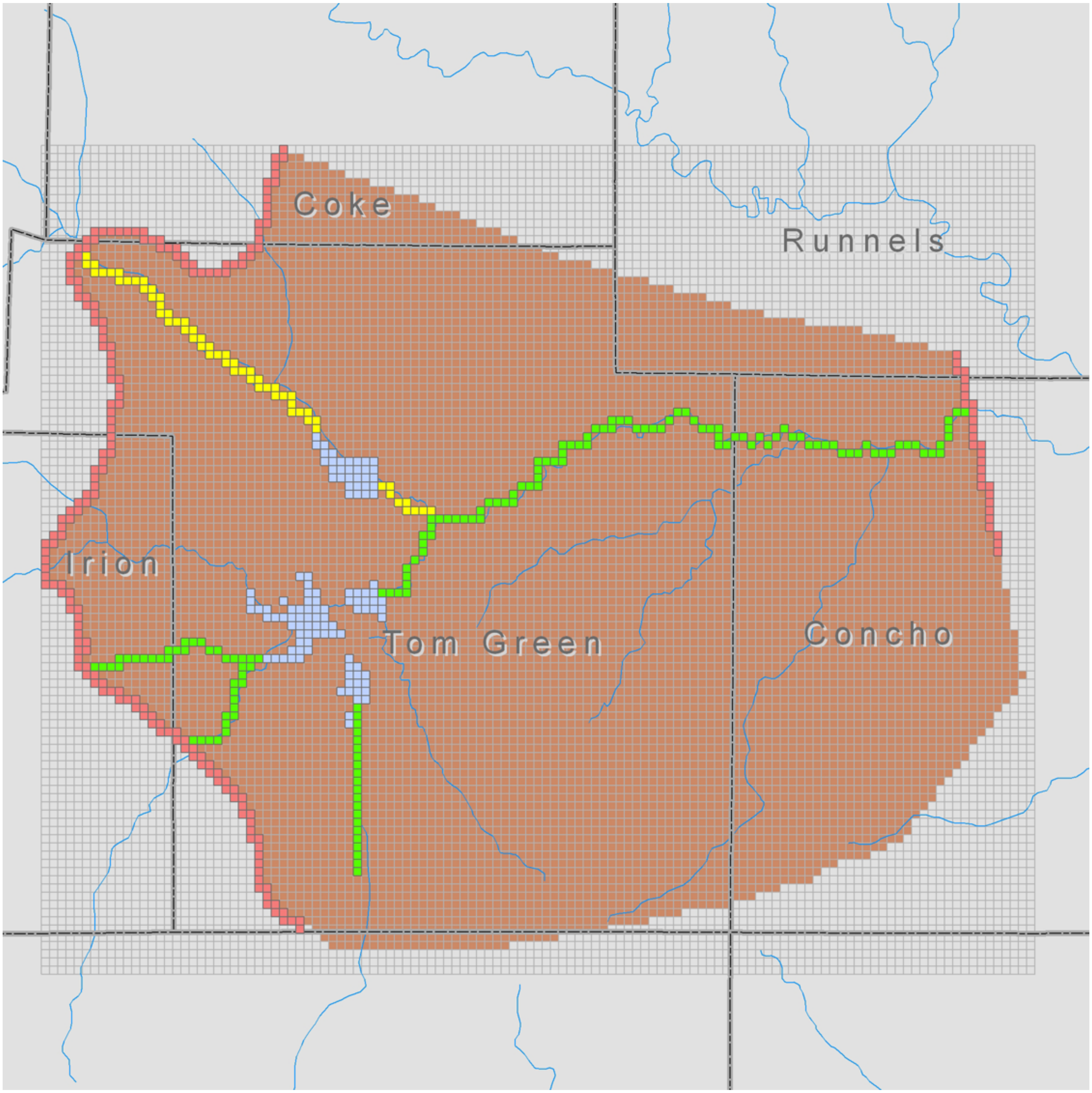

QuickReference

for the Groundwater Availability Model

of the Lipan Aquifer

QuickReference for the Groundwater Availability Model of the Lipan Aquifer

September 18, 2009

Purpose: This reference guide is intended to assist people with using the GAM. It is primarily intended for people with experience in hydrogeology, groundwater modeling, MODFLOW, the TWDB GAM program, and the Lipan 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 Lipan Aquifer. It is not intended for site-specific use, such as small well fields or individual wells. For details on how the Lipan Aquifer GAM was developed, calibrated, and for limitations of this model, please refer to the Lipan Aquifer GAM report (Beach and others, 2004).

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

Lipan Aquifer GAM report reference:

Beach, J. A., Burton, S., and Kolarik, B., 2004, Groundwater availability model for the Lipan Aquifer in Texas: contract report to the Texas Water Development Board, 246 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 QuickReference Guide

December 1, 2006—Original version of this QuickReference guide.

April 17, 2008—Corrected information page at start of the reference, which previously had references to the West Texas Bolsons and Igneous Aquifer (that QuickReference was used as a template for this one).

September 18, 2009—Updated contact information for comments, corrections, and suggestions.

2. Versions of the Model

December 1, 2006—Version 1.01—Initial GAM constructed by LBG-Guyton Associates. The initial model was provided in PMWin and standard MODFLOW-96 model files. This version was imported into Groundwater Vistas with no changes to the original model files.

3. Notes on Running the Model

- There are no problems or special considerations for running the original model version (Version 1.01). Both the historic and predictive models take less than 5 minutes to run on a Dell PWS470 with a 3 GHz processor and 1 GB of RAM with Microsoft Windows XP.
- **If using pumpage from the last stress period as the basis for predictive model runs, it is necessary to use 1998 pumpage for this GAM rather than 1999 pumpage. This is because 1999 estimated historic pumpage appears to be too low in the existing well file.**

4. Model Summary

101 Rows—Grid-spacing = **2,640 feet**

121 Columns—Grid-spacing = **2,640 feet**

1 Layer

- **Layer 1—**Lipan Aquifer (Figure 1)—This includes the Quaternary Leona Formation, the underlying Permian Formations, and the Edwards-Trinity (Plateau) Aquifer to the west, south, and north. The basis for the extent of the model boundaries for the Lipan Aquifer was developed using the boundaries recognized by TWDB prior to the boundary changes discussed in the 2007—Water For Texas state water plan.

Units—feet and days

Coordinate System or Projection—The model was developed in the GAM projection (shown below).

Projection: Albers Equal Area Conic
Units: feet
Datum: NAD83
Spheroid: GRS80
1st Std. Parallel: 27 30 00 (27.50000)
2nd Std. Parallel: 35 00 00 (35.00000)
Central Meridian: -100 00 00 (-100.00000)
Latitude of Projection: 31 15 00 (31.25000)
False Easting: 4921250.00000 (US survey feet)
False Northing: 19685000.00000 (US survey feet)

Model Grid Origin (GAM Coordinates)—X=4,663,606 ; Y=19,612,470 (to lower left of model grid (i.e. Row 101, Column 1)

Model Grid Rotation—0 degrees

Steady-State Model—Included as the first stress period in the transient model. The steady-state stress period is 10,000,000 days in length and represents pre-1980's aquifer conditions.

Transient Calibration-Verification Model—21 stress periods (pre-1980–1999)—Note: The final stress period represents the year 1999 (Table 1).

MODFLOW Version—MODFLOW-96

Aquifer Parameters—Aquifer parameters for each of the model layers are summarized in Table 2 below. Distribution of hydraulic conductivities and specific yields are shown in Figures 2 and 3, respectively.

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

Stress Period	Length (days)	Year
1	10,000,000	pre-1980
2	366	1980
3	365	1981
4	365	1982
5	365	1983
6	366	1984
7	365	1985
8	365	1986
9	365	1987
10	366	1988
11	365	1989
12	365	1990
13	365	1991
14	366	1992
15	365	1993
16	365	1994
17	365	1995
18	366	1996
19	365	1997
20	365	1998
21	365	1999

Table 2. Aquifer properties.

Layer	Hydraulic Conductivity	Specific Yield
1	4 to 20 feet per day	0.05 or 0.005

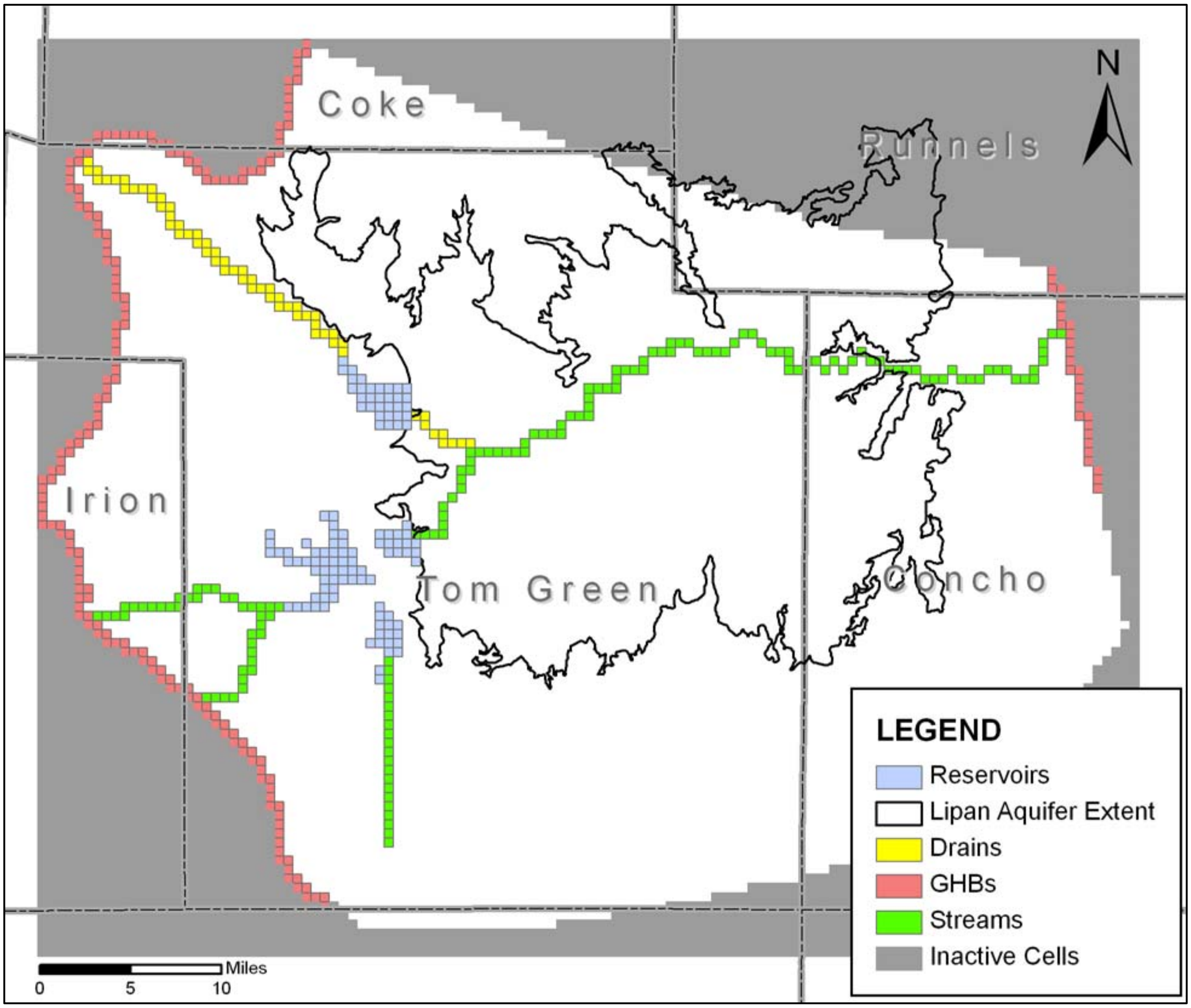

Figure 1. Active cells and boundary conditions in layer 1.

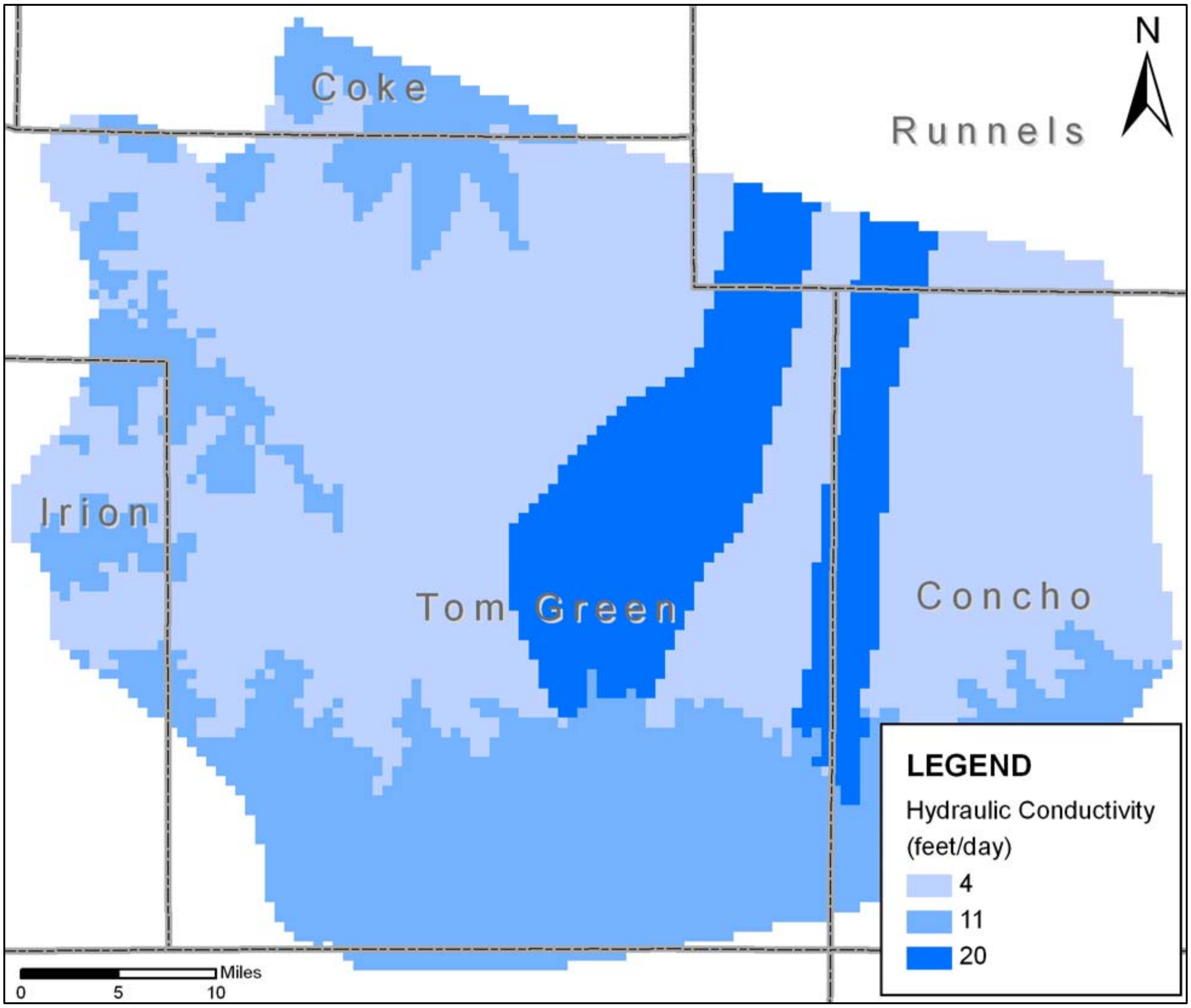

Figure 2. Calibrated horizontal and vertical hydraulic conductivities in Layer 1.

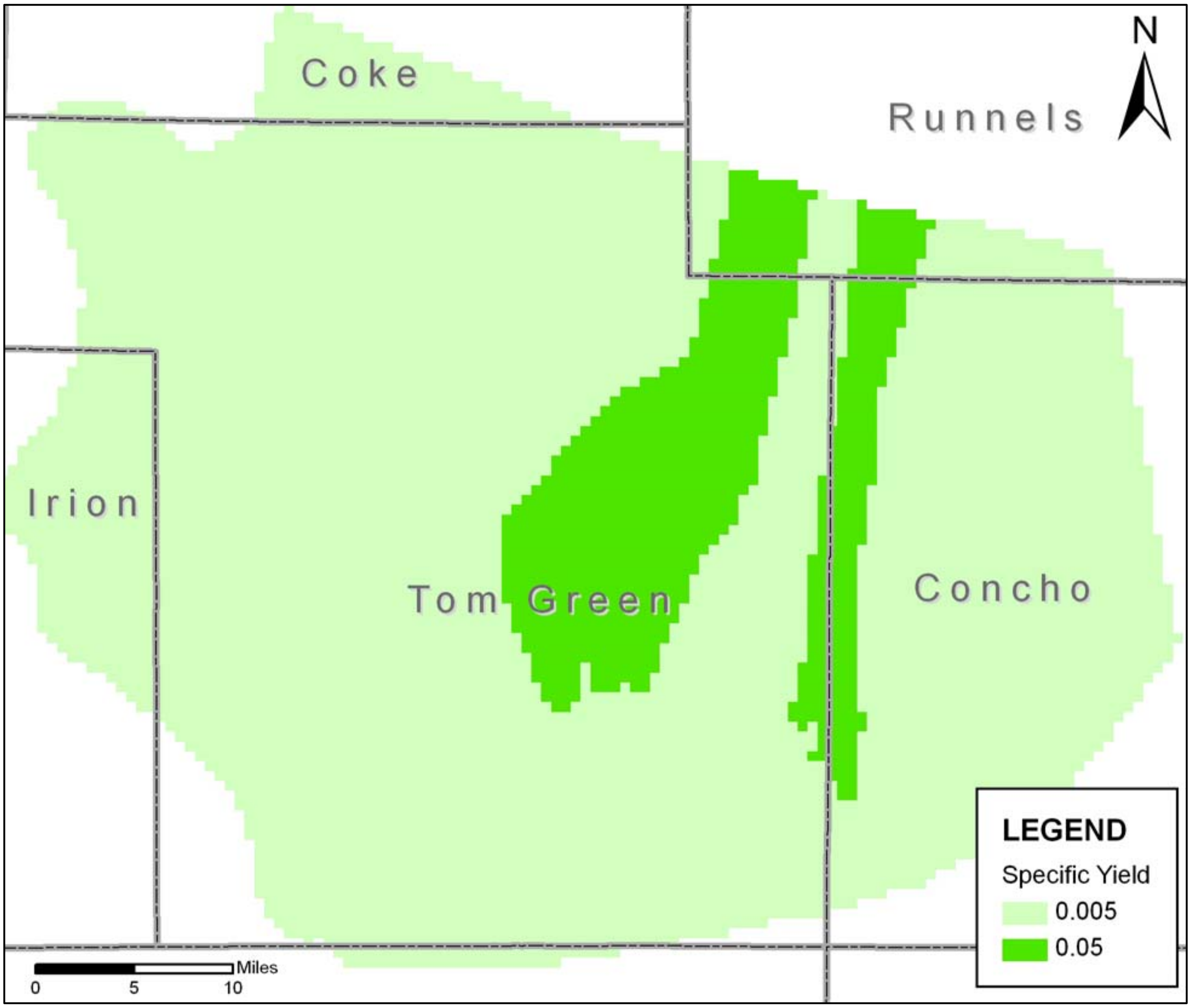

Figure 3. Calibrated specific yields in Layer 1.

5. MODFLOW Packages used in the 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)—**Standard MODFLOW package required in all models.
- **Well (WEL) Package—**The GAM uses the MODFLOW well package to represent rural domestic, municipal, industrial, irrigation, and livestock pumpage. Pumpage included in each county in the GAM during the transient calibration-verification time period is summarized in Appendix A.
- **Recharge (RCH) Package—**The GAM uses the MODFLOW recharge package to model recharge to the aquifer from precipitation. Distribution of steady-state recharge rates are based on annual precipitation and is shown in Figure 4. Transient values were created by multiplying the steady-state rates by a factor directly correlated to precipitation in the model area. The factors used to create the transient recharge rates are summarized in Table 3.

  Drought-of-Record- The drought-of-record for this GAM has been defined as a seven-year time period from 1950 to 1956.
- **Strongly Implicit Procedure (SIP) Solver Package—**This GAM uses the SIP solver.
- **Drain (DRN) Package—**The GAM uses drains to simulate discharge to the North Concho River. Locations of the drain cells are shown in Figure 1. Drains were used instead of the stream-routing package because historically there has been little or no flow in this river. Drain elevations were assigned based on the land surface elevation. The conductance of all drain cells to the northwest of O.C. Fisher Reservoir was 132,000 feet squared per day, and the conductance of all other drain cells was 26,400 feet squared per day. The total number of drain cells included the model is summarized in Table 4.
- **Reservoir (RES) Package—**The GAM uses reservoirs to simulate the interaction of the aquifer with several reservoirs in the model area, including Twin Buttes and O.C. Fisher Reservoirs and Lake Nasworthy. Locations of the reservoir cells are shown in Figure 1. Reservoir parameters are summarized in Table 5 below. The total number of reservoir cells included the model is summarized in Table 4.
- **Stream (STR) Package—**The GAM uses the MODFLOW stream-routing package to model the interaction between the aquifer and major streams, rivers, and springs in the area. The streams and rivers that were included are the Concho River, the South Concho River, Dove Creek, and Spring Creek. Locations of the stream cells are shown in Figure 1. Springflow at the head of selected stream segments was also incorporated using the stream package. The streams included

in the GAM are summarized in Table 6. The total number of stream cells included the model is summarized in Table 4.

- **General-Head Boundary (GHB) Package**—The GAM uses GHBs to model the eastern and western boundaries of the model area. Locations of the GHB cells are shown in Figure 1. GHB elevations are based on observed water levels in 1981. The western boundary was set to match the 2,100-foot water elevation contour, and the eastern was set at variable contours. Te GHB conductance of the western boundary was 2,460 feet squared per day, and the conductance of the eastern boundary was 1,001 feet squared per day. The total number of GHB cells included the model is summarized in Table 4.
- **Evapotranspiration (EVT) Package**—The GAM uses the MODFLOW evapotranspiration package to simulate discharge of water to evaporation and transpiration. ET rates and extinction depths were based on vegetation types. ET rates are shown in Figure 5. Extinction depths are shown in Figure 6. All ET parameters were held constant for all transient stress periods.

Table 3. Factors applied to mean annual precipitation to create historic recharge rates.

Year	Recharge Factor
1980	1.20
1981	1.27
1982	1.00
1983	0.75
1984	0.90
1985	0.97
1986	1.51
1987	1.34
1988	0.72
1989	0.82
1990	1.32
1991	1.41
1992	1.17
1993	0.75
1994	0.95
1995	1.09
1996	0.78
1997	1.08
1998	0.66
1999	0.55

Table 4. Number of drain, stream, reservoir, and GHB cells included in the GAM.

	Total
Drains	59
Streams	154
Reservoirs	112
GHBs	209

Table 5. Summary of reservoir parameters.

Reservoir Name	Reservoir Number	Land-surface Elevation (BRES) (feet)	Hydraulic Conductivity (feet per day)	Bed Thickness (feet)	Stage (feet above msl)
Twin Buttes	1	1,900	0.01	1	1,940
O.C. Fisher	3	1,880	0.01	1	1,908
Lake Nasworthy	2	1,840	0.01	1	168

Table 6. Summary of stream parameters.

Stream/River	Segment	Number of Reaches	Initial Flow (cubic feet per day)	Conductance (square feet per day)	Width (feet)
Concho River	4	93	3,157,920	79,200	20
South Concho River	1	21	728,000	58,200	5
Dove Creek	2	17	150,000	58,200	5
Spring Creek	3	23	128,456	58,200	5

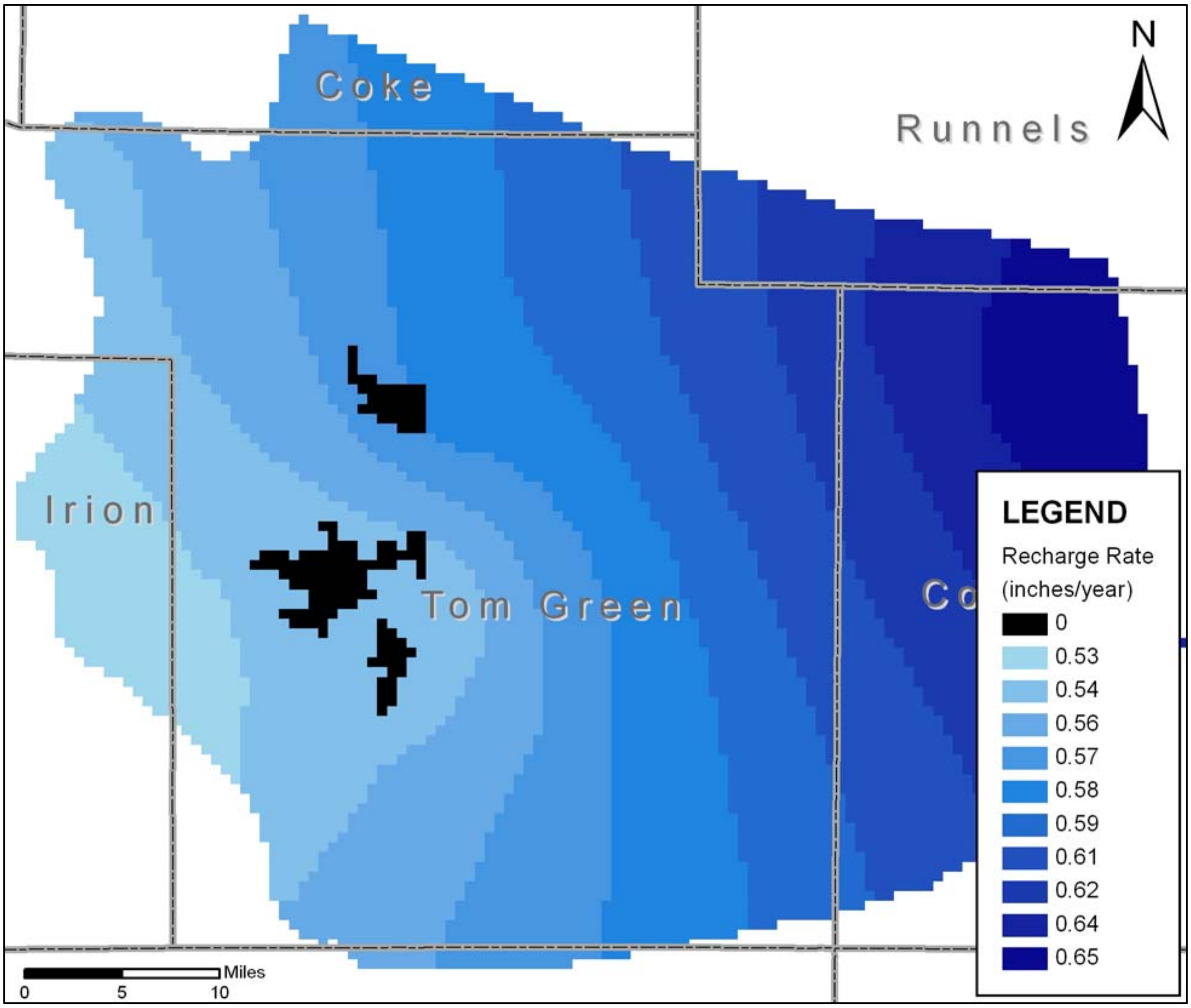

Figure 4. Steady-State Recharge Rates.

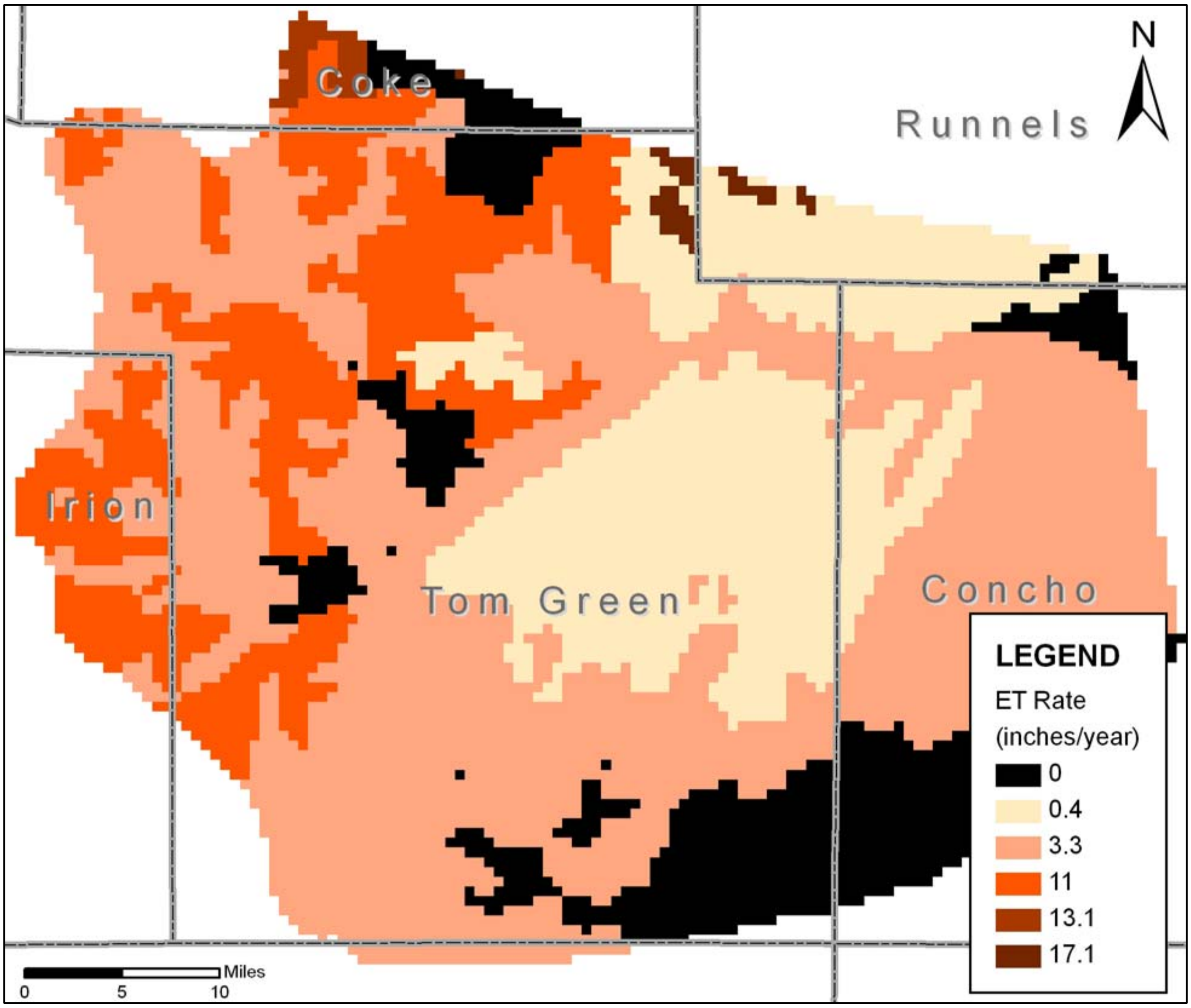

Figure 5. Evapotranspiration rates.

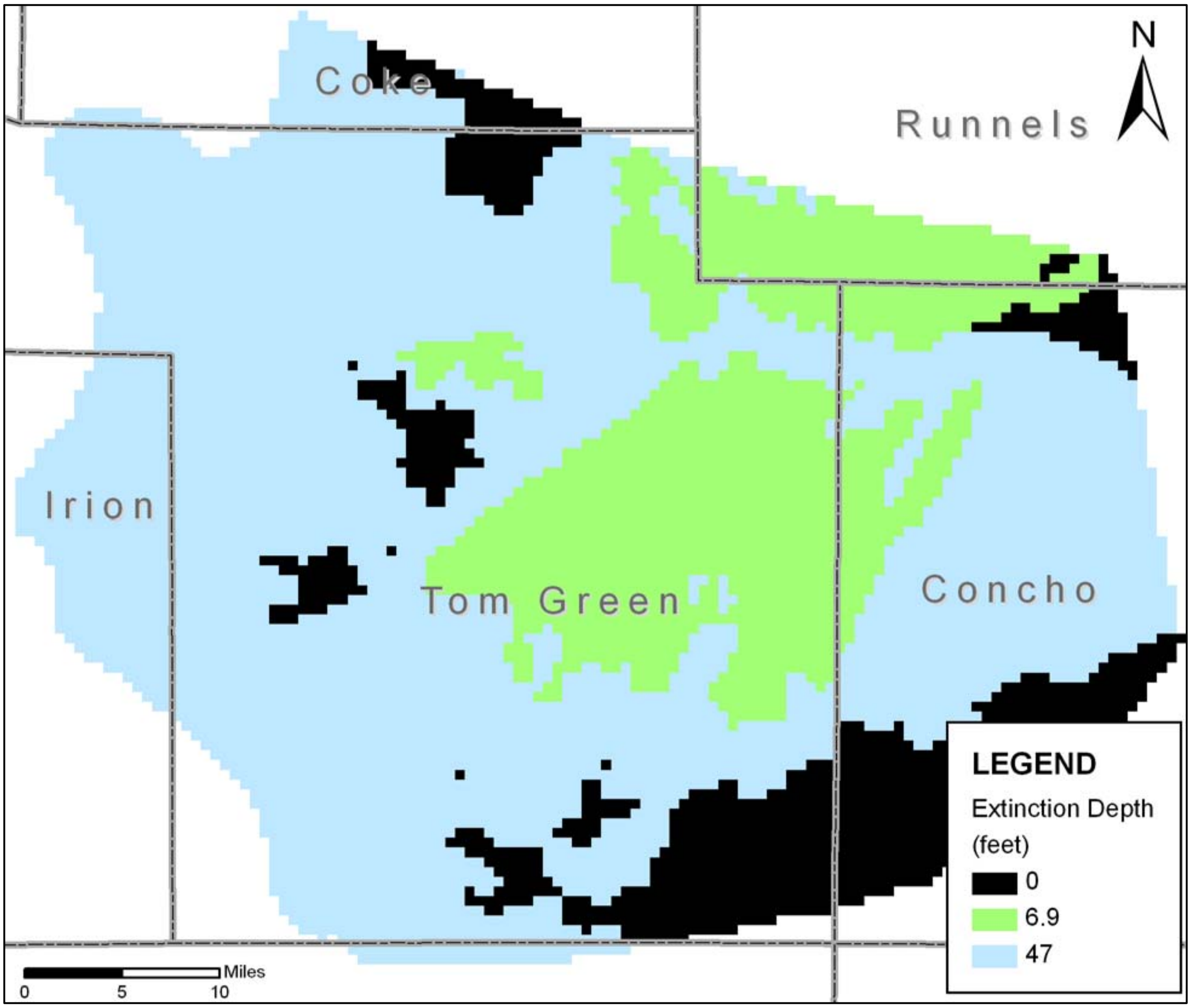

Figure 6. Evapotranspiration extinction depths.

Appendix A

Summary of Estimated Historic Pumpage

Table A-1. Historic pumpage included in the GAM for all aquifers (in acre-feet per year).

Year	Total	Coke	Runnels	Tom Green	Concho	Irion	Schleicher
Pre-1980	10,788	0.6	54	10,253	471	8.8	0.1
1980	10,788	0.6	54	10,253	471	8.8	0.1
1981	13,935	0.6	57	13,030	839	9.1	0.1
1982	17,099	0.6	58	15,827	1,204	9.5	0.1
1983	20,229	0.7	60	18,587	1,570	11.1	0.1
1984	23,383	0.7	62	21,370	1,936	13.1	0.2
1985	20,269	0.7	61	17,009	3,183	14.6	0.2
1986	18,088	0.6	59	15,463	2,552	13.3	0.2
1987	15,386	0.6	59	12,104	3,208	13.9	0.2
1988	23,457	0.6	60	20,610	2,771	14.9	0.1
1989	25,268	0.7	57	22,076	3,123	11.4	0.2
1990	26,579	0.8	63	25,428	1,074	13.3	0.2
1991	22,450	0.8	61	21,479	896	12.5	0.2
1992	15,843	0.8	61	15,158	610	12.4	0.2
1993	65,900	0.9	63	63,042	2,781	11.9	0.2
1994	62,361	0.9	64	59,658	2,624	13.5	0.2
1995	78,090	0.9	65	74,704	3,307	13.8	0.2
1996	37,290	0.9	67	35,681	1,528	13.7	0.2
1997	68,299	0.9	52	65,355	2,877	13.4	0.2
1998	51,129	0.9	52	48,932	2,130	13.4	0.2
1999	3,306	0.9	52	3,188	51	13.4	0.2