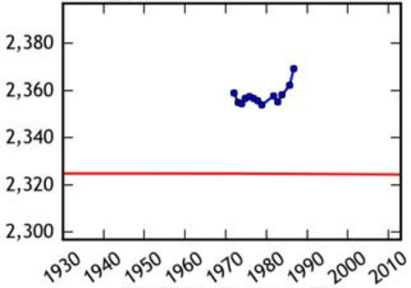
2926502 (Scurry, TX)
HP_023889 LSD: 2357 TD: unk



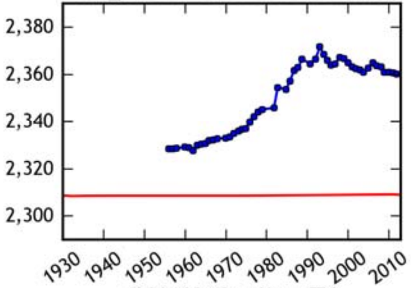
2926601 (Scurry, TX)
HP_023890 LSD: 2407 TD: unk



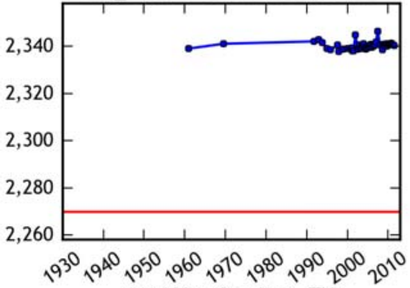
2927401 (Scurry, TX)
HP_023909 LSD: 2380 TD: 103



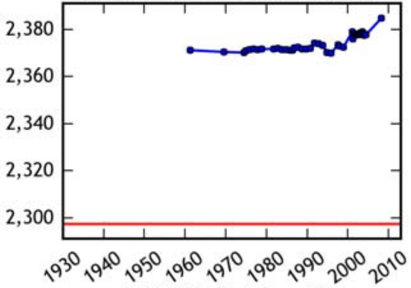
2927702 (Scurry, TX)
HP_023913 LSD: 2397 TD: 108



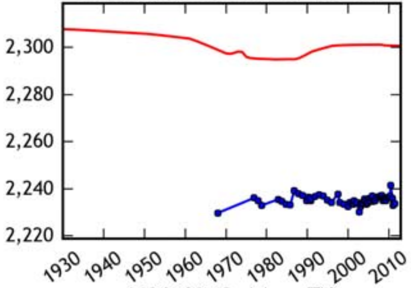
2864601 (Sterling, TX)
HP_023641 LSD: 2370 TD: 50



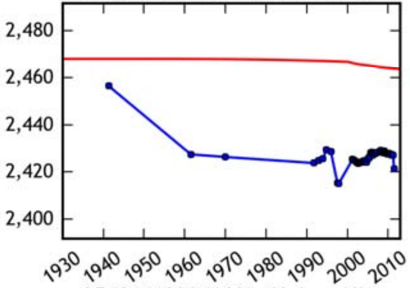
2864901 (Sterling, TX)
HP_023651 LSD: 2414 TD: 107



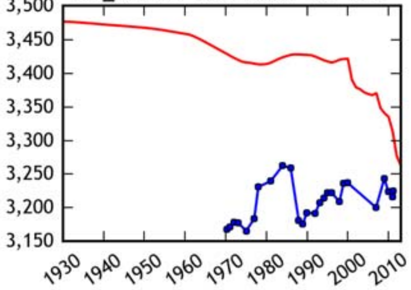
4309102 (Sterling, TX)
HP_024960 LSD: 2273 TD: 107



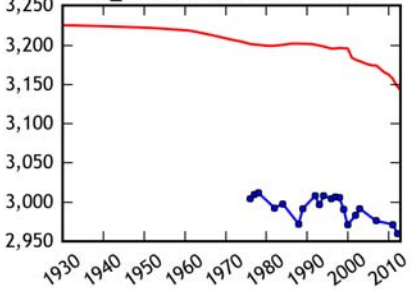
4414601 (Sterling, TX)
HP_026107 LSD: 2511 TD: 93



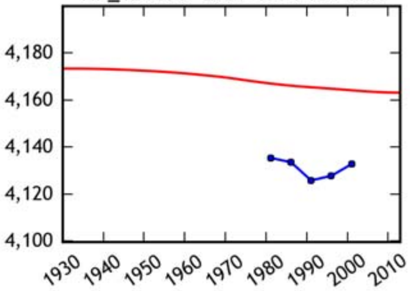
1125502 (Swisher, TX)
HP_012165 LSD: 3623 TD: 1000



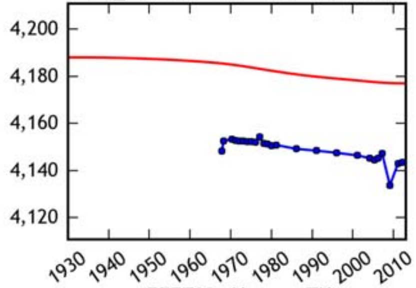
1136109 (Swisher, TX)
HP_012706 LSD: 3361 TD: 631



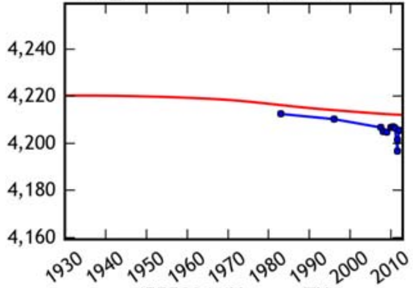
354814103041601 (Union, NM)
HP_126379 LSD: 4334 TD: unk



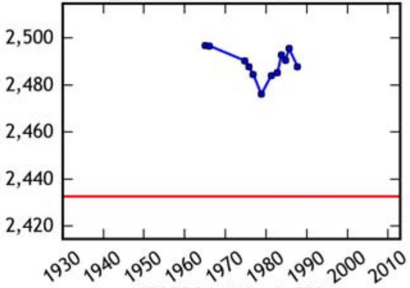
355052103030901 (Union, NM)
HP_126389 LSD: 4302 TD: unk



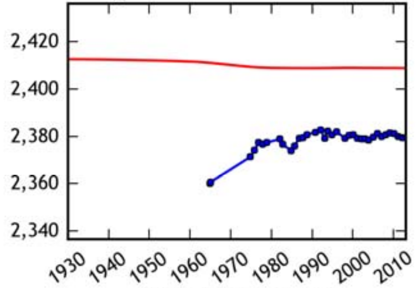
355144103041901 (Union, NM)
HP_126393 LSD: 4327 TD: unk



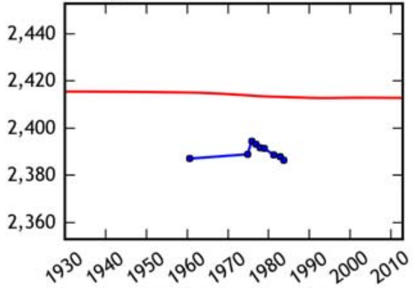
4555601 (Upton, TX)
HP_030760 LSD: 2680 TD: 203



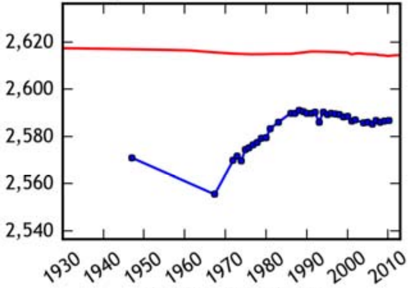
4555702 (Upton, TX)
HP_030766 LSD: 2456 TD: 100



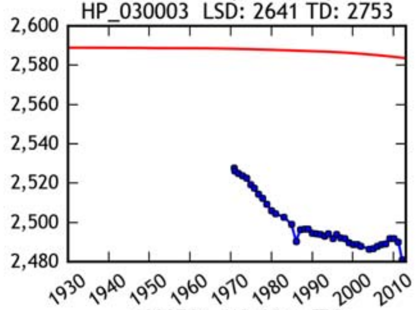
4555801 (Upton, TX)
HP_030770 LSD: 2477 TD: 160



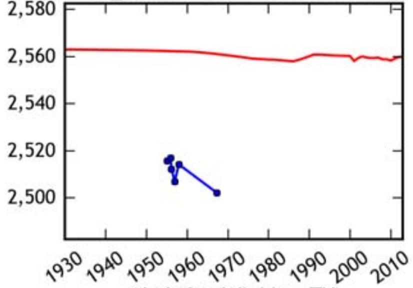
4525321 (Ward, TX)
HP_029946 LSD: 2612 TD: 220



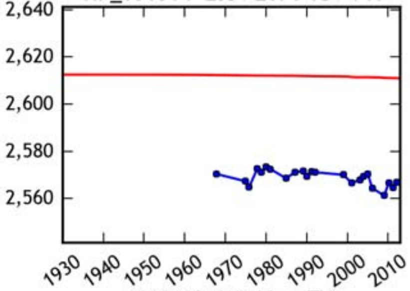
4525713 (Ward, TX)
HP_030003 LSD: 2641 TD: 2753



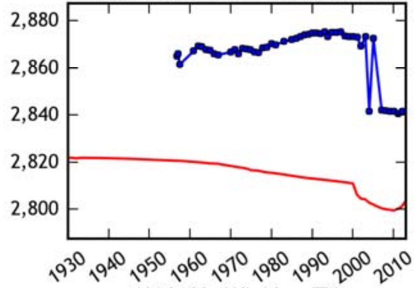
4526701 (Ward, TX)
HP_030063 LSD: 2552 TD: 213



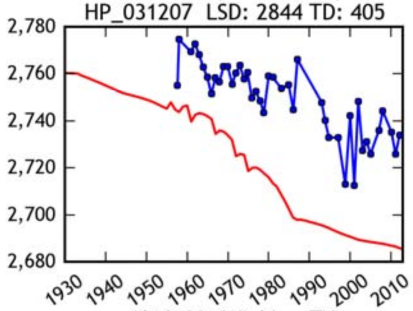
4630501 (Ward, TX)
HP_031514 LSD: 2671 TD: 141



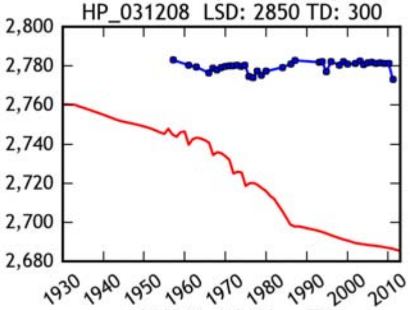
4608501 (Winkler, TX)
HP_031035 LSD: 2951 TD: 332



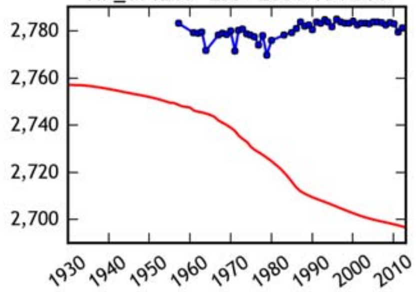
4616101 (Winkler, TX)
HP_031207 LSD: 2844 TD: 405



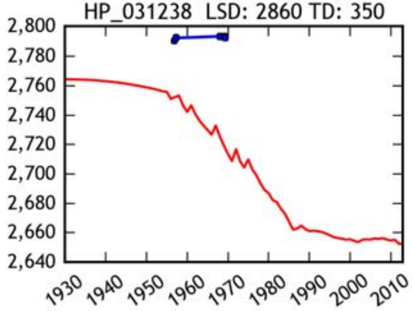
4616102 (Winkler, TX)
HP_031208 LSD: 2850 TD: 300



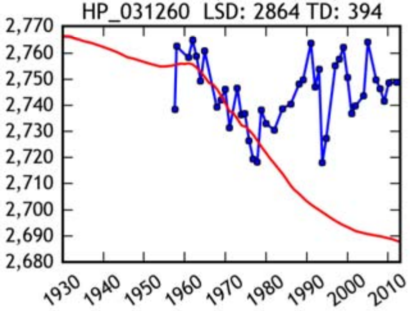
4616103 (Winkler, TX)
HP_031209 LSD: 2850 TD: 300

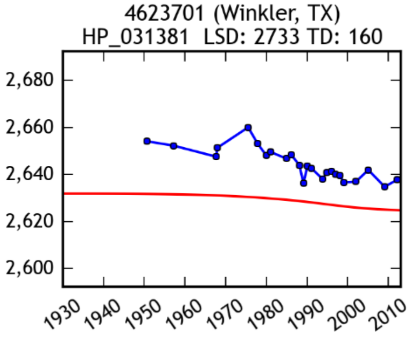


4616132 (Winkler, TX)
HP_031238 LSD: 2860 TD: 350



4616201 (Winkler, TX)
HP_031260 LSD: 2864 TD: 394




4623701 (Winkler, TX)
HP_031381 LSD: 2733 TD: 160
2,680
2,660
2,640
2,620
2,600
1930
1940
1950
1960
1970
1980
1990
2000
2010

This page intentionally left blank.

Appendix C

Total Pumping by County and Stress Period

This page intentionally left blank.

The tables of this appendix provide the total pumping by county and stress period in terms of volume in acre-feet per year for the period from 1930 to 2012. Pumping values are presented by aquifer.

This page intentionally left blank.

Table C.1.1 Annual pumping for the Ogallala Aquifer by county. All values are reported in acre-feet per year.

Year	Andrews	Armstrong	Bailey	Beaver	Borden	Briscoe	Carson	Castro
1930	0	0	0	0	0	0	0	0
1931	68	419	2,349	37	18	616	2,028	3,882
1932	136	838	4,698	75	35	1,231	4,056	7,764
1933	204	1,257	7,047	112	53	1,847	6,084	11,646
1934	272	1,676	9,396	150	71	2,462	6,664	15,528
1935	340	2,095	11,745	187	89	3,078	10,140	19,410
1936	408	2,514	14,094	225	106	3,694	12,168	23,292
1937	476	2,934	16,443	262	124	4,309	14,196	27,174
1938	543	3,353	18,792	300	142	4,925	16,224	31,056
1939	610	3,772	21,141	337	159	5,541	18,253	34,938
1940	678	4,191	23,490	374	177	6,156	20,281	38,820
1941	707	4,549	25,817	412	182	6,776	22,309	42,619
1942	739	4,907	28,183	449	188	7,355	24,337	46,419
1943	851	5,274	30,484	487	228	7,934	26,365	50,219
1944	969	5,642	32,786	524	269	8,512	28,393	54,018
1945	1,096	6,009	35,089	562	309	9,091	30,421	57,818
1946	1,236	6,376	37,391	599	349	9,670	32,449	61,617
1947	1,394	6,744	39,693	636	390	10,249	34,477	65,417
1948	1,630	7,118	41,996	674	454	10,828	36,505	69,217
1949	1,902	7,492	44,299	711	519	11,407	38,533	73,016
1950	2,225	7,865	46,602	839	584	11,986	40,561	76,816
1951	2,490	8,239	48,905	5,795	648	12,569	42,589	80,621
1952	2,780	8,613	51,208	6,824	713	13,151	44,617	84,427
1953	3,041	8,979	53,512	7,853	749	13,734	46,645	88,233
1954	3,337	9,346	55,815	8,881	786	14,317	48,673	92,040
1955	3,668	9,712	58,119	9,910	822	14,899	50,701	95,848
1956	4,101	11,438	60,918	10,939	858	15,490	60,218	99,619
1957	4,496	13,120	63,027	11,968	895	16,078	64,426	103,454
1958	5,016	14,856	65,473	12,996	931	16,647	71,071	107,281
1959	7,495	16,563	69,528	14,025	915	21,763	80,028	121,344
1960	10,629	18,276	73,597	15,054	898	26,809	85,099	135,328
1961	12,528	17,884	77,841	14,838	882	31,878	87,007	149,259
1962	15,736	17,556	82,170	17,200	865	36,935	91,343	163,297
1963	17,914	17,121	86,367	19,562	849	42,041	97,947	177,304
1964	20,897	16,740	90,808	21,924	832	47,157	102,459	191,513
1965	17,286	16,261	82,579	24,286	834	45,873	103,219	186,297
1966	14,128	15,817	73,980	26,648	835	44,558	107,067	181,170
1967	11,632	15,373	65,358	29,010	836	43,261	109,385	176,019
1968	7,855	14,894	56,157	31,372	838	41,955	106,765	170,949
1969	4,874	14,440	47,235	33,734	839	40,674	105,889	165,749
1970	5,679	14,024	56,882	36,096	821	41,266	111,509	165,523

Table C.1.1, cont.

Year	Andrews	Armstrong	Bailey	Beaver	Borden	Briscoe	Carson	Castro
1971	6,680	13,767	86,191	36,213	804	43,637	112,952	204,239
1972	7,380	13,508	121,538	36,773	786	46,071	113,359	242,952
1973	7,835	13,268	134,811	37,332	769	48,532	116,050	281,527
1974	8,920	13,038	135,529	37,892	751	51,068	116,352	319,895
1975	9,156	12,705	135,074	38,451	662	52,262	119,042	341,251
1976	10,123	12,457	136,545	39,011	573	53,404	122,218	359,422
1977	11,314	12,171	137,434	39,571	485	54,511	124,317	373,958
1978	11,992	12,027	138,940	40,130	441	55,471	126,644	382,715
1979	12,641	11,806	137,123	40,690	396	56,303	128,387	389,124
1980	15,732	11,720	137,475	41,250	680	52,196	130,466	439,478
1981	19,215	11,039	136,869	40,701	940	46,242	125,933	460,571
1982	22,697	10,400	136,544	40,233	1,199	40,288	122,739	481,664
1983	40,024	9,812	136,219	39,765	108	34,775	122,963	409,545
1984	18,302	9,163	135,894	39,297	274	28,786	117,111	424,571
1985	15,935	8,650	136,045	38,829	527	26,584	113,374	427,096
1986	16,394	8,214	114,623	38,361	820	26,131	111,606	289,943
1987	12,780	7,699	101,446	37,892	1,038	22,923	109,381	263,256
1988	12,207	7,220	61,903	37,424	2,671	21,109	105,665	231,065
1989	10,286	6,792	137,163	36,956	1,297	24,694	101,504	314,063
1990	16,443	6,429	153,530	36,488	1,227	31,365	99,381	393,366
1991	16,187	6,054	139,822	35,361	2,380	26,708	97,329	277,707
1992	15,405	6,018	130,715	35,451	3,186	31,134	94,335	313,566
1993	13,327	5,771	143,688	35,541	88	36,703	92,651	379,157
1994	14,413	5,290	128,382	35,634	2,902	33,983	91,796	171,659
1995	18,522	4,828	113,445	35,727	1,579	24,408	89,257	212,195
1996	17,670	4,580	135,888	35,820	5,186	23,115	87,819	251,775
1997	24,407	4,146	104,981	35,913	5,951	14,730	84,152	293,236
1998	15,772	5,733	118,407	35,918	3,444	31,271	98,728	262,544
1999	15,870	7,551	79,804	37,912	2,723	25,616	112,273	196,864
2000	17,534	9,245	107,235	40,372	1,946	30,543	125,506	243,967
2001	24,577	8,562	107,610	42,832	4,050	36,940	119,661	226,708
2002	23,474	8,569	99,658	43,096	4,361	35,936	115,314	245,170
2003	26,775	7,964	91,629	43,359	4,199	41,148	106,741	191,279
2004	22,781	8,296	93,269	43,623	4,418	36,697	104,654	188,092
2005	25,347	7,247	37,477	43,886	4,672	47,236	95,193	145,034
2006	25,489	6,906	55,465	44,150	4,370	39,797	93,320	164,678
2007	32,770	7,030	92,304	44,413	4,534	36,325	96,151	241,825
2008	25,289	5,560	90,596	44,677	4,337	44,746	78,671	247,366
2009	21,032	6,284	69,373	45,059	6,052	55,326	78,662	193,061
2010	19,574	4,735	43,665	45,323	3,645	33,456	89,291	173,502
2011	20,825	8,470	82,483	45,588	5,832	36,892	129,313	203,969
2012	20,825	8,470	82,483	45,588	5,832	36,892	129,313	203,969

Table C.1.1, cont.

Year	Cimarron	Cochran	Collingsworth	Crosby	Curry	Dallam	Dawson	Deaf Smith
1930	0	0	0	0	0	0	0	0
1931	4,453	255	0	2,531	158	2,013	883	5,282
1932	8,906	509	0	5,062	316	4,025	1,765	10,563
1933	13,359	764	0	7,593	474	6,038	2,648	15,845
1934	17,812	1,018	0	10,124	631	8,051	3,530	21,126
1935	22,265	1,273	0	12,655	789	10,063	4,413	26,408
1936	26,718	1,527	0	15,186	947	12,076	5,295	31,689
1937	31,171	1,782	0	17,717	1,105	14,088	6,178	36,971
1938	35,624	2,036	0	20,249	1,263	16,101	7,060	42,252
1939	40,077	2,291	0	22,780	1,421	18,114	7,943	47,534
1940	44,530	2,545	0	25,311	1,579	20,126	8,825	52,815
1941	48,983	2,770	0	27,812	1,636	22,139	9,961	57,943
1942	53,436	2,995	0	30,296	1,693	24,152	10,710	63,073
1943	57,889	4,635	0	32,779	1,751	26,164	16,014	68,204
1944	62,342	6,275	0	35,263	1,808	28,177	21,320	73,333
1945	66,795	7,916	0	37,746	1,866	30,189	26,627	78,469
1946	71,248	9,558	0	40,230	1,923	32,202	31,936	83,608
1947	75,701	11,200	0	42,713	1,981	34,215	37,245	88,749
1948	80,154	13,821	0	45,197	2,038	36,227	45,710	93,892
1949	84,607	16,444	0	47,680	2,096	38,240	54,176	99,038
1950	886	19,067	0	50,164	2,153	40,253	62,644	104,187
1951	7,979	21,679	0	52,651	2,204	42,265	71,054	109,332
1952	11,297	24,292	0	55,138	8,240	44,278	79,464	114,480
1953	14,616	25,762	0	57,625	43,507	46,290	84,195	119,630
1954	17,934	27,233	0	60,112	104,958	48,303	88,926	124,783
1955	21,253	28,703	0	62,599	140,790	50,316	93,657	129,939
1956	24,572	30,161	0	65,048	158,462	57,978	98,392	135,180
1957	27,890	31,635	0	67,546	142,514	65,053	102,842	140,144
1958	31,209	33,103	0	70,078	108,056	72,386	107,785	145,196
1959	34,527	33,938	0	74,150	97,619	80,035	115,169	149,003
1960	37,846	34,768	0	78,250	72,671	87,398	122,514	152,519
1961	37,998	35,580	0	82,372	98,708	92,918	129,798	156,259
1962	47,188	36,410	0	86,460	124,745	98,826	137,266	159,901
1963	56,378	37,242	0	90,556	150,782	104,584	144,476	163,779
1964	65,569	38,097	0	94,733	176,819	110,266	151,833	167,731
1965	74,759	34,546	0	97,469	202,856	115,727	130,352	169,372
1966	83,949	30,933	0	100,201	228,893	121,754	108,733	170,025
1967	93,139	27,318	0	102,939	255,480	127,505	87,439	171,066
1968	102,329	23,674	0	105,665	281,586	132,987	65,190	171,408
1969	111,519	20,081	0	108,390	288,705	138,337	43,225	171,774
1970	120,709	21,314	0	110,096	289,185	144,296	42,353	176,135

Table C.1.1, cont.

Year	Cimarron	Cochran	Collingsworth	Crosby	Curry	Dallam	Dawson	Deaf Smith
1971	122,291	27,774	0	122,975	289,515	153,862	38,918	212,906
1972	118,542	34,785	0	136,191	289,845	163,589	36,552	249,730
1973	114,794	42,413	0	149,781	290,173	173,310	34,396	286,609
1974	111,045	50,636	0	163,667	290,503	183,090	32,225	326,054
1975	107,297	49,190	0	146,865	290,832	192,805	28,061	332,134
1976	103,548	45,861	0	126,299	281,639	202,596	24,027	337,097
1977	99,800	41,588	0	101,936	272,445	212,453	20,271	335,026
1978	96,051	34,971	0	73,766	263,236	222,629	15,618	325,761
1979	92,303	27,434	0	41,786	254,028	232,068	10,733	312,600
1980	88,554	64,299	0	71,132	244,820	242,234	21,620	329,870
1981	82,566	99,530	0	98,324	200,233	253,664	33,246	326,619
1982	81,336	134,760	0	125,516	139,683	265,547	44,872	323,368
1983	80,106	94,530	0	159,794	100,974	277,479	43,391	285,275
1984	78,877	103,354	0	164,451	107,002	289,298	40,400	248,941
1985	77,647	69,780	0	89,716	99,410	300,651	48,750	166,866
1986	76,417	72,651	0	95,160	92,255	312,068	23,142	158,351
1987	75,187	45,060	0	72,515	85,099	323,645	25,175	183,314
1988	73,958	72,271	0	93,882	91,020	334,894	18,483	195,501
1989	72,728	40,540	0	121,663	96,941	346,572	37,458	174,432
1990	71,498	48,565	0	141,480	102,862	357,989	33,758	230,464
1991	69,008	51,736	0	149,799	108,753	346,154	39,383	180,367
1992	69,098	77,194	0	154,515	114,623	334,948	32,677	220,136
1993	69,188	82,350	0	193,937	121,586	323,476	55,139	260,682
1994	69,285	82,518	0	155,232	145,216	312,204	55,706	240,332
1995	69,381	79,029	0	139,582	130,821	300,548	50,501	209,102
1996	69,478	108,721	0	143,709	115,528	289,350	108,269	219,225
1997	69,574	76,036	0	109,778	100,236	278,580	97,902	194,753
1998	69,501	79,606	1	155,966	125,854	290,540	98,628	188,549
1999	74,242	65,725	1	156,197	125,854	302,828	80,313	332,082
2000	79,587	77,862	1	108,391	125,854	315,145	108,637	268,685
2001	84,931	82,188	1	152,588	126,001	320,019	107,053	222,211
2002	85,501	85,963	1	143,837	126,001	324,863	101,075	231,179
2003	86,070	102,985	1	143,053	126,001	329,156	94,959	176,490
2004	86,639	95,967	1	133,974	126,001	333,539	77,727	172,305
2005	87,208	53,040	1	72,170	126,001	339,636	78,305	111,923
2006	87,777	63,703	1	86,275	126,001	343,053	96,481	106,047
2007	88,346	107,441	1	149,490	126,001	347,633	53,914	187,386
2008	88,915	83,828	1	164,138	126,001	377,077	103,920	213,863
2009	90,924	71,162	0	123,833	126,001	389,544	98,454	158,724
2010	90,776	49,843	0	78,202	126,001	336,684	61,114	138,671
2011	90,629	71,384	0	131,300	126,001	455,177	119,199	173,719
2012	90,629	71,384	0	131,116	126,001	455,239	119,199	173,719

Table C.1.1, cont.

Year	Dickens	Donley	Ector	Ellis	Floyd	Gaines	Garza	Glasscock
1930	0	0	0	0	0	0	0	0
1931	55	147	88	16	6,230	1,361	111	42
1932	109	295	176	33	13,417	2,723	222	85
1933	164	442	264	49	20,126	4,084	333	127
1934	218	589	352	65	26,834	5,445	444	170
1935	273	737	439	82	33,543	6,807	555	212
1936	327	884	527	98	40,251	8,168	666	254
1937	382	1,031	615	114	46,960	9,529	777	297
1938	436	1,179	703	131	53,668	10,891	888	339
1939	491	1,326	791	147	60,377	12,252	999	381
1940	545	1,473	879	163	67,085	13,613	1,110	424
1941	580	1,621	1,051	180	73,655	14,914	1,210	430
1942	615	1,768	1,260	196	80,187	15,967	1,310	436
1943	878	1,915	1,515	213	86,719	23,743	2,060	483
1944	1,140	2,062	1,827	229	93,251	31,447	2,810	529
1945	1,403	2,210	2,206	245	99,783	39,151	3,560	575
1946	1,666	2,357	2,669	262	106,315	46,855	4,310	622
1947	1,928	2,504	3,232	278	112,847	54,560	5,060	668
1948	2,348	2,652	3,920	294	119,379	66,869	6,260	742
1949	2,768	2,799	4,758	311	125,911	79,178	7,460	817
1950	3,189	2,946	5,780	655	132,443	91,488	8,660	891
1951	3,609	3,094	6,526	2,272	138,998	103,827	9,860	965
1952	4,029	3,241	7,371	2,399	145,554	116,245	11,060	1,039
1953	4,265	3,388	8,327	2,525	152,110	123,297	11,735	1,081
1954	4,502	3,536	9,409	2,652	158,666	130,354	12,410	1,123
1955	4,738	3,683	10,633	2,779	165,224	137,418	13,085	1,165
1956	4,974	3,911	12,235	2,906	171,793	144,445	13,760	1,206
1957	5,211	4,253	12,619	3,033	178,470	151,148	14,435	1,248
1958	5,447	4,841	10,210	3,159	184,841	158,295	15,110	1,290
1959	5,571	5,099	8,120	3,286	195,779	179,430	15,613	1,463
1960	5,695	5,381	7,737	3,413	206,729	201,224	16,115	1,636
1961	5,819	6,275	10,004	3,264	217,561	222,987	16,617	1,809
1962	5,944	6,884	9,220	4,302	228,530	244,834	17,120	1,984
1963	6,068	7,881	10,087	5,339	239,516	266,716	17,622	2,157
1964	6,192	8,699	11,749	6,376	250,661	289,918	18,124	2,328
1965	6,684	9,242	11,774	7,414	262,638	262,184	17,818	2,482
1966	7,176	9,968	10,946	8,451	274,493	234,250	17,512	2,636
1967	7,669	10,651	11,020	9,488	286,386	207,336	17,206	2,789
1968	8,161	10,718	9,733	10,526	298,177	179,590	16,900	2,943
1969	8,653	11,498	9,783	11,563	310,251	151,958	16,594	3,097
1970	8,490	12,248	8,473	12,600	304,490	184,954	16,431	3,431

Table C.1.1, cont.

Year	Dickens	Donley	Ector	Ellis	Floyd	Gaines	Garza	Glasscock
1971	8,327	12,188	9,465	12,831	298,529	217,976	16,267	3,766
1972	8,165	12,280	8,332	14,170	292,588	251,094	16,104	4,101
1973	8,002	12,254	8,058	15,509	286,630	283,518	15,941	4,436
1974	7,839	12,312	8,098	16,848	280,900	316,655	15,777	4,770
1975	6,602	12,276	8,409	18,187	259,466	336,375	15,007	4,482
1976	5,365	12,309	8,417	19,527	238,204	356,705	14,236	4,194
1977	4,127	12,371	8,420	20,866	216,882	376,812	13,466	3,904
1978	2,923	12,308	7,525	22,205	195,520	397,564	12,745	3,637
1979	1,719	12,325	7,691	23,544	173,953	418,130	12,024	3,369
1980	3,396	12,409	3,884	24,884	224,649	422,025	10,105	4,039
1981	5,067	13,309	3,834	25,517	275,103	426,667	8,194	4,668
1982	6,737	14,116	3,785	26,967	325,557	431,381	6,284	5,297
1983	3,625	15,198	804	28,416	235,076	329,585	6,887	5,609
1984	4,989	16,129	945	29,866	257,035	263,308	7,697	5,211
1985	2,494	17,019	1,956	31,316	167,808	306,985	5,575	2,657
1986	3,121	17,906	1,870	32,765	143,638	211,959	3,498	5,180
1987	1,264	18,869	3,255	34,215	153,046	235,069	3,730	3,154
1988	1,821	19,742	1,757	35,665	170,301	204,835	4,711	3,558
1989	1,989	20,712	2,175	37,114	155,774	303,642	7,091	3,701
1990	2,304	21,674	5,523	38,564	192,055	323,001	5,049	3,222
1991	1,391	20,260	8,987	39,275	206,103	352,996	3,919	4,234
1992	2,075	18,825	6,144	39,382	215,493	328,008	5,174	4,297
1993	1,332	17,410	6,259	39,489	232,894	311,626	6,265	4,095
1994	2,092	15,986	5,152	39,600	217,898	330,529	9,872	5,346
1995	2,259	14,557	7,181	39,711	189,661	323,049	11,034	6,894
1996	6,931	13,182	7,304	39,822	174,872	284,740	16,850	5,538
1997	6,539	11,823	3,553	39,933	141,146	319,231	14,900	6,417
1998	6,154	15,142	500	39,945	181,356	335,936	24,968	6,250
1999	5,750	19,063	1,174	42,693	185,334	320,712	12,320	2,478
2000	3,992	25,950	3,616	45,447	166,457	267,175	17,694	3,266
2001	3,787	24,377	5,450	48,201	123,911	350,065	21,138	2,382
2002	4,147	25,258	3,500	48,501	132,815	318,804	28,811	2,437
2003	4,217	26,383	99	48,801	136,600	269,227	19,436	4,134
2004	3,936	27,751	101	49,101	121,393	288,741	19,321	4,062
2005	4,790	28,424	136	49,401	83,215	271,410	17,179	4,062
2006	4,899	30,205	142	49,700	90,482	266,248	16,789	4,279
2007	3,603	30,099	170	50,000	117,809	263,870	21,149	3,493
2008	3,513	30,821	97	50,300	134,397	342,193	13,043	3,931
2009	4,495	29,978	977	50,486	121,735	253,412	21,994	4,204
2010	3,858	26,277	712	50,782	73,658	230,353	10,824	5,240
2011	4,581	39,752	238	51,079	119,804	291,267	16,846	4,886
2012	4,581	39,752	238	51,079	119,804	291,274	16,846	4,886

Table C.1.1, cont.

Year	Gray	Hale	Hansford	Harper	Hartley	Hemphill	Hockley	Howard	Hutchinson
1930	0	0	0	0	0	0	0	0	0
1931	348	7,340	1,102	32	698	26	1,507	30	1,693
1932	695	14,681	2,203	65	1,395	52	3,014	59	3,386
1933	1,043	22,021	3,305	97	2,093	78	4,521	89	5,079
1934	1,391	29,362	4,406	130	2,791	103	6,028	119	6,772
1935	1,738	36,702	5,508	162	3,488	129	7,535	149	8,465
1936	2,086	44,043	6,610	195	4,186	155	9,043	178	10,158
1937	2,434	51,383	7,711	227	4,884	181	10,550	208	11,851
1938	2,781	58,724	8,813	260	5,581	207	12,057	238	13,544
1939	3,129	66,064	9,915	292	6,279	233	13,564	267	15,237
1940	3,476	73,405	11,016	325	6,977	258	15,071	297	16,930
1941	3,824	80,702	12,118	357	7,674	284	16,557	307	18,623
1942	4,172	87,947	13,317	389	8,372	310	18,044	318	20,316
1943	4,519	95,195	14,321	422	9,069	336	19,531	394	22,009
1944	4,867	102,445	15,423	454	9,767	362	21,020	471	23,702
1945	5,215	109,699	16,524	487	10,465	388	22,510	548	25,395
1946	5,562	116,955	17,626	519	11,162	414	24,000	624	27,088
1947	5,910	124,214	18,728	552	11,860	439	25,492	701	28,781
1948	6,258	131,477	19,829	584	12,558	465	26,985	824	30,474
1949	6,605	138,743	20,931	617	13,255	491	28,479	947	32,167
1950	6,953	146,013	22,032	127	13,953	517	29,975	1,069	33,860
1951	7,301	153,256	23,134	3,431	14,651	543	31,452	1,192	35,553
1952	7,648	160,500	24,236	3,768	15,348	569	32,929	1,315	37,246
1953	7,996	167,746	25,337	4,105	16,046	594	34,406	1,384	38,939
1954	8,343	174,993	26,439	4,442	16,744	620	35,883	1,453	40,632
1955	8,691	182,265	27,541	4,779	17,441	646	37,360	1,522	42,325
1956	10,963	189,775	32,737	5,116	20,882	760	38,936	1,592	48,110
1957	10,937	196,703	37,431	5,453	24,195	917	40,436	1,661	52,230
1958	11,351	204,005	42,346	5,790	27,538	751	42,205	1,729	51,808
1959	12,493	234,990	47,923	6,127	30,942	771	51,885	1,834	58,178
1960	13,463	266,045	52,507	6,464	34,324	720	61,585	1,939	63,655
1961	14,318	295,552	67,981	6,270	46,209	762	71,333	2,044	64,906
1962	15,353	327,897	83,751	6,506	58,214	809	81,126	2,149	68,177
1963	19,433	358,984	98,835	6,743	70,221	1,070	90,926	2,255	70,210
1964	18,456	389,992	115,112	6,979	82,142	1,023	100,78	2,361	73,240
1965	19,669	360,781	130,245	7,216	94,117	1,165	91,717	2,203	72,118
1966	21,290	330,734	145,821	7,452	106,15	1,215	82,382	2,045	73,792
1967	22,774	300,290	161,236	7,689	117,91	1,235	73,062	1,888	75,352
1968	24,293	270,549	177,226	7,925	129,81	1,410	63,621	1,730	77,346
1969	25,094	241,389	192,315	8,162	141,51	1,509	54,410	1,573	78,832
1970	26,393	251,453	207,790	8,398	153,68	1,627	60,970	1,798	81,676

Table C.1.1, cont.

Year	Gray	Hale	Hansford	Harper	Hartley	Hemphill	Hockley	Howard	Hutchinson
1971	25,519	310,869	205,018	8,123	163,605	1,723	87,550	2,023	84,564
1972	31,645	373,963	202,285	8,540	173,570	1,699	118,323	2,248	87,950
1973	21,338	440,801	198,788	8,957	183,546	1,621	152,738	2,473	89,892
1974	20,459	511,229	195,974	9,373	193,581	1,718	191,425	2,697	90,464
1975	19,281	502,273	192,914	9,790	203,514	1,611	179,734	2,364	91,409
1976	18,951	481,602	190,118	10,207	213,580	1,764	159,528	2,021	94,076
1977	18,068	448,309	187,684	10,623	223,895	1,883	129,986	1,682	95,663
1978	17,859	403,083	185,278	11,040	234,224	1,907	91,999	1,650	97,426
1979	17,153	344,866	182,729	11,457	244,499	1,923	43,884	1,643	97,139
1980	17,010	406,091	180,324	11,873	254,951	2,333	112,920	5,489	95,095
1981	16,183	441,597	172,905	11,958	249,465	2,052	178,871	9,309	92,705
1982	16,427	477,103	165,514	11,870	244,029	1,888	244,822	13,129	88,601
1983	16,282	418,074	158,439	11,781	238,765	1,482	211,742	4,821	83,033
1984	16,584	432,725	151,255	11,692	233,402	1,490	176,726	5,755	77,842
1985	16,515	391,168	144,573	11,603	228,556	1,357	145,830	5,973	72,721
1986	15,374	298,175	134,479	11,514	222,259	1,436	114,458	5,897	67,500
1987	14,851	265,503	128,776	11,425	217,605	815	86,780	3,410	63,136
1988	13,078	245,696	118,563	11,336	210,563	1,109	88,358	4,389	58,998
1989	14,924	431,549	110,974	11,247	205,121	978	147,564	5,341	54,583
1990	15,191	441,391	103,398	11,158	199,764	1,006	147,003	7,025	50,102
1991	16,031	295,421	108,892	10,864	192,764	1,440	145,728	6,640	49,764
1992	17,067	384,318	114,869	10,892	186,932	2,197	177,751	8,971	46,257
1993	18,195	407,826	120,282	10,920	179,843	2,534	179,850	5,533	43,023
1994	19,224	394,884	125,458	10,948	172,562	2,956	190,314	4,356	43,872
1995	19,531	328,352	130,790	10,977	165,943	3,287	173,599	4,212	42,984
1996	19,478	334,227	135,585	11,005	159,426	3,926	173,174	4,200	40,958
1997	20,292	239,293	141,561	11,034	152,577	4,414	154,010	5,489	39,728
1998	22,802	304,303	141,780	11,035	199,416	4,661	165,173	9,498	48,602
1999	26,493	285,761	141,884	11,780	246,124	6,110	195,206	12,684	62,314
2000	29,663	273,558	142,131	12,544	293,017	6,384	175,046	6,813	76,766
2001	29,193	251,577	136,580	13,309	294,045	6,332	187,755	5,547	73,056
2002	29,601	285,065	131,106	13,390	295,200	6,710	165,837	5,245	66,486
2003	29,313	290,993	125,530	13,472	296,465	7,282	192,397	4,153	63,006
2004	29,320	261,698	120,008	13,554	297,578	7,987	186,175	4,542	59,112
2005	28,274	182,261	114,514	13,636	298,674	7,161	92,003	4,572	56,120
2006	29,038	209,626	109,217	13,718	299,930	8,087	110,896	6,110	52,263
2007	27,336	362,216	103,185	13,800	300,971	9,166	198,338	9,509	42,543
2008	27,253	390,763	145,555	13,881	367,995	12,877	131,632	7,623	59,940
2009	41,068	273,534	157,452	13,963	388,040	8,771	152,183	9,837	80,140
2010	26,306	166,304	134,274	14,045	346,449	14,175	101,261	10,807	63,416
2011	41,569	288,789	239,003	14,127	490,652	21,951	152,075	13,768	88,136
2012	41,569	288,789	239,003	14,127	490,652	21,951	152,075	13,768	88,136

Table C.1.1, cont.

Year	Lamb	Lea	Lipscomb	Lubbock	Lynn	Martin	Midland	Moore
1930	0	0	0	0	0	0	0	0
1931	4,338	475	74	3,875	671	558	116	1,528
1932	8,676	950	149	7,750	1,343	1,117	232	3,218
1933	13,014	1,424	223	11,626	2,014	1,675	347	4,827
1934	17,352	1,899	298	15,501	2,686	2,233	463	6,436
1935	21,690	2,374	372	19,376	3,357	2,792	579	8,045
1936	26,028	2,849	447	23,251	4,029	3,350	695	9,654
1937	30,366	3,324	521	27,126	4,700	3,909	811	11,263
1938	34,704	3,799	596	31,002	5,372	4,467	927	12,872
1939	39,042	4,273	670	34,877	6,043	5,025	1,042	14,481
1940	43,380	4,748	745	38,737	6,715	5,584	1,158	15,705
1941	47,631	3,133	819	42,563	7,442	6,011	1,293	17,275
1942	51,882	5,117	894	46,409	7,963	6,282	1,440	18,846
1943	56,134	7,652	968	50,276	11,928	8,315	1,861	20,917
1944	60,385	5,186	1,043	54,167	15,893	10,348	2,298	22,526
1945	64,637	8,221	1,117	58,084	19,859	12,381	2,755	24,135
1946	68,889	5,256	1,192	62,030	23,824	14,414	3,233	25,744
1947	73,141	20,790	1,266	66,009	27,790	16,447	3,735	27,353
1948	77,393	40,825	1,341	70,022	34,141	19,700	4,444	28,962
1949	81,645	63,426	1,415	74,075	40,492	22,953	5,185	30,571
1950	85,897	98,507	1,490	78,171	46,843	26,207	5,962	32,180
1951	90,147	156,657	1,564	82,089	53,202	29,437	6,924	33,789
1952	94,396	169,807	1,639	86,068	59,561	32,668	7,980	35,398
1953	98,646	168,957	1,713	90,021	63,138	34,475	8,939	37,007
1954	102,895	167,107	1,788	93,993	66,715	36,283	10,033	38,616
1955	107,145	174,257	1,862	97,983	70,291	38,090	11,287	40,225
1956	111,532	164,407	2,204	101,720	73,680	39,266	12,099	46,868
1957	116,089	146,123	2,494	104,352	77,225	41,472	11,800	53,385
1958	120,694	114,835	2,882	108,196	80,831	43,229	12,187	60,032
1959	135,457	156,983	3,225	103,829	80,709	45,100	12,144	67,321
1960	150,140	113,132	3,565	99,316	80,759	46,745	11,125	74,649
1961	164,364	115,290	3,726	94,418	80,665	47,625	10,092	83,908
1962	179,102	117,446	3,963	90,404	80,694	48,897	10,006	94,213
1963	193,955	119,603	4,177	86,147	80,578	50,160	9,849	104,426
1964	208,420	121,760	4,495	81,828	80,480	52,105	9,484	113,897
1965	190,659	123,916	4,717	80,660	69,390	48,517	10,186	122,569
1966	172,782	126,072	4,945	78,846	58,221	44,586	10,406	133,435
1967	154,981	128,234	5,175	79,444	46,996	42,210	12,302	143,191
1968	136,361	130,387	5,461	72,692	35,659	38,945	13,568	153,001
1969	118,199	132,544	5,651	69,619	24,662	34,893	13,723	161,902
1970	119,855	132,607	5,877	76,169	34,159	31,340	10,095	171,229

Table C.1.1, cont.

Year	Lamb	Lea	Lipscomb	Lubbock	Lynn	Martin	Midland	Moore
1971	149,456	132,536	7,366	96,849	43,894	31,781	10,850	172,660
1972	179,944	132,464	8,986	120,978	53,629	30,838	10,065	183,881
1973	210,967	132,393	10,460	146,915	63,411	31,150	10,773	193,573
1974	243,089	132,320	12,127	175,286	73,231	31,677	11,719	199,052
1975	259,799	132,247	13,693	158,510	66,307	28,262	10,619	204,675
1976	274,412	128,756	15,439	137,524	59,548	25,530	10,383	214,804
1977	287,168	125,266	17,023	109,084	52,661	23,684	11,088	223,566
1978	297,351	121,776	18,465	76,235	45,990	21,096	11,503	232,873
1979	302,528	118,287	20,025	32,420	39,013	17,761	10,956	241,267
1980	371,854	114,796	21,644	109,846	39,114	14,816	9,403	250,141
1981	417,263	86,549	20,888	186,050	39,281	13,885	13,247	245,243
1982	462,673	58,304	19,964	262,254	39,449	12,954	17,092	240,082
1983	381,079	37,985	19,182	230,691	50,797	14,942	16,133	233,239
1984	328,219	36,410	18,449	266,373	55,723	11,275	20,151	229,148
1985	288,835	41,302	17,454	220,274	56,704	10,640	20,796	224,784
1986	282,944	48,154	16,740	183,602	32,980	8,204	16,202	219,113
1987	254,745	55,007	15,741	151,842	29,974	6,512	13,405	213,662
1988	268,479	57,721	14,878	171,102	31,157	9,942	16,105	206,819
1989	246,054	60,434	13,984	247,982	38,668	13,565	19,283	202,593
1990	403,963	63,148	13,255	298,936	60,600	14,358	16,898	197,986
1991	328,417	65,919	15,530	226,235	51,346	8,410	14,245	192,338
1992	300,318	68,681	17,675	230,604	70,231	16,458	15,431	189,210
1993	329,509	44,380	19,991	260,071	55,745	17,614	14,657	184,231
1994	308,636	46,121	22,261	230,386	55,652	15,916	17,301	178,994
1995	294,127	50,614	24,459	250,808	62,740	14,375	12,813	174,446
1996	295,395	54,743	26,860	224,033	53,230	15,084	12,751	169,682
1997	237,026	58,870	29,245	191,669	48,292	12,633	11,639	164,389
1998	290,131	58,695	28,346	216,632	89,008	22,802	12,047	170,254
1999	264,726	58,694	27,123	183,438	61,745	21,666	12,751	174,856
2000	306,328	58,694	26,303	200,051	109,018	16,800	6,810	180,936
2001	338,910	58,756	26,660	186,772	104,676	18,182	7,760	176,269
2002	339,440	58,744	27,558	200,926	91,199	18,451	9,463	172,052
2003	314,901	58,732	28,477	187,754	83,722	15,433	11,765	167,600
2004	305,358	58,720	29,262	183,915	84,794	16,917	12,533	161,880
2005	203,183	58,707	29,955	103,516	59,064	18,696	12,728	159,213
2006	208,322	58,695	30,787	111,931	58,734	18,297	15,478	154,940
2007	373,797	58,683	31,480	190,571	102,136	28,861	13,687	147,940
2008	325,385	58,671	32,300	230,668	107,812	30,747	18,996	198,708
2009	262,326	58,659	32,421	163,254	85,280	37,759	20,577	213,644
2010	158,134	58,647	36,541	100,371	51,716	37,190	16,269	173,866
2011	253,470	58,647	53,740	136,326	95,945	41,800	15,220	282,405
2012	253,470	58,647	53,740	136,326	95,945	41,800	15,220	282,421

Table C.1.1, cont.

Year	Morton	Motley	Ochiltree	Oldham	Parmer	Potter	Quay	Randall
1930	0	0	0	0	0	0	0	0
1931	0	3	447	74	8,415	150	189	953
1932	0	5	894	147	16,829	300	378	1,906
1933	0	8	1,342	221	25,244	450	567	2,859
1934	0	10	1,789	294	33,659	600	756	3,812
1935	0	13	2,236	368	42,074	749	945	4,764
1936	0	15	2,683	442	50,488	899	1,134	5,717
1937	0	18	3,131	515	58,903	1,049	1,322	6,670
1938	0	20	3,578	589	67,318	1,199	1,511	7,623
1939	0	23	4,025	662	75,733	1,349	1,700	8,576
1940	0	25	4,472	736	84,147	1,499	1,889	9,529
1941	0	26	4,919	803	92,405	1,642	899	10,407
1942	0	27	5,367	870	100,756	1,785	2,819	11,302
1943	0	36	5,814	1,355	109,048	2,188	3,619	13,723
1944	0	44	6,261	1,840	117,340	2,592	2,819	16,163
1945	0	53	6,708	2,325	125,632	2,995	4,569	18,624
1946	0	61	7,156	2,810	133,924	3,399	6,919	21,110
1947	0	69	7,603	3,295	142,216	3,803	8,069	23,622
1948	0	83	8,050	4,069	150,508	4,387	4,619	27,206
1949	0	96	8,497	4,844	158,799	4,971	2,619	30,822
1950	191	110	8,945	5,618	167,091	5,555	6,919	34,473
1951	810	123	9,392	6,392	175,397	6,143	8,319	38,455
1952	1,152	137	9,839	7,166	183,704	6,731	5,619	42,558
1953	1,494	144	10,286	7,603	192,012	7,109	6,019	45,587
1954	1,836	152	10,733	8,039	200,322	7,488	5,319	48,783
1955	2,178	159	11,181	8,476	208,632	7,868	5,719	52,175
1956	2,520	167	13,171	8,911	216,959	8,545	3,719	57,572
1957	2,862	175	15,162	9,379	225,266	9,131	3,519	56,716
1958	3,204	182	17,314	9,826	233,554	9,784	3,319	59,825
1959	3,546	201	19,699	10,798	223,583	11,400	4,819	67,678
1960	3,888	220	21,432	11,758	213,580	13,038	2,319	71,300
1961	3,900	239	28,680	12,731	203,569	14,443	2,939	76,415
1962	4,662	258	35,797	13,705	193,631	15,755	3,559	80,919
1963	5,425	278	43,293	14,680	183,664	17,195	4,179	87,462
1964	6,187	297	50,603	15,657	173,715	18,707	4,800	93,906
1965	6,949	340	57,745	15,000	168,877	18,448	5,420	86,255
1966	7,712	383	64,877	14,359	164,016	18,359	6,040	82,315
1967	8,474	427	72,034	13,708	159,196	18,243	6,660	76,466
1968	9,237	470	79,382	13,041	154,373	18,028	7,280	61,401
1969	9,999	513	86,764	13,240	149,479	17,952	7,426	48,209
1970	10,761	505	94,168	12,506	156,287	18,339	9,094	52,093

Table C.1.1, cont.

Year	Morton	Motley	Ochiltree	Oldham	Parmer	Potter	Quay	Randall
1971	10,841	497	95,748	14,462	201,112	19,988	10,685	58,423
1972	10,763	489	97,164	17,819	248,992	21,591	12,276	62,007
1973	10,684	481	98,633	20,036	300,205	23,598	13,867	73,800
1974	10,606	473	100,400	22,984	354,579	25,256	15,458	79,227
1975	10,528	423	101,877	23,436	395,604	26,207	17,049	83,960
1976	10,449	373	103,504	23,926	436,409	26,805	16,042	90,973
1977	10,371	323	105,680	24,162	476,900	27,312	15,035	97,841
1978	10,293	272	107,611	22,371	516,993	27,814	14,028	99,952
1979	10,214	222	109,016	20,157	556,620	28,549	13,021	105,727
1980	10,136	352	110,658	24,278	551,211	26,934	12,014	93,729
1981	9,786	482	105,972	30,195	504,372	23,055	6,781	71,246
1982	9,715	613	100,592	35,784	457,532	19,194	766	50,464
1983	9,643	448	95,497	33,013	377,620	32,676	601	81,656
1984	9,572	570	90,187	30,360	358,230	43,833	618	95,225
1985	9,500	428	85,048	23,481	324,772	30,133	621	91,147
1986	9,429	435	78,939	30,297	280,806	30,856	666	80,323
1987	9,357	456	74,365	22,939	221,450	18,087	711	78,439
1988	9,286	454	68,149	34,416	164,354	32,933	765	79,388
1989	9,214	478	62,978	11,332	238,722	12,769	820	63,722
1990	9,143	478	58,037	12,570	400,118	9,925	879	74,636
1991	8,904	403	54,932	27,156	226,511	13,889	933	86,794
1992	8,926	388	51,531	19,531	272,373	17,515	988	77,129
1993	8,949	248	48,501	13,160	339,787	17,298	854	79,961
1994	8,972	452	45,875	19,350	312,826	19,274	928	83,204
1995	8,996	518	42,969	16,249	278,028	20,574	1,379	86,977
1996	9,019	417	40,336	18,833	290,036	23,690	1,450	89,596
1997	9,043	414	39,019	28,224	227,515	27,042	1,521	79,498
1998	9,044	1,096	62,114	22,178	307,215	14,363	1,623	84,242
1999	9,654	920	84,863	6,629	230,781	9,322	1,623	75,167
2000	10,280	209	108,289	7,986	267,955	6,396	1,623	89,301
2001	10,907	89	100,022	12,131	232,873	6,827	1,195	93,609
2002	10,974	209	92,728	18,112	289,951	9,152	1,195	95,894
2003	11,041	233	84,950	14,669	271,307	6,346	1,195	93,587
2004	11,108	226	77,170	13,979	296,648	6,147	1,195	89,458
2005	11,175	210	69,588	18,417	190,297	5,514	1,195	91,520
2006	11,242	230	61,963	19,666	179,181	4,580	1,195	88,822
2007	11,309	215	54,098	17,044	261,879	8,056	1,195	67,934
2008	11,376	280	78,930	21,137	264,765	14,259	1,195	65,460
2009	11,443	256	70,269	19,043	197,596	32,750	1,195	35,630
2010	11,510	153	65,645	12,463	169,872	5,579	1,195	32,389
2011	11,577	273	114,261	17,124	164,421	10,388	1,195	46,071
2012	11,577	273	114,261	17,124	164,421	10,388	1,195	46,071

Table C.1.1, cont.

Year	Roberts	Roosevelt	Seward	Sherman	Stevens	Swisher	Terry	Texas
1930	0	0	0	0	0	0	0	0
1931	75	2,700	0.1	1,770	2	3,424	330	12
1932	151	5,400	0.1	3,539	4	6,849	661	23
1933	226	8,099	0.1	5,309	6	10,273	991	35
1934	301	10,799	0.2	7,078	8	13,697	1,321	47
1935	377	13,499	0.3	8,848	10	17,122	1,652	58
1936	452	16,199	0.3	10,618	12	20,546	1,982	70
1937	527	18,898	0.3	12,387	14	23,970	2,312	82
1938	603	21,598	0.4	14,125	16	27,394	2,643	93
1939	678	24,298	0.5	15,891	18	30,819	2,973	105
1940	753	26,998	0.5	17,656	20	34,243	3,303	116
1941	829	10,974	1	19,422	22	37,560	3,584	128
1942	904	24,750	1	21,188	24	40,877	3,865	140
1943	979	46,276	1	22,953	26	44,194	5,909	151
1944	1,055	24,803	1	24,719	28	47,512	7,954	163
1945	1,130	38,829	1	26,485	31	50,829	9,998	175
1946	1,205	38,355	1	28,250	33	54,147	12,042	186
1947	1,281	46,381	1	30,016	35	57,464	14,087	198
1948	1,356	38,407	1	31,781	37	60,782	17,352	210
1949	1,431	38,434	1	33,547	39	64,100	20,617	221
1950	1,507	53,460	327	35,313	649	67,418	23,883	1,669
1951	1,582	85,474	3,616	37,078	11,322	70,737	27,153	18,895
1952	1,657	83,488	4,544	38,844	15,774	74,056	30,424	26,665
1953	1,733	102,502	5,472	40,610	20,226	77,375	32,272	34,434
1954	1,879	118,765	6,400	42,375	24,678	80,694	34,120	42,204
1955	1,957	105,779	7,328	44,240	29,131	84,014	35,968	49,973
1956	2,346	110,793	8,257	52,970	33,583	87,403	37,772	57,769
1957	2,729	99,807	9,185	61,757	38,035	90,679	39,513	65,540
1958	3,085	80,821	10,113	70,563	42,488	94,008	41,352	73,309
1959	3,464	100,085	11,041	79,362	46,940	106,085	43,181	81,078
1960	3,819	86,599	11,969	88,146	51,392	118,121	44,724	88,864
1961	4,271	95,820	11,891	115,189	51,487	130,213	46,672	89,153
1962	4,754	105,041	13,901	142,328	58,438	142,308	48,534	108,876
1963	5,256	114,263	15,911	169,806	65,389	154,406	49,936	128,580
1964	5,709	123,484	17,922	196,908	72,339	166,544	51,960	148,324
1965	6,144	132,705	19,932	223,875	79,290	159,439	45,033	168,015
1966	6,621	141,926	21,942	251,003	86,241	152,308	38,206	187,765
1967	7,061	151,148	23,952	278,040	93,192	145,154	31,382	207,484
1968	7,515	160,369	25,962	305,207	100,142	137,881	24,452	227,231
1969	7,989	159,134	27,972	332,371	107,093	130,738	17,611	246,935
1970	8,465	170,665	29,982	359,461	114,044	138,209	22,954	266,681

Table C.1.1, cont.

Year	Roberts	Roosevelt	Seward	Sherman	Stevens	Swisher	Terry	Texas
1971	8,210	181,775	30,097	355,816	113,827	172,560	34,819	269,634
1972	7,990	192,884	31,100	352,183	117,792	209,599	49,033	266,605
1973	7,784	203,993	32,102	348,545	121,757	249,474	65,808	263,535
1974	7,604	215,102	33,104	345,007	125,722	292,192	84,975	260,481
1975	7,370	226,212	34,106	341,263	129,686	280,494	83,631	257,449
1976	7,172	213,106	35,109	337,673	133,651	260,682	80,115	254,425
1977	6,943	200,000	36,111	334,321	137,616	232,540	73,755	251,391
1978	6,744	186,894	37,113	330,985	141,581	196,079	65,563	248,374
1979	6,510	173,788	38,115	327,700	145,546	151,305	54,464	245,356
1980	6,372	160,682	39,118	324,487	149,510	212,852	80,488	242,339
1981	6,089	148,796	39,037	316,294	149,333	264,026	102,351	232,949
1982	5,851	126,351	39,346	308,120	150,422	315,201	124,213	231,733
1983	5,596	65,582	39,655	299,420	151,510	273,971	186,629	230,518
1984	5,412	65,728	39,964	290,932	152,598	311,624	154,035	229,302
1985	5,152	67,597	40,272	282,693	153,686	242,087	171,070	228,087
1986	4,576	69,202	40,581	273,872	154,775	241,121	100,336	226,893
1987	4,551	70,808	40,890	265,190	155,863	137,365	82,251	225,590
1988	4,405	77,946	41,199	255,613	156,951	122,031	49,511	224,433
1989	4,174	85,083	41,508	247,023	158,040	118,274	185,870	223,124
1990	3,947	92,457	41,817	238,561	159,128	155,100	161,119	221,897
1991	4,156	99,851	41,347	226,385	157,254	152,594	154,983	216,637
1992	4,336	107,246	41,451	215,632	157,653	166,203	153,273	217,083
1993	4,522	100,569	41,556	204,057	158,052	189,843	168,866	217,554
1994	4,689	107,873	41,665	192,091	158,466	191,008	159,488	218,025
1995	4,882	107,426	41,774	180,385	158,881	161,016	164,235	218,487
1996	5,038	106,111	41,883	167,988	159,295	142,386	157,291	218,961
1997	5,373	104,797	41,992	156,416	159,710	109,513	171,894	219,420
1998	5,457	104,381	41,997	203,793	159,726	140,905	268,421	219,368
1999	6,847	104,381	44,830	251,422	170,504	152,914	174,909	233,128
2000	1,812	104,381	47,740	298,857	181,568	141,785	213,762	248,375
2001	3,440	104,339	50,649	286,556	192,632	138,699	194,007	263,620
2002	34,018	104,339	50,960	274,187	193,817	130,952	215,139	265,189
2003	40,843	104,339	51,271	261,739	195,001	139,639	171,256	266,760
2004	45,014	104,339	51,583	248,997	196,185	138,921	121,806	268,329
2005	41,750	104,339	51,894	236,550	197,369	137,697	145,566	269,899
2006	48,134	104,339	52,206	224,233	198,554	126,013	186,584	271,469
2007	45,946	104,339	52,517	211,997	199,738	187,249	104,286	273,039
2008	48,343	104,339	52,828	280,222	200,922	203,116	168,020	274,609
2009	21,356	104,339	53,140	290,246	202,106	198,266	193,455	275,963
2010	48,287	104,339	53,451	253,982	203,291	94,323	145,191	277,548
2011	36,261	104,339	53,762	400,585	204,475	128,796	222,147	279,133
2012	36,261	104,339	53,762	400,674	204,475	128,796	222,147	279,133

Table C.1.1, cont.

Year	Union	Wheeler	Yoakum
1930	0	0	0
1931	36	78	242
1932	71	156	484
1933	107	235	726
1934	142	313	968
1935	178	391	1,210
1936	213	469	1,452
1937	249	548	1,694
1938	284	626	1,936
1939	320	704	2,178
1940	356	782	2,419
1941	391	861	2,551
1942	427	939	2,682
1943	462	1,017	3,697
1944	498	1,095	4,711
1945	533	1,174	5,725
1946	569	1,252	6,740
1947	604	1,330	7,754
1948	640	1,408	9,380
1949	675	1,487	11,006
1950	233	1,565	12,632
1951	2,404	1,643	14,280
1952	2,635	1,721	15,930
1953	2,866	1,800	16,869
1954	3,097	1,878	16,891
1955	3,328	1,956	18,741
1956	3,559	2,272	18,764
1957	3,790	2,646	19,668
1958	4,021	3,003	20,604
1959	4,252	2,931	20,327
1960	4,482	2,626	20,060
1961	4,459	2,293	19,751
1962	5,067	2,459	19,464
1963	5,674	3,725	19,157
1964	6,281	3,907	18,910
1965	6,889	3,727	19,643
1966	7,496	3,574	20,333
1967	8,103	3,887	21,089
1968	8,710	4,070	21,840
1969	9,318	4,348	22,557
1970	9,925	4,501	26,496
1971	10,074	4,495	37,426
1972	10,382	4,420	50,152
1973	10,691	4,421	64,685
1974	10,999	4,789	81,124
1975	11,307	4,357	88,737
1976	11,616	4,926	96,134
1977	11,924	5,084	103,013
1978	12,236	5,124	109,527
1979	12,548	5,637	115,423
1980	12,861	6,043	121,658
1981	12,944	5,410	119,120
1982	12,976	4,919	116,643
1983	13,008	4,448	80,941
1984	13,040	3,872	72,408
1985	13,072	3,304	44,555
1986	13,103	2,782	35,294
1987	13,135	2,332	15,077
1988	13,163	1,948	28,221
1989	13,192	1,424	84,996
1990	13,223	1,038	75,908
1991	13,125	1,522	83,261
1992	12,932	1,992	98,881
1993	12,747	2,471	78,746
1994	12,558	3,045	101,621
1995	12,367	3,416	105,794
1996	12,176	3,937	133,377
1997	11,984	4,621	133,849
1998	11,787	5,912	144,985
1999	9,772	6,958	100,709
2000	10,529	8,481	115,527
2001	11,286	9,837	107,713
2002	11,382	10,258	130,958
2003	11,479	9,897	120,548
2004	11,575	11,958	115,080
2005	11,671	11,010	116,268
2006	11,768	12,919	112,571
2007	11,864	12,083	141,253
2008	11,960	10,344	156,511
2009	12,791	11,863	169,144
2010	12,354	11,678	180,729
2011	11,917	13,792	142,681
2012	11,917	13,792	142,582

Table C.1.2 **Annual pumping for the Rita Blanca Aquifer by county. All values are reported in acre-feet per year.**

Year	Dallam	Union
1930	0	0
1931	56	825
1932	119	1,276
1933	180	1,794
1934	240	2,295
1935	301	2,788
1936	358	2,872
1937	420	3,396
1938	481	3,933
1939	542	4,439
1940	603	4,916
1941	664	5,406
1942	725	5,890
1943	787	6,357
1944	848	6,790
1945	910	7,208
1946	971	7,616
1947	1,032	7,955
1948	1,092	8,207
1949	1,151	8,376
1950	1,210	8,471
1951	1,213	8,503
1952	1,215	8,482
1953	1,216	8,417
1954	1,217	8,309
1955	1,217	8,160
1956	1,386	7,972
1957	1,545	7,830
1958	1,709	7,719
1959	1,877	7,629
1960	2,041	7,554
1961	2,164	7,490
1962	2,294	7,434
1963	2,421	7,384
1964	2,547	7,335
1965	2,670	7,296
1966	2,802	7,264
1967	2,929	7,247
1968	3,051	7,234
1969	3,171	7,217
1970	3,302	7,232
1971	3,515	7,251
1972	3,731	7,265
1973	3,948	7,281
1974	4,167	7,306
1975	4,384	7,330
1976	4,602	7,360
1977	4,823	7,398
1978	5,049	7,434
1979	5,263	7,474
1980	6,683	7,481
1981	7,926	7,493
1982	9,169	7,514
1983	11,235	7,438
1984	12,475	7,440
1985	5,298	7,459
1986	6,030	7,484
1987	5,099	7,497
1988	5,033	7,528
1989	5,928	7,621
1990	7,547	7,602
1991	3,387	7,659
1992	4,464	7,744
1993	8,722	7,798
1994	4,707	7,881
1995	5,068	7,970
1996	5,417	8,119
1997	6,364	8,263
1998	5,681	8,392
1999	6,098	8,529
2000	6,320	8,640
2001	5,499	8,756
2002	7,258	8,796
2003	5,280	8,912
2004	5,052	9,145
2005	5,072	9,351
2006	4,358	9,520
2007	4,603	9,635
2008	5,175	10,711
2009	5,309	10,374
2010	4,643	10,119
2011	6,205	9,889
2012	6,202	9,821

Table C.1.3 **Annual pumping for the Edwards Trinity (High Plains) Aquifer by county. All values are reported in acre-feet per year.**

Year	Bailey	Borden	Cochran	Dawson	Floyd	Gaines	Garza	Hale
1930	0	0	0	0	0	0	0	0
1931	0	0	0	14	0	84	0	0
1932	0	0	0	27	0	168	0	0
1933	0	0	0	41	0	251	0	0
1934	0	0	0	54	0	335	0	0
1935	0	0	0	68	0	419	0	0
1936	0	0	0	81	0	503	0	0
1937	0	0	0	95	0	587	0	0
1938	0	0	0	108	0	671	0	0
1939	0	0	0	122	0	754	0	0
1940	5	0.1	4	135	43	838	0.4	151
1941	11	0.2	9	149	86	922	1	303
1942	17	0.4	13	162	130	1,006	1	454
1943	23	0.5	17	266	173	1,646	1	605
1944	30	1	22	369	216	2,286	2	757
1945	38	1	27	473	259	2,926	2	908
1946	45	1	31	576	302	3,566	3	1,060
1947	52	1	36	679	346	4,206	3	1,211
1948	60	1	41	839	389	5,194	3	1,362
1949	69	1	46	998	432	6,182	4	1,514
1950	78	1	51	1,158	475	7,169	4	1,665
1951	87	1	56	1,318	518	8,157	4	1,816
1952	96	2	62	1,477	562	9,144	5	1,968
1953	105	2	67	1,361	605	7,477	5	2,119
1954	112	2	72	1,367	648	8,016	5	2,271
1955	120	2	76	625	691	3,794	6	2,422
1956	127	2	81	1,649	734	10,557	6	2,573
1957	135	2	86	1,603	778	7,666	7	2,725
1958	143	2	91	1,557	821	4,775	7	2,876
1959	151	2	95	1,664	864	5,457	7	3,027
1960	159	3	99	1,772	907	6,140	8	3,179
1961	174	3	106	1,880	950	6,822	8	3,330
1962	183	3	110	1,988	994	7,505	8	3,482
1963	191	3	114	2,095	1,037	8,187	9	3,633
1964	199	3	119	2,203	1,080	8,870	9	3,784
1965	196	3	121	1,888	1,123	8,010	10	3,936
1966	199	3	125	1,572	1,166	7,150	10	4,087
1967	195	3	127	1,256	1,210	6,290	10	4,238
1968	191	4	129	940	1,253	5,430	11	4,390
1969	187	4	131	625	1,296	4,570	11	4,541
1970	201	4	136	592	1,339	5,590	11	4,693

Table C.1.3, cont.

Year	Bailey	Borden	Cochran	Dawson	Floyd	Gaines	Garza	Hale
1971	222	4	143	560	1,382	6,610	12	4,844
1972	237	4	148	528	1,426	7,630	12	4,995
1973	253	4	152	495	1,469	8,651	12	5,147
1974	268	4	157	463	1,512	9,671	13	5,298
1975	266	4	158	399	1,555	10,307	13	5,449
1976	271	5	160	335	1,598	10,943	14	5,601
1977	268	5	160	271	1,642	11,579	14	5,752
1978	265	5	161	207	1,685	12,215	14	5,904
1979	262	5	161	144	1,728	12,851	15	6,055
1980	264	5	347	340	1,883	13,536	15	6,271
1981	346	11	302	339	1,684	12,802	11	5,099
1982	429	17	258	338	1,485	12,068	8	3,926
1983	511	23	213	338	1,285	11,334	4	2,754
1984	594	29	169	337	1,086	10,600	0	1,581
1985	626	36	153	438	611	7,665	0	1,447
1986	531	61	152	226	519	993	0	1,108
1987	427	58	140	219	677	4,389	0	932
1988	369	58	117	310	706	6,574	0	836
1989	762	29	81	633	612	9,649	0	1,438
1990	851	28	68	634	801	10,190	0	1,499
1991	782	54	72	739	856	11,082	0	1,014
1992	746	54	96	647	939	11,177	0	907
1993	928	80	121	1,049	1,710	12,309	0	1,409
1994	99	4	19	1,175	1,518	12,355	0	3,150
1995	116	4	22	1,339	1,468	12,398	0	4,900
1996	111	3	21	1,499	1,385	12,473	0	6,641
1997	88	3	21	1,674	1,262	12,504	0	8,380
1998	117	3	14	1,819	1,422	12,506	0	10,120
1999	122	3	17	1,967	1,453	12,549	0	11,860
2000	0	6	11	2,000	0	12,664	191	13,508
2001	0	6	19	1,945	0	15,843	228	12,406
2002	0	6	3	1,838	0	14,342	310	14,170
2003	0	6	6	1,725	0	11,938	209	14,490
2004	0	6	6	1,399	0	12,559	208	13,010
2005	0	19	14	1,403	0	12,021	187	8,918
2006	0	16	54	1,735	0	11,772	183	10,236
2007	0	19	42	935	0	11,585	230	18,085
2008	0	14	19	1,873	0	15,105	142	19,507
2009	0	13	19	1,796	0	10,533	238	13,561
2010	0	15	16	1,087	0	9,779	118	8,085
2011	0	15	20	2,163	0	12,225	184	14,288
2012	0	15	20	2,163	0	12,225	184	14,288

Table C.1.3, cont.

Year	Hockley	Lamb	Lubbock	Lynn	Terry	Yoakum
1930	0	0	0	0	0	0
1931	0	0	0	0	0	0
1932	0	0	0	0	0	0
1933	0	0	0	0	0	0
1934	0	0	0	0	0	0
1935	0	0	0	0	0	0
1936	0	0	0	0	0	0
1937	0	0	0	0	0	0
1938	0	0	0	0	0	0
1939	0	0	0	0	0	0
1940	2	7	9	10	10	43
1941	4	15	18	19	20	85
1942	6	22	27	29	31	128
1943	8	29	36	39	41	171
1944	10	36	45	48	51	213
1945	12	44	53	58	61	256
1946	14	51	62	68	72	298
1947	16	58	71	78	82	341
1948	18	66	80	87	92	384
1949	20	73	89	97	102	426
1950	21	80	98	107	112	469
1951	23	88	107	116	123	512
1952	25	95	116	126	133	554
1953	27	102	125	136	143	597
1954	29	109	134	145	153	640
1955	31	117	143	155	164	682
1956	33	124	151	165	174	725
1957	35	131	160	174	184	768
1958	37	139	169	184	194	810
1959	39	146	178	194	205	853
1960	41	153	187	203	215	895
1961	43	161	196	213	225	938
1962	45	168	205	223	235	981
1963	47	175	214	233	245	1,023
1964	49	182	223	242	256	1,066
1965	51	190	232	252	266	1,109
1966	53	197	241	262	276	1,151
1967	55	204	249	271	286	1,194
1968	57	212	258	281	297	1,237
1969	59	219	267	291	307	1,279
1970	61	226	276	300	317	1,322

Table C.1.3, cont.

Year	Hockley	Lamb	Lubbock	Lynn	Terry	Yoakum
1971	62	234	285	310	327	1,364
1972	64	241	294	320	337	1,407
1973	66	248	303	329	348	1,450
1974	68	255	312	339	358	1,492
1975	70	263	321	349	368	1,535
1976	72	270	330	359	378	1,578
1977	74	277	339	368	389	1,620
1978	76	285	347	378	399	1,663
1979	78	292	356	388	409	1,706
1980	93	299	365	407	760	2,179
1981	74	224	274	386	735	1,696
1982	54	150	183	365	709	1,214
1983	35	75	91	344	684	731
1984	15	0	0	323	658	248
1985	16	0	0	236	773	185
1986	14	0	0	143	533	174
1987	14	0	0	96	435	168
1988	11	0	0	100	447	198
1989	12	0	0	121	1,165	359
1990	16	0	0	177	1,048	331
1991	18	0	0	165	1,015	378
1992	26	0	0	259	765	278
1993	27	0	0	176	1,204	291
1994	23	0	0	343	68	123
1995	23	0	0	511	72	163
1996	22	0	0	684	73	162
1997	20	0	0	851	74	169
1998	25	0	0	1,027	65	170
1999	23	0	0	1,192	51	165
2000	64	0	1,483	1,344	0	5
2001	60	0	1,388	1,296	0	5
2002	62	0	1,406	1,128	0	8
2003	53	0	1,218	1,031	0	8
2004	24	0	1,259	1,045	0	7
2005	36	0	691	730	0	9
2006	85	8	776	725	14	11
2007	62	6	1,386	1,262	13	5
2008	80	13	1,521	1,330	17	7
2009	77	13	1,123	1,057	16	6
2010	75	13	668	624	16	6
2011	56	0	1,000	1,162	0	6
2012	56	0	1,000	1,162	0	6

Table C.1.4 **Annual pumping for the Upper Dockum Aquifer by county. All values are reported in acre-feet per year.**

Year	Bailey	Castro	Dallam	Deaf Smith	Ector	Hale	Hartley	Lamb
1930	0	0	0	0	0	0	0	0
1931	54	0.1	3	0	1	0.05	2	2
1932	20	3	4	0.1	1	1	1	6
1933	16	4	5	2	2	1	1	7
1934	15	5	6	4	2	1	1	8
1935	17	5	7	4	3	1	1	9
1936	13	4	6	4	3	1	1	7
1937	17	6	8	6	4	1	2	9
1938	18	7	9	9	4	1	2	9
1939	19	7	10	17	6	1	2	10
1940	20	8	11	43	12	2	2	10
1941	20	8	12	65	21	2	2	10
1942	21	9	13	82	43	2	2	10
1943	21	9	13	104	59	2	3	10
1944	36	10	14	128	71	2	3	9
1945	55	10	15	147	80	2	3	9
1946	70	11	16	161	87	2	3	10
1947	78	11	17	166	90	2	3	9
1948	82	11	17	166	89	3	3	9
1949	82	11	17	161	87	3	3	10
1950	80	11	18	152	82	2	3	10
1951	75	11	18	142	76	3	3	10
1952	70	11	18	128	70	4	3	10
1953	63	10	18	121	62	4	3	10
1954	56	10	18	111	54	5	3	10
1955	40	10	17	94	45	5	3	10
1956	26	9	17	75	36	5	3	10
1957	15	9	17	60	29	6	3	10
1958	14	9	17	49	25	6	3	10
1959	20	9	17	41	21	6	3	10
1960	25	8	17	35	18	7	3	10
1961	30	8	16	31	16	7	3	10
1962	33	8	16	28	15	22	3	10
1963	36	8	16	26	14	32	3	9
1964	37	8	16	24	13	44	3	9
1965	35	7	16	23	12	53	3	9
1966	30	7	16	22	12	57	3	9
1967	26	7	16	21	11	58	3	9
1968	17	7	16	21	9	57	3	9
1969	13	7	16	19	9	56	3	8
1970	10	7	16	18	9	52	3	8

Table C.1.4, cont.

Year	Bailey	Castro	Dallam	Deaf Smith	Ector	Hale	Hartley	Lamb
1971	5	7	15	17	9	46	3	8
1972	4	6	15	16	9	39	3	8
1973	4	6	15	15	9	31	3	8
1974	4	6	15	15	9	25	3	8
1975	3	6	15	16	9	20	3	8
1976	3	6	15	17	9	17	3	8
1977	3	6	14	16	9	14	3	8
1978	3	5	14	14	8	12	3	7
1979	3	5	14	15	8	11	3	7
1980	3	5	14	13	9	9	3	7
1981	3	5	14	14	8	9	3	7
1982	4	4	14	17	8	8	3	7
1983	3	4	14	18	8	8	3	7
1984	3	4	14	19	8	7	3	6
1985	4	3	14	22	8	7	3	6
1986	4	3	14	21	8	7	3	6
1987	4	3	14	24	8	6	3	6
1988	4	3	14	27	8	6	3	6
1989	4	2	14	28	8	6	3	6
1990	4	2	14	34	9	6	3	6
1991	4	2	14	33	10	6	3	5
1992	5	1	14	33	9	6	3	5
1993	6	1	13	34	10	6	2	5
1994	6	1	13	35	12	6	2	5
1995	7	1	13	31	12	6	2	5
1996	7	0.3	13	32	14	6	2	5
1997	7	0	13	30	13	6	2	5
1998	7	0	13	33	13	6	2	4
1999	7	0	13	37	12	5	2	4
2000	7	0	13	41	11	5	2	4
2001	7	0	13	40	10	5	2	4
2002	7	0	12	31	10	5	2	4
2003	7	0	12	24	9	5	2	4
2004	7	0	12	22	8	5	2	4
2005	7	0	12	21	7	5	2	4
2006	7	0	12	30	5	5	2	4
2007	7	0	12	39	6	5	2	4
2008	8	0	17	61	6	5	2	5
2009	8	0	14	65	6	5	1	4
2010	8	0	15	68	6	5	2	4
2011	7	0	14	66	7	5	2	4
2012	7	0	23	56	7	5	2	4

Table C.1.4, cont.

Year	Lubbock	Martin	Oldham	Randall	Swisher	Winkler	Yoakum
1930	0	0	0	0	0	0	0
1931	0.2	0.1	0	4	0.01	5	7
1932	1	2	0.1	59	1	4	4
1933	1	2	0.4	101	1	0	5
1934	1	3	1	144	2	0	5
1935	1	3	1	164	2	0	5
1936	1	3	1	150	2	0	4
1937	1	4	1	175	2	0	6
1938	1	4	1	196	2	0	6
1939	1	5	1	213	3	0	6
1940	2	5	1	224	3	0	6
1941	2	6	1	232	3	0	7
1942	2	6	1	240	3	0	7
1943	2	7	2	245	4	0	7
1944	2	7	2	249	4	0	8
1945	2	8	2	252	4	0	8
1946	2	8	2	255	4	0	8
1947	2	9	2	251	4	0	8
1948	2	9	2	241	4	0	8
1949	2	9	2	228	4	0	8
1950	2	9	2	212	4	0	8
1951	2	9	2	194	4	0	7
1952	2	9	2	174	4	0	7
1953	2	9	2	153	4	0	7
1954	2	9	2	132	4	0	6
1955	2	9	2	109	4	0	6
1956	2	9	2	86	3	0	6
1957	2	9	2	69	3	0	6
1958	2	9	2	56	3	0	6
1959	2	9	2	47	3	0	6
1960	2	9	2	40	3	0	6
1961	2	9	2	34	3	0	5
1962	2	9	2	31	3	0	6
1963	2	9	2	28	3	0	6
1964	2	8	2	26	2	0	5
1965	2	8	2	24	2	0	5
1966	2	8	2	23	2	0	5
1967	2	8	2	22	2	0	5
1968	2	8	2	21	2	0	5
1969	2	8	2	21	2	0	5
1970	2	8	2	20	2	0	5

Table C.1.4, cont.

Year	Lubbock	Martin	Oldham	Randall	Swisher	Winkler	Yoakum
1971	2	8	2	20	2	0	5
1972	2	8	2	20	1	0	5
1973	2	8	2	20	1	0	5
1974	1	8	2	20	1	0	5
1975	1	8	2	19	1	0	5
1976	1	8	2	19	1	0	4
1977	1	8	2	19	1	0	4
1978	1	8	2	19	1	0	4
1979	1	8	2	19	1	0	3
1980	1	8	2	19	1	0	2
1981	1	8	2	19	1	0	1
1982	1	8	2	21	1	0	5
1983	1	7	2	23	1	0	7
1984	1	7	2	25	1	0	9
1985	1	7	2	28	1	0	12
1986	1	6	2	28	1	0	12
1987	1	6	2	28	1	0	13
1988	1	6	2	28	1	0	13
1989	0.5	5	2	26	1	0	15
1990	0.4	5	2	24	1	0	16
1991	0.3	5	2	22	1	0	18
1992	0.5	5	2	17	1	0	14
1993	0.5	4	2	13	1	0	13
1994	0.3	4	2	10	1	0	12
1995	0.3	4	2	9	1	0	10
1996	0.3	4	2	12	1	0	10
1997	0.3	4	2	15	1	0	10
1998	0.3	4	2	16	1	0	10
1999	0.4	4	2	18	5	0	9
2000	0.4	4	2	23	12	0	9
2001	0.4	4	2	27	13	0	9
2002	0.3	4	2	30	14	0	9
2003	0.4	4	2	33	17	0	9
2004	1	4	2	32	21	0	9
2005	0.5	4	2	30	25	0	9
2006	0.5	4	2	25	28	0	9
2007	1	4	2	22	28	0	9
2008	1	6	2	17	60	0	9
2009	0.4	5	2	17	49	0	9
2010	0.4	5	1	18	37	0	9
2011	0.4	6	1	19	27	0	9
2012	0.4	6	1	22	21	0	9

Table C.1.5 Annual pumping for the Lower Dockum Aquifer by county. All values are reported in acre-feet per year.

Year	Andrews	Armstrong	Borden	Briscoe	Carson	Crane	Crockett	Crosby
1930	0	0	0	0	0	0	0	0
1931	0.01	1	1	0.1	3	0.3	0.02	28
1932	0.02	2	1	0.2	5	1	0.05	55
1933	0.02	2	2	0.4	8	1	0.1	83
1934	0.03	3	2	0.5	11	1	0.1	111
1935	0.04	4	3	1	13	2	0.1	138
1936	0.05	5	3	1	16	2	0.1	166
1937	0.1	6	4	1	19	2	0.2	194
1938	0.1	6	4	1	22	3	0.2	221
1939	0.1	7	5	1	24	3	0.2	249
1940	0.1	8	5	1	27	3	0.2	277
1941	0.1	9	6	1	30	4	0.3	304
1942	0.1	10	6	1	32	4	0.3	332
1943	0.1	10	7	2	35	4	0.3	360
1944	0.1	11	7	2	38	5	0.3	387
1945	0.1	12	8	2	40	5	0.3	415
1946	0.1	13	8	2	43	5	0.4	443
1947	0.1	14	9	2	46	6	0.4	471
1948	0.1	14	9	2	48	6	0.4	498
1949	0.1	15	10	2	51	6	0.4	526
1950	0.2	16	10	2	54	6	0.5	554
1951	0.2	17	11	3	59	7	1	606
1952	0.2	19	12	3	64	8	1	658
1953	0.2	20	13	3	69	8	1	710
1954	0.2	22	14	3	74	9	1	763
1955	0.2	23	15	4	79	10	1	815
1956	0.2	25	16	4	84	10	1	867
1957	0.3	26	17	4	89	11	1	920
1958	0.3	28	18	4	95	11	1	972
1959	0.3	29	19	5	100	12	1	1,024
1960	0.3	31	20	5	105	13	1	1,077
1961	0.4	37	23	6	124	15	1	1,270
1962	0.4	42	27	7	142	17	1	1,464
1963	0.5	48	30	7	161	19	1	1,658
1964	1	53	34	8	180	22	2	1,852
1965	1	59	37	9	199	24	2	2,046
1966	1	64	41	10	218	26	2	2,239
1967	1	70	44	11	237	29	2	2,433
1968	1	76	48	12	255	31	2	2,627
1969	1	81	51	13	274	33	2	2,821
1970	1	87	55	13	293	35	3	3,014

Table C.1.5, cont.

Year	Andrews	Armstrong	Borden	Briscoe	Carson	Crane	Crockett	Crosby
1971	1	91	57	14	308	37	3	3,162
1972	1	95	60	15	322	39	3	3,309
1973	1	100	63	15	336	41	3	3,457
1974	1	104	65	16	351	42	3	3,604
1975	1	108	68	17	365	44	3	3,751
1976	1	108	68	17	364	44	3	3,741
1977	1	107	68	17	363	44	3	3,730
1978	1	107	68	17	362	44	3	3,720
1979	1	107	67	17	361	44	3	3,709
1980	1	103	65	16	348	42	3	3,578
1981	2	94	64	15	311	44	3	3,118
1982	4	85	62	14	274	47	3	2,658
1983	5	75	61	14	236	49	3	2,199
1984	7	66	59	13	199	52	3	1,739
1985	8	57	58	12	162	54	3	1,279
1986	8	65	58	12	186	54	3	1,565
1987	7	73	58	12	209	53	3	1,852
1988	7	80	58	13	233	53	3	2,138
1989	6	88	58	13	256	52	3	2,425
1990	6	96	58	13	280	52	3	2,711
1991	7	93	58	12	258	133	3	2,858
1992	8	90	57	11	237	215	3	3,005
1993	8	88	57	10	215	296	3	3,151
1994	9	85	56	9	194	378	3	3,298
1995	10	82	56	8	172	459	3	3,445
1996	10	81	56	7	146	250	3	3,499
1997	10	80	56	6	121	41	3	3,554
1998	10	80	56	6	121	41	3	3,554
1999	10	80	56	6	121	41	3	3,554
2000	4	182	62	68	121	515	5	2,469
2001	4	151	62	67	121	558	5	3,439
2002	3	177	62	70	121	696	4	3,245
2003	2	188	62	84	121	519	4	3,229
2004	2	184	62	80	121	518	4	3,007
2005	4	192	75	81	121	518	5	1,635
2006	5	205	72	71	121	474	5	1,957
2007	6	153	75	68	121	475	5	3,355
2008	4	168	70	97	128	684	5	3,677
2009	5	160	69	107	133	93	5	2,790
2010	4	138	71	80	138	103	4	1,737
2011	4	172	71	76	138	158	4	2,908
2012	4	172	71	76	138	158	4	2,908

Table C.1.5, cont.

Year	Curry	Dallam	Dawson	Deaf Smith	Dickens	Ector	Eddy	Fisher
1930	0	0	0	0	0	0	0	0
1931	4	13	0.01	24	0.2	1	0.02	0.1
1932	8	27	0.02	48	0.3	2	0.05	0.2
1933	12	40	0.02	72	1	2	0.1	0.3
1934	16	54	0.03	96	0.4	3	0.1	0.3
1935	19	67	0.04	120	1	4	0.1	0.4
1936	23	81	0.05	144	1	5	0.1	1
1937	27	94	0.1	168	1	5	0.2	1
1938	31	108	0.1	192	1	6	0.2	1
1939	35	121	0.1	216	2	7	0.2	1
1940	39	135	0.1	240	2	8	0.2	1
1941	43	148	0.1	264	2	8	0.3	1
1942	47	162	0.1	288	2	9	0.3	1
1943	50	175	0.1	312	2	10	0.3	1
1944	54	189	0.1	336	2	11	0.3	1
1945	58	202	0.1	360	3	11	0.3	1
1946	62	216	0.1	384	3	12	0.4	1
1947	66	229	0.1	408	3	13	0.4	1
1948	70	243	0.1	431	3	14	0.4	2
1949	74	256	0.1	455	3	14	0.4	2
1950	78	270	0.2	479	3	15	0.5	2
1951	85	295	0.2	525	4	17	1	2
1952	92	321	0.2	570	4	18	1	2
1953	99	346	0.2	615	4	19	1	2
1954	107	372	0.2	661	5	21	1	2
1955	114	397	0.2	706	5	22	1	3
1956	121	423	0.2	751	5	24	1	3
1957	129	448	0.3	797	6	25	1	3
1958	136	474	0.3	842	6	27	1	3
1959	143	499	0.3	887	6	28	1	3
1960	151	525	0.3	933	7	29	1	3
1961	178	619	0.4	1,100	8	35	1	4
1962	205	713	0.4	1,268	9	40	1	5
1963	232	808	0.5	1,436	10	45	1	5
1964	259	902	1	1,604	11	51	2	6
1965	286	996	1	1,772	13	56	2	6
1966	314	1,091	1	1,940	14	61	2	7
1967	341	1,185	1	2,107	15	67	2	7
1968	368	1,280	1	2,275	16	72	2	14
1969	395	1,374	1	2,443	17	77	2	15
1970	422	1,468	1	2,611	19	83	3	16

Table C.1.5, cont.

Year	Curry	Dallam	Dawson	Deaf Smith	Dickens	Ector	Eddy	Fisher
1971	443	1,540	1	2,739	19	87	3	16
1972	463	1,612	1	2,866	20	91	3	16
1973	484	1,684	1	2,994	21	95	3	17
1974	505	1,756	1	3,122	22	99	3	17
1975	525	1,827	1	3,249	23	103	3	18
1976	524	1,822	1	3,240	23	102	3	18
1977	522	1,817	1	3,231	23	102	3	18
1978	521	1,812	1	3,222	23	102	3	18
1979	519	1,807	1	3,213	23	102	3	17
1980	501	1,743	1	3,099	22	98	3	17
1981	478	1,702	1	3,007	21	97	3	18
1982	455	1,660	1	2,914	21	96	3	18
1983	432	1,619	1	2,822	20	95	4	19
1984	409	1,577	1	2,729	20	94	4	19
1985	386	1,536	1	2,637	19	93	4	20
1986	439	1,622	1	2,687	18	87	7	20
1987	493	1,708	1	2,737	17	81	9	21
1988	546	1,794	2	2,786	17	74	12	21
1989	600	1,880	2	2,836	16	68	14	21
1990	653	1,966	2	2,886	15	62	17	22
1991	627	2,041	2	2,876	14	55	19	21
1992	601	2,117	2	2,866	13	48	22	20
1993	576	2,192	1	2,856	13	40	24	16
1994	550	2,268	1	2,846	12	33	27	13
1995	524	2,343	1	2,836	11	26	29	13
1996	516	2,550	1	2,916	12	26	40	12
1997	508	2,757	2	2,997	13	26	51	10
1998	508	2,757	2	2,997	13	26	51	10
1999	508	2,757	2	2,997	13	26	51	10
2000	508	2,757	2	3,092	56	961	51	9
2001	508	2,757	2	3,021	49	36	51	9
2002	508	2,757	2	3,019	53	373	51	9
2003	508	2,757	2	2,998	54	334	51	9
2004	508	2,757	2	3,015	51	466	51	9
2005	508	2,757	2	3,023	100	668	51	36
2006	508	2,757	2	3,063	126	743	51	38
2007	508	2,757	2	3,041	119	578	51	33
2008	508	2,757	2	3,019	113	587	51	42
2009	508	2,757	2	3,021	116	542	51	39
2010	508	2,757	2	1,914	108	580	51	49
2011	508	2,757	2	2,423	116	492	51	53
2012	508	2,757	2	2,423	116	492	51	53

Table C.1.5, cont.

Year	Floyd	Garza	Hale	Hartley	Hockley	Howard	Kent	Lea
1930	0	0	0	0	0	0	0	0
1931	13	1	2	11	0	0.2	0.02	22
1932	25	1	4	22	0	0.4	0.05	45
1933	38	2	6	32	0	1	0.1	67
1934	50	2	8	43	0	1	0.1	90
1935	63	3	9	54	0	1	0.1	112
1936	76	4	11	65	0	1	0.1	135
1937	88	4	13	76	0	2	0.2	157
1938	101	5	15	87	0	2	0.2	180
1939	113	5	17	97	0	2	0.2	202
1940	126	6	19	108	0	2	0.2	224
1941	139	7	21	119	0	2	0.3	247
1942	151	7	23	130	0	3	0.3	269
1943	164	8	24	141	0	3	0.3	292
1944	176	9	26	152	0	3	0.3	314
1945	189	9	28	162	0	3	0.3	337
1946	201	10	30	173	0	3	0.4	359
1947	214	10	32	184	0	4	0.4	382
1948	227	11	34	195	0	4	0.4	404
1949	239	12	36	206	0	4	0.4	427
1950	252	12	38	216	0	4	0.5	449
1951	276	13	41	237	0	5	1	491
1952	299	15	45	257	0	5	1	534
1953	323	16	48	278	0	6	1	576
1954	347	17	52	298	0	6	1	619
1955	371	18	55	319	0	6	1	661
1956	395	19	59	339	0	7	1	704
1957	418	20	62	360	0	7	1	746
1958	442	21	66	380	0	8	1	788
1959	466	23	70	401	0	8	1	831
1960	490	24	73	421	0	8	1	873
1961	578	28	86	497	0	10	1	1,030
1962	666	32	99	573	0	11	1	1,188
1963	754	37	113	648	0	13	1	1,345
1964	843	41	126	724	0	14	2	1,502
1965	931	45	139	800	0	16	2	1,659
1966	1,019	49	152	876	0	18	2	1,816
1967	1,107	54	165	951	0	19	2	1,973
1968	1,195	58	178	1,027	0	21	2	2,131
1969	1,283	62	192	1,103	0	22	2	2,288
1970	1,372	67	205	1,179	0	24	3	2,445

Table C.1.5, cont.

Year	Floyd	Garza	Hale	Hartley	Hockley	Howard	Kent	Lea
1971	1,439	70	215	1,236	0	25	3	2,564
1972	1,506	73	225	1,294	0	26	3	2,684
1973	1,573	76	235	1,352	0	27	3	2,804
1974	1,640	80	245	1,409	0	28	3	2,923
1975	1,707	83	255	1,467	0	29	3	3,043
1976	1,702	83	254	1,463	0	29	3	3,034
1977	1,697	82	253	1,459	0	29	3	3,026
1978	1,693	82	253	1,454	0	29	3	3,017
1979	1,688	82	252	1,450	0	29	3	3,009
1980	1,628	79	243	1,399	0	28	3	2,902
1981	1,406	72	225	1,449	0	31	3	2,887
1982	1,183	66	207	1,499	0	34	3	2,871
1983	961	59	188	1,549	0	37	3	2,856
1984	738	53	170	1,599	0	40	3	2,840
1985	516	46	152	1,649	0	43	3	2,825
1986	553	49	152	1,528	0	46	3	2,733
1987	590	51	152	1,406	0	49	3	2,640
1988	627	54	152	1,285	0	51	3	2,548
1989	664	56	152	1,163	0	54	3	2,455
1990	701	59	152	1,042	0	57	3	2,363
1991	818	63	149	1,140	0	52	3	2,415
1992	935	67	147	1,238	0	47	3	2,467
1993	1,051	72	144	1,335	0	43	3	2,518
1994	1,168	76	142	1,433	0	38	3	2,570
1995	1,285	80	139	1,531	0	33	3	2,622
1996	1,185	88	135	1,615	0	47	3	2,798
1997	1,084	96	130	1,700	0	61	2	2,975
1998	1,084	96	130	1,700	0	61	2	2,975
1999	1,084	96	130	1,700	0	61	2	2,975
2000	3,538	218	130	1,132	32	357	5	2,975
2001	2,579	254	130	1,132	30	251	5	2,975
2002	2,784	335	130	1,145	31	235	4	2,975
2003	2,841	231	130	1,197	27	182	4	2,975
2004	2,564	231	130	1,242	12	209	4	2,975
2005	1,996	218	130	1,469	18	215	18	2,975
2006	2,423	217	130	1,898	36	311	23	2,975
2007	2,653	266	130	1,540	25	524	16	2,975
2008	2,955	225	130	1,679	27	399	21	2,975
2009	2,741	324	130	1,639	26	535	21	2,975
2010	1,545	205	130	1,543	24	541	19	2,975
2011	2,451	271	130	1,775	28	779	19	2,975
2012	2,451	271	130	1,775	28	779	19	2,975

Table C.1.5, cont.

Year	Loving	Lubbock	Mitchell	Moore	Motley	Nolan	Oldham	Pecos
1930	0	0	0	0	0	0	0	0
1931	0.1	0.02	26	33	1	6	4	7
1932	0.1	0.03	53	67	1	13	7	15
1933	0.2	0.05	79	100	2	19	11	22
1934	0.2	0.1	106	134	2	25	14	30
1935	0.3	0.1	132	167	3	32	18	37
1936	0.4	0.1	159	200	3	38	21	44
1937	0.4	0.1	185	234	4	44	25	52
1938	0.5	0.1	212	267	5	51	28	59
1939	1	0.1	238	300	5	57	32	66
1940	1	0.2	265	334	6	63	35	74
1941	1	0.2	291	367	6	70	39	81
1942	1	0.2	318	401	7	76	43	89
1943	1	0.2	344	434	7	82	46	96
1944	1	0.2	371	467	8	89	50	103
1945	1	0.2	397	501	9	95	53	111
1946	1	0.2	424	534	9	101	57	118
1947	1	0.3	450	567	10	108	60	126
1948	1	0.3	477	601	10	114	64	133
1949	1	0.3	503	634	11	121	67	140
1950	1	0.3	530	668	11	127	71	148
1951	1	0.3	580	731	13	139	78	162
1952	1	0.4	630	794	14	151	84	176
1953	2	0.4	680	857	15	163	91	190
1954	2	0.4	730	920	16	175	98	204
1955	2	0.5	780	983	17	187	104	186
1956	2	0.5	830	1,046	18	199	111	205
1957	2	1	880	1,109	19	211	118	226
1958	2	1	930	1,172	20	223	124	246
1959	2	1	980	1,235	21	235	131	265
1960	2	1	1,030	1,298	22	247	138	285
1961	3	1	1,215	1,532	26	291	163	339
1962	3	1	1,401	1,766	30	336	187	391
1963	4	1	1,586	2,000	34	380	212	443
1964	4	1	1,772	2,233	38	424	237	494
1965	5	1	1,957	2,467	42	469	262	546
1966	5	1	2,142	2,701	46	513	287	598
1967	5	1	2,328	2,934	50	558	311	649
1968	6	1	2,513	3,168	54	602	336	701
1969	6	2	2,698	3,402	58	646	361	753
1970	7	2	2,884	3,635	62	691	386	805

Table C.1.5, cont.

Year	Loving	Lubbock	Mitchell	Moore	Motley	Nolan	Oldham	Pecos
1971	7	2	3,025	3,813	65	725	405	844
1972	7	2	3,166	3,991	68	758	424	883
1973	8	2	3,307	4,169	71	792	442	923
1974	8	2	3,448	4,346	75	826	461	962
1975	8	2	3,589	4,524	78	860	480	1,001
1976	8	2	3,579	4,511	77	857	479	998
1977	8	2	3,569	4,499	77	855	478	996
1978	8	2	3,559	4,486	77	853	476	993
1979	8	2	3,549	4,473	77	850	475	990
1980	8	2	3,423	4,315	74	820	458	955
1981	7	2	3,667	4,263	71	832	450	927
1982	6	2	3,911	4,212	69	844	441	899
1983	5	2	4,155	4,160	66	857	433	872
1984	4	2	4,399	4,109	64	869	424	844
1985	3	2	4,643	4,057	61	881	416	816
1986	4	2	4,073	4,361	64	864	395	780
1987	4	2	3,502	4,665	67	847	375	744
1988	5	3	2,932	4,968	71	830	354	708
1989	5	3	2,361	5,272	74	813	334	672
1990	6	3	1,791	5,576	77	796	313	636
1991	6	3	1,571	5,430	82	775	331	674
1992	7	4	1,351	5,284	86	754	348	712
1993	7	4	1,131	5,137	91	732	366	749
1994	8	5	911	4,991	95	711	383	787
1995	8	5	691	4,845	100	690	401	825
1996	7	4	963	4,942	72	706	591	801
1997	7	3	1,235	5,040	44	721	781	777
1998	7	3	1,235	5,040	44	721	781	777
1999	7	3	1,235	5,040	44	721	781	777
2000	19	3	6,478	2,012	656	5,058	699	777
2001	19	3	4,736	1,778	283	2,994	701	777
2002	17	3	5,518	2,212	657	3,018	916	777
2003	17	3	6,766	2,016	730	3,481	771	777
2004	17	3	7,404	2,021	710	4,430	760	777
2005	47	3	7,778	2,008	658	5,703	1,242	777
2006	54	3	9,070	1,254	721	5,413	1,571	777
2007	34	3	10,506	1,728	673	5,957	1,244	777
2008	22	3	9,524	1,297	875	10,328	919	777
2009	24	3	12,967	1,362	803	11,438	862	777
2010	18	3	10,947	1,129	483	8,306	899	777
2011	19	3	11,470	1,852	854	12,402	1,129	777
2012	19	3	11,470	1,852	854	12,402	1,129	777

Table C.1.5, cont.

Year	Potter	Quay	Randall	Reagan	Reeves	Roosevelt	Scurry	Sherman
1930	0	0	0	0	0	0	0	0
1931	6	39	8	6	13	2	69	4
1932	11	78	17	12	27	4	138	9
1933	17	117	25	18	40	6	207	13
1934	22	156	33	24	53	8	276	17
1935	28	195	42	30	67	10	345	22
1936	33	234	50	36	80	12	414	26
1937	39	273	58	42	93	14	483	30
1938	44	313	67	48	107	16	552	35
1939	50	352	75	54	120	18	621	39
1940	55	391	83	60	133	20	690	43
1941	61	430	91	66	147	23	759	48
1942	67	469	100	72	160	25	828	52
1943	72	508	108	78	173	27	897	57
1944	78	547	116	84	187	29	966	61
1945	83	586	125	90	200	31	1,035	65
1946	89	625	133	96	213	33	1,104	70
1947	94	664	141	102	227	35	1,173	74
1948	100	703	150	108	240	37	1,242	78
1949	105	742	158	114	254	39	1,311	83
1950	111	781	166	121	267	41	1,380	87
1951	121	855	182	132	292	45	1,510	95
1952	132	929	198	143	317	49	1,640	103
1953	142	1,003	213	155	343	53	1,771	112
1954	153	1,077	229	166	368	56	1,901	120
1955	163	1,150	245	177	393	60	2,031	128
1956	174	1,224	261	189	418	64	2,162	136
1957	184	1,298	276	200	443	68	2,292	144
1958	195	1,372	292	212	469	72	2,423	153
1959	205	1,446	308	223	494	76	2,553	161
1960	216	1,520	323	234	519	80	2,683	169
1961	255	1,793	382	277	613	94	3,166	200
1962	293	2,067	440	319	706	108	3,649	230
1963	332	2,340	498	361	799	123	4,132	260
1964	371	2,614	556	403	893	137	4,615	291
1965	410	2,887	615	445	986	152	5,098	321
1966	449	3,161	673	488	1,080	166	5,581	352
1967	488	3,434	731	530	1,173	180	6,064	382
1968	526	3,708	789	572	1,266	195	6,547	413
1969	565	3,981	847	614	1,360	209	7,029	443
1970	604	4,255	906	656	1,453	223	7,512	473

Table C.1.5, cont.

Year	Potter	Quay	Randall	Reagan	Reeves	Roosevelt	Scurry	Sherman
1971	634	4,463	950	688	1,524	234	7,880	497
1972	663	4,671	994	720	1,595	245	8,247	520
1973	693	4,879	1,039	753	1,666	256	8,614	543
1974	722	5,087	1,083	785	1,738	267	8,982	566
1975	752	5,295	1,127	817	1,809	278	9,349	589
1976	750	5,280	1,124	814	1,804	277	9,323	588
1977	748	5,265	1,121	812	1,798	276	9,297	586
1978	745	5,250	1,118	810	1,793	276	9,271	584
1979	743	5,235	1,114	808	1,788	275	9,244	583
1980	717	5,050	1,075	779	1,725	265	8,917	562
1981	687	4,625	1,058	825	1,674	277	7,752	537
1982	656	4,200	1,041	871	1,623	290	6,587	513
1983	626	3,776	1,024	917	1,572	302	5,422	488
1984	595	3,351	1,007	963	1,521	315	4,255	464
1985	565	2,926	990	1,009	1,470	327	3,087	439
1986	544	3,104	968	1,139	1,386	332	2,749	440
1987	524	3,283	946	1,268	1,302	337	2,405	440
1988	503	3,461	925	1,398	1,218	343	2,054	441
1989	483	3,640	903	1,527	1,134	348	1,715	441
1990	462	3,818	881	1,657	1,050	353	1,374	442
1991	501	4,191	907	1,706	1,074	331	1,318	451
1992	540	4,564	933	1,756	1,099	310	1,262	460
1993	578	4,938	958	1,805	1,123	288	1,206	469
1994	617	5,311	984	1,855	1,148	267	1,149	478
1995	656	5,684	1,010	1,904	1,172	245	1,091	487
1996	713	4,840	982	1,984	1,195	245	1,074	486
1997	770	3,997	954	2,064	1,217	245	1,210	485
1998	770	3,997	954	2,064	1,217	245	1,210	485
1999	770	3,997	954	2,064	1,217	245	1,210	485
2000	449	3,997	1,087	61	1,218	245	3,214	485
2001	495	3,997	1,263	45	1,215	245	2,606	485
2002	602	3,997	1,293	57	1,215	245	3,585	485
2003	490	3,997	1,376	38	1,209	245	2,977	485
2004	484	3,997	1,284	40	1,212	245	3,486	485
2005	510	3,997	1,364	47	1,215	245	4,296	485
2006	1,477	3,997	1,843	72	1,219	245	6,553	485
2007	1,530	3,997	1,638	65	1,210	245	5,414	485
2008	1,354	3,997	1,680	75	1,209	245	5,016	485
2009	1,444	3,997	1,713	65	1,213	245	8,642	485
2010	1,462	3,997	3,755	75	1,203	245	7,064	485
2011	1,500	3,997	2,607	101	1,204	245	7,803	485
2012	1,500	3,997	2,607	101	1,204	245	7,803	485

Table C.1.5, cont.

Year	Sterling	Swisher	Upton	Ward	Winkler
1930	0	0	0	0	0
1931	0.2	2	2	1	22
1932	0.3	3	4	2	44
1933	0.5	5	6	3	66
1934	1	7	8	4	88
1935	1	8	10	4	110
1936	1	10	12	5	131
1937	1	12	14	6	153
1938	1	14	16	7	175
1939	1	15	18	8	197
1940	2	17	19	9	219
1941	2	19	21	10	241
1942	2	20	23	11	263
1943	2	22	25	11	285
1944	2	24	27	12	307
1945	2	25	29	13	329
1946	2	27	31	14	351
1947	3	29	33	15	373
1948	3	30	35	16	394
1949	3	32	37	17	416
1950	3	34	39	18	438
1951	3	37	43	19	480
1952	4	40	46	21	521
1953	4	43	50	23	563
1954	4	47	54	24	604
1955	5	50	57	26	645
1956	5	53	61	28	687
1957	5	56	65	29	728
1958	5	59	68	31	770
1959	6	63	72	33	811
1960	6	66	76	34	853
1961	7	78	89	40	1,006
1962	8	90	103	47	1,159
1963	9	101	117	53	1,313
1964	10	113	130	59	1,466
1965	11	125	144	65	1,620
1966	13	137	158	71	1,773
1967	14	149	171	78	1,926
1968	15	161	185	84	2,080
1969	16	173	199	90	2,233
1970	17	185	212	96	2,387

Table C.1.5, cont.

Year	Sterling	Swisher	Upton	Ward	Winkler
1971	18	194	223	101	2,503
1972	18	203	233	105	2,620
1973	19	212	243	110	2,737
1974	20	221	254	115	2,854
1975	21	230	264	120	2,970
1976	21	229	263	119	2,962
1977	21	228	263	119	2,954
1978	21	228	262	119	2,945
1979	21	227	261	118	2,937
1980	20	219	252	114	2,833
1981	20	205	236	114	2,938
1982	20	192	220	114	3,043
1983	20	178	205	113	3,149
1984	20	165	189	113	3,254
1985	20	151	173	113	3,359
1986	19	149	181	106	3,151
1987	18	148	189	100	2,943
1988	16	146	197	93	2,735
1989	15	145	205	87	2,527
1990	14	143	213	80	2,319
1991	13	154	224	79	2,321
1992	13	165	236	79	2,323
1993	12	175	247	78	2,326
1994	12	186	259	78	2,328
1995	11	197	270	77	2,330
1996	11	179	245	75	2,191
1997	11	162	220	74	2,052
1998	11	162	220	74	2,052
1999	11	162	220	74	2,052
2000	19	443	155	110	2,197
2001	22	434	119	87	2,169
2002	20	409	114	79	1,808
2003	17	437	110	80	1,945
2004	17	435	104	82	1,975
2005	18	427	107	82	1,857
2006	19	381	112	79	1,975
2007	19	588	103	89	1,811
2008	19	636	120	102	1,936
2009	19	620	113	108	1,959
2010	18	861	209	125	1,663
2011	18	1,177	278	116	2,057
2012	18	1,177	278	116	2,057

APPENDIX D

Comments and Responses
for
Review of "Draft Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model" Report and Deliverables for TWDB Contract No. 1248301494 Dated August 31, 2015
and
Review of "Predictive Simulations using Updated Draft Groundwater Availability Numerical Model for the High Plains Aquifer System" Memo and Model Files Received July 13, 2015 for TWDB Contract No. 1248301494 Dated August 31, 2015

This page intentionally left blank.

Appendix D

Comments and Responses
for
Review of “Draft Numerical Model Report for the High Plains Aquifer System Groundwater Availability Model” Report and deliverables for TWDB Contract No. 1248301494
Dated August 31, 2015

Attachment 1

The following report and model review comments shall be addressed and included in the final deliverables due August 31, 2015. Section 2.1 is a very clear and understandable explanation of packages. The figures and table are very helpful. Please note the items listed under suggestions are editorial in context and are not contractually required; however, adjustments noted may improve the readability of the report.

Draft Numerical Model Comments:

1. Some of the storage coefficient values for the Edwards-Trinity (Plateau) and Pecos Valley Alluvium portions of the model are very high (up to 0.782 [specific storage of 0.0024 per foot], Figures below). Please provide a figure in the report and provide discussion of storage properties for all active areas of layer 2, not just Rita Blanca and Edwards-Trinity (High Plains) aquifers. Please verify and discuss why these values are high in the text of the report.

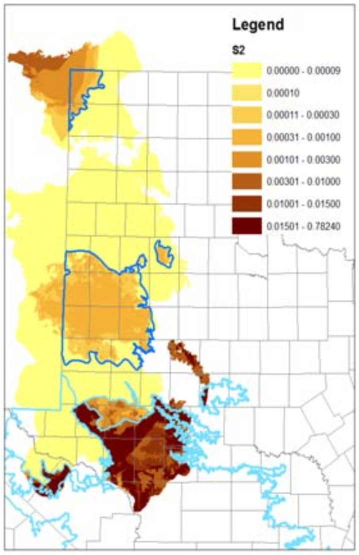


Figure 2. Storage Coefficients for Layer 2 of the draft High Plains Aquifer System model. Note maximum value of 0.7824 in the Edwards-Trinity (Plateau) Aquifer portion.

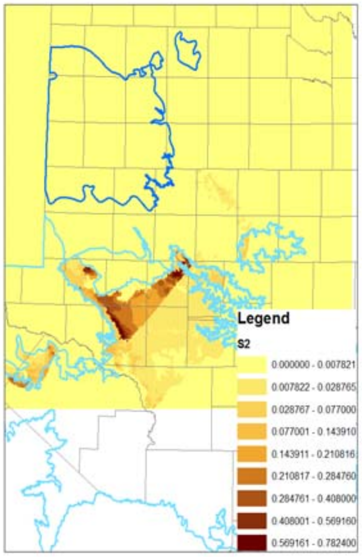


Figure 2. Storage Coefficients for Layer 2 of the draft High Plains Aquifer System model (zoomed into the Edwards-Trinity (Plateau) Aquifer area). Note values greater than 0.5 in Edwards-Trinity (Plateau) Aquifer portion.

The Edwards-Trinity (Plateau) and Pecos Valley aquifer storage properties were taken directly from the updated Edwards-Trinity (Plateau) and Pecos Valley aquifer groundwater availability model (Hutchinson and others, 2011) Because head boundaries (River package) exist in every cell of the model that represents these aquifers, and these aquifers are not part of the High Plains Aquifer System (nor should the model be used so simulate them), we are do not put a high priority on parameterization of their storage parameters. In response to your comment, we did clip the storage coefficients in the Edwards-Trinity (Plateau) portion, so that the upper limit was 0.074. This value is based on the values reported in Ashworth (1983) and referenced in Anaya and Jones (2009). Because the portion of the Pecos Valley Alluvium represented in the model is strictly unconfined, only the specific yield is relevant. Figure 3.1.10 shows the modified storativity of the Edwards-Trinity (Plateau).

2. The calibrated horizontal hydraulic conductivities of the upper and lower Dockum (Figures 3.1.13 and 3.1.14) are at least an order of magnitude lower than the calibrated horizontal hydraulic conductivities of the original groundwater availability model for the Dockum Aquifer and the hydraulic conductivity data presented in the conceptual model for the Dockum Aquifer (Figures 4.6.5 and 4.6.11 from the original Dockum Aquifer GAM report below). Please discuss the changes to the hydraulic properties in the report and the implications for the original conceptualization of the High Plains Aquifer System. Discussion shall include any justification for the adjustments, how this affects areas where the Ogallala and Dockum aquifers are connected with comparable properties, and in the outcrop portions of the Dockum Aquifer. Please also see public comments for Lone Wolf Groundwater Conservation District located at the end of this document.

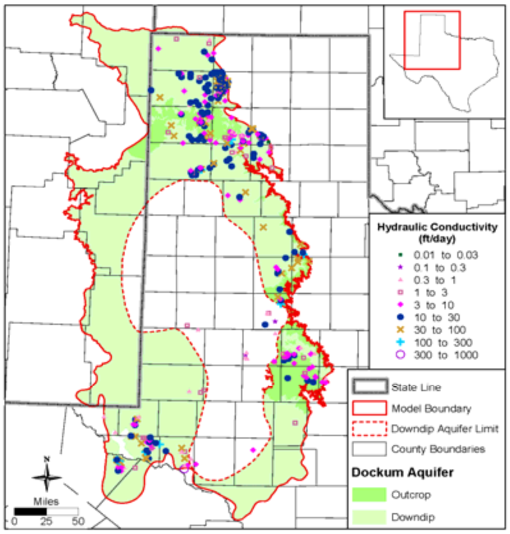


Figure 4.6.5 Sand hydraulic conductivities in feet per day for the lower portion of the Dockum Aquifer.

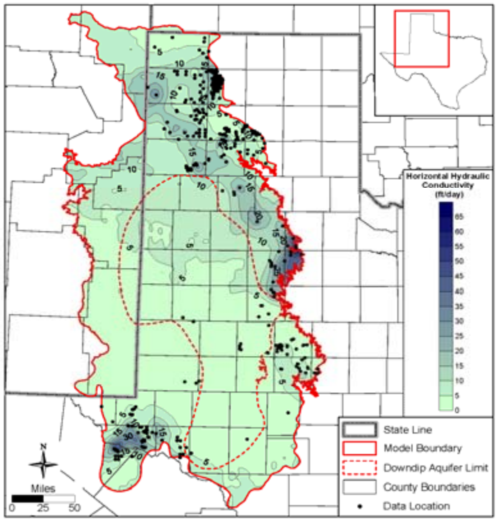


Figure 4.6.11 Kriged map of sand hydraulic conductivity in feet per day for the lower portion of the Dockum Aquifer.

Based on the comments from Lone Wolf Groundwater Conservation District (see responses below) and discussions with TWDB staff, we revisited the calibration of hydraulic conductivity (both horizontal and vertical) and recharge in the Dockum Aquifer. We were able to achieve nearly as good a calibration in the Dockum Aquifer by increasing recharge and horizontal hydraulic conductivity to the Lower Dockum Aquifer, and decreasing vertical conductivity in the lower Dockum Aquifer. In the shallow regions of the lower Dockum Aquifer, such as Mitchell County, the horizontal hydraulic conductivity is now nearly identical to the original conceptualization. Note that both figures shown above in the TWDB comment are for sand conductivities, not the "effective" horizontal hydraulic conductivity distribution that is calculated when multiplying by the sand fraction in the lower Dockum Aquifer (as described in Ewing and others (2008)). The conceptual model figure for comparison is Figure 6.4.4 in Ewing and others (2008) or Figure 4.6.8 from Deeds and others (2015).

In summary, the updated calibration, after comments were considered, results in a horizontal hydraulic conductivity in the lower Dockum Aquifer that is nearly the same as the conceptualization, in the shallow units where the Dockum Aquifer is freshest and most productive.

Draft numerical model comments:

General comments to be addressed

3. Please do not use any acronyms except TWDB. Please spell out everything else including, but not limited to, groundwater conservation district, groundwater availability model, acre-feet per year, and High Plains Aquifer System.

   Done.

4. Section 4.0 Sensitivity Analysis: Please proofread the entire section. Several words seem to missing and/or there are several incorrect words.

   Done.

Specific comments to be addressed

5. Executive Summary, Page ES-1, Paragraph 1, last Sentence: Please revise to," The purpose of the High Plains Aquifer System model is to provide a tool for managing the groundwater resources in the study area."

   Corrected.

6. Section 1.1, Page 1-1, Paragraph 1: Figures 1.0.1 and 1.0.2 are cited in the text, but the figures of the major and minor aquifers are missing. Please add Figures 1.0.1 and 1.0.2 to the report.

   Figures added.

7. Section 1.1, Per Exhibit B, Attachment 1, (Scope of Work page 20 of 27) of the contract: Please include a figure of the location of the aquifers in the study area and cite the figure in paragraph 2 of this section.

   Figure added.

8. Section 1.2, Page 1-1, Paragraph 1: Please cite legislative session or year when referring to bills since each legislative session could use the same bill number. For example, Senate Bill 1 (75th Texas Legislative Session, 1997) concerned the development and management of the water resources in the state and now references ad valorem taxes in the 84th session in 2015.

   Corrected.

9. Section 1.2, Page 1-2, last Paragraph: Please cite legislative session or year when referring to bills since each legislative session could use the same bill number. For example, House Bill 1763 concerned groundwater in 2005 (79th session) and now references public education in the 84th session in 2015.

   Corrected.

10. Section 2.0, Page 2-1, Paragraph 1, sentence 1: "…boundary condition packages to handle recharge, streams, reservoirs, etc." Please either list all of the boundary condition types or replace etc. with "and others".

    Corrected.

11. Section 2.1, Paragraph 2: Text describes aquifers in each layer. Please update text for layer 2 to also include parts of the Edwards-Trinity (Plateau) Aquifer.

    Corrected.

12. Figures 2.1.5a and 2.1.5b, Pages 2-10 and 2-11: Please consider using different colors for springs and river cells or making the spring cells larger in the figures since they are hard to discern.

    Figures updated.

13. Section 2.4, Page 2-19, Paragraph 4, Sentence 3: Text cites Figures 4.2.2 through 4.2.4, should be 2.4.2 through 2.4.2. Please update figure numbers in the text of the report.

    Corrected.

14. Section 2.4, Page 2-20, Paragraph. 3: Text cites Figures 4.2.5 and 4.2.6, should be 2.4.5 and 2.4.6. Please update figure numbers in the text of the report.

    Corrected.

15. Section 2.4, Page 2-20, Paragraph. 3: The text mentions a second zone used to modify specific yield in a four county area as shown in Figure [2.4.6]. However, Figure 2.4.6 shows a much larger area covering more than four counties. Please correct text or figure so they agree. Also, please explain (or provide a reference) in the text as to why this second zone was created.

    Text added.

16. Figure 2.4.2, Page 2-22: Shading (light purple) is missing from ETHP zone. Please update figure to include shading in Edwards-Trinity (High Plains) Aquifer area.

    Corrected.

17. Section 2.5.2, Page 2-28 and Page 2-29: The text on Page 2-28 mentions that, "wells without depth or screen information were excluded since they could not be assigned to an aquifer". However, on Page 2-29 it is stated that, "If no screen information was known[;] screen information of nearby wells of similar type was used". These two statements are contradictory. Please explain or correct text of the report, as needed.

    Text clarified.

18. Section 2.5, Page 2-29, Bullet “b”: Line 3 refers to bullet (6), please clarify if this should be (3) and adjust as needed.

    Corrected.

19. Section 2.5, Page 2-29, Numbered list in the middle of the page, (wells outside of Texas): Numbering starts over with 1, 2, then 3; however, items 2 and 3 refer to item (5) above “within 20 feet of a well in (5)”. There is no (5) because numbering started over with 1. Please update text and/or numbering so text/numbering agrees with point being addressed.

    Corrected.

20. Section 2.5.3, Page 2-30, item 2: The text mentions that production limits for Ogallala were set according to Hecox and others (2002). Please explain or provide a reference as to how production limits were set for other aquifers.

    Text added to explain how production limits were set for other aquifers.

21. Section 2.5.5, Page 2-31, last sentence: Please provide name of the file where the well package totals by county and aquifer are provided as part of the electronic submittal to aid the reader in finding the data. In addition, we recommend providing a figure of irrigation wells—delineated by aquifer and county (and showing location of paleo valleys) —which were used for the pumping distribution for irrigation throughout the active model domain. Please note that “point” distribution of irrigation and livestock was deemed insufficient in previous models due to the scarcity of wells and due to pumping exceeding aquifer properties, especially for predictive simulations.

    Added the name of the file to text. Added figure showing location of irrigation wells in the model region.

22. Section 2.5: Per Exhibit B, Attachment 1, of the contract (page 21 of 27), please provide a table of total pumping per county per stress period in an Appendix of the report. Alternatively please provide (or reference) a table in Section 3.1.6 with initial pumping and reduced pumping.

    Tables of annual pumping by county and aquifer added. See Appendix C.

23. Section 2.6, Page 2-33, Paragraph 2, last sentence: Please update text and "hpas.drn" file to note the drain cells representing "low-lying seepage" are also specifically identified.

    Done.

24. Section 2.6, Page 2-33, Paragraph 3, last sentence: Please explain in the text of the report why a value of 10 feet was used for placing the drain elevations above the bottom of the model layer in which they were placed.

    Explanation added.

25. Section 2.9.1, Page 2-37, Paragraph 2, lines 5 and 6: Please explain why values of 10 and 5 feet were used as stated.

    Explanation added.

26. Section 2.9.1, Page 2-38, Paragraph 1, line 6: Please explain why a value of 5 feet was used as stated.

    We assume you mean Section 2.9.3. Explanation added.

27. Section 2.9.1, Page 2-38, Paragraph 1, line 8: " Dockum and these units" Please state the name of the units for clarity.

    We assume you mean Section 2.9.3. Unit names added.

28. Section 3.1.1, Page 3-1, Paragraph 1, line 1: Please mention in the text of the report, the relevant year that represents the conditions prior to significant development of the aquifer.

    Year added to text.

29. Section 3.1.2, Page 3-2, last Paragraph: Please include the plots to assess spatial bias that are mentioned in this paragraph in the text of the report.

    Text notes that "Post plots of hydraulic head residuals for both the steady-state and transient portions of the model were used to check for spatial bias." These plots are discussed in Section 3.2.2, and we don't think a forward reference to them is necessary in this introductory discussion.

30. Section 3.1.3, Pages 3-3 to 3-4: In the text of the report please clarify the source of the initial values for the pilot points. It is unclear in Section 2.4.2 or 3.1.3 if the initial pilot point values were based on data from previous calibrated models, measured data, or some other documented approach. Please confirm that measured data was honored in this calibration approach.

    The initial values of all the pilot points were 1.0, since the pilot points were multipliers. The text was modified to reflect this.

31. Section 3.1.3, Page 3-3, Last Paragraph: Text states that similar to the previous Dockum Aquifer modeling effort horizontal conductivities were decreased during calibration in the Upper and Lower Dockum aquifer units. However, it appears the starting horizontal conductivities for this modeling effort were the final calibrated horizontal conductivities from the original modeling effort. See comment #2 in the modeling section and please update text with justification of further lowering horizontal conductivities away from measured values.

    As noted in the response to comment #2, we have since updated the lower Dockum Aquifer calibration so that in the shallow portions of the Dockum Aquifer the calibrated field is nearly identical to the hydraulic conductivity field in the conceptual model (Figure 4.6.8 in Deeds and others (2015)) (not the final calibrated horizontal conductivities from the previous Dockum Aquifer model). In fact, the final calibrated Dockum Aquifer hydraulic conductivities in the High Plains Aquifer System groundwater availability model are now higher than the final calibrated Dockum Aquifer hydraulic conductivities in the previous groundwater availability model (except in the deeper, brackish areas).

32. Section 3.1.3, Page 3-4, Paragraph 2: Text suggests that the model may be limited in modeling the relationship of the Ogallala and Dockum aquifers in the region where the Ogallala Aquifer overlies the Santa Rosa portion of the Dockum Aquifer. The text states this was possibly due to the non-uniqueness of parameter combinations within their acceptable ranges. This needs to be discussed in the Executive Summary and in the Limitation Section of the report, as modeling the relationships between the Ogallala and Dockum aquifers was the main objective of this modeling project.

    The intention was to say that this zone where the Santa Rosa Formation was in direct contact with the Ogallala Aquifer did not require any special approach for parameterization of vertical conductivity. The basic approach for estimating the vertical conductivity of the lower Dockum Aquifer was driven by clay percentage and depth. The conductance term calculated by MODFLOW between two layers is

dependent on vertical conductivity and layer thickness. Because the lower Dockum Aquifer in this zone is relatively sandy, is shallow, and thin compared to areas more basinward, the vertical connection calculated from the basic approach results in a vertical conductance that creates satisfactory calibration to heads in the area. We added this explanation to the text.

33. Section 3.1.3, Page 3-4: Please cite Figures 3.1.5 through 3.1.8 in the text.

    Citations added.

34. Section 3.1.3, Page 3-4: Please cite Figures 3.1.10 through 3.1.12 in the text.

    Citations added.

35. Section 3.1.3, Figures 3.1.3, 3.1.4, 3.1.11, and 3.1.12, Pages 3-13, 3-14 and 3-21, and 3-22: Low areas of horizontal hydraulic conductivity seem to correspond to areas of higher storage coefficient for the Upper and Lower Dockum. This is the reverse of what might be expected. Please review these four figures and discuss possible reasons for the relationship.

    Storativity is dependent on thickness, whereas hydraulic conductivity is not. Storativity increases towards the center of the basin because the Dockum Aquifer is thickening in that direction and specific storage was assumed to be constant for the Dockum Aquifer. We cannot find literature that indicates that *specific* storage and hydraulic conductivity would necessarily be correlated, for a system consisting of sands and shales.

36. Section 3.1.3, Page 3-4, Paragraph 2, last sentence: Please provide values in decimals rather 1E-2 and 1E-4.

    Corrected.

37. Section 3.1.4, Page 3-5, Paragraph. 1, Sentence 6: “The model sensitivity to recharge was dominated by the steady-state stress period, where initial head elevations were very sensitive to the recharge rate.” Please rephrase for clarity, “ heads at the end of the steady-state stress period were sensitive to the recharge rate”?

    Rephrased as suggested.

38. Section 3.1.4, Page 3-5, Paragraph 2: The text states that recharge rates were decreased but doesn't mention whether this was done for the steady-state conditions or transient. Please expand discussion in the text to clarify this.

    The updated conductivity and recharge in response to comments caused a general rewrite of this paragraph.

39. Section 3.1.5, Page 3-5, Paragraph 1, last sentence: Text mentions that fluxes were compared with those from previous models and verified to be within reasonable range and plausible bounds. Please consider either providing these comparisons or quantitatively stating the 'reasonable range' and 'plausible bounds'.

    Agreed that this was poorly phrased. We took a second look at these fluxes and rewrote paragraphs to more specifically discuss how they were evaluated.

40. Section 3.1.6, Pages 3-6 to 3-7: Please see Table A (at the end of this review) which shows the comparison between pumping in the input well package, from the Water Use Survey and the curtailed pumping applied by the NWT package. There is a consistently large positive bias (averaging 20 percent and as high as 31 percent) in the input well package from 1984 through 1992 and a consistently large negative bias from 1995 to 2000 (averaging 14 percent and as high as 20 percent) when compared to the Water Use Survey. It appears that consistently high pumping (than what is estimated in the Water Use Survey) in the earlier years (1984 to 1992) may have resulted in curtailed pumping in the latter years. While Water Use Survey estimates may not have been used for preparing the input files for the model, please explain why such a large discrepancy (31 percent to -20 percent) might occur in the input pumping. Also, please discuss what effects such a discrepancy might have on the calibration process and therefore on the model results. Please be specific about what discrepancies would occur if calibration is conducted to much higher (or lower) than actual pumping both spatially as well as temporally.

    The difference between the pumping shown in Table A and the model pumping is due to two reasons:

    1. **Table A shows pumping only in Texas. The model includes pumping in Texas and other states, primarily New Mexico and Oklahoma. This explains the positive bias early on, that is, Table A is comparing Texas pumping to (Texas plus non-Texas) pumping.**
    2. **The conceptual model for total pumping by county did not depend exclusively on the water use survey results. As noted in Deeds and others (2015), irrigation pumping in the Ogallala Aquifer was based on the same sources as the existing southern Ogallala Aquifer groundwater availability model Blandford and others**

(2008) and northern Ogallala Aquifer groundwater availability model (INTERA and Dutton, 2010). These sources are studies from Amosson and others (Appendix B in Blandford and others (2008)), and the Texas Agricultural Experiment Station (Dutton and others, 2001).

In short, the post-1980 pumping in the numerical model followed the post-1980 pumping in conceptual model, and the conceptual model report explains the sources for the pumping, which were not necessarily the same as the water use survey.

41. Section 3.1, Table 3.1.1, Page 3-8: Please distinguish between storage coefficient and specific storage in the table, "S" is used for both. For the Ogallala, Rita Blanca outcrop, Edwards Trinity (Plateau) outcrop, Upper Dockum outcrop, and Lower Dockum outcrop the values are specific storage. For the Rita Blanca downdip, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau) downdip, and Upper Dockum downdip the values are storage coefficient. Please use "S" for storage coefficient and "Ss" for specific storage.

    To avoid confusion, we changed our approach to report only specific storage, since that is the parameter that is input in the Upstream Weighting package. We used "Ss" to denote specific storage.

42. Section 3.1, Table 3.1.1, Page 3-8: Please check the final mean values for horizontal and vertical hydraulic conductivities for the Edwards-Trinity (Plateau) downdip. We calculate 2.04 and 2.04 x 10^{-4} respectively. Please check the values and update the table if appropriate.

    The problem was labeling. The label should have been "Edwards-Trinity (Plateau)" rather than "Edwards-Trinity (Plateau) Downdip". We included both IBOUND==51 and IBOUND==52 in the calculation. We corrected the label.

43. Section 3.1, Table 3.1.1, Page 3-8: Please mark or indicate the values that were not changed in the calibration process. Perhaps, shade the applicable cells or underline the values.

    Shaded the cells for parameter and aquifer when parameter values were not modified from initial estimates during calibration, and noted this at the bottom of the table.

44. Section 3.1.6, Page 3-10, Table 3.1.2: Suggest changing table caption to "Fraction of initial pre-1980 Ogallala Aquifer pumping by county". Current table caption is misleading. Also, please consider adding a column to the table showing the percent reduction, for the benefit of the readers.

    Done.

45. Figure 3.1.9, Page 3-19: It is difficult to discern the specific yield values in the figure. Please consider grouping the specific yield values into 4 to 5 groups and using visibly distinct shades or colors.

    Figure updated.

46. Figures 3.1.13 and 3.1.14, Pages 3-23 and 3-24: Please use visibly distinct shades or colors.

    Figures updated

47. Section 3.2, Pages 3-25 to 3-32: The text points out various observations in the figures by county name. However, counties are not labeled in the figures. Please update figures with county labels so reader can easily locate observations.

    Figures updated.

48. Section 3.2.1, Page 3-25, Paragraph 2, line 2: "This bias is not obvious.." The bias is observable and therefore, obvious. Please consider rephrasing the sentence.

    Rephrased.

49. Section 3.2.2, Page 3-28, Paragraphs 2 and 3: The discussion outlines the presence of bias in the calibration results. However, there is no discussion on the probable cause of the reported bias. Please include a discussion on probable reason(s) for the bias for each of the aquifers discussed.

    Discussion regarding negative bias in New Mexico for the Ogallala Aquifer already present in paragraph two. Discussion regarding negative bias for Edwards-Trinity (High Plains) Aquifer already present in paragraph three. Discussion expanded for other aquifers in paragraph three.

50. Section 3.2.4, Page 3-32, Paragraph 3: The text states a tolerance value of 40 feet for flooding and a maximum flood value of 48 feet above tolerance is reported. Later, however, it is mentioned that the maximum flood height is 55 feet. Please address the discrepancies in the text of the report. Also, please provide the reasoning behind selecting the tolerance value in the text of the report.

The numbers were updated for the updated model. The 48 feet referred to the steady-state model, while the 55 feet referred to the end of the transient model. The reasoning behind selecting that tolerance was that it represented the approximate mean absolute error among the aquifers. This is stated in the text.

51. Figures 3.2.10a through 3.2.14, Pages 3-43 through 3-50: It is hard to discern between the shades of blue dots. Please consider changing some of the blue shades to green or any other distinctly visible shade that may benefit the readers. There appear to be clusters of negative values (indicating bias) but it is hard to check if the values are highly negative or mildly.

    Also, please consider changing the shade of the (-49 to 50) range to a blank circle instead of black dot to aid in visualization. In addition please adjust legends and replace "-" with "to".

    Figures updated. See Figures 3.2.10a through 3.2.15.

52. Figure 3.2.20, Page 3-55: To aid in visualization of the saturated thickness, please consider reducing the number of zones to 4 or 5 rather than 10 used currently

    Figure updated. See Figure 3.2.20.

53. Figure 3.2.25 through Figure 3.2.30, Pages 3-68 to 3-73: To aid in visualization please consider reducing the number of zones or using different shades of colors rather than orange which are hard to discern

    Figures updated. See Figures 3.2.25 through 3.2.30.

54. Section 3.3, Figures 3.3.5 and 3.3.9, Pages. 3-101 and 3-105: Please use a different color for the outline of the Ogallala or different colors for the downward flow. The outline of the Ogallala is the same color as large upward flow.

    Figures updated.

55. Section 3.3, Figures 3.3.5, 3.3.6, 3.3.9, and 3.3.10, Pages 3-101,3-102, 3-105, and 3-106: Please clarify in the text of the report the juxtaposed reversals of flow along the Edwards-Trinity (High Plains) Aquifer that appears in the steady-state (no pumping) and continues through the transient calibration.

This is due to the rivers crossing the Ogallala where the Edwards-Trinity (High Plains) Aquifer is thinning in Gaines/Dawson (and also Lubbock) counties. Explanation added to section 3.3.2.

56. Section 3.4.1, Table 3.4.1., Page 3-113: Please clarify why "Cross-formational other into Ogallala" (44,401 IN) is not equal to total cross-formational OUT to the Ogallala from the underlying units (-41,532). Please clarify if there flow from other units besides Rita Blanca, Edwards-Trinity (High Plains), and Dockum aquifers.

    This comment made us take a second look at the table in general. We added the Edwards-Trinity (Plateau) and Pecos Valley zones so that "Cross Formational (Other)" (44,330 IN) now can be compared to "Cross Formational (Ogallala) (-44,330 OUT). We added a sum for "Cross Formational (Other)" (49,687 IN) that does not include the Ogallala Aquifer, for comparison to the sum "Cross Formational (Other)" (-49,687 OUT) which also does not include the Ogallala Aquifer. We also broke out layer totals (which would include cross-formational flow) from model totals (which do not include cross-formational flow, since it is internal to the model). We added text to help explain the additions to the table.

57. Section 3.4, Figures 3.4.7 to 3.4.10, Pages 3-122 to 3-125: Please consider using a darker color than yellow in the graphs as this is hard to see and does not photocopy well.

    Changed to dark green.

58. Section 4.2.1, Page 4-2, Paragraph. 3: Text states "For those parameters that would affect the shallow hydraulic heads, both flow and hydraulic head output metrics were considered." However, all of the parameters indicate both hydraulic head and flow were considered except specific yield and specific storage for which only hydraulic head was considered. This difference doesn't seem to be related to whether shallow heads were or weren't affected. Please clarify or provide a different explanation or just remove that sentence. In addition, storage values may have a significant impact on the flux values. Therefore, please consider adding the flow metric to the storage value sensitivity analyses.

    Removed sentence, added flow metric to specific yield of the Ogallala Aquifer. Flows were not sensitive to confined storage, and this is now noted in the text.

59. Figures 4.2.20 through 4.2.40, Pages. 4-28 to 4-48: Please discuss the relative significance of the difference in mean flux values. The maximum values appear to be around 10 acre-fee

across all figures. Please discuss what is indicated by the relative magnitude of the flux values especially in context of the different boundary conditions.

Added text regarding relative magnitude of mean flux values at the end of the section.

60. Section 4.2.1, Page 4-8, Last Paragraph.: Please add some discussion of Figures 4.2.39 and 4.2.40, sensitivity of flow to evapotranspiration parameters.

    Discussion added.

61. Section 4.2.2, Page 4-49, Paragraph 1, Sentence 2: Text states that transient model head sensitivity to horizontal and vertical hydraulic conductivities (Figures 4.41 through 4.50) are very similar to steady-state sensitivities (Figures 4.1 through 4.10). However, Figure 4.49 (vertical conductivity of the Upper Dockum) is not similar to Figure 4.9. Please verify that these are the correct figures and if they are correct please discuss the difference between the sensitivities in the text.

    Text modified to note and explain exceptions to the claim of similarity in responses.

62. Section 4.2.2, Page 4-49, Paragraph 1, Sentence 4: Text states that transient model flow sensitivity to horizontal and vertical hydraulic conductivities (Figures 4.68 through 4.77) are very similar to steady-state sensitivities (Figures 4.21 through 4.30). However, Figure 4.72 (horizontal conductivity of the Upper Dockum) is not similar to Figure 4.25 (steady-state version). Please verify that these are the correct figures and if they are correct please discuss the difference between the sensitivities in the text.

    Text modified to note and explain exceptions to the claim of similarity in responses.

63. Section 4.2.2, Page 4-49, Paragraph 1, Sentence 5: Text states that transient model flow sensitivity to recharge and boundary conductance (Figures 4.78 through 4.87) are very similar to steady-state sensitivities (Figures 4.31 through 4.40). However, Figures 4.82 and 4.83 (river boundary conductance and river boundary conductance for ghb cells) are not similar to Figures 4.35 and 4.36 (steady-state versions). Please verify that these are the correct figures and if they are correct please discuss the difference between the sensitivities in the text.

    Text modified to note and explain exceptions to the claim of similarity in responses.

64. Section 4.2.2, Figures 4.2.90 through 4.2.94, Pages 4-101 to 4-105: Please consider adding the observed water level data from the wells. Also, please discuss how modifications in the

parameter values impact the residuals between observed and multiple simulated values (from the sensitivity analysis).

Observed water level data added. Discussion added.

65. Section 5.3: Please consider adding discussion about how pre-1980 pumping was modified based on change in storage (obtained from water levels) and the transient model was calibrated to the same water levels thereby increasing the uncertainty in model predictions. Also, please note in the text of the report that this makes the model highly sensitive to starting water levels or saturated thickness conditions.

    We added text to 5.3 discussing the concerns expressed in this comment.

    We are interpreting the first part of this comment to mean that because pre-1980 pumping was estimated based on change in storage, rather than using estimates independent of water levels, that the amount of constraint placed on the parameterization was reduced. This may be true, but would require an actual uncertainty analysis to show one way or the other, and that is beyond the scope of this effort. We provide evidence (Deeds and others (2015), Section 4.7.2.7), that some of the pre-1980 pumping estimates from the irrigation survey are biased high, and so high that it was impossible to calibrate the model using them (as the previous modelers found as well).

    Even if we treated the portion of the transient model prior to 1980 as an exercise in producing initial 1980 heads, we still have more than 30 years of transient calibration where non-storage-based pumping estimates were used. Our confidence in both pumping and water levels increases through time, so the value of the last 30 years of calibration is at least equal to or higher than the 30 years prior to 1980.

    We don't agree with the second part of the comment. Predictive results of a model that consists mostly of a large, unconfined aquifer is going to be sensitive to starting saturated thickness, regardless of how pumping was parameterized prior to 1980.

66. Appendix A, Table A.1.1, Page A-4: Please verify the steady-state water budget entries for Lynn (ET and total drains) and Ochiltree (ET) counties. We extracted the steady-state water budget values by county and generally reproduced Table A.1.1 for all Texas counties except Lynn and Ochiltree (ET and total drains). Please verify and update if necessary.

    We verified the water budgets and the numbers are correct. The discrepancy probably stems from the fact that you restricted the analysis to the official aquifer boundary. In our meeting from June 17, 2015 at TWDB's headquarters we brought up the fact that

while the active area closely matches the official aquifer boundary, slight changes were made (by adding/subtracting active cells) to enhance model stability.

67. Appendix A, Table A.3.5, Page A-28: Please review table format on the last few pages (A-29 and A-30). The columns are shifted. Please review and correct if appropriate.

Final Model Report General Suggestions

68. When listing a range of values or figure numbers please use 'through" rather than a dash. For example, we prefer "Figures 3.2.1 through 3.2.6" rather than "Figures 3.2.1 – 3.2.6", or (1980 through 2012) rather than (1980 - 2012).

    Corrected.

69. Within the figures, in the legend, please use 'to' rather than a dash; for example (-1000 to -300) rather than (-1000 - -300).

    Figures with negative values updated to avoid confusion. See Figures 3.2.10a through 3.2.15, 3.2.25 through 3.2.28, and 3.3.1a through 3.3.2b.

70. When referencing the Edwards-Trinity (High Plains) Aquifer, please use parenthesis around High Plains.

    Corrected.

Final Model Report Specific Suggestions

71. Section 2.0, Page 2-1, Paragraph 1: Line 5 refers to United States Geological Survey and line 8 refers to U. S. Geological Survey. Please update the text of the report to identify this agency consistently.

    Corrected.

72. Section 2.0, Page 2-1, Paragraph 2, line 3: "model creation did not necessary follow". Please use necessarily rather than necessary.

    Corrected.

73. Figure 2.1.1, Page 2-6: Please correct spelling of Ogallala in legend.

    Corrected.

74. Section 2.5.2, Page 2-29: Please spell out “UWCD” and “GCD” for South Plains and Panhandle.

    Corrected.

75. Section 2.5.3, Page 2-30, item 2, last sentence: “……Ogallala were based on (Hecox and others, 2002) which …”. Please change citation to “….on Hecox and others (2002)…”.

    Corrected.

76. Section 2.5.1, Pg 2-27, Paragraph 5: “is likely to decline significantly from Brune”. Please use ‘as stated in’ (or a variation thereof) rather than ‘from’

    Corrected.

77. Section 3.1.4, Page 3-5, Paragraph 1, Sentence 4: “…transient period, i.e., the initial variation in recharge from steady-state to transient was maintained for the calibrated case.” Please don’t use latin (i.e, e.g., etc.). Please replace i.e. with “in other words”.

    Corrected.

78. Section 3.1.6, Page 3-7, Paragraph 1, Sentence 3: “Bailey County was the one county were post-1980 pumping was also decreased as in input…”. Please change ‘were’ to ‘where’ and consider removing the word ‘as’ and changing to ‘decreased in the input files’.

    Corrected.

79. Section 3.1, Table 3.1.1, Page 3-8: Please provide a footnote for the table that explains what each of the parameters are. For example, Kh = horizontal hydraulic conductivity, Kv = vertical hydraulic conductivity, Sy = specific yield.

    Corrected

80. Section 3.2.4: Please provide figures showing dry and flooded cells in steady-state and in 2012.

    Added figures and references to them in the text. See Figures 3.2.45 and 3.2.46.

81. Figures 3.2.10a through 3.2.14, Pages 3-43 through 3-50: In the legend, please consider using ‘to’ rather than the dash (-) while reporting the value ranges such as (-1000 to -300) rather than (-1000 - -300).

    Figures updated. See Figures 3.2.10a through 3.2.15.

82. Section 3.4.1, Page 3-109, Paragraph 2, line 1: “steady-state model in in ..” Please delete one “in”

    Corrected.

83. Section 4.2.1, Page 4-5, Paragraph 2, line 4: “= Figure 4.2.7 depicts…” please remove ‘=’

    Corrected.

Final Conceptual Model Report

Specific Comments to be addressed

84. Unable to review “Chapter 3 Previous Investigations” as this chapter is missing from the pdf document provided. Please include Chapter 3 in the final version of the conceptual model report.

    Chapter 3 added.

85. Comment 81 from draft comments was not addressed for the Lower Dockum Group. Page 4.3-18, last Paragraph: Please cite Table 4.3.4 for each trend discussed that is not based on a hydrograph in Figure 4.3-24.

    Corrected.

Table 1. Comparison between pumpage from the input files (.wel package), Water Use Survey, and the final model results as curtailed by the NWT package. The last column details the percentage difference between Input pumpage and Water Use Survey estimates. All values reported in acre-feet per year.

Year	Stress Period	Input-wel	TWDB Water Use Survey	NWT-pumping	Input>WUS ? in Percent
		Layer 1	Ogallala	Layer 1	
1980	52	6,794,872	7,078,788	6,523,850	-4
1981	53	7,037,904	Not reported	6,808,666	Not applicable
1982	54	7,271,706	Not reported	7,091,950	Not applicable
1983	55	6,565,698	Not reported	6,436,031	Not applicable
1984	56	6,426,570	5,726,598	6,294,512	12
1985	57	5,866,706	4,649,101	5,737,056	23
1986	58	5,205,091	4,020,366	5,083,256	26
1987	59	4,787,568	3,502,956	4,655,378	31
1988	60	4,691,664	3,571,094	4,549,340	27
1989	61	5,438,538	4,719,780	5,283,144	14
1990	62	6,086,628	5,554,632	5,909,783	9
1991	63	5,480,339	4,796,361	5,274,400	13
1992	64	5,730859	4,502,649	5,505,806	24
1993	65	6,010,052	5,909,222	5,771,931	2
1994	66	5,687,956	5,973,734	5,426,284	-5
1995	67	5,447,544	6,215,598	5,184,050	-13
1996	68	5,516,778	6,456,173	5,254,496	-16
1997	69	5,087,932	6,231,052	4,845,638	-20
1998	70	5,790,196	6,603,075	5,512,386	-13
1999	71	5,669,730	6,278,999	5,388,064	-10
2000	72	5,975,411	6,615,001	5,698,954	-10
2001	73	5,976,699	6,170,983	5,701,624	-3
2002	74	6,089,603	6,731,156	5,793,082	-10
2003	75	5,823,435	6,203,758	5,562,356	-6
2004	76	5,681,250	6,111,827	5,446,019	-7
2005	77	4,883,732	5,039,652	4,685,960	-3
2006	78	5,014,270	4,780,052	4,809,424	5
2007	79	5,881,578	6,089,454	5,628,986	-3
2008	80	6,402,056	6,523,636	6,114,018	-2
2009	81	5,916,189	5,706,845	5,654,955	4
2010	82	4,861,566	4,414,738	4,648,556	10
2011	83	6,475,514	6,287,859	6,216,727	3
2012	84	6,475,323	6,127,376	6,190,139	6

Public Comments

[Editors Note: The response to this comment is at the end of the model review, starting on page D-24.]

Draft Model Review for Lone Wolf Groundwater Conservation District

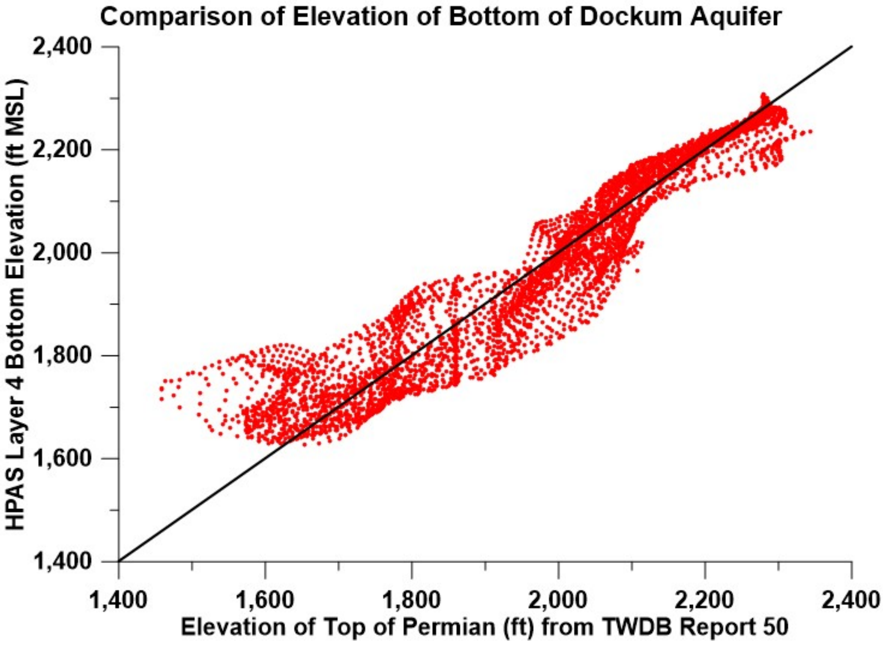
This review covered the following elements of the draft model:

- Elevation of the bottom of the Dockum Aquifer in Mitchell County
- Recharge
- Pumping
- Hydraulic conductivity estimates
- Model Calibration
- Groundwater budgets for Mitchell County

After the review and discussion, the Board of Directors of the Lone Wolf Groundwater Conservation District asked me to provide the following comments regarding the draft model.

Elevation of the Bottom of the Dockum Aquifer in Mitchell County

The bottom of the Dockum Aquifer (bottom of model layer 4) was compared with the Figure 8 of TWDB Report 50 (Ground-Water Resources of Mitchell and Western Nolan Counties, Texas, herein referred to as Shamburger, 1967), which was a contour map of the top of the Permian rocks. The comparison is shown below, and appears to be a reasonable match.



Recharge

Recharge in the HPAS was assumed not to change with time. The draft HPAS report describes changes to steady state recharge using pilot points. However, it is unclear whether recharge values were adjusted in Mitchell County during the transient calibration.

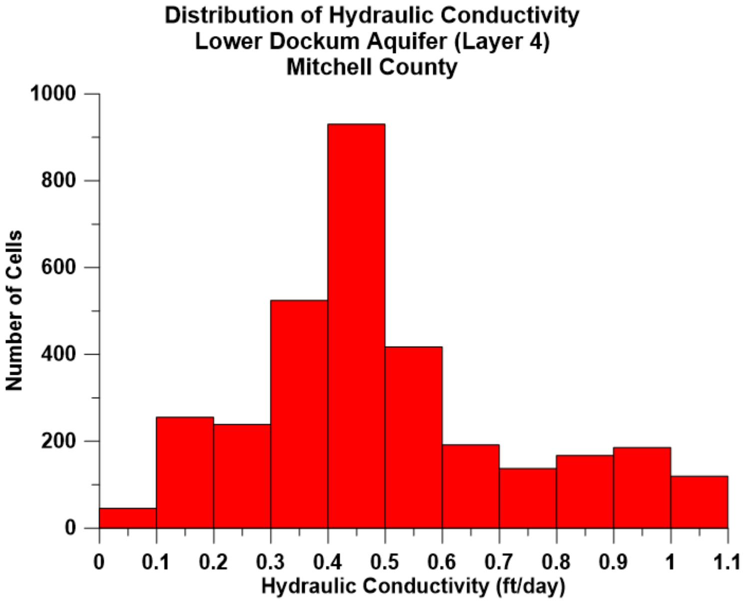
Some hydrographs in Mitchell County show variation in groundwater elevation that are likely due to variations in recharge. Using a constant recharge assumption results in a situation where pumping reduction is the only mechanism to cause groundwater elevation rises in the model.

Pumping

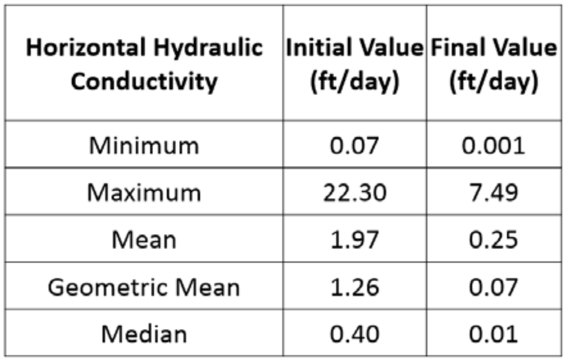
Pumping input for the HPAS in Mitchell County was reviewed and compared with TWDB estimates of groundwater pumping. The review showed close agreement between input estimates and the TWDB estimates.

Hydraulic Conductivity

In Mitchell County, the original Dockum GAM used two hydraulic conductivity values (0.14 ft/day and 0.34 ft/day). The revised Dockum model also used two hydraulic conductivity values (5.0 ft/day and 7.0 ft/day). In these two models, the same zonation was used, just different values. The draft HPAS uses a range of hydraulic conductivity values from 0.7 ft/day to 1.1 ft/day. The distribution of these values is shown below:



The draft HPAS model report includes Table 3.1.1 that shows the changes in various parameters during calibration. The horizontal hydraulic conductivity values for the Lower Dockum for the entire model area are reproduced below:



Horizontal Hydraulic Conductivity	Initial Value (ft/day)	Final Value (ft/day)
Minimum	0.07	0.001
Maximum	22.30	7.49
Mean	1.97	0.25
Geometric Mean	1.26	0.07
Median	0.40	0.01

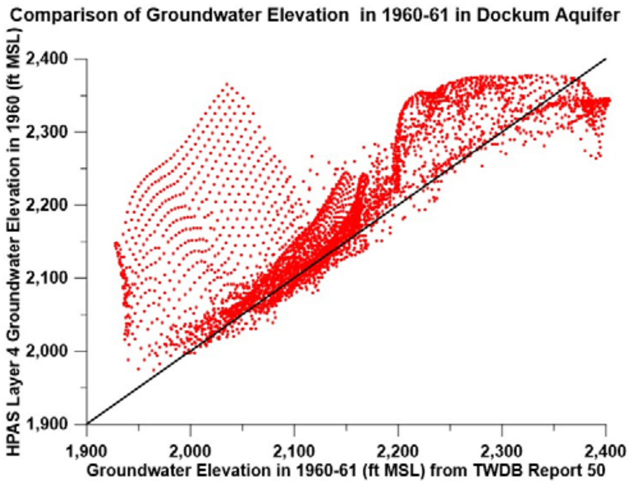
Please note that during calibration, hydraulic conductivity was lowered significantly during calibration.

When combined with the saturated thickness, the hydraulic conductivity values used in Mitchell County result in transmissivity values that are much lower than those reported in Shamburger (1967).

Shamburger (1967) reported the results of aquifer tests in four wells with a range of transmissivity of about 5,800 gpd/ft to about 12,000 gpd/ft. Calculated transmissivities using parameters from the HPAS in Mitchell County yield that are generally less than 1,500 gpd/ft. It appears that changes to hydraulic conductivity may have been made during transient calibration in Mitchell County while holding recharge constant. If recharge were to be increased slightly, the hydraulic conductivity estimates would be higher, and likely more consistent with the aquifer test results. As a result, more water moving through the system, and a similar head match would be achieved.

Model Calibration

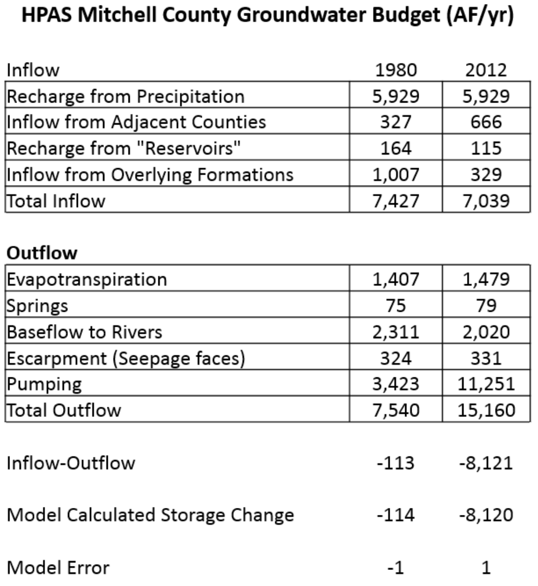
The hydrograph comparisons for the Lower Dockum in Appendix B-5 were reviewed. Also, the heads in 1960 and 1961 were compared with the 1960-61 contour map of groundwater elevation (Figure 14 of Shamburger, 1967). HPAS heads in 1960 and 1961 were nearly identical. The result is shown below:



Please note that the HPAS heads tend to be higher than the groundwater elevations from the contour map, especially at the lower elevations. This is also an indication that the hydraulic conductivity values in the HPAS in Mitchell County may be too low.

Groundwater Budget of Mitchell County

The groundwater budget data for Mitchell County for 1980 and 2012 are presented in the draft HPAS report in Tables A.2.5 and A.3.5, respectively, and are presented below:



HPAS Mitchell County Groundwater Budget (AF/yr)

Inflow	1980	2012
Recharge from Precipitation	5,929	5,929
Inflow from Adjacent Counties	327	666
Recharge from "Reservoirs"	164	115
Inflow from Overlying Formations	1,007	329
Total Inflow	7,427	7,039
Outflow		
Evapotranspiration	1,407	1,479
Springs	75	79
Baseflow to Rivers	2,311	2,020
Escarpment (Seepage faces)	324	331
Pumping	3,423	11,251
Total Outflow	7,540	15,160
Inflow-Outflow	-113	-8,121
Model Calculated Storage Change	-114	-8,120
Model Error	-1	1

Please note that the large increase in pumping from 1980 to 2012 has resulted in little or no response in the flow system, except for a decrease in storage. This is directly attributable to the low hydraulic conductivity values used in the HPAS. In contrast, the revised Dockum model groundwater that had higher hydraulic conductivity estimates shows more recharge and inflow from adjacent counties, and more natural discharge.

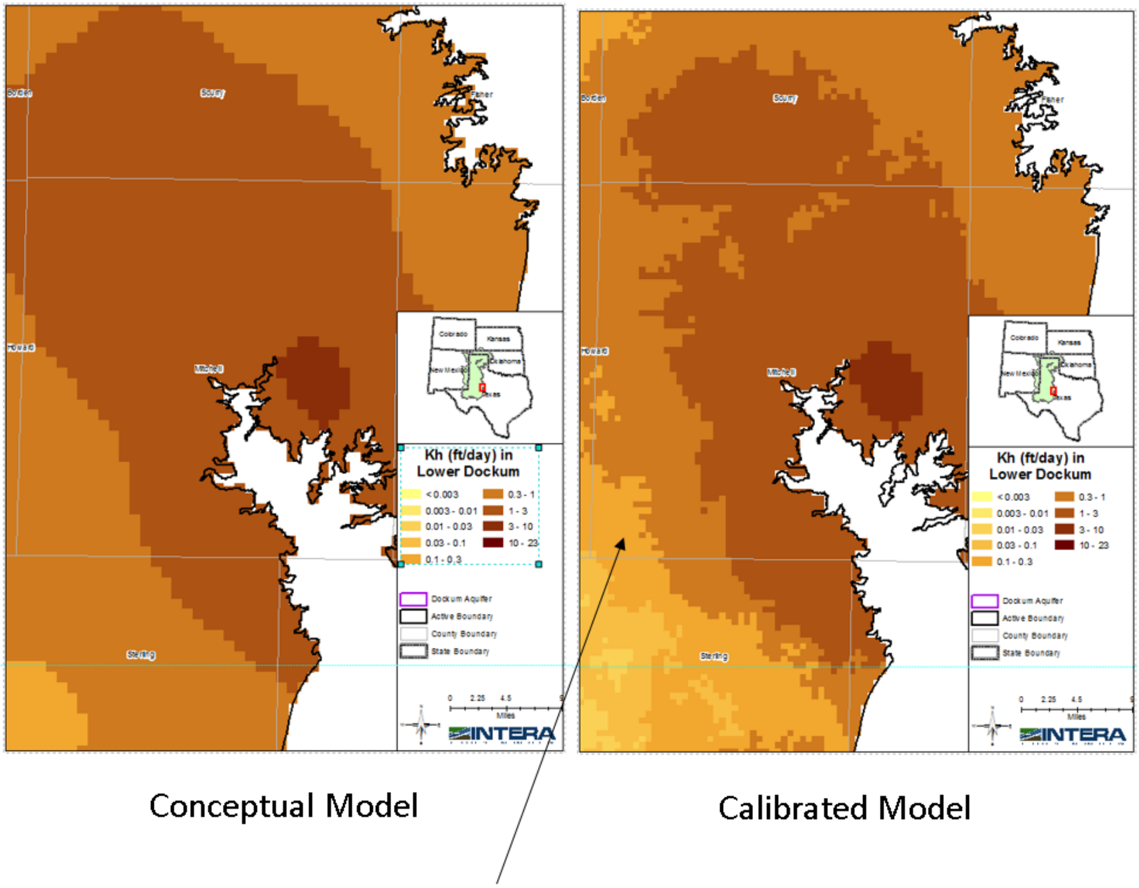
Summary

Based on this review, the Mitchell County area of the HPAS needs additional attention due to the significant differences between the HPAS and previous studies and models. Specifically, it appears that the recharge needs to be increased slightly and needs to be variable during the transient calibration period. More importantly, the hydraulic conductivity values in the Mitchell County part of the HPAS appear to be too low based on a comparison with previously published estimates of transmissivity that were derived from aquifer tests, and from a synoptic comparison of HPAS heads with a published groundwater elevation contour map.

Response to comments:

Hydraulic Properties

As noted in the response to TWDB comment #2, after comments were received the horizontal hydraulic conductivity and recharge in the Dockum Aquifer were revisited. The recharge and horizontal hydraulic conductivity (in the shallow regions, like Mitchell County) are now more consistent with the conceptual model. The recharge is basically unchanged from the conceptual model and the hydraulic conductivity has been decreased with depth, which was essential for calibration. A comparison of initial and final hydraulic conductivity in Mitchell County is shown below.



Conceptual Model

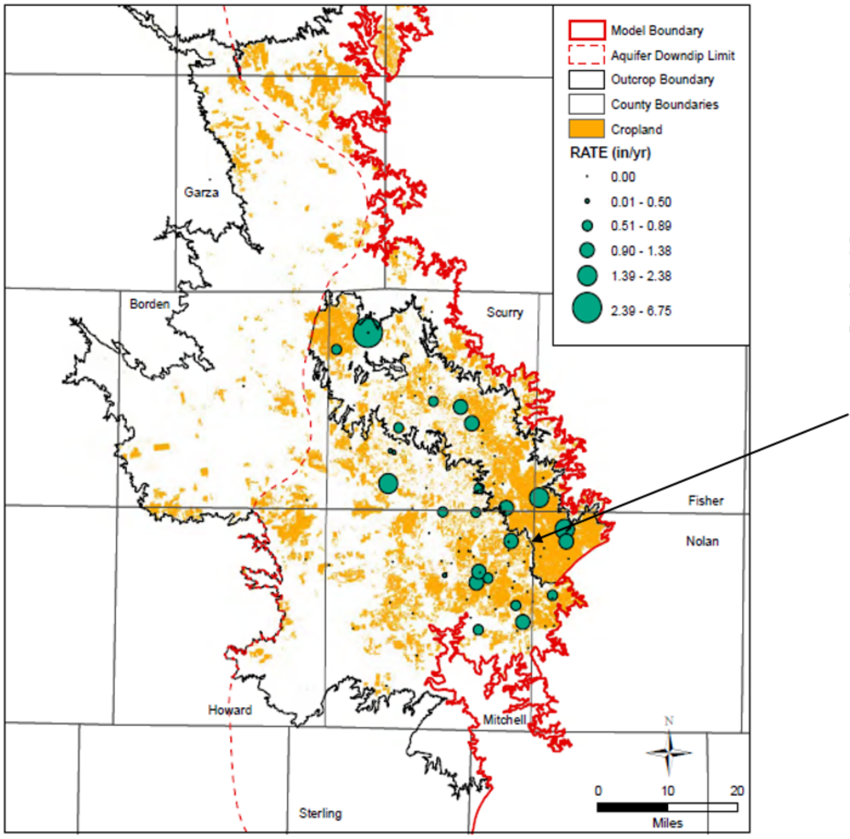
Calibrated Model

Depth decreases values in county corner

The hydraulic conductivity conceptualization was based on all available estimates of hydraulic conductivity (Ewing and others, 2008), not just those in Shamburger (1967).

Recharge

The conceptual model for recharge in the Dockum Aquifer was based on a rigorous study by the Bureau of Economic Geology (BEG) (Ewing and others, 2008). We feel that the BEG updated study (40 more years of data) complements the Shamburger (1967) report. The BEG findings indicate that land use changes (not precipitation) were the reason for the increase in post-development recharge in these areas. The BEG used the rising hydrographs in the Colorado River Basin to estimate post-development recharge rates, as shown in the figure below:



From Scanlon's analysis in Ewing and others (2008)

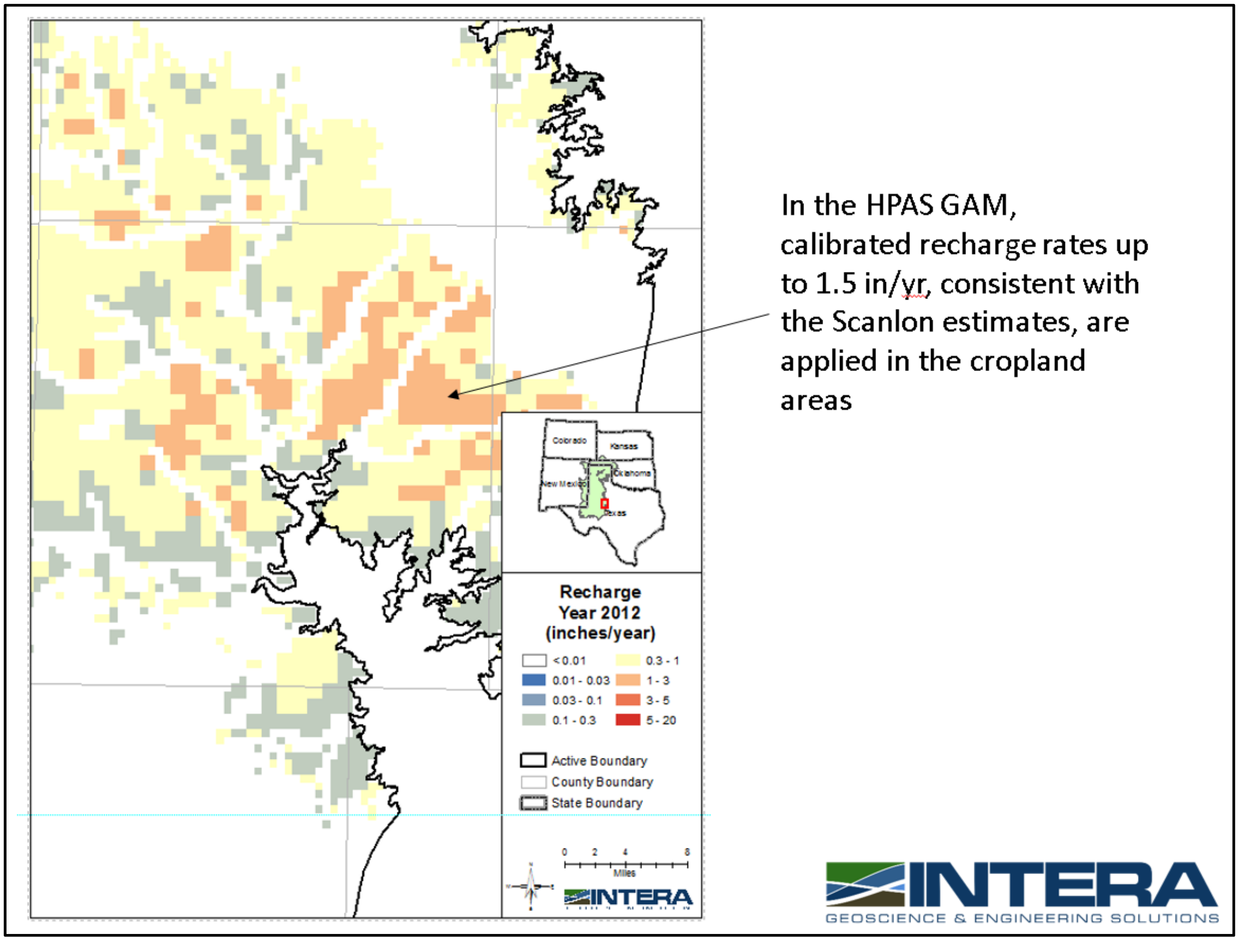
Some hydrographs show rises corresponding to up to 1.4 in/yr increased recharge

Most hydrographs in Mitchell show rises that do not indicate an increase in recharge rate

Figure 4.4.8 Rates of linear water-level rises in inches per year and spatial distribution of cropland in the Colorado River outcrop area.

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

The recharge in the High Plains Aquifer System groundwater availability model reflects this, as shown on the next page.

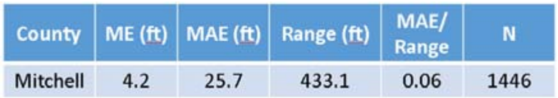


In the HPAS GAM, calibrated recharge rates up to 1.5 in/yr, consistent with the Scanlon estimates, are applied in the cropland areas

So the numerical model has implemented recharge in a way that is consistent with the conceptualization.

Calibration

We recognize that some measured hydrographs which show recovery of 40 feet are not matched by the simulated heads. However, to match those few hydrographs with larger increases in measured water levels would require us to "point calibrate" pumping or recharge to fit the increase. This would not improve our confidence in the model calibration nor would it improve the predictive capability of the model. The calibration statistics for the Dockum Aquifer in Mitchell County are well within industry standards:



County	ME (ft)	MAE (ft)	Range (ft)	MAE/ Range	N
Mitchell	4.2	25.7	433.1	0.06	1446

Given these good calibration statistics, the solid conceptualization of recharge and hydraulic conductivity, and the consistency between the conceptual model and the numerical model, we feel that the High Plains Aquifer System groundwater availability model is a good predictive tool for Mitchell County.

Model Review for Groundwater Management Area 2

After the review and discussion, the representatives of the groundwater conservation districts in Groundwater Management Area 2 asked me to provide the following comments regarding the recharge and pumping used in the draft model.

I have included the PowerPoint presentation used during the GMA 2 meeting that include aquifer-county level hydrographs comparing groundwater pumping estimates for the calibration period that are summarized in this letter.

Recharge

Recharge in the HPAS was assumed not to change with time. The draft HPAS report describes changes to steady state recharge using pilot points.

Some hydrographs in the GMA 2 portion of the model domain show variation in groundwater elevation that are likely due to variations in recharge. Using a constant recharge assumption results in a situation where pumping reduction is the only mechanism to cause groundwater elevation rises in the model.

Pumping

Pumping estimates in the HPAS were compared with TWDB estimates of groundwater pumping. The draft HPAS report documents how pumping locations were chosen, but does not elaborate further on how pumping volumes were developed beyond the conceptual model.

The review was completed on an aquifer-county level, and is summarized below:

- For the Ogallala Aquifer (model layer 1), the HPAS estimates of pumping do not always agree with the TWDB estimates. In several counties, the HPAS estimates are significantly lower.
- For the Edwards-Trinity (High Plains) Aquifer (model layer 2 in the GMA 2 area), HPAS pumping estimates are generally consistent with TWDB estimates.
- For the Dockum Aquifer (model layers 3 and 4), there are many counties where HPAS estimates and TWDB estimates are in agreement. However, there are others where there are significant differences.

During the GMA 2 meeting, there was consensus that the HPAS estimates are likely more accurate because of the fact that the calibration process requires that various inputs and outputs of the model must be internally consistent. However, the draft HPAS report includes no discussion of how these estimates were modified from the TWDB estimates, assuming that the TWDB estimates were used as a starting point. The draft HPAS report only describes modification of pre-1980 pumping. We recommend that additional documentation of post-1980 pumping is needed, especially given the differences between HPAS pumping estimates and TWDB estimates.

It is recommended that if it is found that the estimates in the HPAS are determined to be more accurate than the TWDB estimates of groundwater pumping, the TWDB database of groundwater pumping estimates be updated and revised to reflect these estimates.

Response to comments:

Recharge in the model is not varied with precipitation. This is because the conceptual model did not propose short term correlation between precipitation and recharge on a regional scale. The time lag for wetting and travel through the vadose zone is significant, as shown in the Bureau of Economic Geology work in the High Plains Aquifer System conceptual model report (Deeds and others, 2015), where breakthrough from agricultural return flow can take decades or longer to occur.

Recharge does increase through time in those areas that were identified to have enhanced recharge post-development. This change in recharge between pre- and post-development in some areas was identified as the most important regional factor in recharge rates, and was implemented in the numerical model.

The pumping in the High Plains Aquifer System groundwater availability model was not always based on the water use survey (called “TWDB estimates” by the commenter). The approach to developing pumping datasets is explained in the conceptual model report (Deeds and others, 2015), and the numerical model is consistent with this approach.

Comments and Responses for Review of "Predictive Simulations using Updated Draft Groundwater Availability Numerical Model for the High Plains Aquifer System" Memo and Model Files Received July 13, 2015 for TWDB Contract No. 1248301494 Dated August 31, 2015

The following memo and predictive model review comments shall be addressed and included in the final deliverables due August 31, 2015. The comments below were in response to a memo dated July 13, 2015 and an updated memo dated July 21, 2015. The memo that was dated July 21, 2015 was provided to the groundwater conservation districts in Groundwater Management Area 1 at their meeting on July 23, 2015 in Amarillo, Texas. Following these comments is a summary of a preliminary review of the updated model by a consultant working for Lone Wolf Groundwater Conservation District in Mitchell County, Texas.

Predictive Model Simulation (July 13 and July 21, 2015 memos and deliverables)

1. Please document approaches and assumptions for analyzing and summarizing the model results, so the values noted in the predictive model report/memo can be replicated. Some key aspects to document include:
   a. Using leap years when calculating modeled available groundwater;
   b. When evaluating Dockum available drawdown, the outcrop and subcrop were evaluated separately. Also please document that when model cells convert from confined to unconfined only the remaining confined portions were included in the calculations for both initial volumes and final volumes. Additionally, please document that confined and unconfined portions were considered based on initial zonation and not the simulated or predicted conditions in the aquifer. Also please note that the upper Dockum (layer 3) was not included in the evaluation of the Dockum Aquifer available drawdown;
   c. When evaluating the Rita Blanca Aquifer, Table 1 notes 2015 rates. Per follow up discussions on August 4, 2015, please update to 2012 rates and note that this does not qualify as a desired future condition. The desired future condition must reflect aquifer conditions not pumping assumptions. In addition, please include Hartley County in model results or discuss reason for excluding;
   d. For the Edwards-Trinity (High Plains) Aquifer, please clearly state that layers 1 and 2 in the High Plains Underground Water Conservation District No.1 were combined when evaluating fifty percent remaining in fifty years; and
   e. "Non-HPWD South" in Table 1 reflects the assumption used for the remainder of Groundwater Management Area 2 not within High Plains Underground Water Conservation District No.1.

These approaches and assumptions are documented in the "approach" section of the memo. Please not that we revised the simulations slightly to try to achieve fractions that were closer to the targets, so the model results are slightly different than those that were reviewed.

2. Please use the attributed grid GIS shapefiles developed by TWDB staff that was provided to INTERA on July 30, 2015. Our initial analysis of the modeled available groundwater values did not consistently agree with the tables in the memo dated July 21, 2015 partly due to using a different approach to assign political and aquifer boundaries, as well as assumptions about the number of days per year (average 365.25 for all years versus 365 for non-leap and 366 for leap years).

   TWDB grid assignments used.

3. Please update the attributed grid GIS shapefiles with the same "zones" noted in Table 1 in the July 21, 2015 memo. Specifically, delineate cells located in NPGCD West, NPGCD East, and non-HPWD South.

   Zone shapefile included in electronic files.

4. Please provide model results summarized using the same categories listed in Table 1 in the July 21, 2015 memo; for example, list model-calculated percent remaining of the Ogallala or of the Ogallala and Edwards-Trinity (High Plains) aquifers combined and remaining available drawdown for the Dockum Aquifer for each groundwater conservation district or non-groundwater conservation district area as appropriate. For consistency and to avoid confusion, we suggest changing abbreviation for High Plains Underground Water Conservation District No.1 from HPWD to HPUWCD.

   Results added.

5. For the Ogallala Aquifer, we get some variations in percent remaining. Wording of the desired future condition may address this deviation of results; for example, "The desired future condition of the Ogallala Aquifer within the Hemphill County Underground Water Conservation District is 80 percent of the volume groundwater in 2012 remaining in 2062 , plus or minus two percent ". Our analyses indicates the volumes remaining for the Ogallala Aquifer and remaining available drawdown/volumes for the Dockum from the model files provided are as follows:
   a. North Plains Groundwater Conservation District West has a 40/50 for the Ogallala Aquifer in Table 1. We get 39 percent of storage remaining in 2062. Table 1 lists 40/50 for the Dockum Aquifer and we get 42 percent of available drawdown (or volume) remaining in 2062.
   b. North Plains Groundwater Conservation District East has a 50/50 for the Ogallala Aquifer in Table 1. We get 52 percent of storage remaining in 2062.
   c. Hemphill Underground Water Conservation District has a 80/50 for the Ogallala Aquifer in Table 1. We get 79 percent of storage remaining in 2062.

d. Panhandle Groundwater Conservation District has 50/50 for the Ogallala Aquifer in Table 1 we get 50 percent of storage remaining in 2062. Table 1 lists 50/50 for the Dockum Aquifer and we get 52 percent of available drawdown (or volume) remaining in 2062.
e. High Plains Underground Water Conservation District No.1 has 50/50 for the Ogallala Aquifer in Table 1. We get 49 percent of storage remaining in 2062. Table 1 lists 50/50 for the Dockum Aquifer and we get 49 percent of available drawdown (or volume) remaining in 2062.

Modelled percent remaining or fraction drawdown is reported. The memo will not include a DFC statement, as GMA-1 has not finalized their choices for DFC.

July 28, 2015 Summary of Comments on Second Set of Draft High Plains Aquifer System Model Files on Behalf of the Lone Wolf Groundwater Conservation District

6. Model transmissivity is too low in the Dockum in Mitchell County.

7. Model recharge does not vary annually with precipitation, while measured hydrographs show annual water level variation with precipitation.

8. Model is not well-calibrated in Mitchell County, and not suitable for use in Mitchell County as a planning tool.

See previous comment response starting on page D-24, which addresses these comments.

This page intentionally left blank.