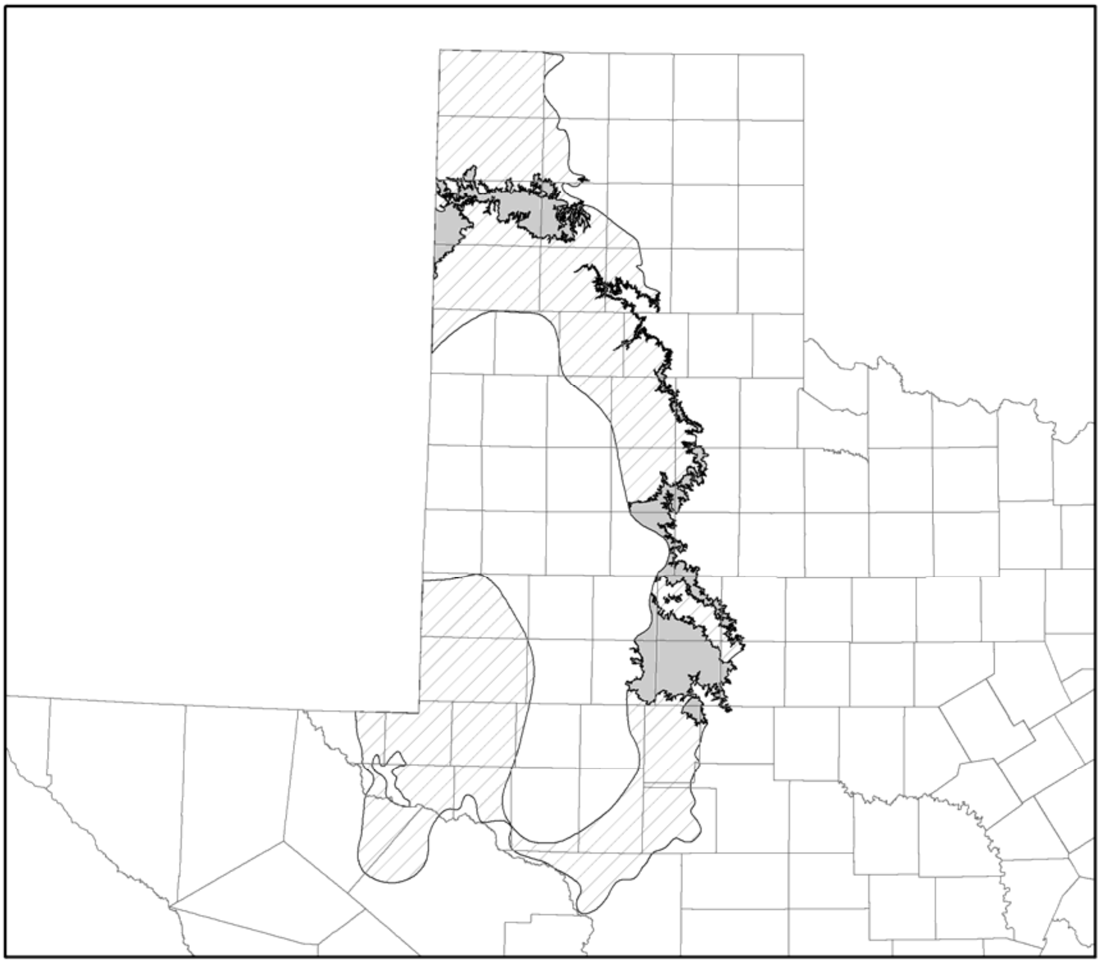

Quick Reference

for the Groundwater Availability Model

for the Dockum Aquifer

Quick Reference for the Groundwater Availability

Model for the Dockum Aquifer

August 18, 2009

Purpose: This reference guide is intended to assist individuals with using the groundwater availability model (GAM). It is primarily intended for people with experience in hydrogeology, groundwater modeling, MODFLOW, the TWDB GAM program, and the Dockum Aquifer. For more information on these subjects, please refer to the appropriate groundwater textbook or modeling reference.

This GAM is appropriate for regional evaluations of groundwater conditions in the Dockum Aquifer. It is not intended for site-specific use, such as small well fields or individual wells. For details on how the GAM for the Dockum Aquifer was developed and calibrated, and for limitations of this model, please refer to the report below (Ewing and others, 2008).

Unique or noteworthy aspects of this GAM are marked in bold and highlighted in red in this document.

Dockum Aquifer report reference:

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 – Final Report: contract report to the Texas Water Development Board, 510 p.

Please forward any comments, corrections, or suggestions to Wade Oliver at the Texas Water Development Board (Wade.Oliver@twdb.state.tx.us).

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1. Updates to this Quick Reference Guide

August 18, 2009 – Original version of this Quick Reference guide.

2. Versions of the Model

January 2009 – Version 1.01 – Initial GAM constructed by INTERA, Inc. in coordination with the Bureau of Economic Geology and LBG-Guton Associates (Ewing and others, 2008). Many of the files associated with the GAM for the Dockum Aquifer are referred to using the abbreviation “dckm.” A location map of the aquifer is shown in Figure 1.

3. Notes on Running the Model

- There are no problems with running the model (version 1.01). Both the steady-state and historic models take less than three minutes to run on a Dell PWS490 with a 3 GHz processor and 3.25 GB of RAM with Microsoft XP.

- **Creating MODFLOW datasets using Groundwater Vistas can take up to 25 minutes if the stream file (.str) is being written. Suggest only recreating the stream package if absolutely necessary.**

- **When running the model in Groundwater Vistas it is important to specify the standard MODFLOW 2000 executable mf2k.exe instead of the default .dll file to obtain results identical to the command line version of the model.**

- **The MODFLOW Drain package is used to simulate discharge from springs as well as evapotranspiration (ET). An ArcGIS shapefile delineating cells that represent ET from cells that represent springs can be found in the model geodatabase labeled "ET_SPR_STR_cells."**

- **The aquifers represented in Layer 1 of the groundwater availability model are only included in the model for the purpose of more accurately representing flow between these units and the Dockum Aquifer. This model is not intended to explicitly simulate flow in these overlying units (Ewing and others, 2008).**

- **The portions of Layer 2 of the model that represent the upper portion of the Dockum Aquifer are delineated in the model geodatabase in the file labeled "UpperDockumExtent." The active cells in Layer 2 outside of this boundary have a thickness of 1 foot and are only included in the model to allow flow between layers 1 and 3 (Ewing and others, 2008).**

4. Model Summary

422 Rows – Grid-spacing = 5,280 feet or 1 mile

212 Columns – Grid-spacing = 5,280 feet or 1 mile

3 Layers –

- **Layer 1: geologic units overlying the Dockum Aquifer including the Ogallala, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Pecos Valley, and Rita Blanca aquifers. This layer is not intended to explicitly represent the above units. Hydraulic heads in this layer are primarily controlled by the general-head boundary package.**
- **Layer 2: the upper portion of the Dockum Aquifer and 1-ft thick dummy cells included to simulate communication between layers 1 and 3**
- Layer 3: the lower portion of the Dockum Aquifer

Units – Feet and days

Coordinate System or Projection – The projection below was used during model development:

Projection: Albers Equal-Area
Horizontal Datum: North American Datum 1983
Vertical Datum: North American Vertical Datum 1988
Speroid: GRS 80
Longitude of Origin: -100.0
Latitude of Origin: 31.25
Standard Parallel 1: 27.5
Standard parallel 2: 35
False Easting: 4,921,250 (US Survey Feet)
False Northing: 19,685,000 (US Survey Feet)

Model Grid Origin (above coordinates) – X = 19,477,268; Y = 3,663,110 (to lower left of model grid). Model grid cells are aligned with the grid of the groundwater availability model for the southern portion of the Ogallala Aquifer.

Model Grid Rotation – No rotation

Steady-State Model – The steady-state GAM is included as the first stress period of the transient calibration model. The steady state model represents predevelopment conditions.

Transient Calibration-Verification Model – 27 stress periods, the first of which is steady-state. The subsequent 26 stress periods represent 1950 to 1997 with annual stress periods from 1975 to 1997 (Table 1). Each of the transient stress periods (i.e. all but the steady-state) are divided into the same number of time steps as the number of years that the stress period represents. The water levels, including dry cells, at the end of the transient period are shown in figures 2, 3, and 4 for layers 1, 2, and 3, respectively.

MODFLOW Version – MODFLOW 2000. This model was delivered in a format for use with Groundwater Vistas 4.

Aquifer Parameters – Active cells and boundary conditions used in the model are shown in figures 5, 6, and 7, for 1ayers 1, 2, and 3, respectively. Values for horizontal and vertical hydraulic conductivities were identical for each cell in the model and are shown in figures 8, 9, and 10 for the same layers. Storage properties were also identified for each cell in the model. The specific yield values for each cell are shown in Figure 11. Storativity values for layers 1, 2, and 3 are shown in figures 12, 13, and 14.

Table 1. Historic (transient calibration-verification) model stress periods

Stress Period	Length (days)	Time Period	Stress Period	Length (days)	Time Period
1	N/A	Steady-State	15	365	1985
2	3652	1950-1959	16	365	1986
3	3653	1960-1969	17	365	1987
4	1826	1970-1974	18	366	1988
5	365	1975	19	365	1989
6	366	1976	20	365	1990
7	365	1977	21	365	1991
8	365	1978	22	366	1992
9	365	1979	23	365	1993
10	366	1980	24	365	1994
11	365	1981	25	365	1995
12	365	1982	26	366	1996
13	365	1983	27	365	1997
14	366	1984			

5. MODFLOW Packages used in this GAM

- **Basic (BAS) Package** – Standard MODFLOW package required in all models
- **Block-Centered Flow (BCF) Package** – Standard MODFLOW package required in all models
- **Output Control (OC) Package** – Standard MODFLOW package required in all models
- **Well (WEL) Package** – The GAM uses the MODFLOW well package to represent rural domestic, municipal, manufacturing, power generation, mining, irrigation, and livestock pumpage. Pumpage included in the GAM in each county for each transient calibration-verification time period is summarized in Appendix A. The distribution of pumping at the end of the transient-calibration period of the model is shown in Figure 15.
- **Recharge (RCH) Package –** This GAM uses the MODFLOW recharge package to represent inflow from direct precipitation on the outcrop areas of the Dockum Aquifer. **This does not include Layer 1 of the model, representing the overlying units, in which the general-head boundary package is used.** Recharge values for each model cell were determined as a function of topography and accounted for additional recharge due to land use changes in the Colorado River outcrop.
- **Geometric Multigrid (GMG) Solver –** This GAM uses the GMG solver with 0.01 ft head change and 0.01 ft^3/d residual convergence criteria.
- **Drain (DRN) Package – The MODFLOW Drain package was used to simulate outflow to springs as well as evapotranspiration (ET). An ArcGIS shapefile delineating cells that represent ET from cells that represent springs can be found in the model geodatabase labeled "ET_SPR_STR_cells."**
- **General-Head Boundary (GHB) Package –** The MODFLOW GHB package was used in all the active cells in Layer 1 of the model to simulate flow from the Ogallala Aquifer and other overlying units. The conductance is set to 1000 ft^2/day.
- **Stream-Routing Package –** The MODFLOW stream-routing package was used to simulate interaction of the aquifer with streams and rivers within the outcrops of the upper and lower portions of the Dockum Aquifer.

Figure 1. Location map

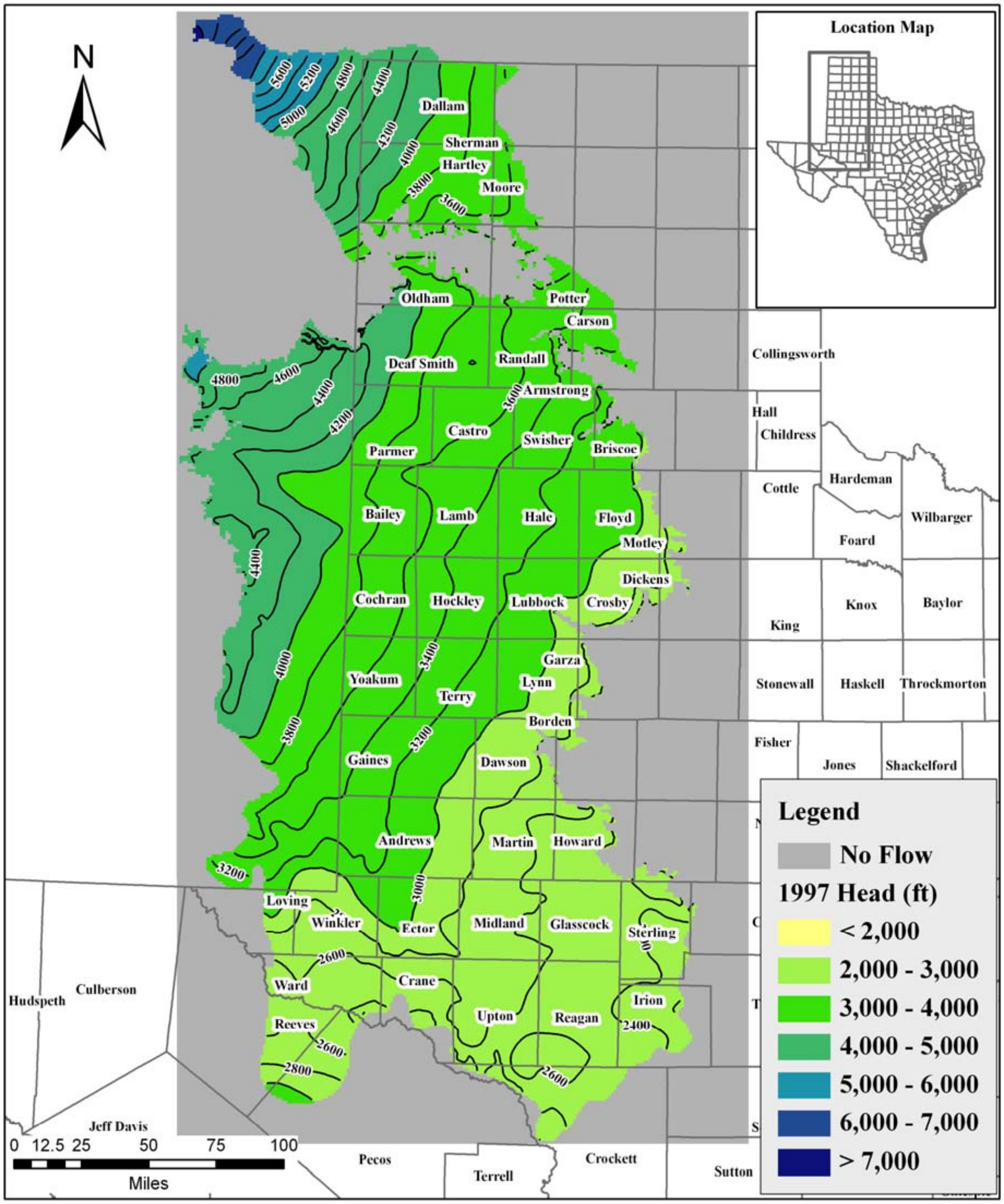

Figure 2. Water levels in Layer 1 at the end of the transient-calibration portion of the model (1997). Note that the units represented in this layer are only included in the model to simulate communication with the underlying Dockum Aquifer. Water levels in this layer are primarily controlled by the general-head boundaries.

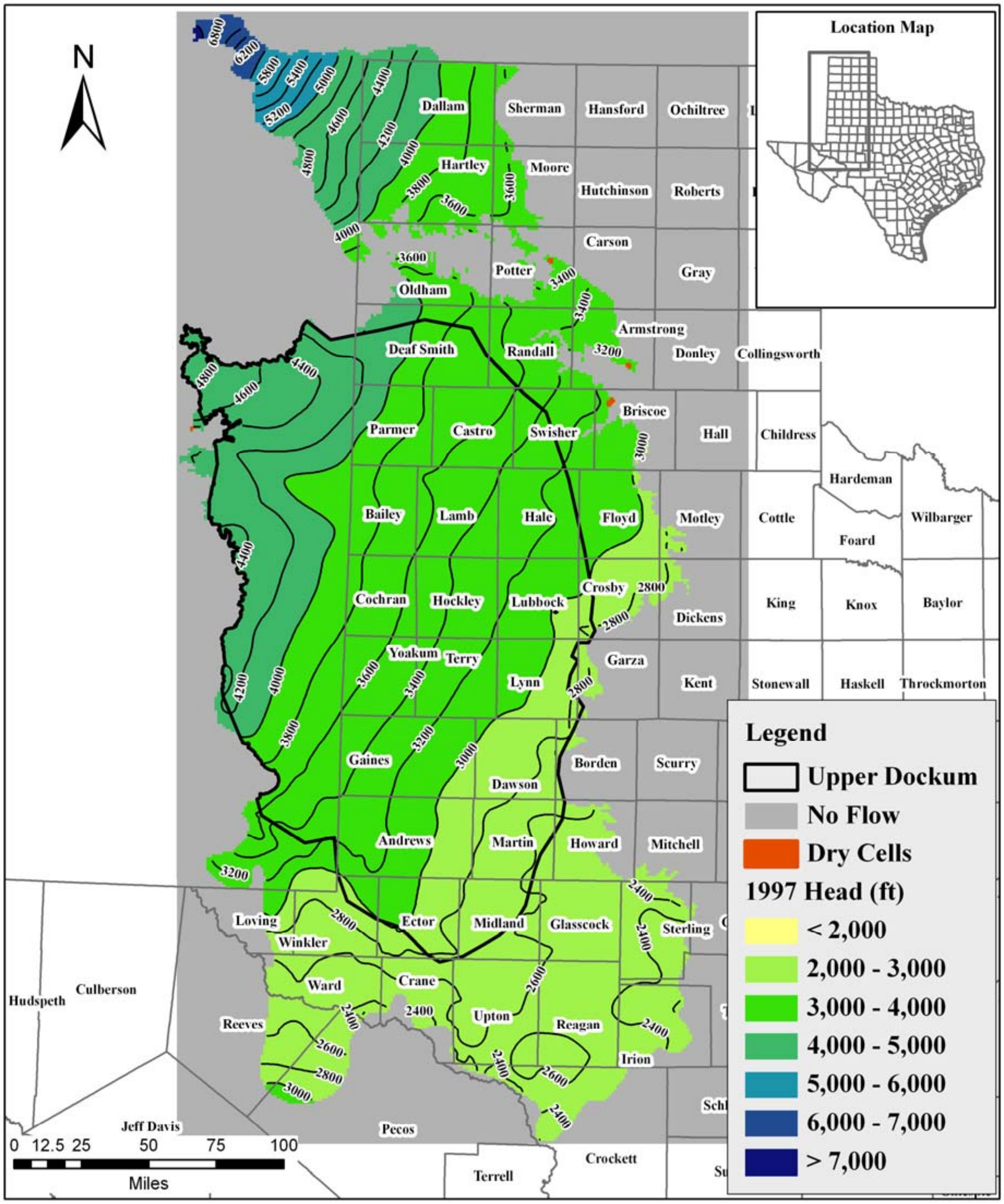

Figure 3. Water levels in Layer 2 at the end of the transient-calibration portion of the model (1997). Note that active cells outside the extent of the Upper Dockum are only included in the model to simulate flow between layers 1 and 3. There are 5 dry cells in Layer 2 at the end of the transient-calibration period.

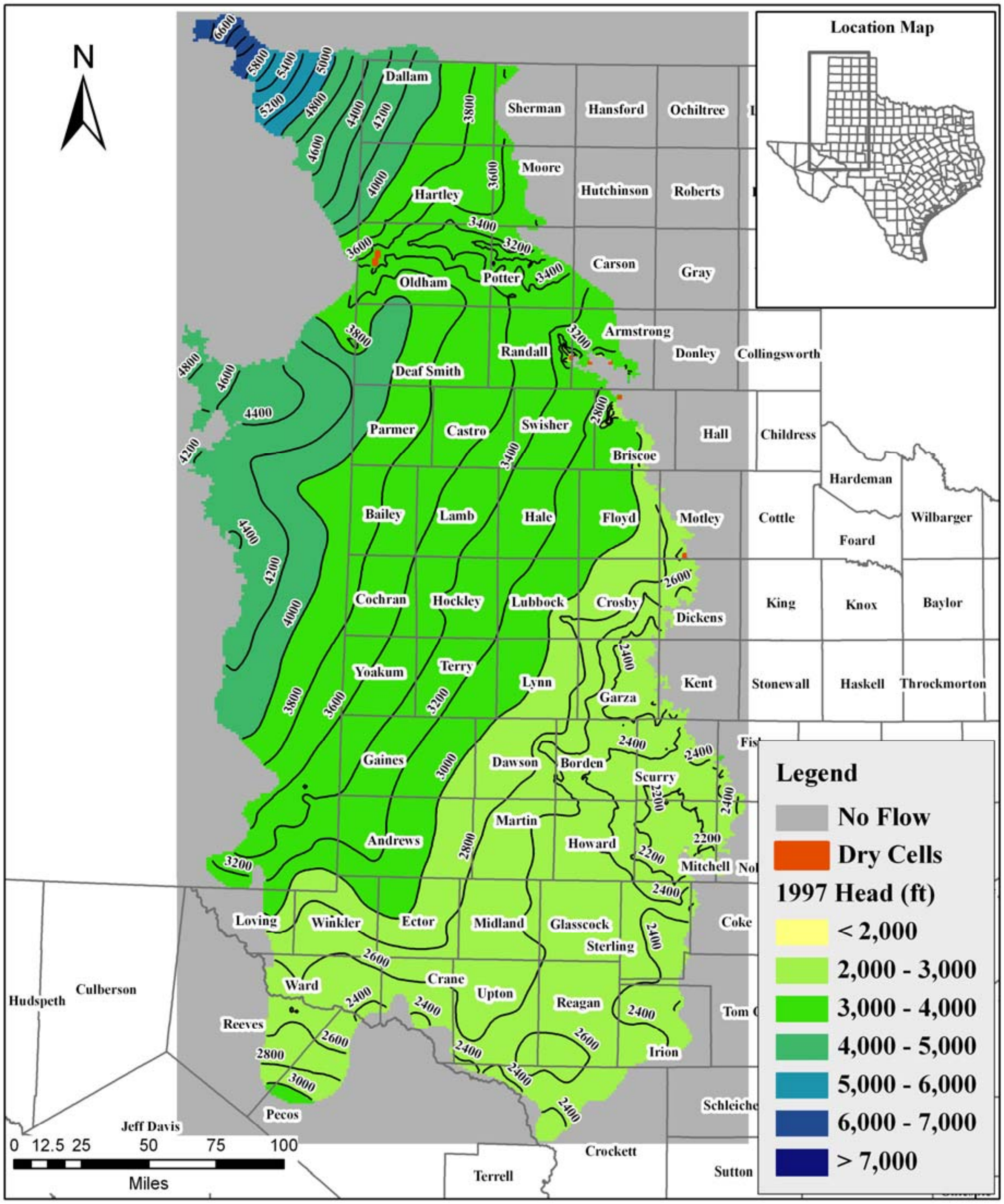

Figure 4. Water levels in Layer 3 at the end of the transient-calibration portion of the model (1997). There are 9 dry cells in Layer 3 at the end of the transient-calibration period.

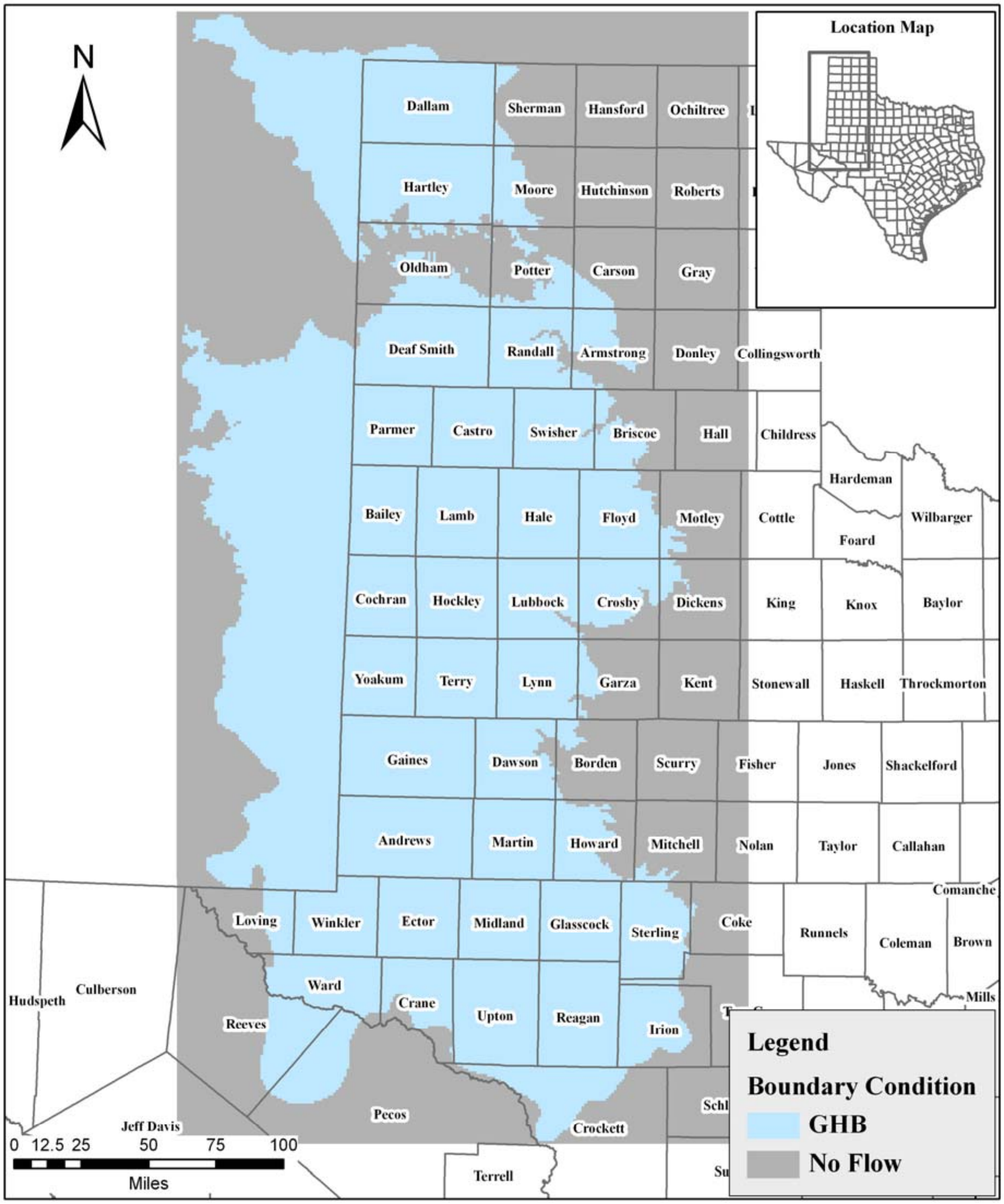

Figure 5. Active cells and boundary conditions in Layer 1.

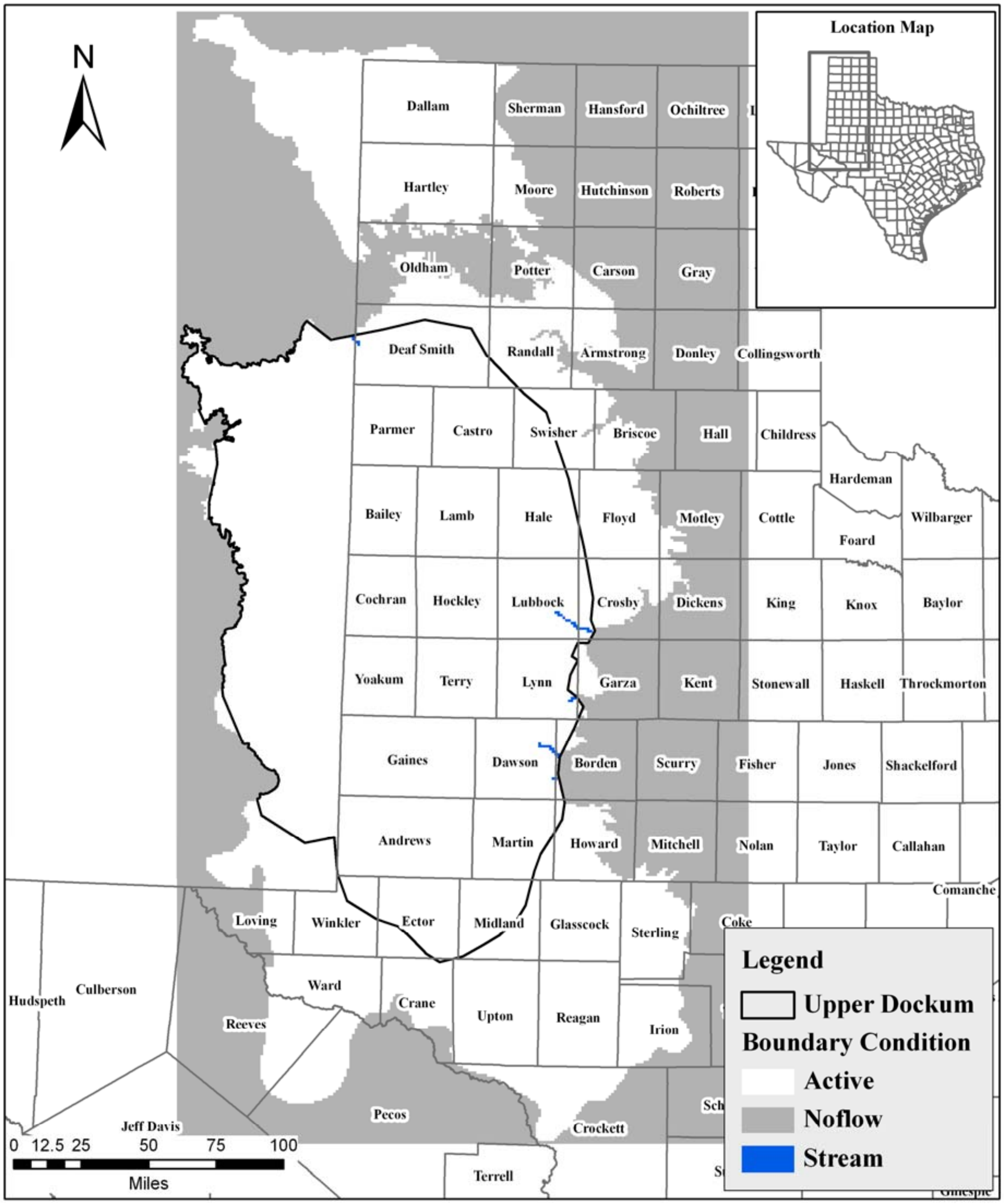

Figure 6. Active cells and boundary conditions in Layer 2. Note that active cells outside the extent of the Upper Dockum are only included in the model to simulate flow between layers 1 and 3.

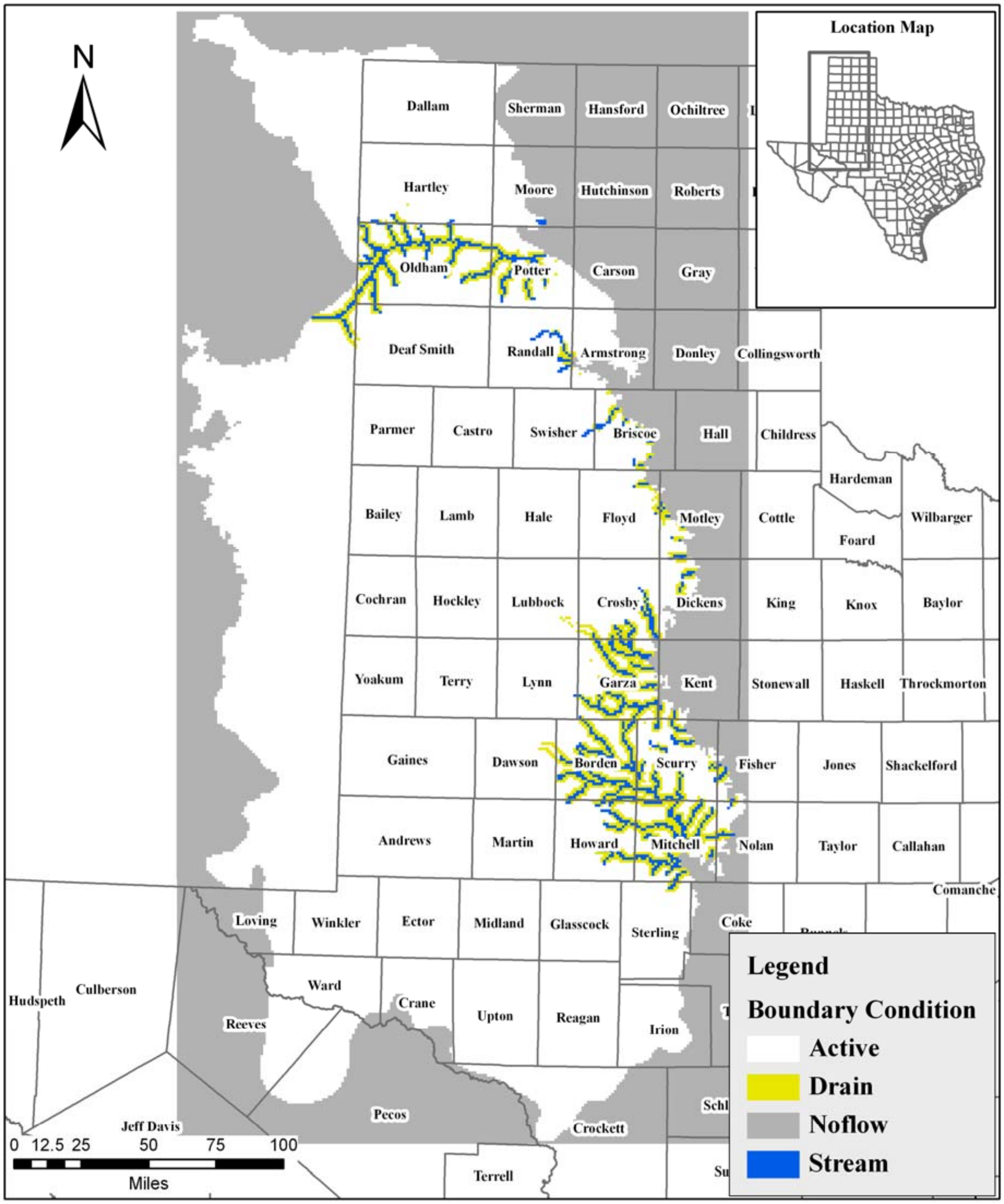

Figure 7. Active cells and boundary conditions in Layer 3

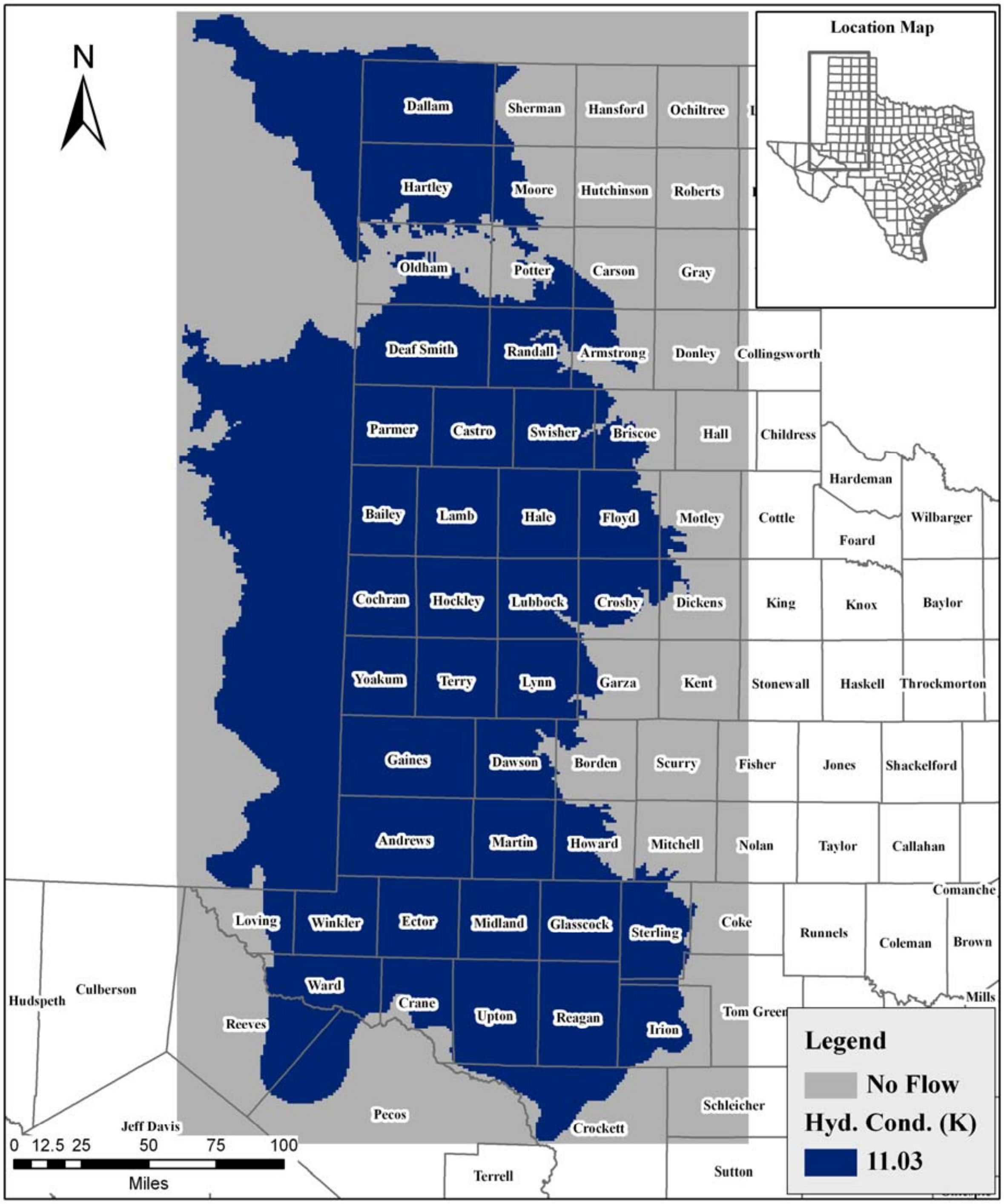

Figure 8. Hydraulic Conductivity (K) in Layer 1

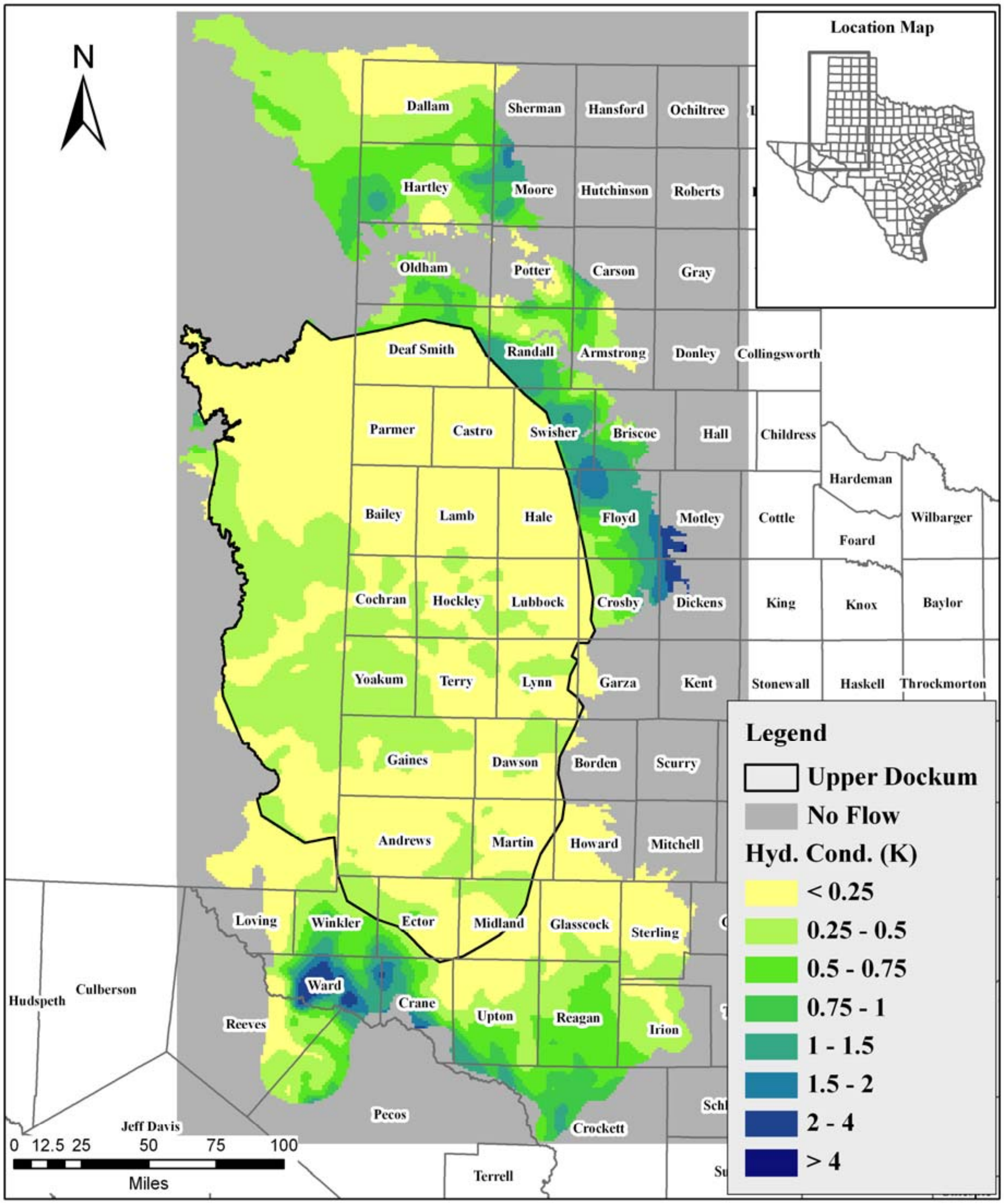

Figure 9. Hydraulic Conductivity (K) in Layer 2. Note that active cells outside the extent of the Upper Dockum are only included in the model to simulate flow between layers 1 and 3. The values for hydraulic conductivity outside the extent of the Upper Dockum are equivalent to those in Layer 3 shown in Figure 10 below.

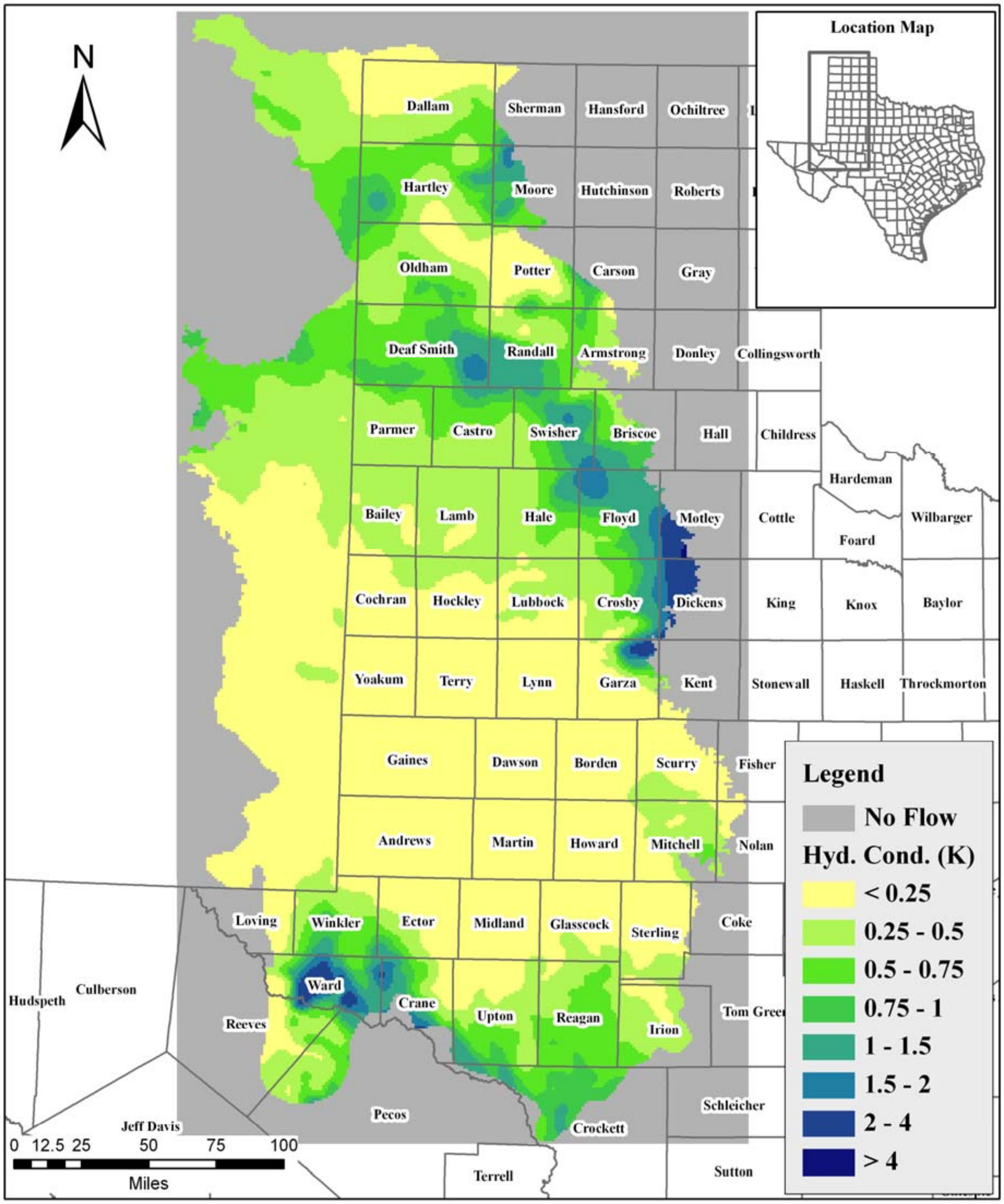

Figure 10. Hydraulic Conductivity (K) in Layer 3

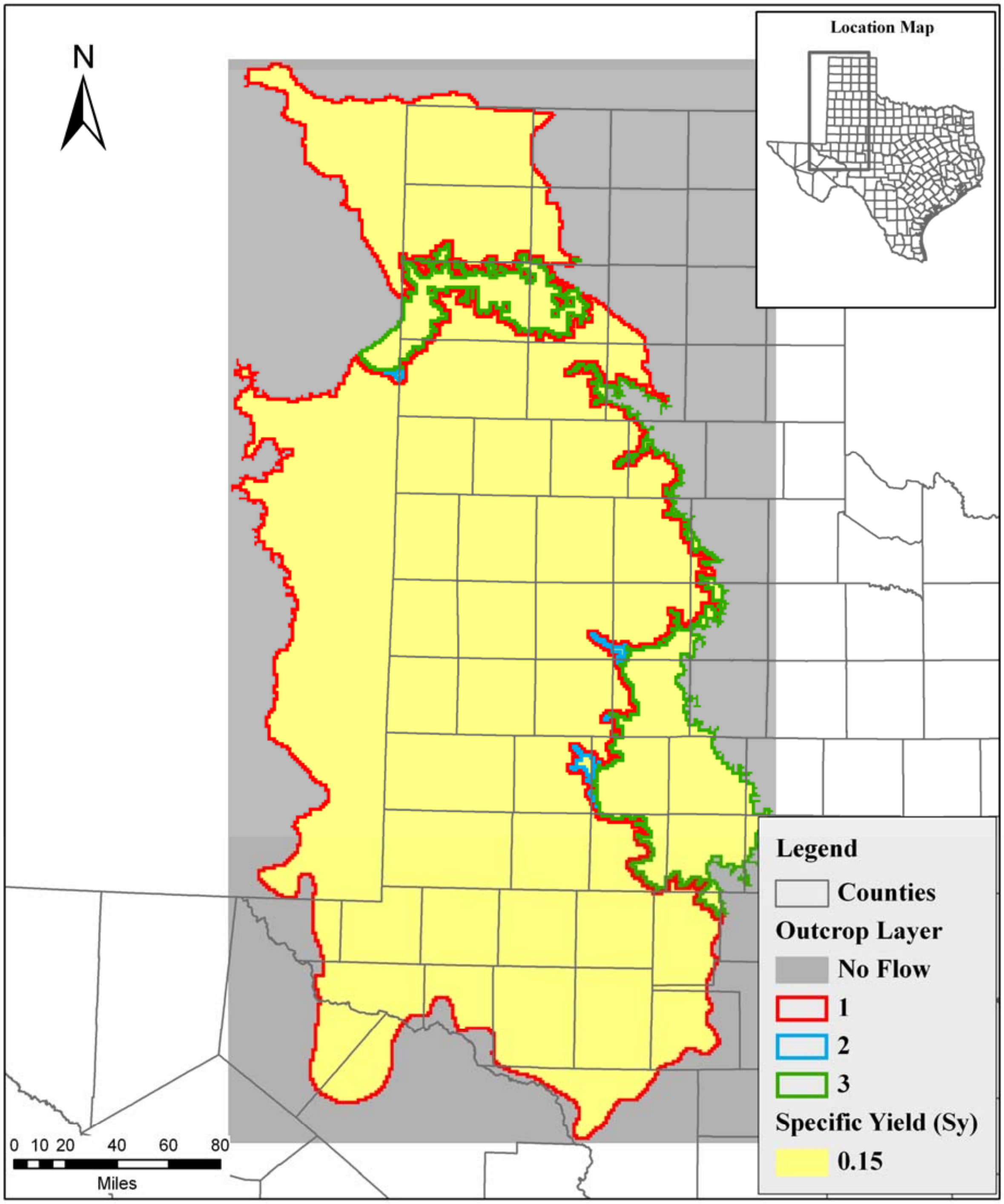

Figure 11. Specific Yield (Sy) for each layer in the model

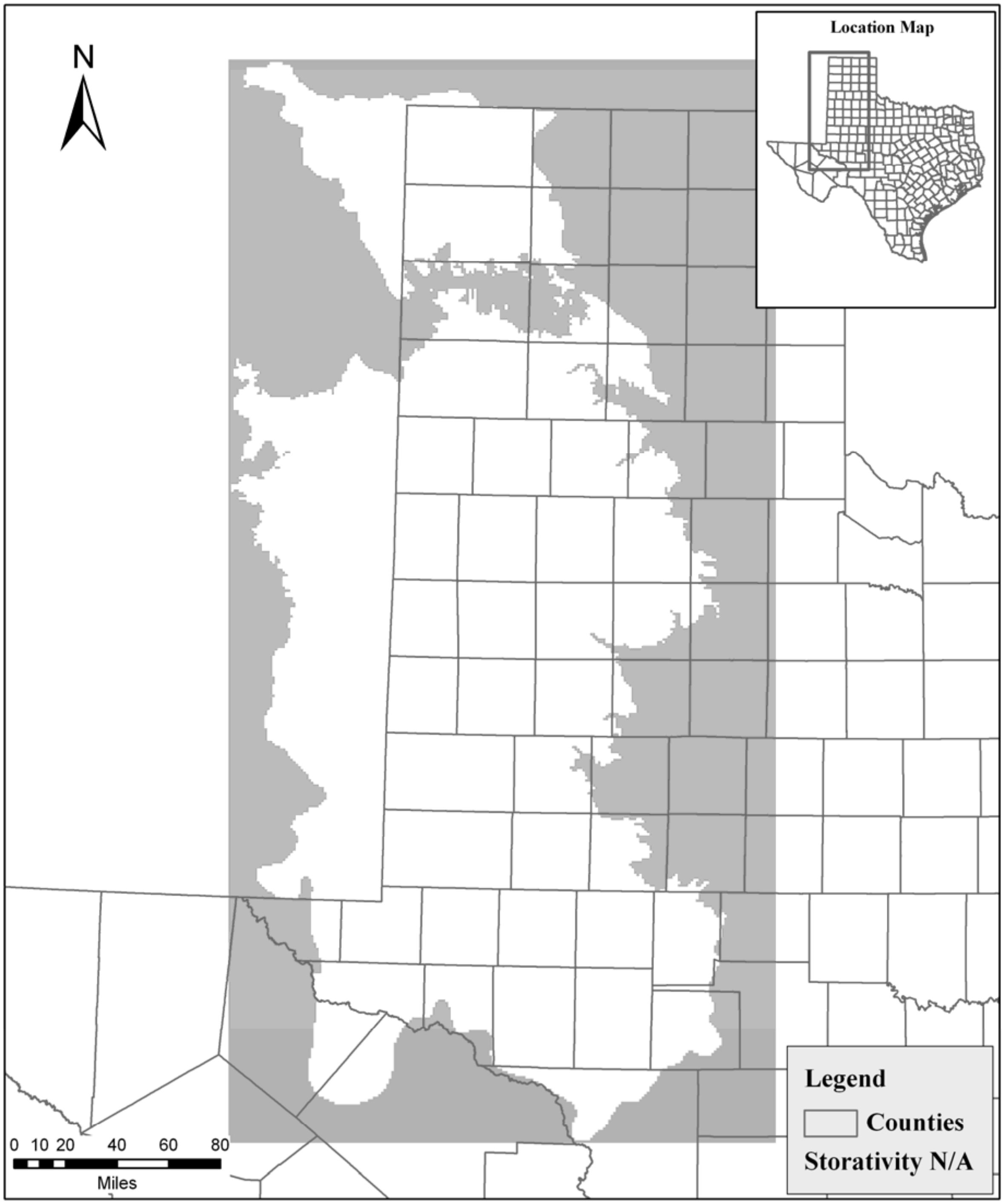

Figure 12. Storativity in Layer 1

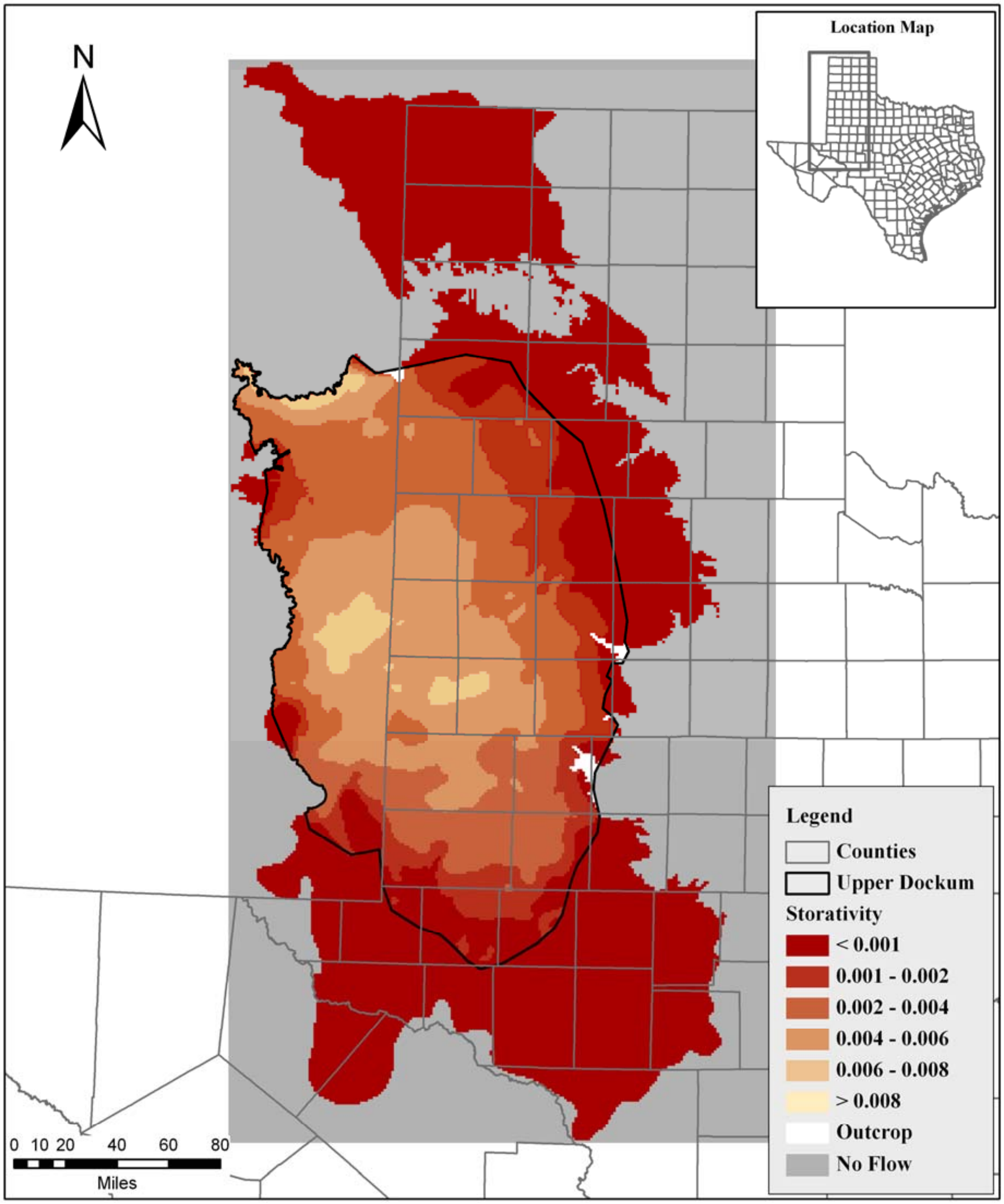

Figure 13. Storativity in Layer 2. Note that active cells outside the extent of the Upper Dockum are only included in the model to simulate flow between layers 1 and 3.

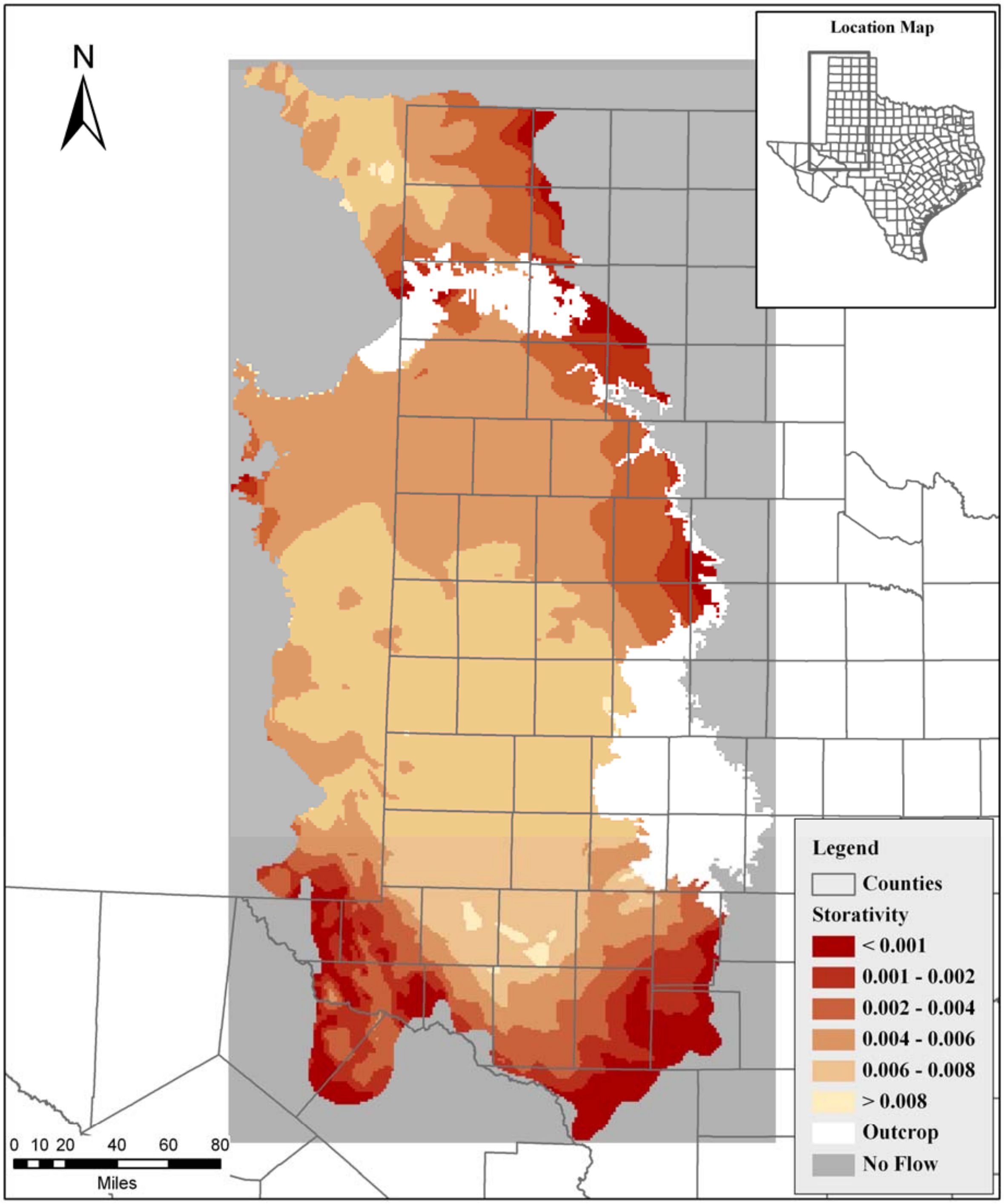

Figure 14. Storativity in Layer 3

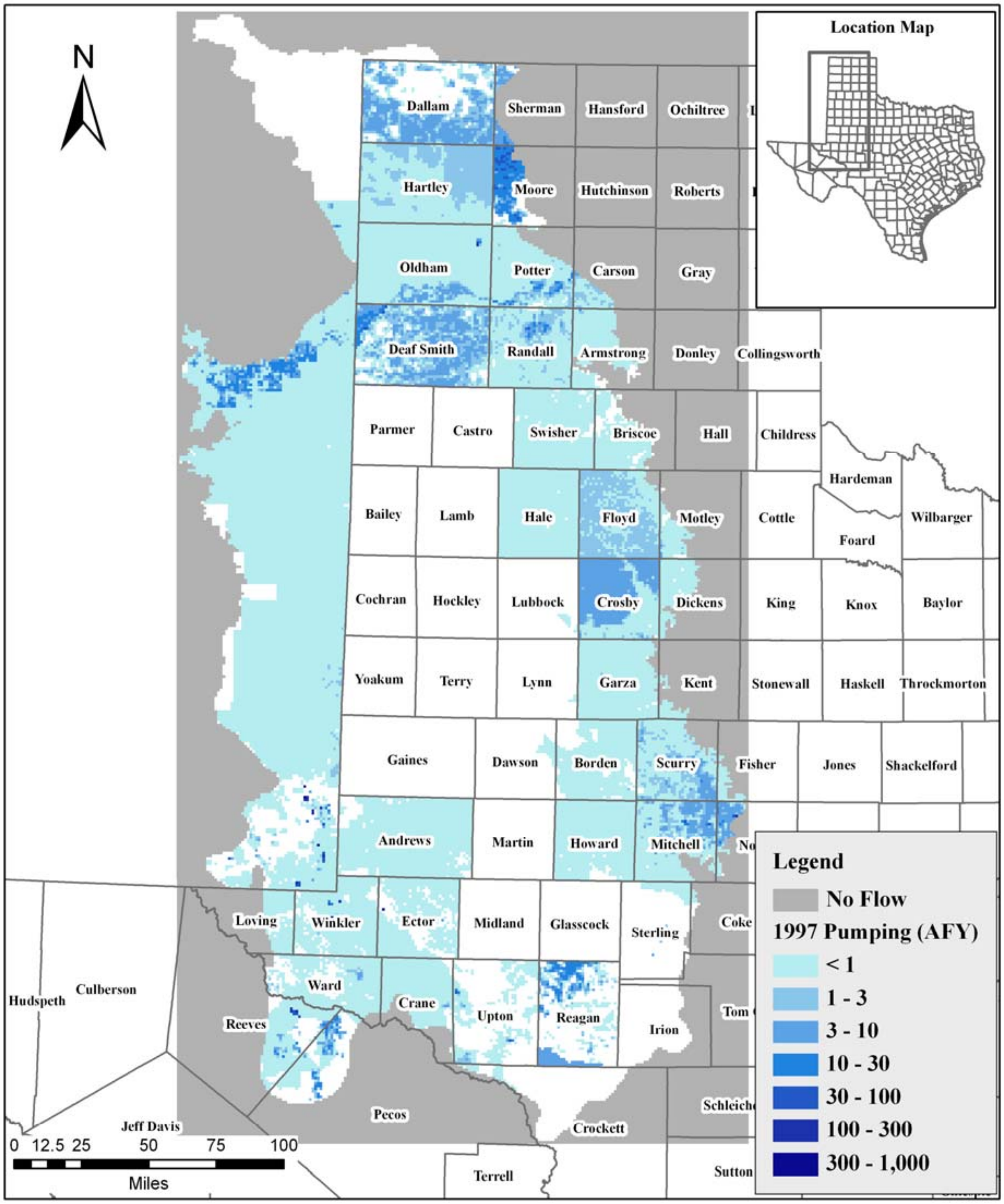

Figure 15. Pumpage distribution in Layer 3 for the last stress period of the transient-calibration portion of the model (1997). Note that pumping does not occur in layers 1 or 2 of the model. Pumping is in acre-feet per year (AFY).

Appendix A

Summary of Estimated Historic Pumpage

Table A-1. Historic pumpage included in the GAM by county (in acre-feet per year).

Time Period	Relation to Aquifer Boundary	Andrews	Armstrong	Bailey	Borden	Briscoe	Carson	Castro	Coke	Crane	Crockett	Crosby
Steady-State	Inside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-33	-167	-	-40	-25	-441	0	0	-382	-6	-4,592
1960-1969		-27	-139	-	-33	-21	-367	0	0	-318	-5	-3,827
1970-1974		-24	-122	-	-29	-18	-323	0	0	-280	-5	-3,368
1975		-24	-120	-	-28	-18	-316	0	0	-274	-4	-3,291
1976		-23	-117	-	-28	-17	-309	0	0	-267	-4	-3,215
1977		-23	-114	-	-27	-17	-301	0	0	-261	-4	-3,138
1978		-22	-111	-	-26	-17	-292	0	0	-253	-4	-3,039
1979		-21	-107	-	-25	-16	-281	0	0	-244	-4	-2,931
1980		-8	-103	-	-21	-17	-348	0	0	-18	-3	-2,818
1981		-11	-94	-	-20	-16	-313	0	0	-20	-3	-2,695
1982		-13	-84	-	-20	-16	-279	0	0	v	-3	-2,571
1983		-39	-75	-	-19	-15	-245	0	0	-24	-3	-2,448
1984		-41	-66	-	-19	-15	-211	0	0	-26	-3	-2,412
1985		-8	-58	-	-18	-12	-163	0	0	-29	-3	-1,008
1986		-6	-59	-	-19	-12	-144	0	0	-34	-3	-1,069
1987		-5	-57	-	-18	-12	-143	0	0	-42	-3	-836
1988		-3	-76	-	-18	-9	-144	0	-	-43	-3	-1,425
1989		-6	-77	-	-18	-10	-189	0	0	-28	-3	-1,834
1990		-38	-95	-	-18	-13	-279	0	0	-28	-3	-2,134
1991		-36	-80	-	-18	-11	-265	0	0	-27	-3	-2,260
1992		-10	-86	-	-18	-12	-245	0	0	-215	-3	-1,801
1993		-10	-82	-	-18	-12	-142	0	0	-459	-3	-3,053
1994		-10	-78	-	-18	-9	-147	0	0	-463	-3	-1,996
1995		-11	-82	-	-18	-8	-172	0	0	-436	-3	-2,712
1996		-11	-75	-	-18	-7	-159	0	0	-113	-3	-2,792
1997		-10	-80	-	-18	-6	-121	0	0	-19	-3	-2,798
Steady-State	Outside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		0	-	-1	-85	0	-	-	-	-51	-	-1,229
1960-1969		0	-	-1	-71	0	-	-	-	-43	-	-1,025
1970-1974		0	-	-1	-62	0	-	-	-	-37	-	-902
1975		0	-	-1	-61	0	-	-	-	-37	-	-881
1976		0	-	-1	-59	0	-	-	-	-36	-	-861
1977		0	-	-1	-58	0	-	-	-	-35	-	-840
1978		0	-	-1	-56	0	-	-	-	-34	-	-813
1979		0	-	-1	-54	0	-	-	-	-33	-	-785
1980		0	-	0	-44	0	-	-	-	-24	-	-754
1981		0	-	0	-43	0	-	-	-	-24	-	-721
1982		0	-	0	-42	0	-	-	-	-24	-	-688
1983		0	-	0	-41	0	-	-	-	-24	-	-655
1984		0	-	0	-40	0	-	-	-	-24	-	-646
1985		0	-	0	-39	0	-	-	-	-24	-	-269
1986		0	-	0	-40	0	-	-	-	-25	-	-286
1987		0	-	0	-39	0	-	-	-	-25	-	-223
1988		0	-	0	-39	0	-	-	-	-25	-	-381
1989		0	-	0	-38	0	-	-	-	-25	-	-491
1990		0	-	0	-39	0	-	-	-	-25	-	-571
1991		0	-	0	-39	0	-	-	-	-24	-	-605
1992		0	-	0	-39	0	-	-	-	-24	-	-482
1993		0	-	0	-38	0	-	-	-	-23	-	-818
1994		0	-	0	-38	0	-	-	-	-23	-	-535
1995		0	-	0	-38	0	-	-	-	-23	-	-726
1996		0	-	0	-38	0	-	-	-	-22	-	-748
1997		0	-	0	-38	0	-	-	-	-22	-	-750

Table A-1. Continued.

Time Period	Relation to Aquifer Boundary	Dallam	Dawson	Deaf Smith	Dickens	Ector	Fisher	Floyd	Garza	Hale	Hartley	Hockley
Steady-State	Inside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-3,917	-	-7,056	-35	-517	-38	-2,105	-16	-79	-2,966	-
1960-1969		-3,265	-	-5,880	-29	-431	-32	-1,754	-13	-65	-2,472	-
1970-1974		-2,873	-	-5,174	-25	-379	-28	-1,543	-11	-58	-2,175	-
1975		-2,808	-	-5,057	-25	-371	-27	-1,508	-11	-56	-2,126	-
1976		-2,742	-	-4,939	-24	-362	-27	-1,473	-11	-55	-2,076	-
1977		-2,677	-	-4,821	-24	-353	-26	-1,438	-11	-54	-2,027	-
1978		-2,592	-	-4,669	-23	-342	-25	-1,393	-10	-52	-1,963	-
1979		-2,501	-	-4,504	-22	-330	-24	-1,343	-10	-50	-1,894	-
1980		-1,743	-	-3,378	-22	-98	-30	-1,607	-8	-60	-1,404	-
1981		-1,892	-	-3,396	-21	-89	-27	-1,445	-8	-56	-1,447	-
1982		-1,833	-	-3,406	-21	-88	-24	-1,271	-8	-52	-1,506	-
1983		-1,774	-	-3,428	-20	-92	-21	-1,111	-8	-49	-1,565	-
1984		-1,715	-	-3,499	-20	-94	-18	-951	-8	-45	-1,613	-
1985		-1,535	-	-3,199	-19	-93	-19	-510	-6	-38	-1,653	-
1986		-1,741	-	-3,035	-17	-75	-17	-436	-4	-28	-1,052	-
1987		-1,473	-	-3,060	-15	-71	-16	-580	-4	-23	-1,397	-
1988		-1,456	-	-2,749	-13	-62	-18	-614	-6	-21	-841	-
1989		-1,719	-	-2,474	-14	-61	-16	-564	-8	-37	-1,067	-
1990		-1,966	-	-3,234	-15	-61	-17	-694	-7	-38	-1,049	-
1991		-955	-	-2,582	-13	-64	-21	-744	-6	-25	-968	-
1992		-1,274	-	-3,201	-12	-19	-12	-802	-5	-22	-1,514	-
1993		-2,296	-	-3,822	-15	-19	-14	-1,562	-7	-35	-1,440	-
1994		-2,167	-	-3,718	-13	-26	-13	-1,307	-9	-32	-1,552	-
1995		-2,343	-	-3,579	-11	-26	-13	-1,270	-9	-35	-1,536	-
1996		-2,342	-	-3,791	-18	-24	-14	-1,178	-12	-35	-1,667	-
1997		-2,757	-	-3,851	-13	-528	-11	-1,073	-10	-32	-1,705	-
Steady-State	Outside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-	-3	-23	0	0	-2	-35	-126	-238	-	-1,383
1960-1969		-	-2	-19	0	0	-1	-29	-105	-198	-	-1,152
1970-1974		-	-2	-17	0	0	-1	-26	-92	-175	-	-1,014
1975		-	-2	-17	0	0	-1	-25	-90	-171	-	-991
1976		-	-2	-16	0	0	-1	-25	-88	-167	-	-968
1977		-	-2	-16	0	0	-1	-24	-86	-163	-	-945
1978		-	-2	-15	0	0	-1	-23	-83	-158	-	-915
1979		-	-2	-15	0	0	-1	-22	-80	-152	-	-883
1980		-	-1	-6	0	0	-1	-27	-71	-183	-	-559
1981		-	-1	-7	0	0	-1	-24	-67	-170	-	-615
1982		-	-1	-8	0	0	-1	-21	-65	-157	-	-674
1983		-	-1	-9	0	0	-1	-19	-63	-147	-	-684
1984		-	-1	-10	0	0	-1	-16	-62	-137	-	-669
1985		-	-1	-12	0	0	-1	-8	-41	-114	-	-761
1986		-	-1	-11	0	0	-1	-7	-29	-85	-	-610
1987		-	-1	-11	0	0	-1	-10	-30	-70	-	-436
1988		-	-1	-6	0	0	-1	-10	-49	-63	-	-490
1989		-	-1	-7	0	0	-1	-9	-68	-112	-	-783
1990		-	-2	-7	0	0	-1	-12	-53	-114	-	-922
1991		-	-1	-8	0	0	-1	-12	-44	-76	-	-729
1992		-	-1	-13	0	0	-1	-13	-33	-67	-	-543
1993		-	-1	-15	0	0	-1	-26	-54	-107	-	-500
1994		-	-1	-14	0	0	-1	-22	-66	-95	-	-500
1995		-	-1	-16	0	0	-1	-21	-71	-105	-	-504
1996		-	-2	-17	0	0	-1	-19	-107	-107	-	-571
1997		-	-2	-18	0	0	-1	-18	-86	-98	-	-571

Table A-1. Continued.

Time Period	Relation to Aquifer Boundary	Howard	Kent	Loving	Lubbock	Lynn	Mitchell	Moore	Motley	Nolan	Oldham	Parmer
Steady-State	Inside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-23	-5	-16	-	-	-4,981	-9,943	-160	-1,674	-1,623	-2
1960-1969		-19	-4	-13	-	-	-4,151	-8,286	-134	-1,395	-1,352	-2
1970-1974		-17	-4	-12	-	-	-3,653	-7,292	-118	-1,227	-1,190	-2
1975		-16	-4	-12	-	-	-3,570	-7,126	-115	-1,199	-1,163	-2
1976		-16	-3	-11	-	-	-3,487	-6,960	-112	-1,171	-1,136	-2
1977		-15	-3	-11	-	-	-3,404	-6,794	-110	-1,144	-1,109	-2
1978		-15	-3	-11	-	-	-3,296	-6,579	-106	-1,107	-1,074	-1
1979		-14	-3	-10	-	-	-3,180	-6,347	-102	-1,068	-1,036	-1
1980		-8	-3	-20	-	-	-3,423	-4,310	-74	-820	-1,193	-1
1981		-9	-3	-15	-	-	-3,283	-4,316	-76	-802	-1,108	-1
1982		-9	-3	-14	-	-	-3,173	-4,312	-78	-788	-586	-1
1983		-9	-3	-6	-	-	-3,089	-4,328	-81	-840	-578	-1
1984		-9	-2	-6	-	-	-2,945	-4,364	-83	-825	-529	-1
1985		-10	-2	-3	-	-	-4,642	-4,052	-61	-881	-752	-1
1986		-9	-2	-3	-	-	-3,015	-3,861	-61	-638	-792	-1
1987		-10	-2	-3	-	-	-2,432	-4,222	-59	-549	-825	-1
1988		-9	-2	-4	-	-	-2,324	-3,001	-74	-650	-917	-1
1989		-10	-2	-7	-	-	-1,670	-5,418	-77	-913	-569	-1
1990		-11	-2	-7	-	-	-1,791	-5,569	-77	-796	-509	-1
1991		-11	-2	-7	-	-	-2,429	-5,337	-66	-699	-753	-1
1992		-16	-2	-7	-	-	-1,209	-4,840	-60	-586	-717	-1
1993		-11	-2	-6	-	-	-1,594	-5,334	-83	-957	-670	-1
1994		-12	-2	-7	-	-	-1,519	-5,079	-113	-876	-535	-1
1995		-10	-2	-7	-	-	-690	-4,839	-100	-690	-589	-1
1996		-12	-2	-6	-	-	-1,476	-5,496	-82	-1,059	-671	-1
1997		-13	-2	-7	-	-	-1,234	-5,033	-44	-721	-1,065	-1
Steady-State	Outside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-62	0	-1	-6	0	-2	-	0	-	-3	-
1960-1969		-51	0	-1	-5	0	-1	-	0	-	-2	-
1970-1974		-45	0	-1	-4	0	-1	-	0	-	-2	-
1975		-44	0	-1	-4	0	-1	-	0	-	-2	-
1976		-43	0	-1	-4	0	-1	-	0	-	-2	-
1977		-42	0	-1	-4	0	-1	-	0	-	-2	-
1978		-41	0	-1	-4	0	-1	-	0	-	-2	-
1979		-39	0	-1	-4	0	-1	-	0	-	-2	-
1980		-19	0	-1	-2	0	-1	-	0	-	-1	-
1981		-17	0	-1	-2	0	-1	-	0	-	-1	-
1982		-16	0	-1	-2	0	-1	-	0	-	-1	-
1983		-15	0	-1	-2	0	-1	-	0	-	-1	-
1984		-13	0	-1	-2	0	-1	-	0	-	-1	-
1985		-32	0	0	-2	0	-1	-	0	-	-1	-
1986		-32	0	0	-2	0	-1	-	0	-	-1	-
1987		-18	0	0	-3	0	-1	-	0	-	-1	-
1988		-25	0	0	-3	0	-1	-	0	-	-1	-
1989		-32	0	-1	-3	0	-1	-	0	-	-1	-
1990		-46	0	-1	-3	0	-1	-	0	-	-1	-
1991		-42	0	-1	-2	0	-1	-	0	-	-1	-
1992		-72	0	-1	-2	0	-1	-	0	-	-1	-
1993		-23	0	-1	-3	0	-1	-	0	-	-2	-
1994		-25	0	-1	-4	0	-1	-	0	-	-1	-
1995		-23	0	-1	-5	0	-1	-	0	-	-2	-
1996		-21	0	-1	-5	0	-1	-	0	-	-2	-
1997		-47	0	-1	-3	0	-1	-	0	-	-2	-

Table A-1. Continued.

Time Period	Relation to Aquifer Boundary	Pecos	Potter	Randall	Reagan	Reeves	Scurry	Sherman	Sterling	Swisher	Terry	Upton
Steady-State	Inside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-1,650	-1,339	-2,091	-413	-2,913	-6,608	-974	-30	-349	-	-101
1960-1969		-1,375	-1,116	-1,743	-344	-2,427	-5,507	-812	-25	-291	-	-84
1970-1974		-1,210	-982	-1,534	-303	-2,136	-4,846	-714	-22	-256	-	-74
1975		-1,183	-959	-1,499	-296	-2,088	-4,736	-698	-21	-250	-	-72
1976		-1,155	-937	-1,464	-289	-2,039	-4,626	-682	-21	-245	-	-71
1977		-1,128	-915	-1,429	-282	-1,990	-4,515	-665	-20	-239	-	-69
1978		-1,092	-886	-1,384	-273	-1,927	-4,372	-644	-20	-231	-	-67
1979		-1,053	-855	-1,335	-263	-1,859	-4,218	-622	-19	-223	-	-64
1980		-955	-709	-1,074	-115	-1,725	-8,903	-562	-20	-217	-	-50
1981		-1,029	-671	-1,060	-165	-1,598	-7,678	-523	-19	-201	-	-50
1982		-995	-634	-1,047	-185	-1,606	-6,397	-484	-18	-186	-	-50
1983		-954	-597	-1,033	-202	-1,584	-5,240	-445	-17	-170	-	-49
1984		-920	-559	-1,020	-218	-1,478	-4,082	-405	-17	-154	-	-49
1985		-816	-556	-989	-148	-1,470	-3,087	-439	-20	-150	-	-49
1986		-678	-595	-932	-158	-1,290	-2,588	-443	-14	-150	-	-49
1987		-620	-609	-883	-132	-1,170	-1,965	-337	-8	-104	-	-49
1988		-598	-778	-962	-147	-1,250	-1,912	-357	-8	-112	-	-49
1989		-664	-501	-798	-212	-1,028	-1,071	-448	-14	-108	-	-49
1990		-636	-455	-881	-238	-1,050	-1,404	-442	-14	-142	-	-48
1991		-612	-507	-1,010	-203	-1,223	-2,953	-464	-14	-140	-	-47
1992		-603	-481	-986	-155	-1,450	-947	-527	-14	-222	-	-46
1993		-741	-919	-1,084	-153	-1,579	-1,649	-409	-11	-159	-	-45
1994		-714	-618	-900	-197	-1,514	-1,087	-480	-10	-200	-	-44
1995		-825	-648	-1,008	-273	-1,172	-1,121	-487	-10	-195	-	-43
1996		-756	-671	-988	-279	-1,120	-1,835	-462	-11	-172	-	-42
1997		-777	-762	-953	-296	-1,217	-1,207	-485	-11	-161	-	-41
Steady-State	Outside Official Aquifer Boundary	-	-	-	-	-	-	-	-	-	-	-
1950-1959		-	-17	-2	-2,441	0	-4	-	-	-3	-5	-375
1960-1969		-	-14	-1	-2,034	0	-3	-	-	-2	-4	-312
1970-1974		-	-12	-1	-1,790	0	-3	-	-	-2	-4	-275
1975		-	-12	-1	-1,750	0	-3	-	-	-2	-4	-269
1976		-	-12	-1	-1,709	0	-3	-	-	-2	-4	-262
1977		-	-12	-1	-1,668	0	-3	-	-	-2	-4	-256
1978		-	-11	-1	-1,615	0	-2	-	-	-2	-4	-248
1979		-	-11	-1	-1,558	0	-2	-	-	-2	-3	-239
1980		-	-8	-1	-664	0	-3	-	-	-2	0	-202
1981		-	-8	-1	-967	0	-2	-	-	-2	-1	-195
1982		-	-8	-1	-1,086	0	-2	-	-	-2	0	-188
1983		-	-8	-1	-1,188	0	-2	-	-	-1	-1	-181
1984		-	-8	-1	-1,285	0	-2	-	-	-1	-3	-174
1985		-	-8	-1	-861	0	-2	-	-	-1	-9	-124
1986		-	-9	-1	-919	0	-1	-	-	-1	-9	-128
1987		-	-9	-1	-771	0	-1	-	-	-1	-10	-107
1988		-	-9	-1	-859	0	-1	-	-	-1	-5	-155
1989		-	-8	-1	-1,264	0	-1	-	-	-1	-4	-167
1990		-	-8	-1	-1,419	0	-1	-	-	-1	-1	-164
1991		-	-8	-1	-1,213	0	-2	-	-	-1	0	-193
1992		-	-7	-1	-923	0	-2	-	-	-2	0	-180
1993		-	-8	-1	-906	0	-2	-	-	-1	0	-168
1994		-	-8	-1	-1,164	0	-1	-	-	-2	-	-215
1995		-	-8	-1	-1,631	0	-2	-	-	-2	-	-226
1996		-	-7	-1	-1,666	0	-2	-	-	-1	-	-212
1997		-	-7	-1	-1,769	0	-2	-	-	-1	-	-179

Table A-1. Continued.

Time Period	Relation to Aquifer Boundary	Ward	Winkler
Steady-State	Inside Official Aquifer Boundary	-	-
1950-1959		-165	-5,837
1960-1969		-137	-4,865
1970-1974		-121	-4,281
1975		-118	-4,184
1976		-115	-4,086
1977		-113	-3,989
1978		-109	-3,862
1979		-105	-3,726
1980		-87	-3,224
1981		-85	-2,858
1982		-82	-3,394
1983		-79	-3,237
1984		-77	-3,803
1985		-85	-3,535
1986		-86	-2,506
1987		-85	-2,216
1988		-72	-2,577
1989		-76	-2,629
1990		-74	-2,352
1991		-73	-2,325
1992		-77	-2,296
1993		-80	-2,433
1994		-71	-2,432
1995		-68	-2,369
1996		-66	-2,227
1997		-66	-2,120
Steady-State	Outside Official Aquifer Boundary	-	-
1950-1959		-30	0
1960-1969		-25	0
1970-1974		-22	0
1975		-22	0
1976		-21	0
1977		-21	0
1978		-20	0
1979		-19	0
1980		-27	0
1981		-23	0
1982		-18	0
1983		-14	0
1984		-9	0
1985		-29	0
1986		-29	0
1987		-28	0
1988		-1	0
1989		-7	0
1990		-6	0
1991		-4	0
1992		-5	0
1993		-18	0
1994		-12	0
1995		-9	0
1996		-8	0
1997		-9	0