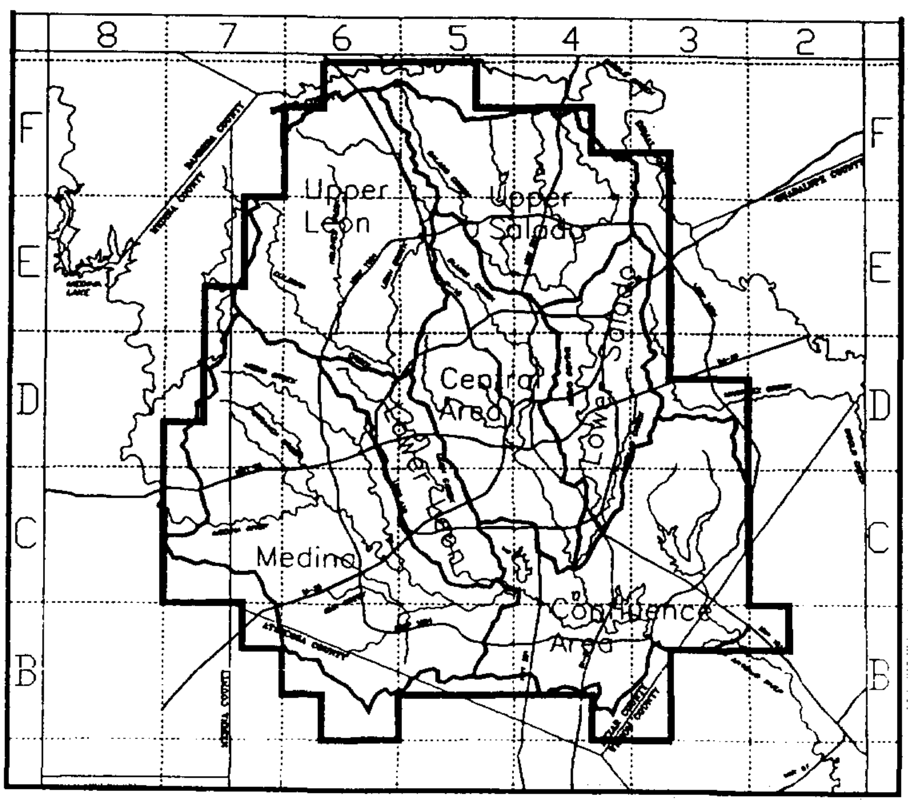
San Antonio Water System

WATER RESOURCES PLANNING PROCESS

DEVELOPMENT TRENDS

RESIDENTIAL CONNECTIONS
by Watershed Planning Area

Report No. 1



Prepared for:

Texas Water Development Board

January 1993

twdbjan.tc

1993

Summary

Central

Confluence

Lower Leon

Lower Salado

Medina

Upper Leon

Upper Salado

SAN ANTONIO WATER SYSTEM

P.O. Box 2449, San Antonio, Texas 78298-2449 210/225-7461

February 1, 1993

MR. CURTIS JOHNSON
TEXAS WATER DEVELOPMENT BOARD
P.O. Box 13231, Capitol Station
Austin, Texas 78711-3231

RE: REPORT NO. 1 - DEVELOPMENT TRENDS
RESIDENTIAL CONNECTIONS BY WATERSHED PLANNING AREA
(TWDB Contract Number 9-483-722)

Dear Curtis:

Today we are providing you with copies of eight documents which give you a status report on the planning process we are implementing for the San Antonio Water System through partial funding provided by your agency. A brief description of each of the other reports is contained in a separate letter to you dated today.

Report No. 1 provides computer listings and maps showing the number of residential connections located within each of the seven watershed planning areas. An analysis of all utility connections have been provided for the following years: 1976, 1977, 1979, 1980, 1988.

A companion document (Report No. 3) provides the same listings. However, the historical utility connection data is first aggregated by 7.5 minute USGS maps and then disaggregated into watersheds. This allows our staff to use USGS maps as a base to record information and to better coordinate our efforts with State agencies such as yours.

I am sure you will have many questions concerning these data. Since these data serve as the launching platform for all other reports, I am suggesting that our staffs have a working session sometime during the week of February 22-26 to allow submittal of computer disks and programs to you and thereby reduce the amount of paper while increasing the amount of information conveyed to you.

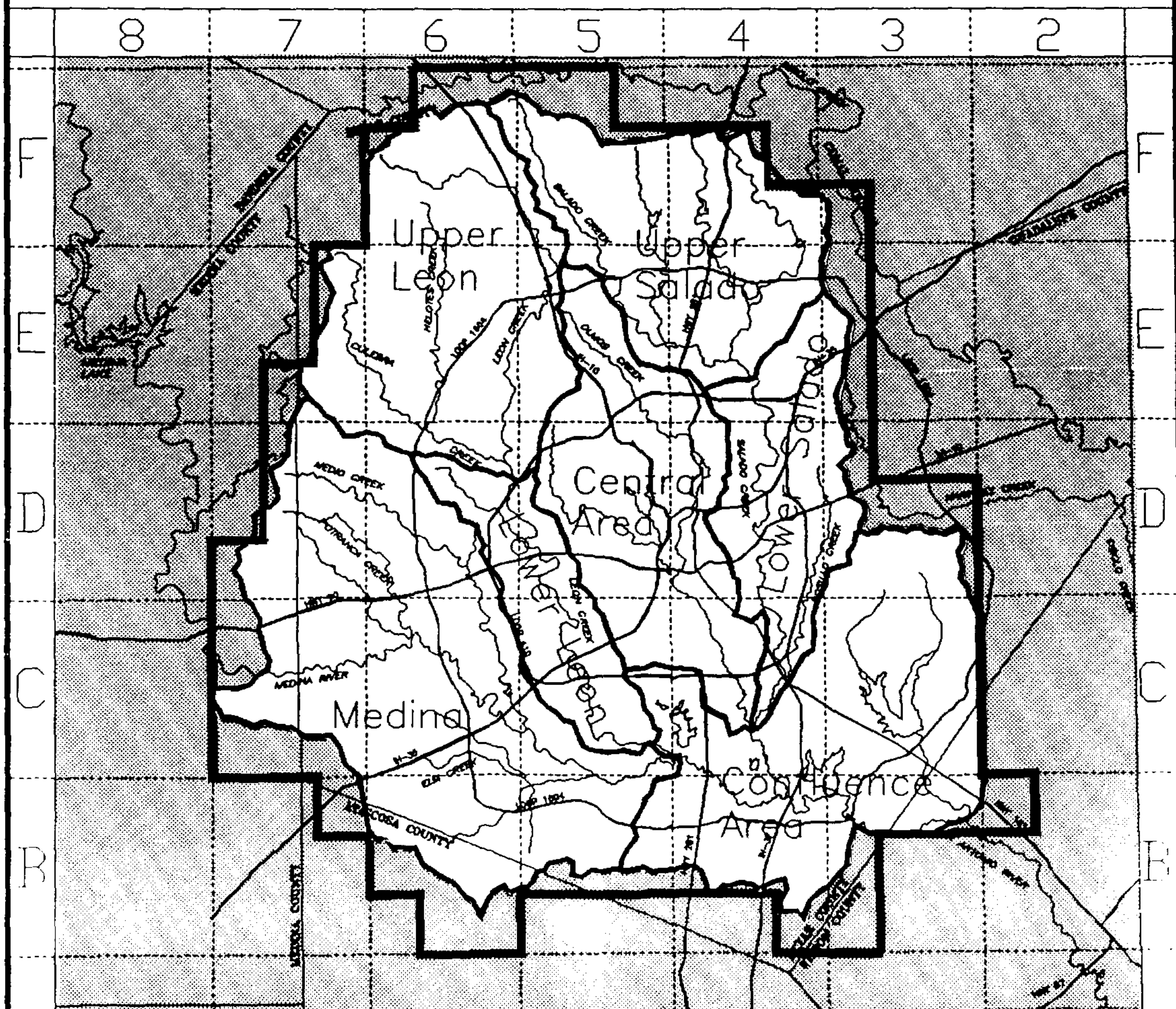
Very truly yours,

JOE A. ACEVES
President and Chief Executive Officer
JA:lk
twdb1.fl

PLANNING AREA	RESIDENTIAL CONNECTIONS	1976 Thru 1988

Watershed	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	93,113	149,908	149,668	157,376	163,160	190,069
Confluence	110,285	3,487	3,575	3,635	3,967	5,062
Lower Leon	32,691	13,388	13,734	15,348	17,524	21,204
Lower Salado	59,963	36,763	39,705	42,319	41,075	61,136
Medina	81,818	4,661	5,073	5,523	5,817	13,252
Upper Leon	97,153	7,835	9,486	16,425	16,968	41,856
Upper Salado	82,645	7,579	8,683	12,054	14,254	38,626
	557,668	223,621	229,924	252,680	262,765	371,205

New Connections = 147,584 or 100% of all New Connections in Study Area



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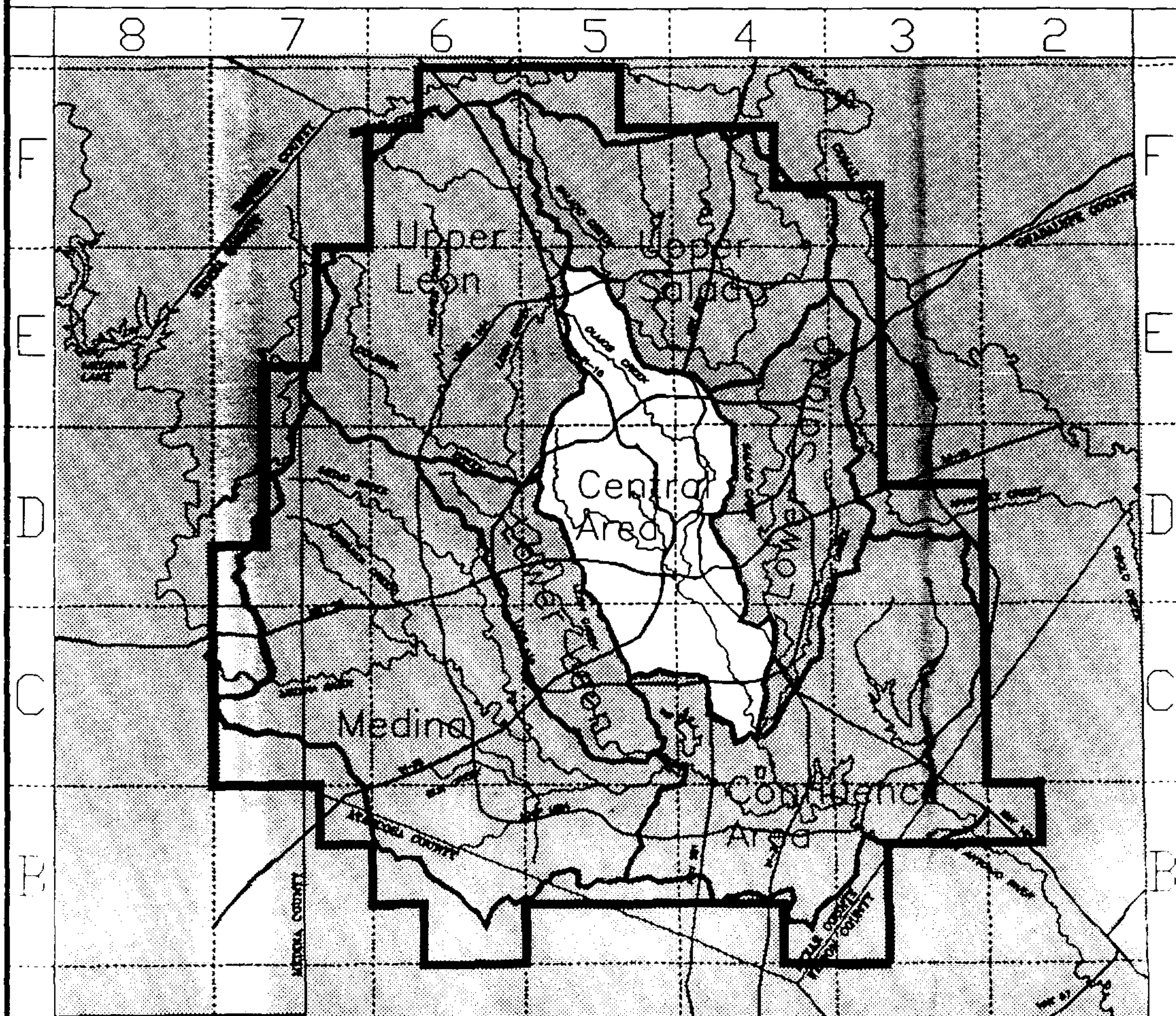
LAND AND WATER RESOURCES CONSULTANT

Central	RESIDENTIAL CONNECTIONS	1976 Thru 1988

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	E - 5	17,631	9,953	11,094	13,520	15,432	32,743
Central	E - 4	2,571	2,061	1,828	2,644	2,710	5,336
Central	D - 5	31,864	80,102	77,586	81,283	84,514	87,140
Central	D - 4	14,141	30,801	31,288	32,314	31,219	32,074
Central	D - 2	459	171	172	172	173	541
Central	C - 5	6,520	11,768	12,608	11,858	13,444	12,874
Central	C - 4	19,927	15,052	15,092	15,585	15,668	19,361
Central		93,113	149,908	149,668	157,376	163,160	190,069

New Connections = <u>40,161</u> or <u>27%</u> of all New Connections in Study Area



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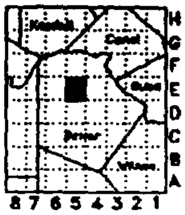

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

Scale 1:100,000

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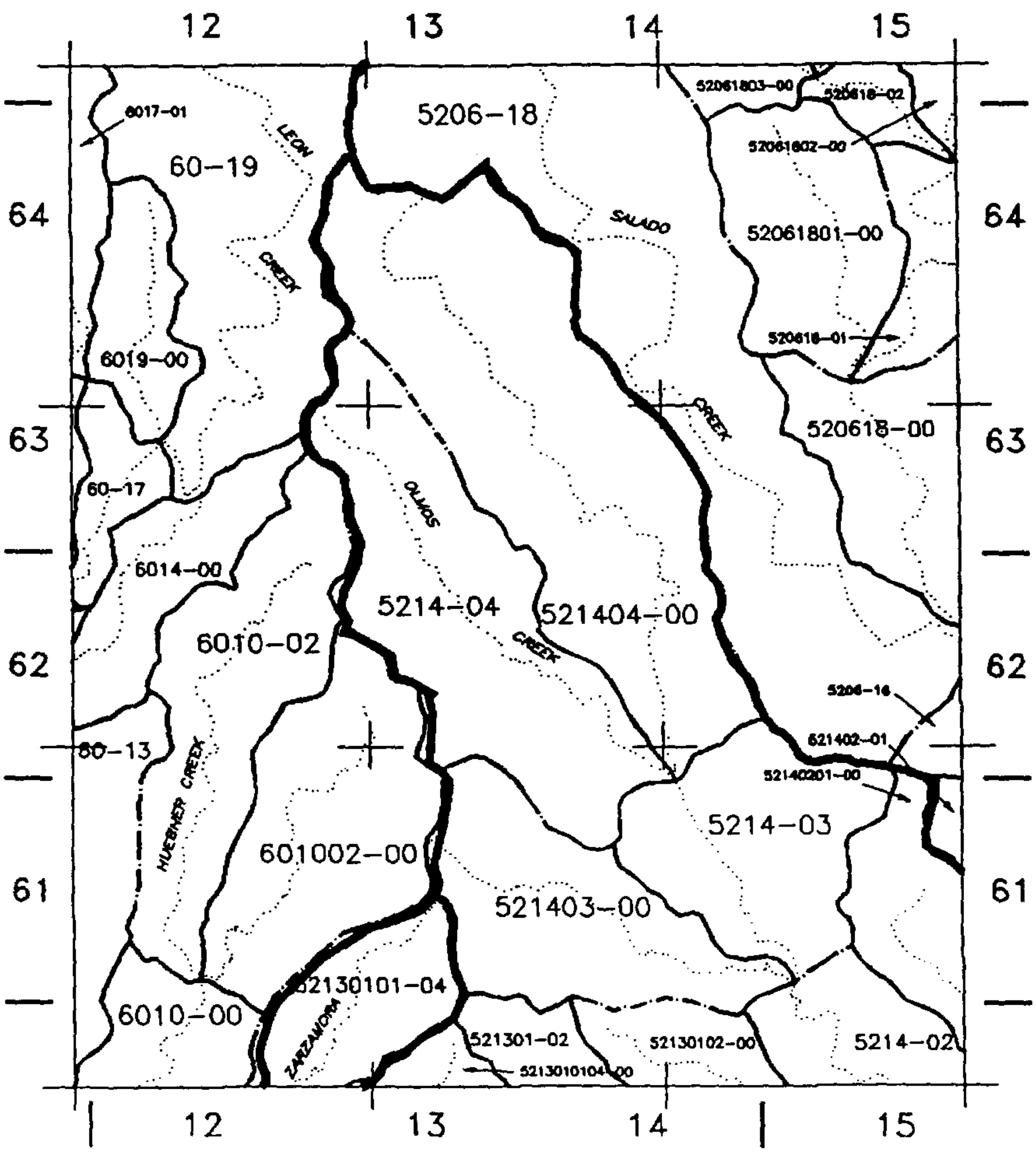
SCALE (MILES)

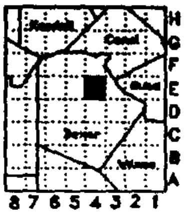
N

Latitude = 29

Longitude = 98

7.5' Area = E5





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7	8	9

7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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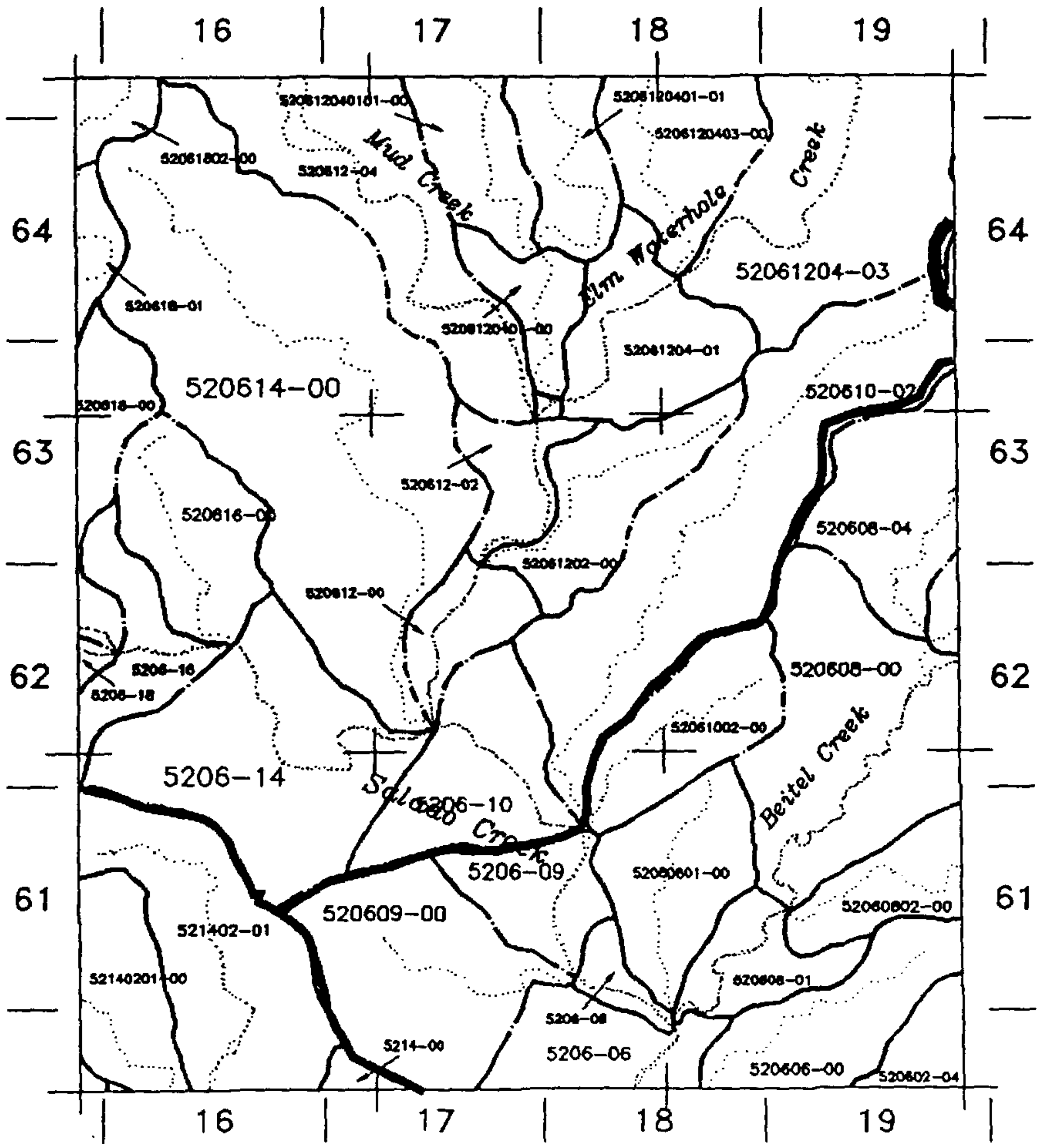

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C. THOMAS KOCH, INC.
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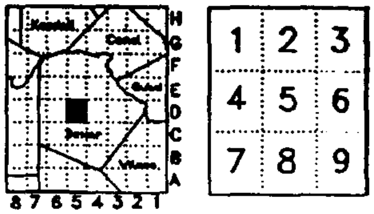

7.5 Minute Area

Water Well ID 68- 36

Map Name SAN ANTONIO WEST

Scale 1:100,000

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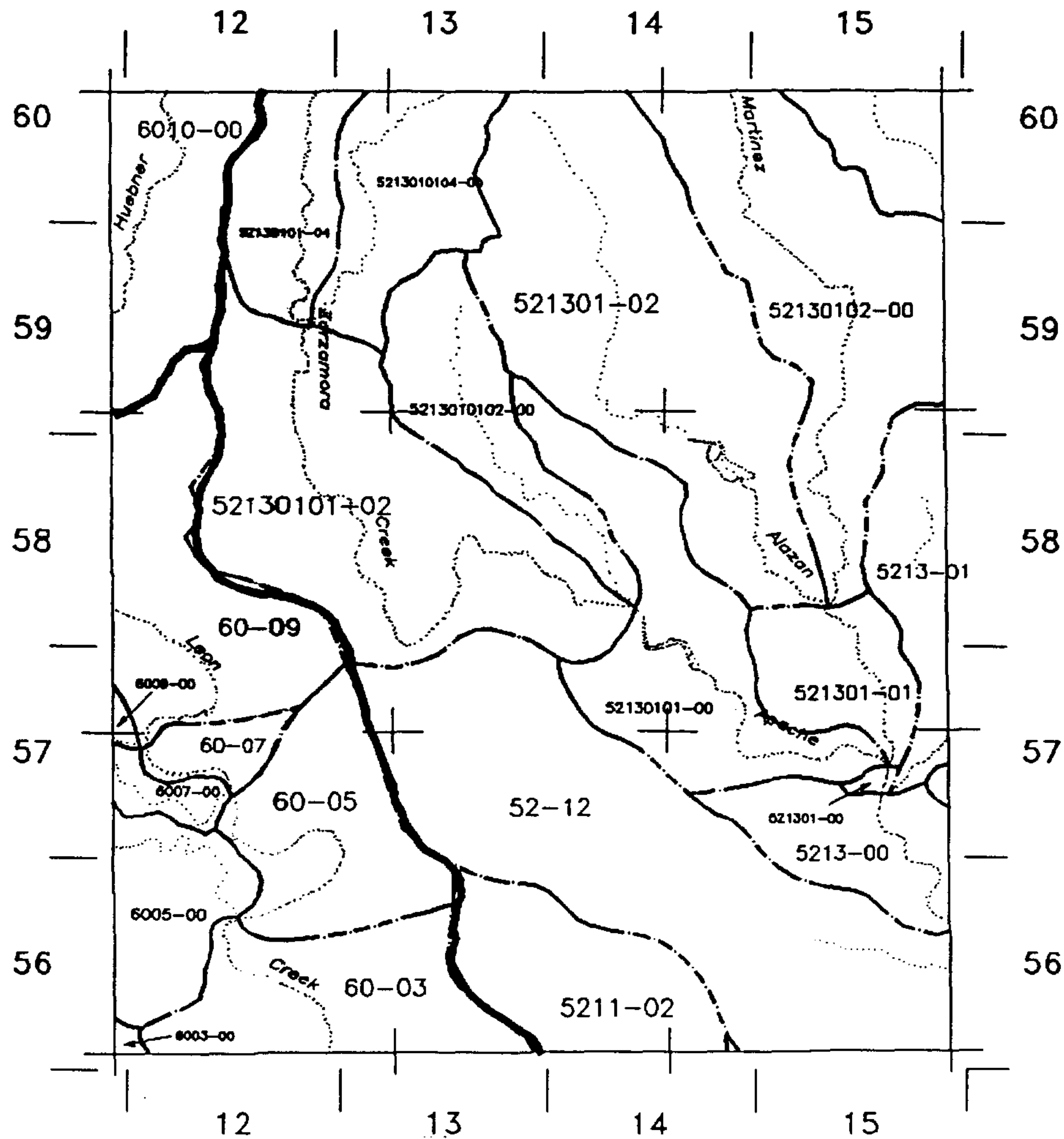

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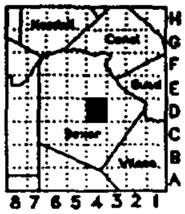

1	2	3
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7	8	9

7.5 Minute Area

Water Well ID 68- 37

Map Name SAN ANTONIO EAST

Scale 1:100,000

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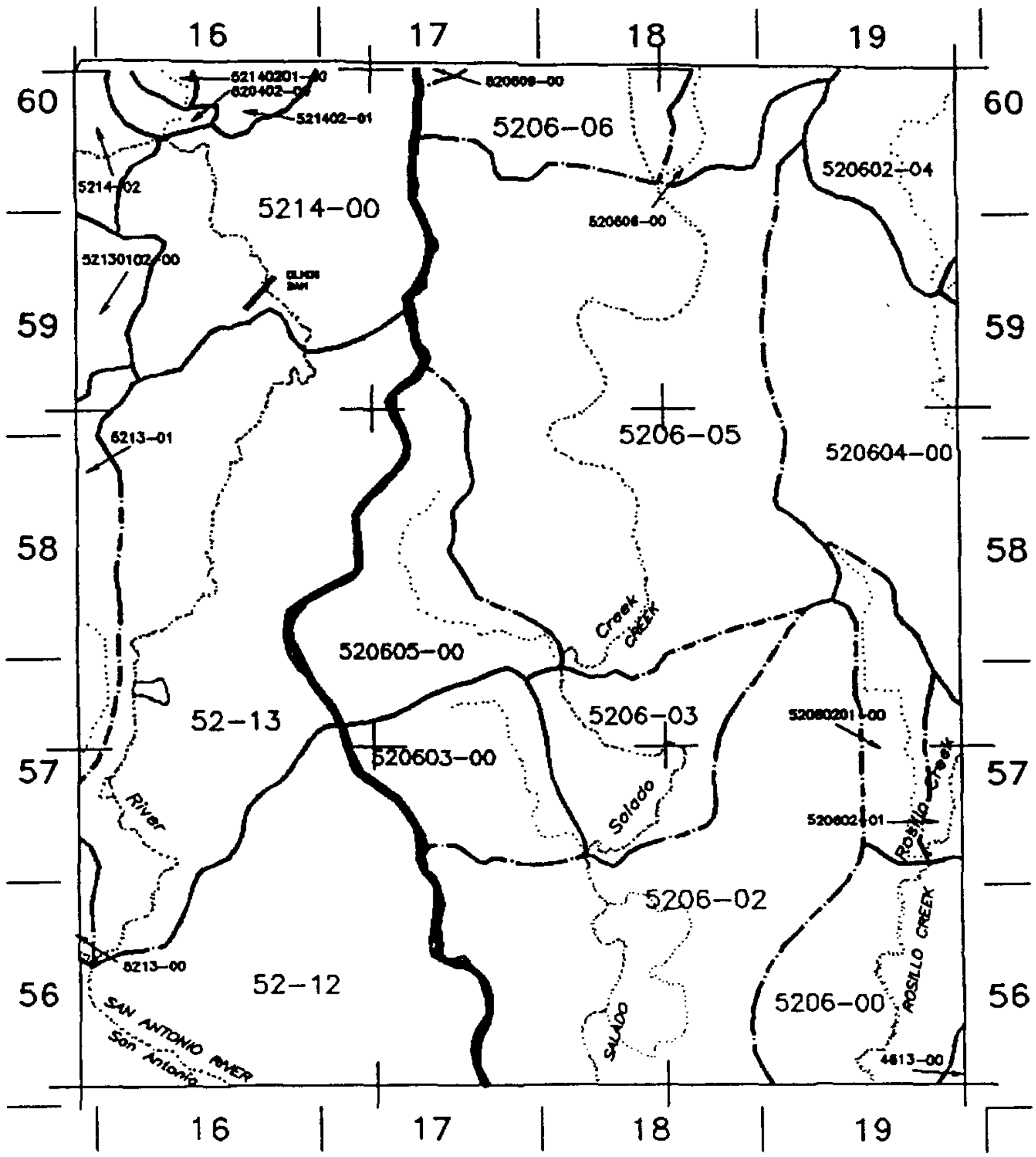
Longitude = 98

7.5' Area = D4



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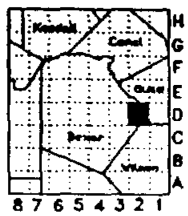
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



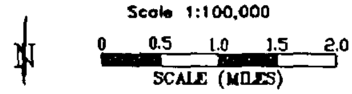
1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68-39

Map Name Saint Hedwig

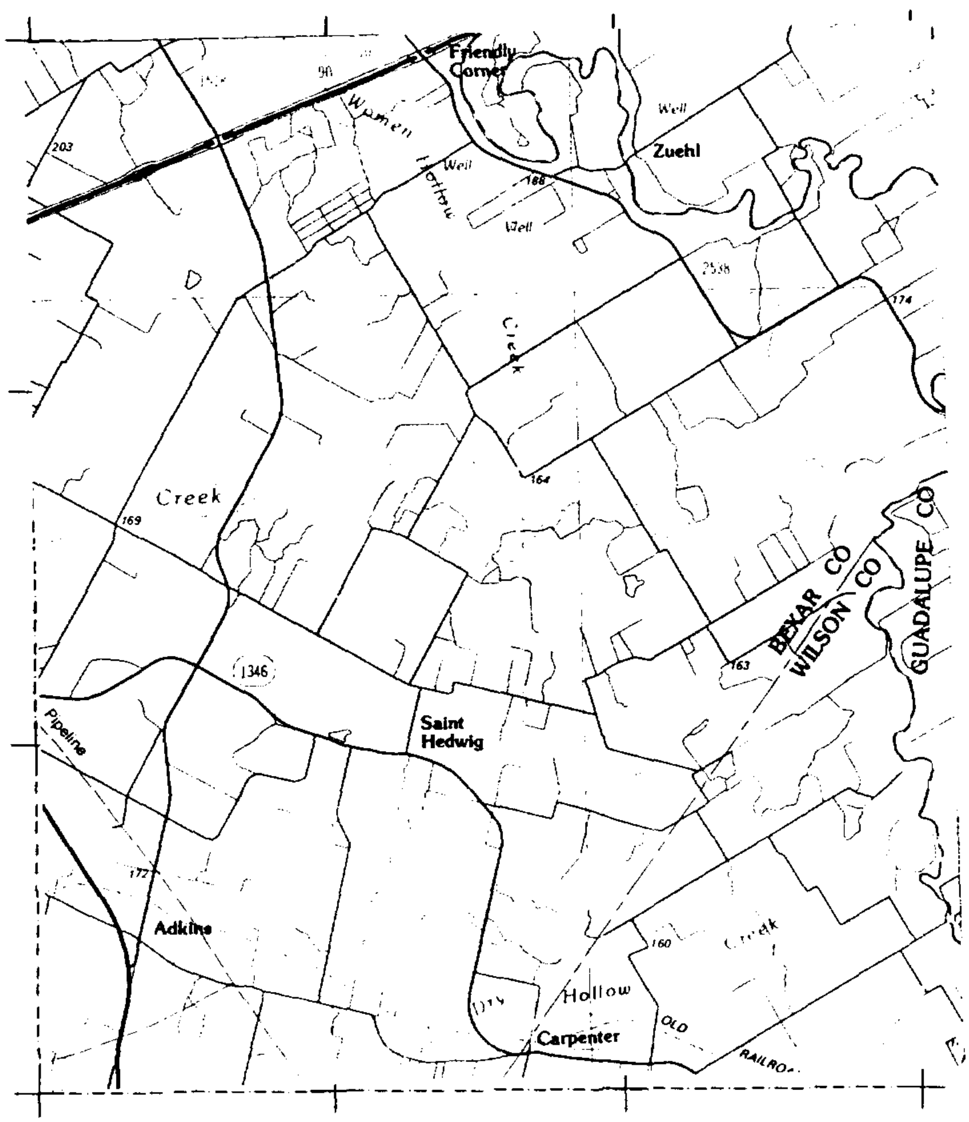
Scale 1:100,000



Latitude = 29

Longitude = 98

7.5' Area = D2



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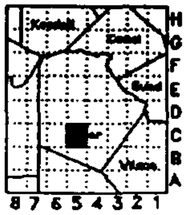
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 44

Map Name TERREL WELLS

Scale 1:100,000

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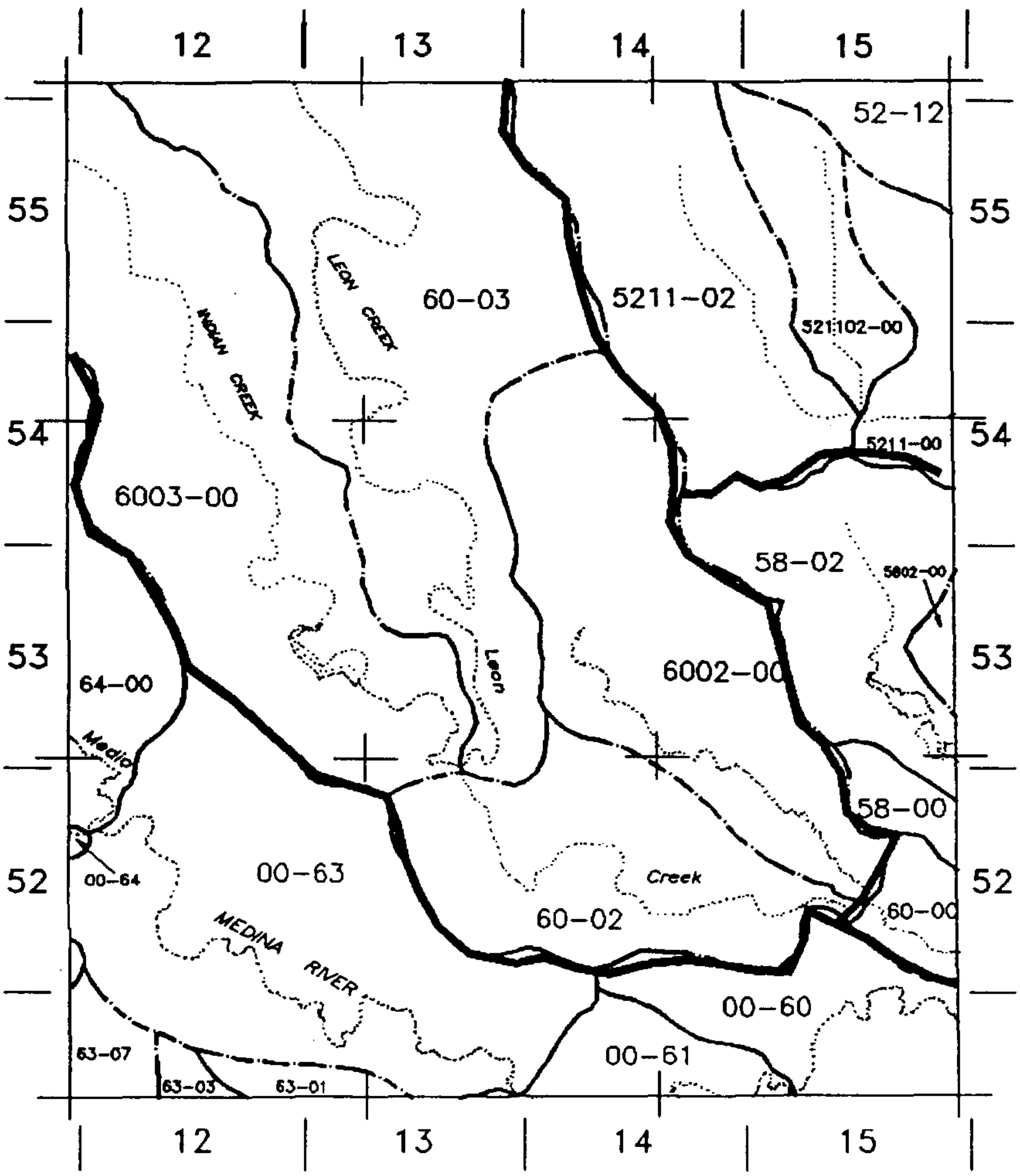
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = C5



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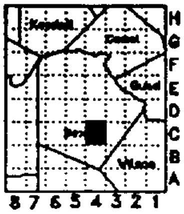
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 45

Map Name SOUTHTON

Scale 1:100,000

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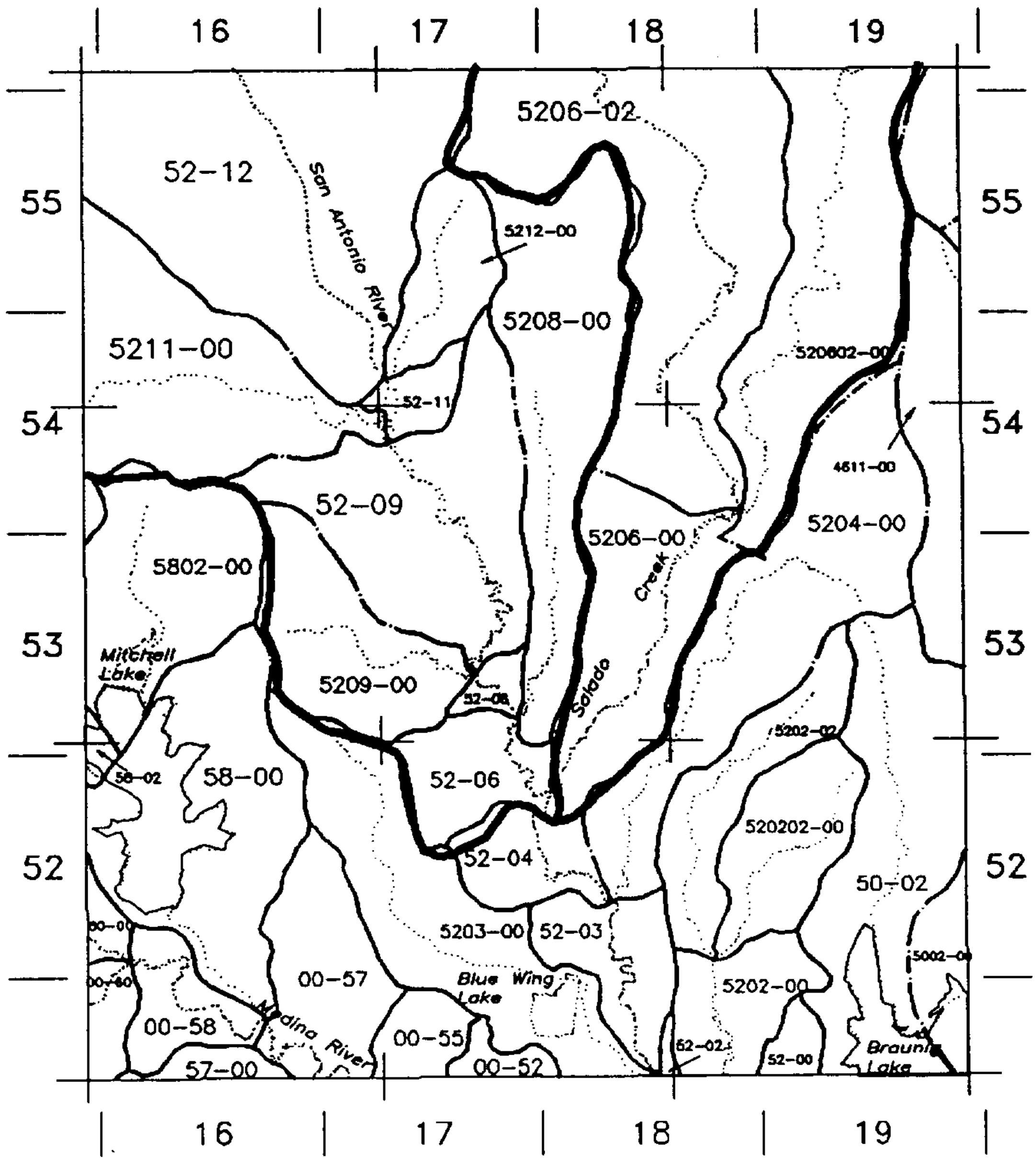
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = C4



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LAND AND WATER RESOURCES CONSULTANT

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5214040000- 0	5,418	1,222	1,443	1,909	2,176	4,681
Central	5214030000- 0	2,112	2,126	1,951	2,216	2,223	5,378
Central	5214020100- 0	1,102	1,325	1,328	1,416	1,417	1,691
Central	5214020000- 1	184	483	502	663	664	657
Central	5214000000- 4	3,398	2,479	3,454	3,824	3,843	5,790
Central	5214000000- 3	1,928	1,795	1,890	2,908	4,391	2,721
Central	5214000000- 2	1,010	326	326	330	329	2,783
Central	5213010200- 0	643					2,057
Central	5213010104- 0	184					215
Central	5213010100- 4	1,102	197	200	254	389	3,760
Central	5213010000- 2	551					3,010
Central		17,631	9,953	11,094	13,520	15,432	32,743

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5214020100- 0	643	309	469	480	482	1,974
Central	5214020000- 1	1,928	1,752	1,359	2,164	2,228	3,362
Central		2,571	2,061	1,828	2,644	2,710	5,336

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5214000000- 2	826	2,079	2,133	2,132	2,142	2,519
Central	5213010200- 0	3,765	13,821	13,491	13,203	13,150	13,609
Central	5213010104- 0	1,561	2,056	2,099	3,179	2,424	3,434
Central	5213010102- 0	1,653	2,743	2,753	2,944	2,945	3,852
Central	5213010100- 2	4,408	7,488	7,771	9,885	13,345	9,557
Central	5213010100- 0	3,030	8,601	8,788	9,047	8,883	9,507
Central	5213010000- 2	5,051	12,409	12,625	13,033	13,479	15,565
Central	5213010000- 1	1,102	7,231	4,184	4,106	4,065	4,227
Central	5213000000- 1	1,286	3,183	3,171	3,311	3,364	3,563
Central	5213000000- 0	1,469	4,107	4,104	4,055	4,057	4,024
Central	5211000000- 2	1,653	962	964	968	973	982
Central	5200000000-12	6,061	15,422	15,503	15,420	15,687	16,301
Central		31,864	80,102	77,586	81,283	84,514	87,140

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5214020000- 0	184	126	135	171	174	180
Central	5214000000- 2	184	213	216	243	231	440
Central	5214000000- 0	3,122	5,573	5,633	5,698	5,761	5,751
Central	5213000000- 1	367	627	592	589	787	772
Central	5200000000-13	5,601	10,632	10,885	10,623	10,618	10,795
Central	5200000000-12	4,683	13,630	13,827	14,990	13,648	14,136
Central		14,141	30,801	31,288	32,314	31,219	32,074

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-2

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5213010100- 4	459	171	172	172	173	541
Central		459	171	172	172	173	541

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5211020000- 0	1,286	2,987	2,999	2,980	2,989	3,255
Central	5211000000- 2	3,398	4,692	5,519	4,752	6,328	5,245
Central	5211000000- 0	1,377	2,833	2,835	2,868	2,874	3,085
Central	5200000000-12	459	1,256	1,255	1,258	1,253	1,289
Central		6,520	11,768	12,608	11,858	13,444	12,874

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5212000000- 0	643	256	265	272	272	311
Central	5212000000- 0	643	256	265	272	272	311
Central	5211000000- 0	1,653	1,942	1,941	1,949	1,954	2,463
Central	5211000000- 0	1,837	2,018	1,993	2,026	2,031	2,588
Central	5209000000- 0	1,102	99	98	117	115	118
Central	5208000000- 0	643	839	894	966	968	1,201
Central	5208000000- 0	2,204	1,316	1,425	1,470	1,489	1,794
Central	5200000000-12	6,979	7,850	7,792	8,096	8,138	9,992
Central	5200000000-11	735	132	128	124	130	128
Central	5200000000- 9	2,571	340	283	286	290	451
Central	5200000000- 8	184	0	1	1	1	2
Central	5200000000- 6	735	4	7	6	8	2
Central		19,927	15,052	15,092	15,585	15,668	19,361

Report file: WPA_swsR

Page 1   1/29/93 11:12:23 a   TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5214040000- 0	5,418	1,222	1,443	1,909	2,176	4,681
Central	5214030000- 0	2,112	2,126	1,951	2,216	2,223	5,378
Central	5214020100- 0	1,745	1,634	1,797	1,896	1,899	3,665
Central	5214020000- 1	2,112	2,235	1,861	2,827	2,892	4,019
Central	5214020000- 0	184	126	135	171	174	180
Central	5214000000- 4	3,398	2,479	3,454	3,824	3,843	5,790
Central	5214000000- 3	1,928	1,795	1,890	2,908	4,391	2,721
Central	5214000000- 2	2,020	2,618	2,675	2,705	2,702	5,742
Central	5214000000- 0	3,122	5,573	5,633	5,698	5,761	5,751
Central	5213010200- 0	4,408	13,821	13,491	13,203	13,150	15,666
Central	5213010104- 0	1,745	2,056	2,099	3,179	2,424	3,649
Central	5213010102- 0	1,653	2,743	2,753	2,944	2,945	3,852
Central	5213010100- 4	459	171	172	172	173	541
Central	5213010100- 4	1,102	197	200	254	389	3,760
Central	5213010100- 2	4,408	7,488	7,771	9,885	13,345	9,557
Central	5213010100- 0	3,030	8,601	8,788	9,047	8,883	9,507
Central	5213010000- 2	5,601	12,409	12,625	13,033	13,479	18,575
Central	5213010000- 1	1,102	7,231	4,184	4,106	4,065	4,227
Central	5213000000- 1	1,653	3,810	3,763	3,900	4,151	4,335
Central	5213000000- 0	1,469	4,107	4,104	4,055	4,057	4,024
Central	5212000000- 0	643	256	265	272	272	311
Central	5212000000- 0	643	256	265	272	272	311
Central	5211020000- 0	1,286	2,987	2,999	2,980	2,989	3,255
Central	5211000000- 0	1,653	1,942	1,941	1,949	1,954	2,463
Central	5211000000- 2	5,051	5,654	6,483	5,720	7,301	6,227
Central	5211000000- 0	3,214	4,851	4,828	4,894	4,905	5,673

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Page 2 1/29/93 11:12:27 a

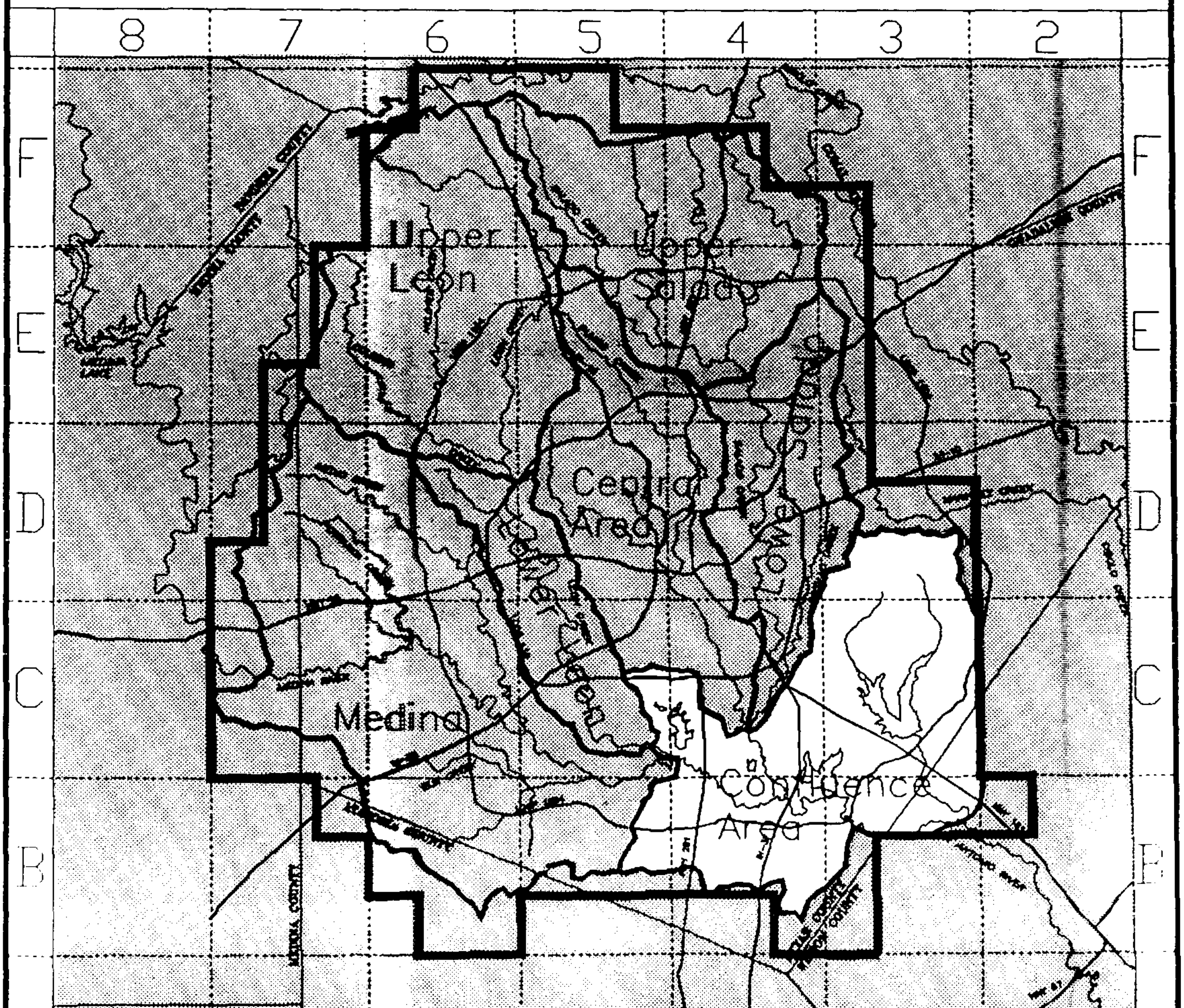
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

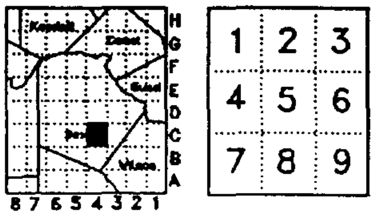
Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Central	5209000000- 0	1,102	99	98	117	115	118
Central	5208000000- 0	643	839	894	966	968	1,201
Central	5208000000- 0	2,204	1,316	1,425	1,470	1,489	1,794
Central	5200000000-13	5,601	10,632	10,885	10,623	10,618	10,795
Central	5200000000-12	18,182	38,158	38,377	39,764	38,726	41,718
Central	5200000000-11	735	132	128	124	130	128
Central	5200000000- 9	2,571	340	283	286	290	451
Central	5200000000- 8	184	0	1	1	1	2
Central	5200000000- 6	735	4	7	6	8	2
Central		93,113	149,908	149,668	157,376	163,160	190,069

Confluence	***RESIDENTIAL CONNECTIONS***	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	C - 4	19,835	1,222	1,244	1,266	1,333	1,722
Confluence	C - 3	40,129	1,397	1,433	1,463	1,690	2,049
Confluence	C - 2	4,408	24	25	27	28	
Confluence	B - 5	4,683	107	109	101	105	173
Confluence	B - 4	26,905	648	674	685	728	997
Confluence	B - 3	13,774	87	88	91	81	121
Confluence	B - 2	459					
Confluence	-	92	2	2	2	2	
Confluence		110,285	3,487	3,575	3,635	3,967	5,062

New Connections = <u>1,575</u> or <u>1%</u> of all New Connections in Study Area





7.5 Minute Area

Water Well ID 68- 45

Map Name SOUTHTON

Scale 1:100,000

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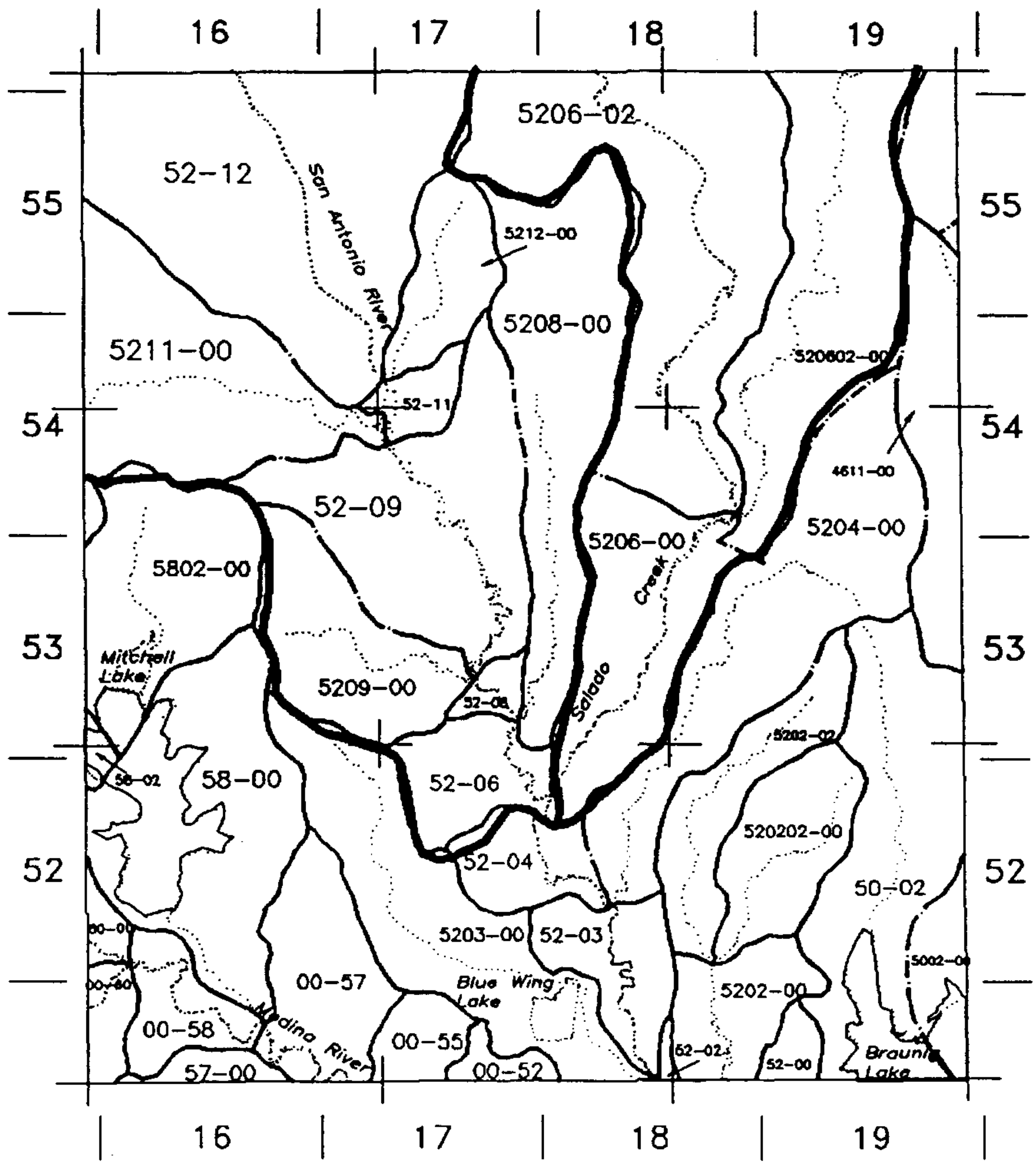
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = C4



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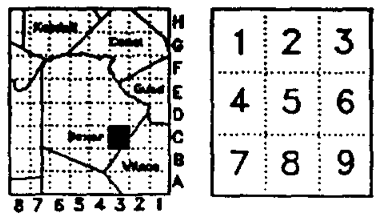
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 46

Map Name ELMENDORF

Scale 1:100,000

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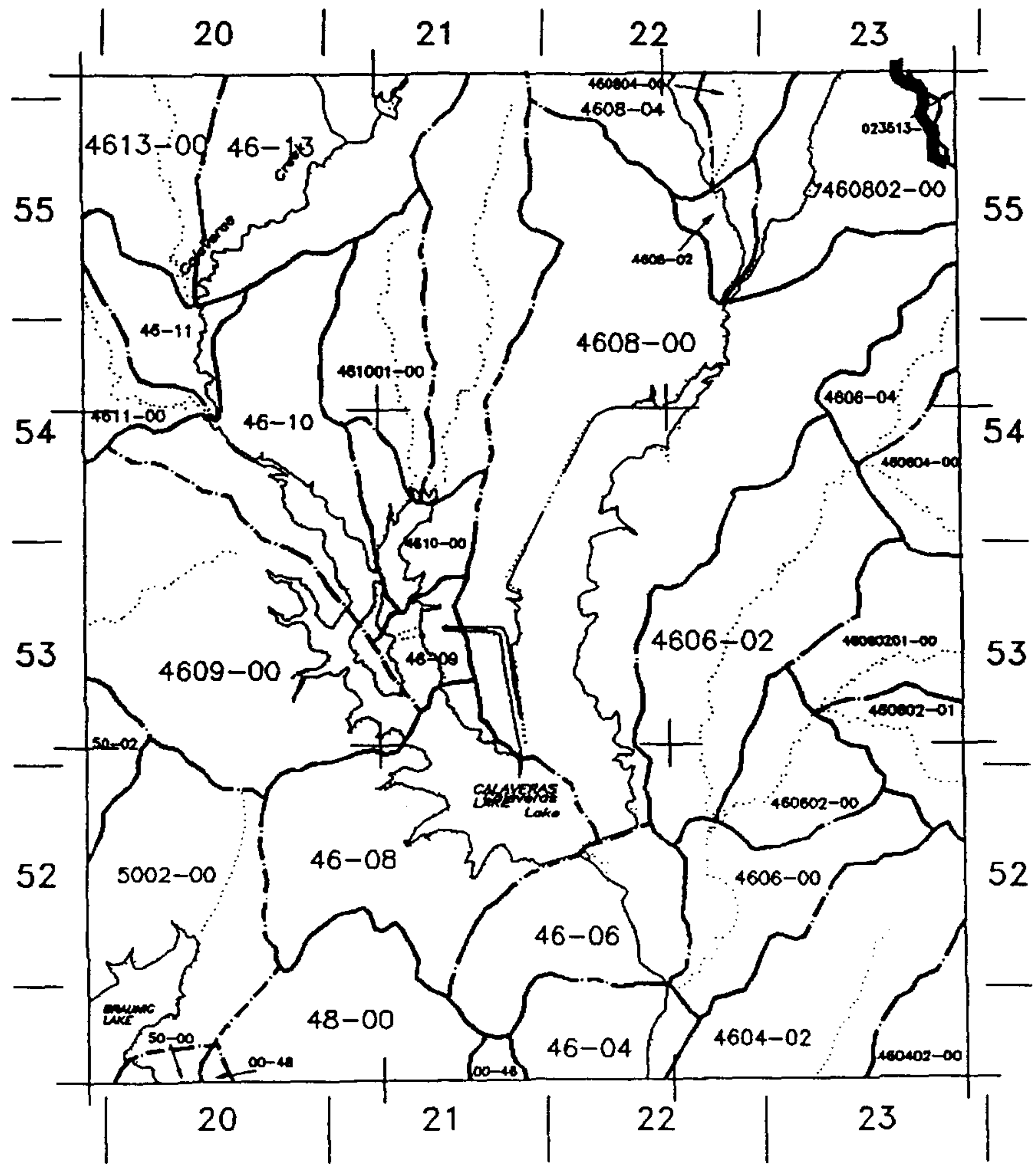
SCALE (MILES)

N

Latitude = 29

Longitude = 98

7.5' Area = C3



GAE 1/29/93 44C3COMP.DWG

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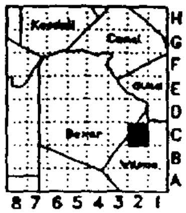

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68-47

Map Name La Vernia SW

Scale 1:100,000

N

0 0.5 1.0 1.5 2.0

SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = C2

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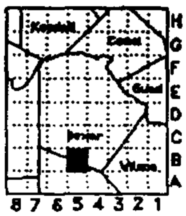
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 52

Map Name THELMA

Scale 1:100,000

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Longitude = 98

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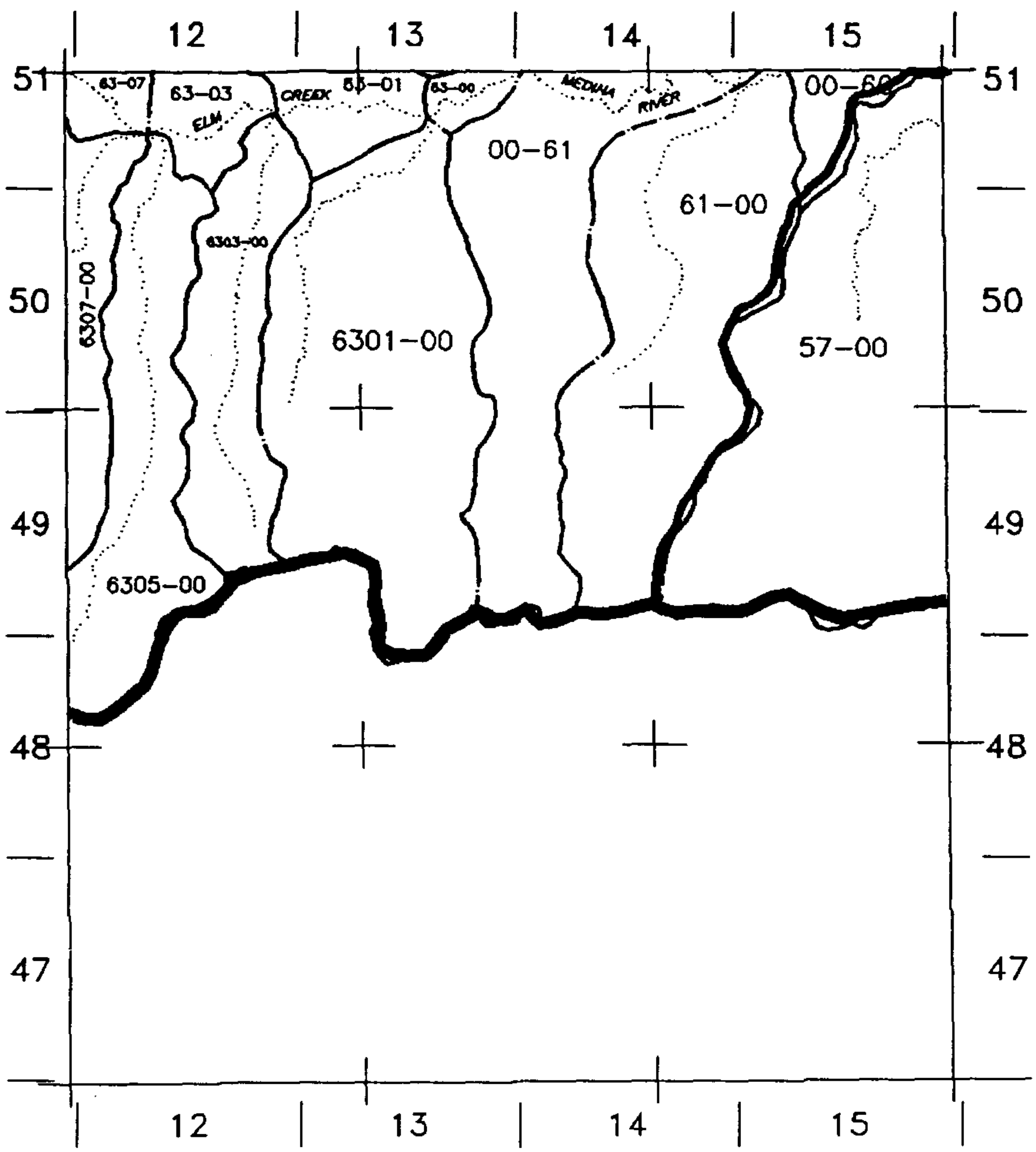

GAE 1/29/93 44B5COMP.DWG

C. THOMAS KOCH, INC.
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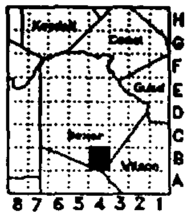

1	2	3
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7	8	9

7.5 Minute Area

Water Well ID 68- 53

Map Name LOSOYA

Scale 1:100,000

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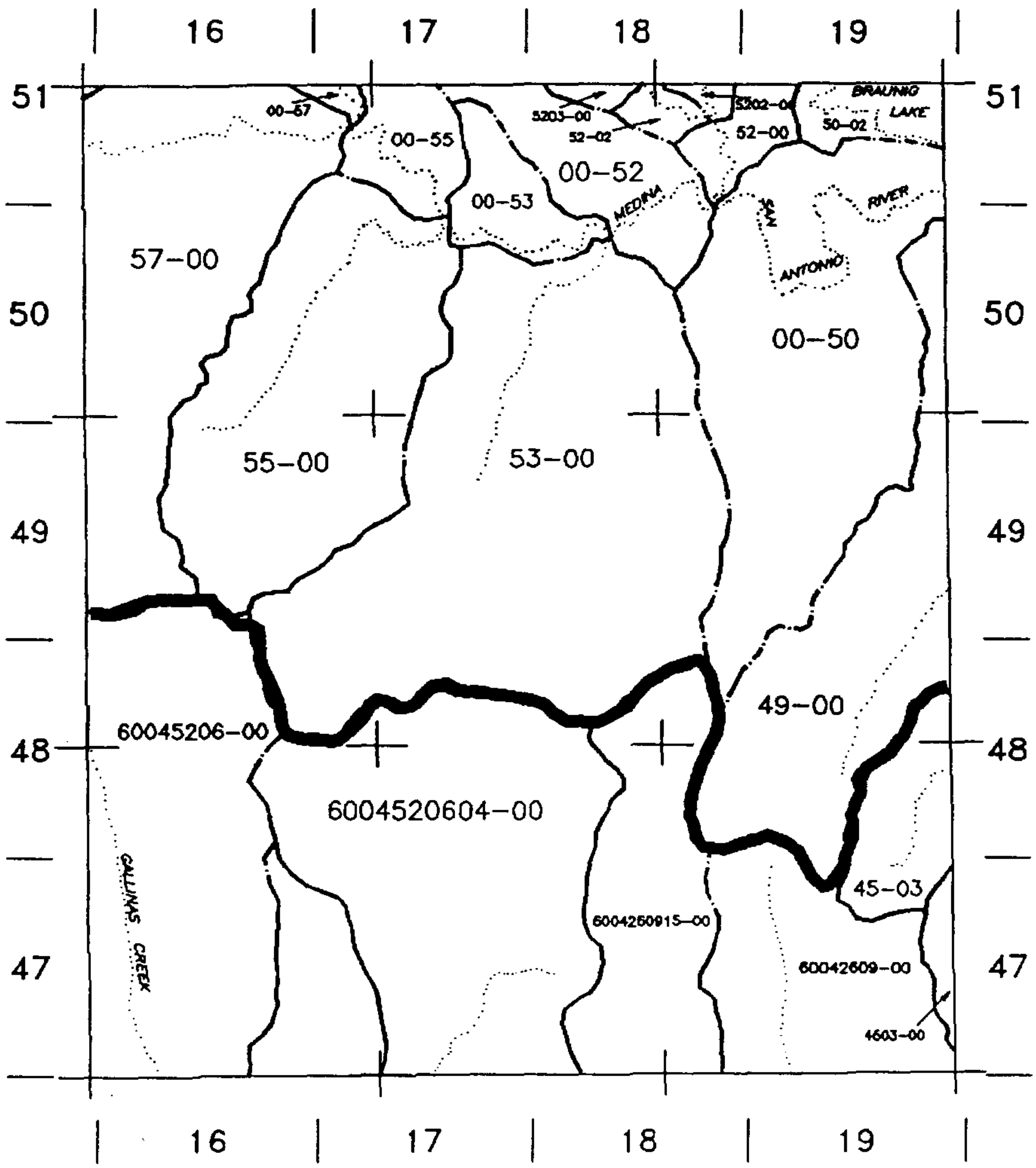
Longitude = 98

7.5' Area = B4



GAE 1/29/93 44B4COMP.DWG

C. THOMAS KOCH, INC.
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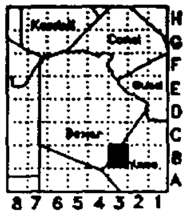

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 54

Map Name SASPAMCO

Scale 1:100,000

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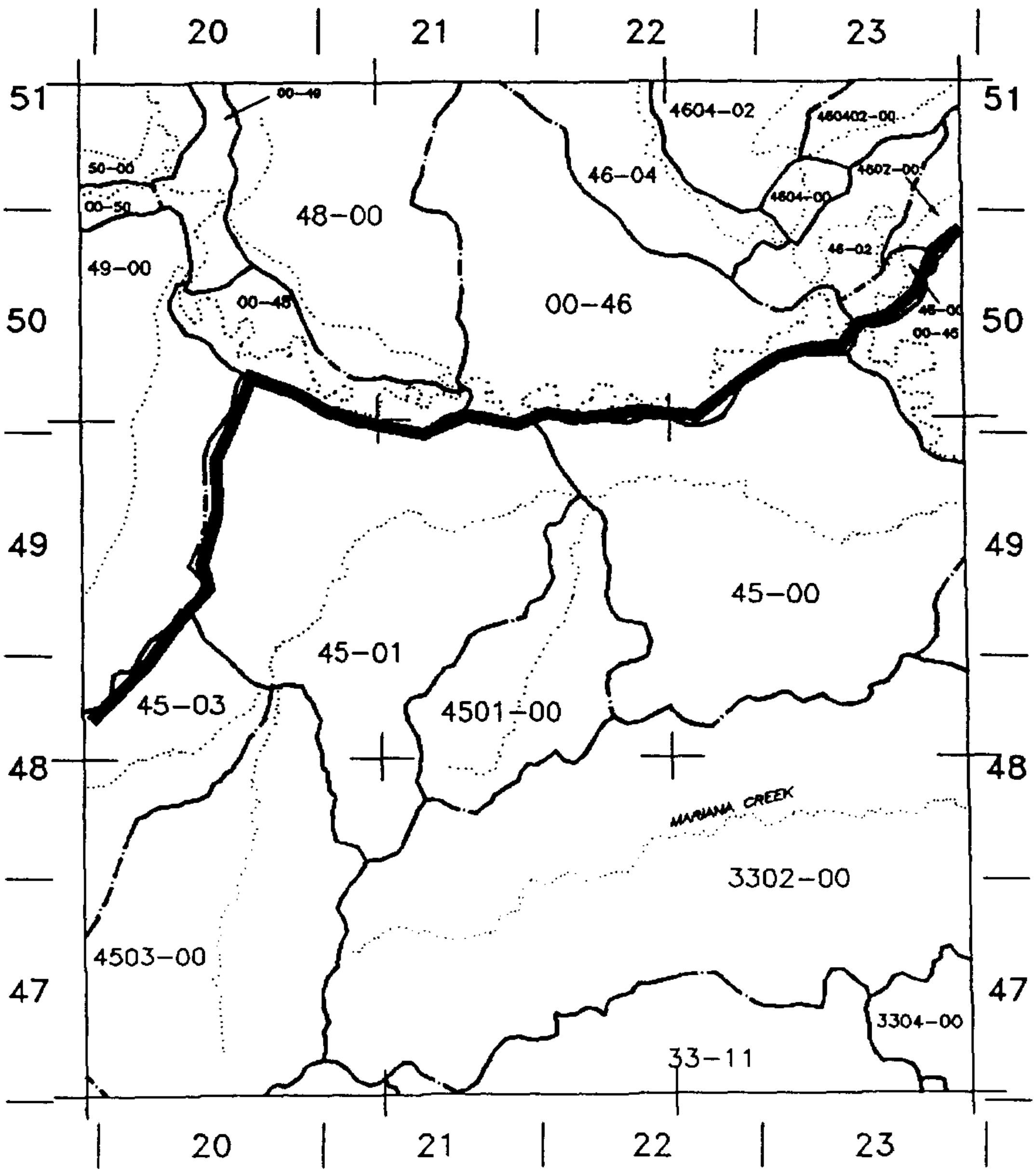
Latitude = 29

Longitude = 98

7.5' Area = B3



GAE 1/29/93 44B3COMP.DWG

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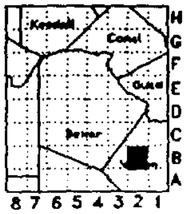


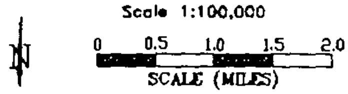
1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 55

Map Name Floresville

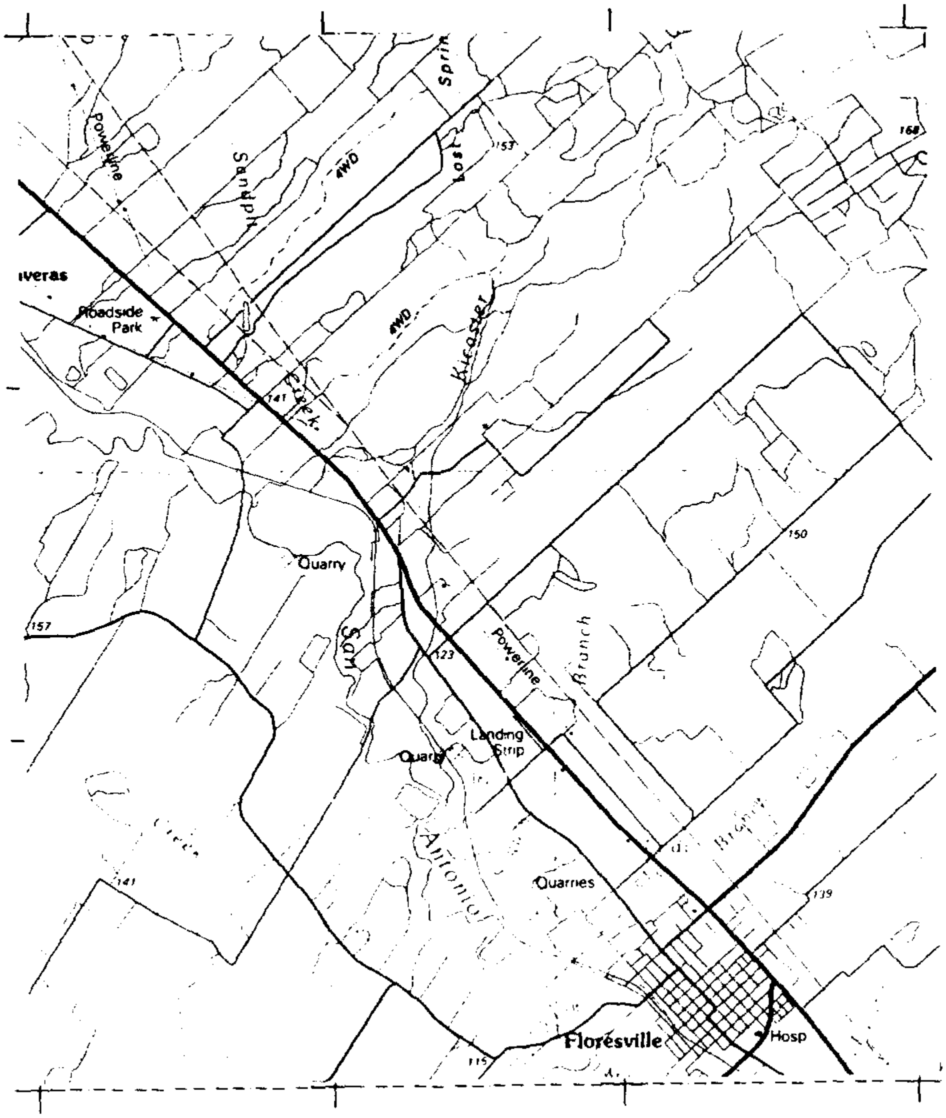
Scale 1:100,000



Latitude = 29

Longitude = 98

7.5' Area = B2



TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	6000000000- 0	184	0	0	0	0	
Confluence	5802000000- 0	92	56	58	57	57	97
Confluence	5802000000- 0	1,653	550	557	538	536	565
Confluence	5800000000- 0	2,388	3	4	4	4	5
Confluence	5700000000- 0	92	1	1	1	1	10
Confluence	5204000000- 0	2,571	169	170	166	204	401
Confluence	5203000000- 0	2,204	61	62	60	60	66
Confluence	5202020000- 0	918	15	14	12	12	17
Confluence	5202000000- 2	918	27	27	25	27	42
Confluence	5202000000- 0	735	9	9	9	8	10
Confluence	5200000000- 4	459	0	0	0	0	0
Confluence	5200000000- 3	826	23	23	24	24	22
Confluence	5200000000- 0	92	1	1	1	1	1
Confluence	5002000000- 0	643	1	1	1	1	1
Confluence	5000000000- 2	2,388	98	102	104	107	139
Confluence	4613000000- 0	551	7	7	7	8	11
Confluence	4611000000- 0	918	12	12	12	12	22
Confluence	4609000000- 0	551	88	82	129	157	171
Confluence	0-58	367	21	23	25	24	33
Confluence	0-57	1,010	70	81	81	80	99
Confluence	0-55	275	10	10	10	10	10
Confluence		19,835	1,222	1,244	1,266	1,333	1,722

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-3

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	5002000000- 0	1,928	41	43	42	41	51
Confluence	5000000000- 2	92	5	5	5	4	7
Confluence	5000000000- 0	92	0	0	0	0	
Confluence	4800000000- 0	1,377	149	152	147	151	231
Confluence	4613000000- 0	643	28	29	30	29	40
Confluence	4611000000- 0	184	3	3	4	3	5
Confluence	4610010000- 0	826	22	23	23	25	36
Confluence	4610000000- 0	2,479	34	36	40	43	74
Confluence	4609000000- 0	3,306	259	257	253	256	292
Confluence	4608040000- 0	184	2	2	3	3	3
Confluence	4608020000- 0	1,286	74	78	85	88	105
Confluence	4608000000- 4	459	16	17	18	19	25
Confluence	4608000000- 2	275	17	17	17	17	20
Confluence	4608000000- 0	7,530	165	179	189	189	321
Confluence	4606040000- 0	735	18	17	17	18	19
Confluence	4606020100- 0	1,102	15	15	19	23	36
Confluence	4606020000- 1	735	3	3	3	3	2
Confluence	4606020000- 0	826	21	21	23	25	35
Confluence	4606000000- 4	551	21	24	24	24	39
Confluence	4606000000- 2	2,479	45	46	44	45	66
Confluence	4606000000- 0	1,286	35	36	37	40	44
Confluence	4604020000- 0	551	0	0	0	0	
Confluence	4604000000- 2	1,561	2	2	2	2	3
Confluence	4604000000- 0	184	0	0	0	0	
Confluence	4600000000-13	1,837	35	36	41	40	77
Confluence	4600000000-11	551	11	11	12	12	18
Confluence	4600000000-10	2,020	49	49	46	49	98
Confluence	4600000000- 9	367	0	0	0	0	0
Confluence	4600000000- 8	2,571	281	285	296	496	330
Confluence	4600000000- 6	1,286	45	46	43	45	72
Confluence	4600000000- 4	735	0	0	0	0	
Confluence	0-46	92	1	1	0	0	
Confluence		40,129	1,397	1,433	1,463	1,690	2,049

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-2

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	4606040000- 0	1,377	17	16	18	18	
Confluence	4606020100- 0	275	1	1	1	1	
Confluence	4606020000- 1	1,377	1	1	1	1	
Confluence	4606000000- 4	735	5	7	7	8	
Confluence	4604020000- 0	459					
Confluence	4602000000- 0	184					
Confluence		4,408	24	25	27	28	

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : B-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	5700000000- 0	4,683	107	109	101	105	173
Confluence		4,683	107	109	101	105	173

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : B-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	5700000000- 0	3,673	137	142	143	147	228
Confluence	5500000000- 0	3,765	242	248	245	250	285
Confluence	5300000000- 0	7,530	127	136	135	163	251
Confluence	5203000000- 0	92	0	0	1	1	
Confluence	5202000000- 0	92	0	0	0	0	
Confluence	5200000000- 2	275	8	10	10	10	16
Confluence	5200000000- 0	367	2	1	2	2	3
Confluence	5000000000- 2	735	12	12	13	13	17
Confluence	4900000000- 0	3,489	19	24	25	27	33
Confluence	0-57	92	0	0	0	0	
Confluence	0-55	551	32	36	37	37	46
Confluence	0-53	735	7	4	5	5	5
Confluence	0-52	1,194	9	10	12	13	12
Confluence	0-50	4,316	53	51	57	60	101
Confluence		26,905	648	674	685	728	997

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : B-3

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	5000000000- 0	367	0	0	0	0	
Confluence	4900000000- 0	1,837	8	10	10	10	13
Confluence	4800000000- 0	2,663	40	39	43	39	57
Confluence	4604020000- 0	459					
Confluence	4604000000- 0	918	0	0	0	0	
Confluence	4602000000- 0	367					
Confluence	4600000000- 4	1,102	0	0	0	0	0
Confluence	4600000000- 0	918					
Confluence	0-50	92	0	0	0	0	
Confluence	0-48	1,377	14	14	13	13	14
Confluence	0-46	3,673	25	25	25	19	37
Confluence		13,774	87	88	91	81	121

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : B-2

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	4602000000- 0	459					
Confluence		459					

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	6000000000- 0	184	0	0	0	0	
Confluence	5802000000- 0	92	56	58	57	57	97
Confluence	5802000000- 0	1,653	550	557	538	536	565
Confluence	5800000000- 0	2,388	3	4	4	4	5
Confluence	5700000000- 0	8,448	245	252	245	253	411
Confluence	5500000000- 0	3,765	242	248	245	250	285
Confluence	5300000000- 0	7,530	127	136	135	163	251
Confluence	5204000000- 0	2,571	169	170	166	204	401
Confluence	5203000000- 0	2,296	61	62	61	61	66
Confluence	5202020000- 0	918	15	14	12	12	17
Confluence	5202000000- 2	918	27	27	25	27	42
Confluence	5202000000- 0	826	9	9	9	8	10
Confluence	5200000000- 4	459	0	0	0	0	0
Confluence	5200000000- 3	826	23	23	24	24	22
Confluence	5200000000- 2	275	8	10	10	10	16
Confluence	5200000000- 0	459	3	2	3	3	4
Confluence	5002000000- 0	2,571	42	44	43	42	52
Confluence	5000000000- 2	3,214	115	119	122	124	163
Confluence	5000000000- 0	459	0	0	0	0	
Confluence	4900000000- 0	5,326	27	34	35	37	46
Confluence	4800000000- 0	4,040	189	191	190	190	288
Confluence	4613000000- 0	1,194	35	36	37	37	51
Confluence	4611000000- 0	1,102	15	15	16	15	27
Confluence	4610010000- 0	826	22	23	23	25	36

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	4610000000- 0	2,479	34	36	40	43	74
Confluence	4609000000- 0	3,857	347	339	382	413	463
Confluence	4608040000- 0	184	2	2	3	3	3
Confluence	4608020000- 0	1,286	74	78	85	88	105
Confluence	4608000000- 4	459	16	17	18	19	25
Confluence	4608000000- 2	275	17	17	17	17	20
Confluence	4608000000- 0	7,530	165	179	189	189	321
Confluence	4606040000- 0	1,377	17	16	18	18	
Confluence	4606040000- 0	735	18	17	17	18	19
Confluence	4606020100- 0	275	1	1	1	1	
Confluence	4606020100- 0	1,102	15	15	19	23	36
Confluence	4606020000- 1	1,377	1	1	1	1	
Confluence	4606020000- 1	735	3	3	3	3	2
Confluence	4606020000- 0	826	21	21	23	25	35
Confluence	4606000000- 4	735	5	7	7	8	
Confluence	4606000000- 4	551	21	24	24	24	39
Confluence	4606000000- 2	2,571	47	48	46	47	66
Confluence	4606000000- 0	1,286	35	36	37	40	44
Confluence	4604020000- 0	459					
Confluence	4604020000- 0	1,010	0	0	0	0	
Confluence	4604000000- 2	1,561	2	2	2	2	3
Confluence	4604000000- 0	1,102	0	0	0	0	
Confluence	4602000000- 0	643					
Confluence	4602000000- 0	367					

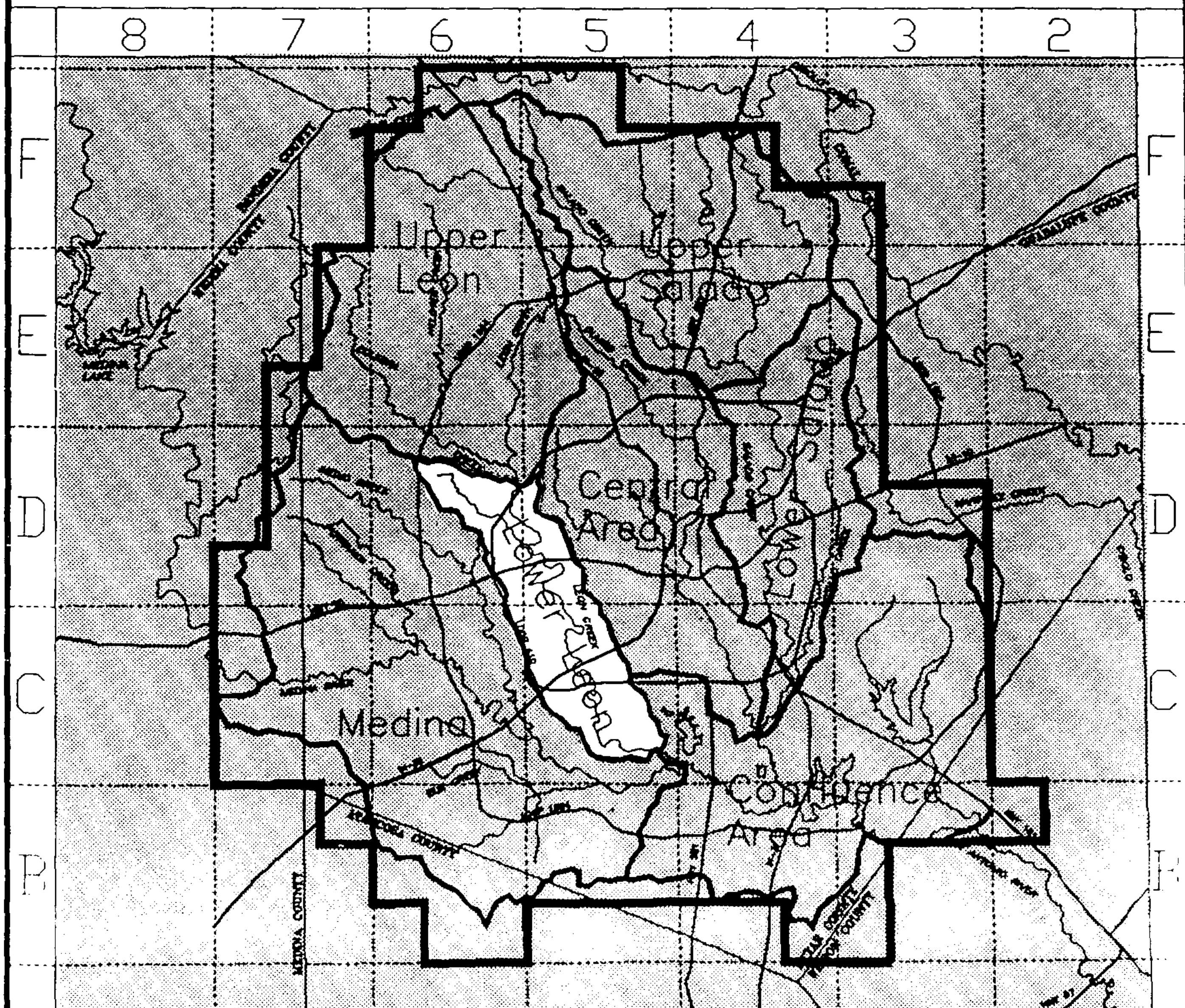
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Confluence	4600000000-13	1,837	35	36	41	40	77
Confluence	4600000000-11	551	11	11	12	12	18
Confluence	4600000000-10	2,020	49	49	46	49	98
Confluence	4600000000- 9	367	0	0	0	0	0
Confluence	4600000000- 8	2,571	281	285	296	496	330
Confluence	4600000000- 6	1,286	45	46	43	45	72
Confluence	4600000000- 4	1,837	0	0	0	0	0
Confluence	4600000000- 0	918					
Confluence	0-58	367	21	23	25	24	33
Confluence	0-57	1,102	70	81	81	80	99
Confluence	0-55	826	42	46	47	47	56
Confluence	0-53	735	7	4	5	5	5
Confluence	0-52	1,194	9	10	12	13	12
Confluence	0-50	4,408	53	51	57	60	101
Confluence	0-48	1,377	14	14	13	13	14
Confluence	0-46	3,765	26	26	25	19	37
Confluence		110,285	3,487	3,575	3,635	3,967	5,062

Lower Leon	*RESIDENTIAL CONNECTIONS*	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Leon	D - 6	11,019	5,163	5,231	5,429	5,669	10,258
Lower Leon	D - 5	8,081	1,392	1,424	2,156	1,565	2,407
Lower Leon	C - 6	735	898	914	914	913	924
Lower Leon	C - 5	12,856	5,935	6,165	6,849	9,377	7,615
Lower Leon		32,691	13,388	13,734	15,348	17,524	21,204

New Connections = 7,816 or 5 % of all New Connections in Study Area



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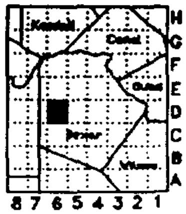

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 35

Map Name CULEBRA HILL

Scale 1:100,000

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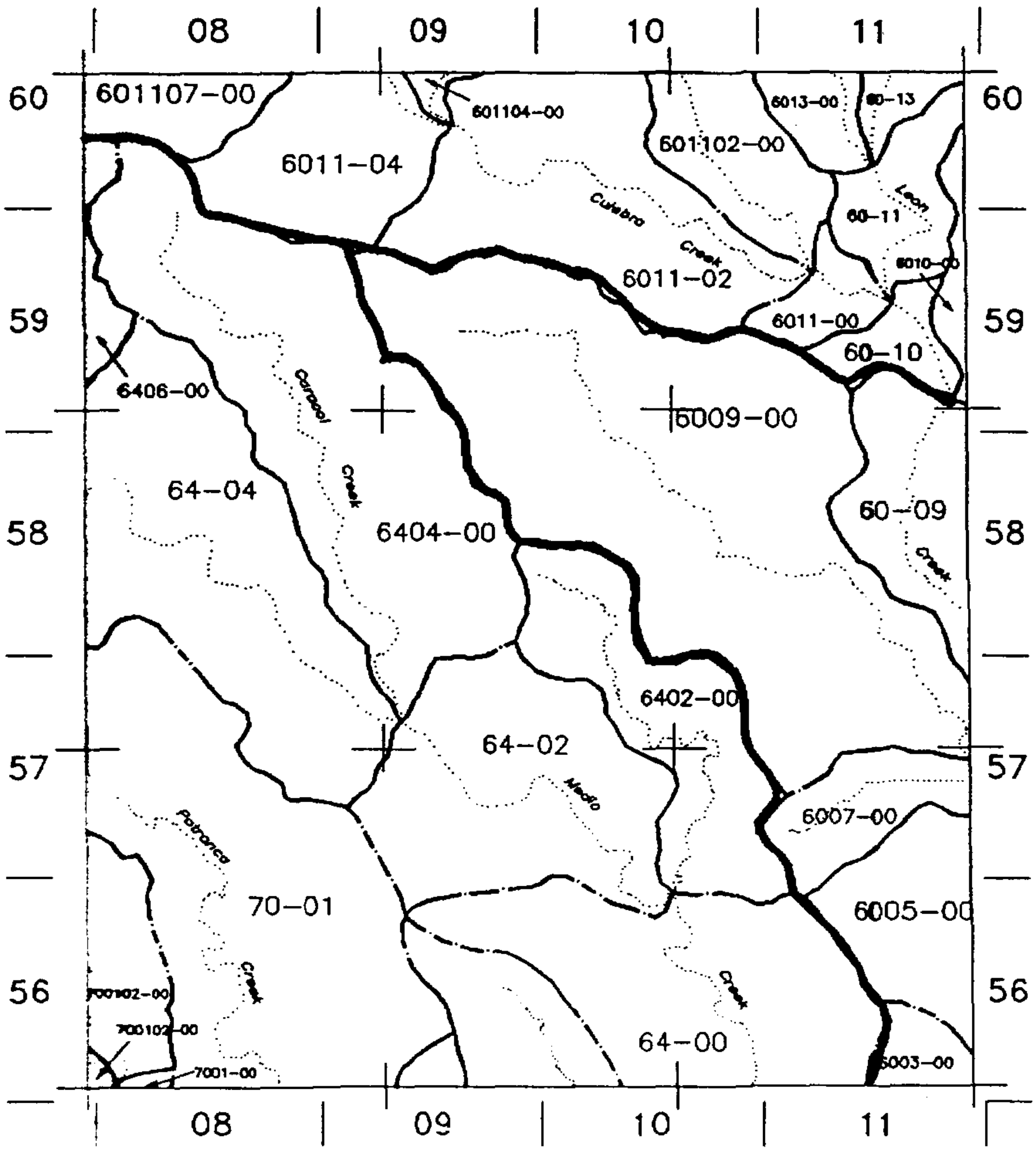
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = D6



GAE 1/29/93 44D6COMP.DWG

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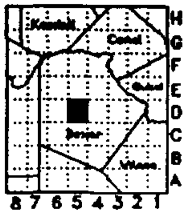

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 36

Map Name SAN ANTONIO WEST

Scale 1:100,000

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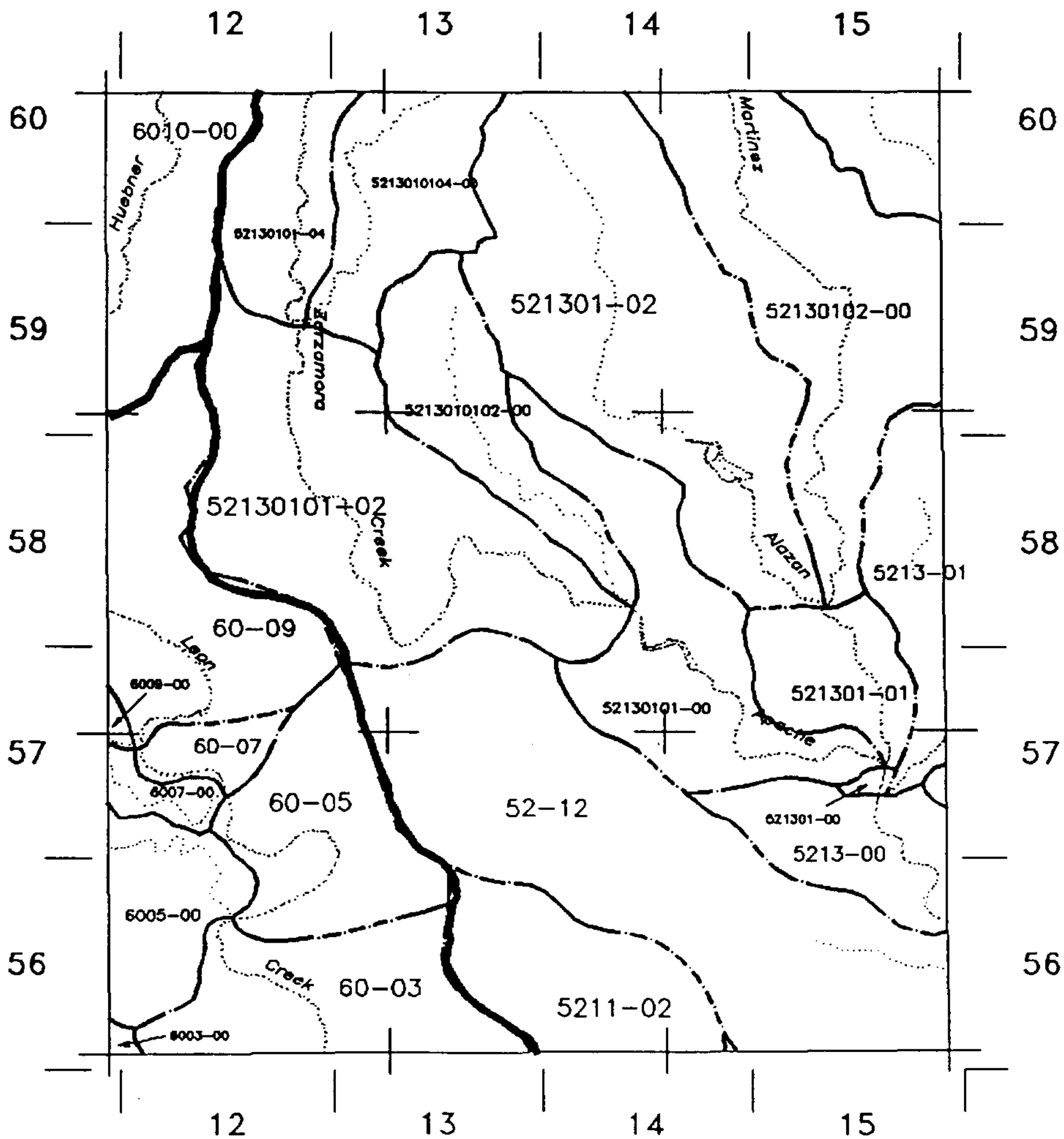
SCALE (MILES)

Latitude = 29

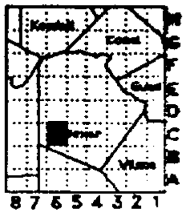
Longitude = 98

7.5' Area = D5



GAE 1/29/93 44D5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 43

Map Name MACDONA

Scale 1:100,000

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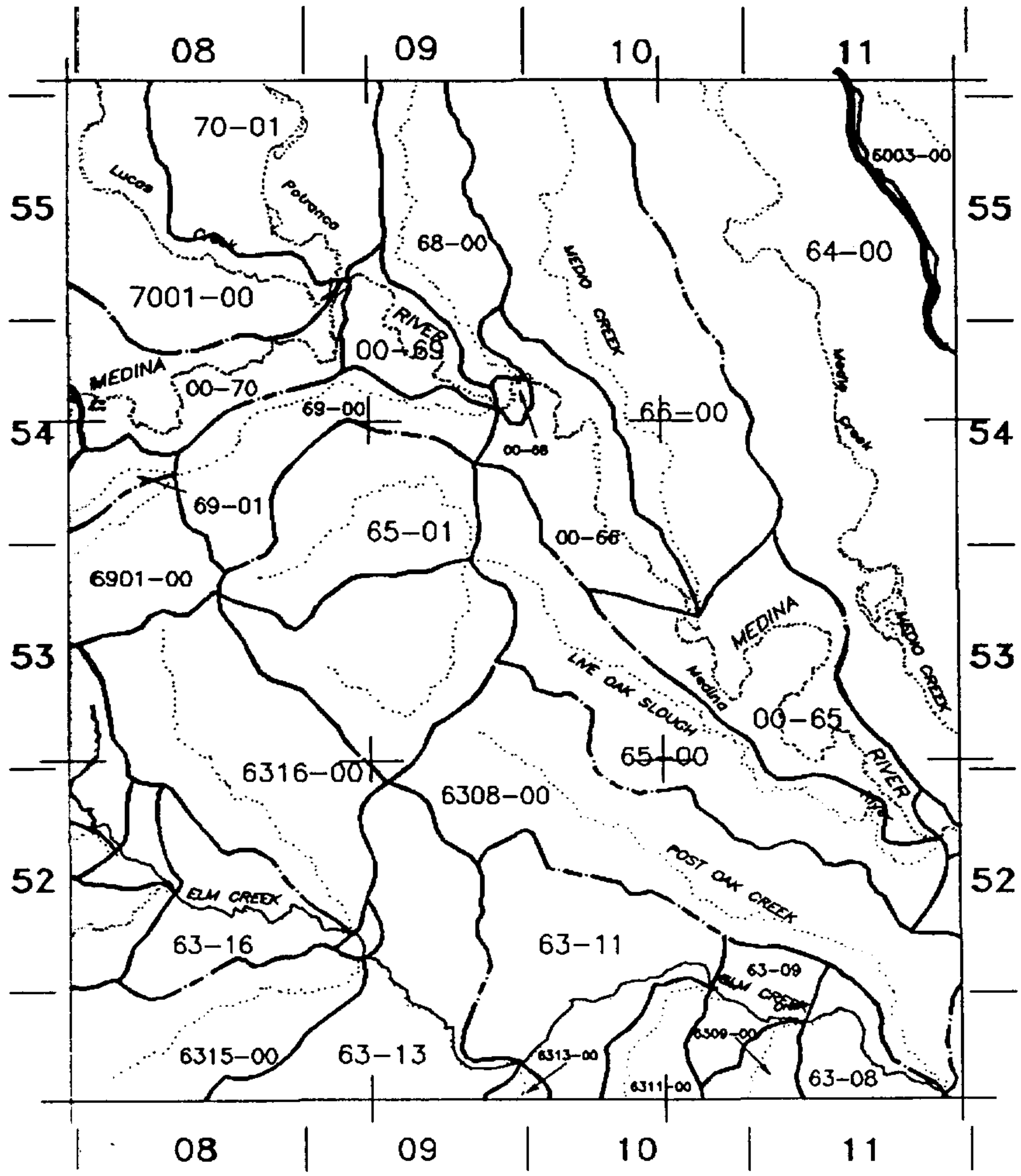
SCALE (MILES)

Latitude = 29

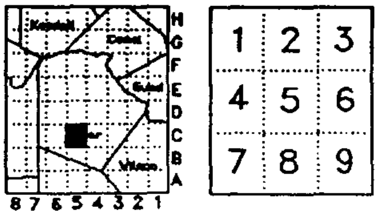
Longitude = 98

7.5' Area = C6



GAE 1/29/93 44C6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 44

Map Name TERREL WELLS

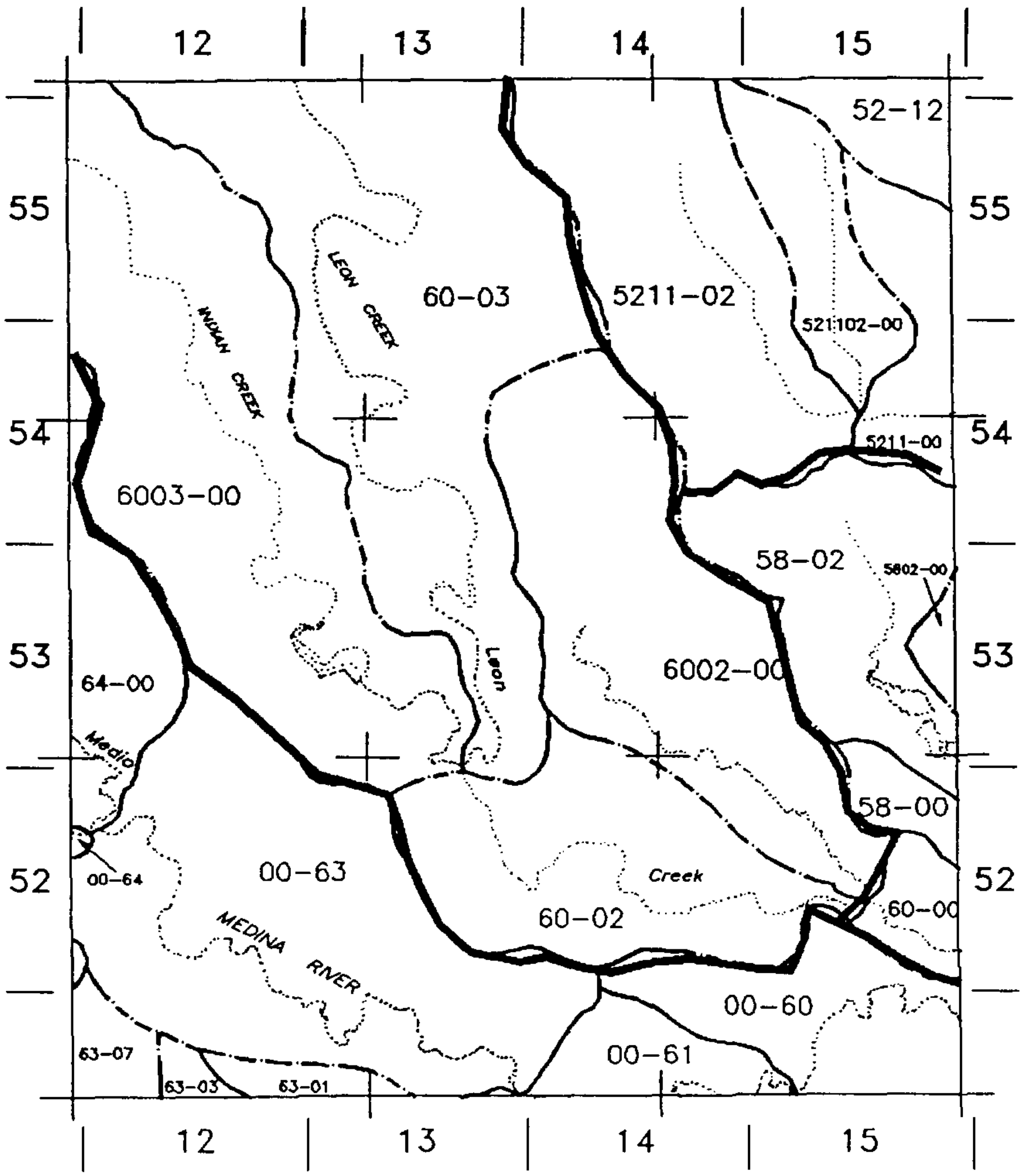
Scale 1:100,000

SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = C5



GAE 1/29/93 44C5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Leon	6009000000- 0	7,163	2,485	2,507	2,698	2,888	5,217
Lower Leon	6007000000- 0	918	2,071	2,104	2,100	2,127	2,413
Lower Leon	6005000000- 0	1,286	479	490	500	498	1,151
Lower Leon	6003000000- 0	367					480
Lower Leon	6000000000- 9	1,286	128	130	131	156	997
Lower Leon		11,019	5,163	5,231	5,429	5,669	10,258

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Leon	6007000000- 0	184	151	158	160	160	178
Lower Leon	6005000000- 0	918	8	8	12	12	25
Lower Leon	6000000000- 9	2,388	569	586	668	727	1,034
Lower Leon	6000000000- 7	275	109	115	117	121	122
Lower Leon	6000000000- 5	2,020	449	449	1,092	440	467
Lower Leon	6000000000- 3	2,296	106	108	107	105	581
Lower Leon		8,081	1,392	1,424	2,156	1,565	2,407

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Leon	6003000000- 0	735	898	914	914	913	924
Lower Leon		735	898	914	914	913	924

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Leon	6003000000- 0	6,336	3,196	3,418	4,132	6,671	5,036
Lower Leon	6000000000- 3	6,520	2,739	2,747	2,717	2,706	2,579
Lower Leon		12,856	5,935	6,165	6,849	9,377	7,615

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Page 6 1/29/93 11:12:35 a

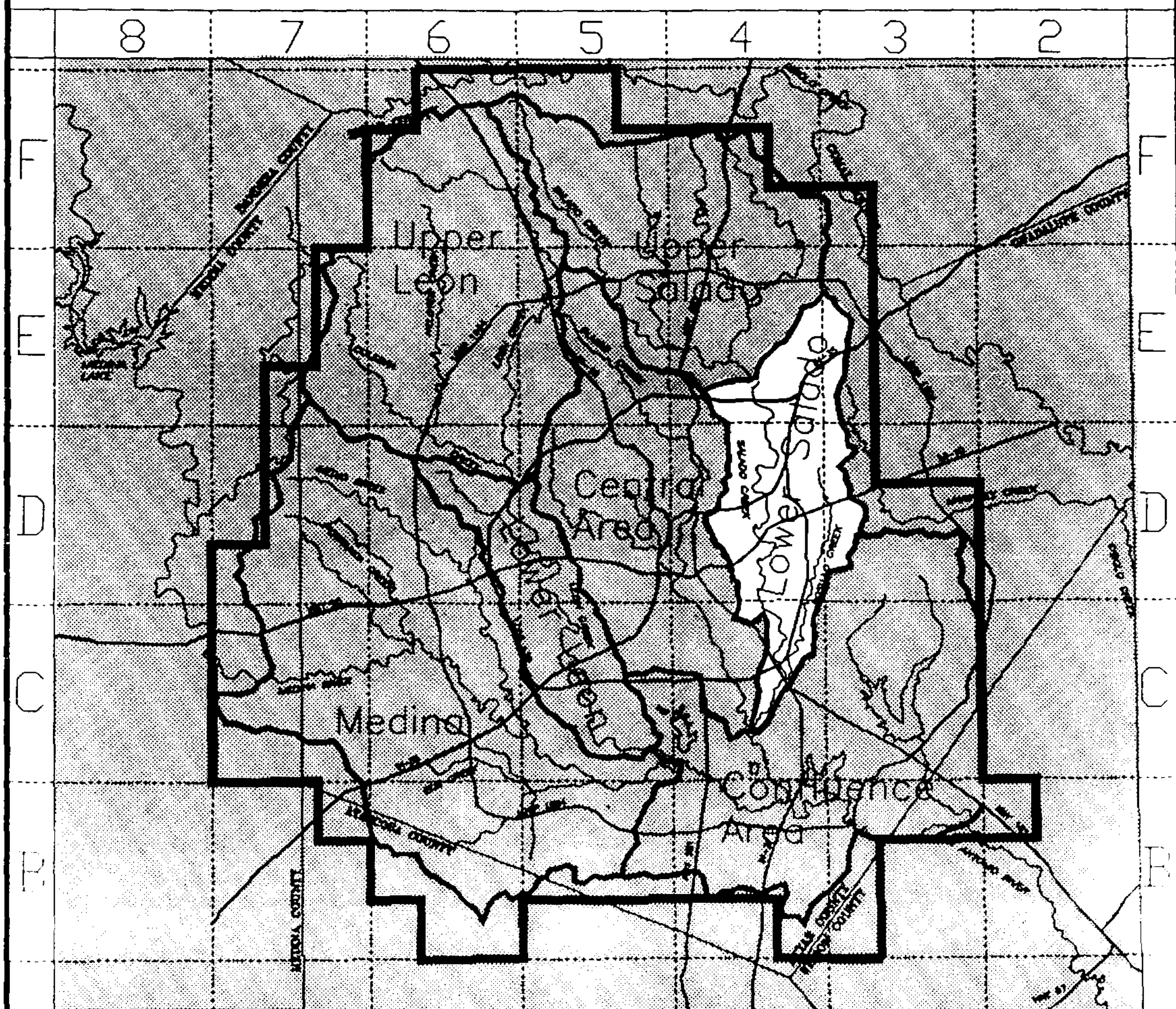
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

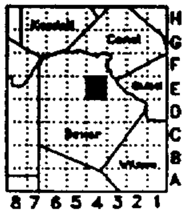
Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Leon	6009000000- 0	7,163	2,485	2,507	2,698	2,888	5,217
Lower Leon	6007000000- 0	1,102	2,222	2,262	2,260	2,287	2,591
Lower Leon	6005000000- 0	2,204	487	498	512	510	1,176
Lower Leon	6003000000- 0	7,438	4,094	4,332	5,046	7,584	6,440
Lower Leon	6000000000- 9	3,673	697	716	799	883	2,031
Lower Leon	6000000000- 7	275	109	115	117	121	122
Lower Leon	6000000000- 5	2,020	449	449	1,092	440	467
Lower Leon	6000000000- 3	8,815	2,845	2,855	2,824	2,811	3,160
Lower Leon		32,691	13,388	13,734	15,348	17,524	21,204

Lower Salado	RESIDENTIAL CONNECTIONS	1976 Thru 1988

Watershed 7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado E - 4	12,213	7,209	8,397	11,170	9,525	23,694
Lower Salado E - 3	2,847					
Lower Salado D - 4	26,814	24,678	26,319	26,115	26,392	30,623
Lower Salado D - 3	5,326					322
Lower Salado C - 4	12,764	4,876	4,989	5,034	5,158	6,497
Lower Salado	59,963	36,763	39,705	42,319	41,075	61,136

New Connections = <u>24,373</u> or <u>17%</u> of all New Connections in Study Area





1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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SCALE (MILES)

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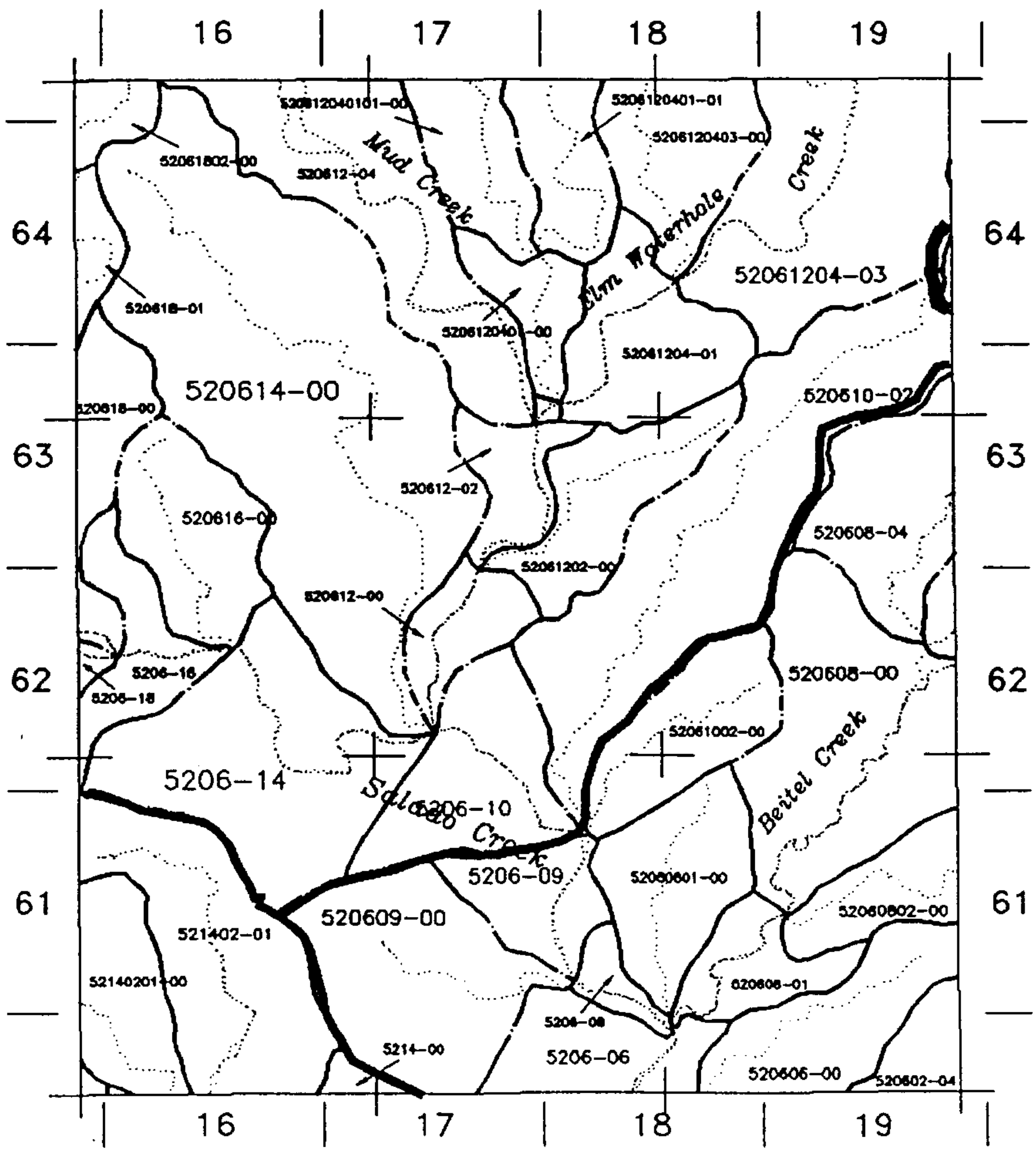
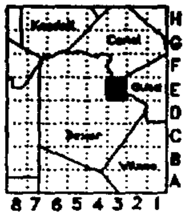
Longitude = 98

7.5' Area = E4



GAE 1/29/93 44E4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 30

Map Name SCHERTZ

Scale 1:100,000

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SCALE (MILES)

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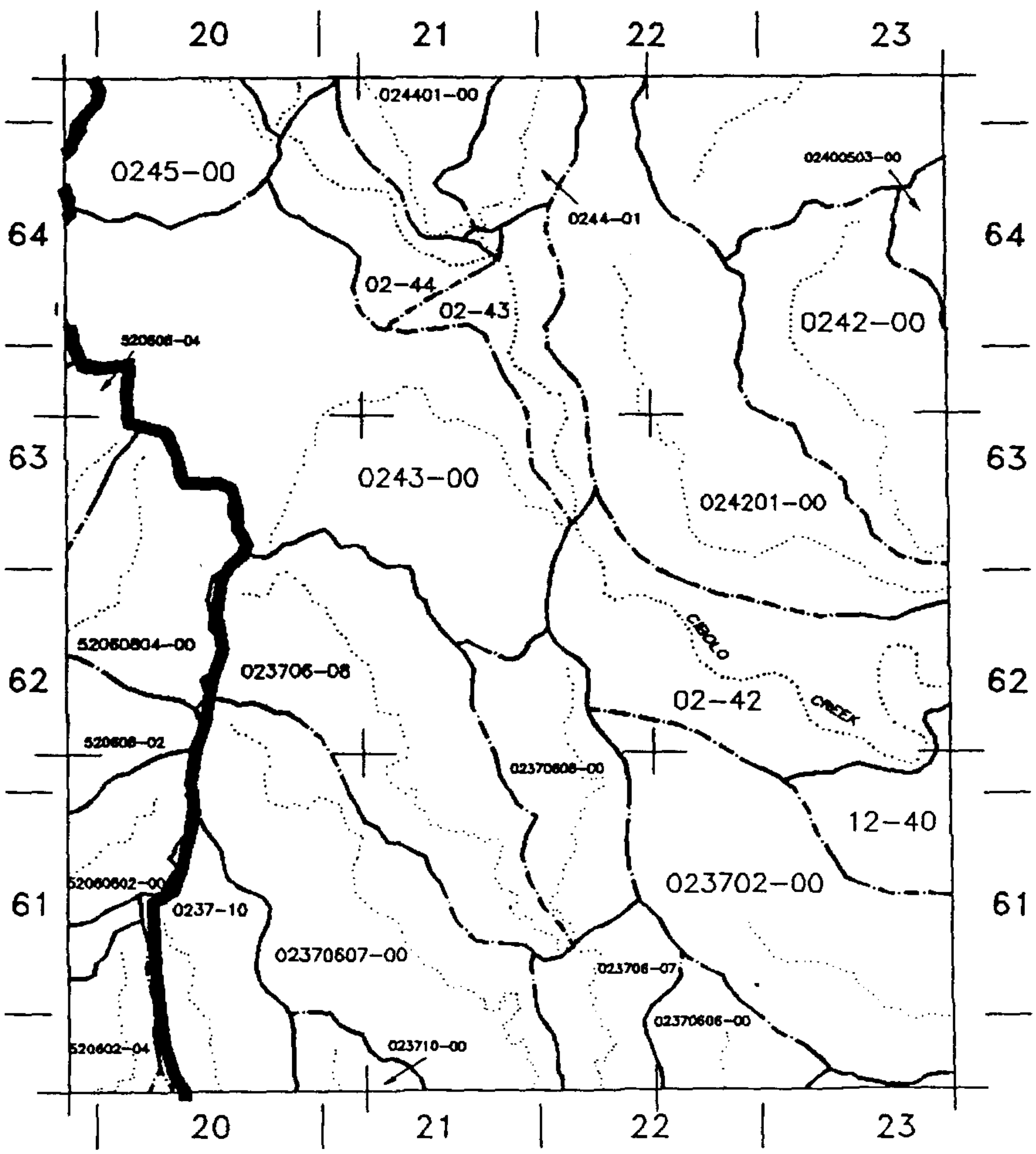
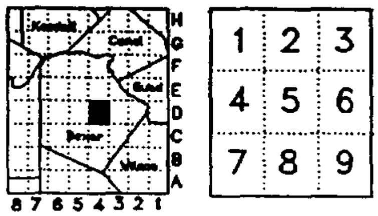
Longitude = 98

7.5' Area = E3



GAE 1/29/93 44E3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 37

Map Name SAN ANTONIO EAST

Scale 1:100,000

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SCALE (MILES)

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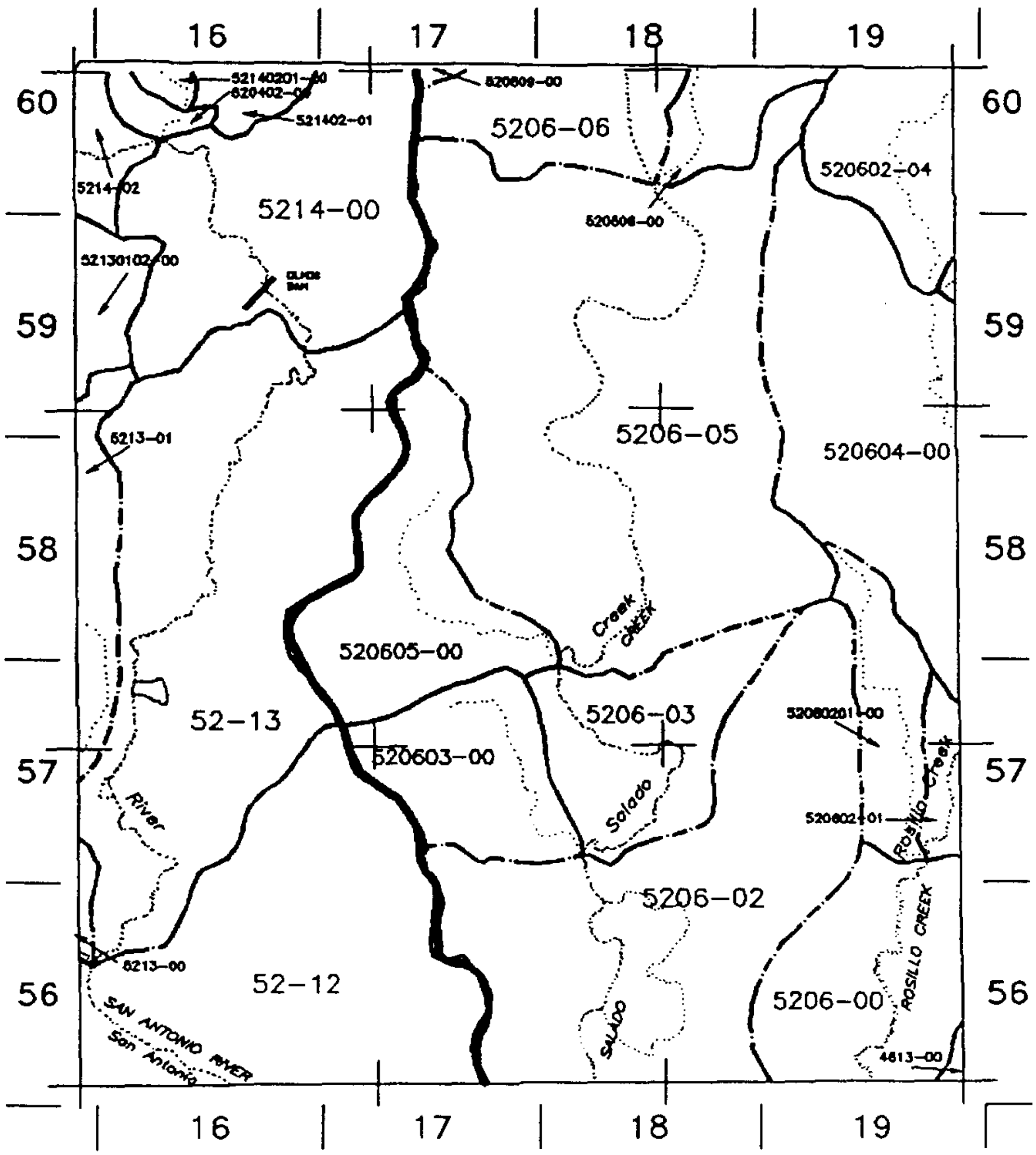
Longitude = 98

7.5' Area = D4



GAE 1/29/93 44D4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area

Water Well ID 68- 38

Map Name MARTINEZ

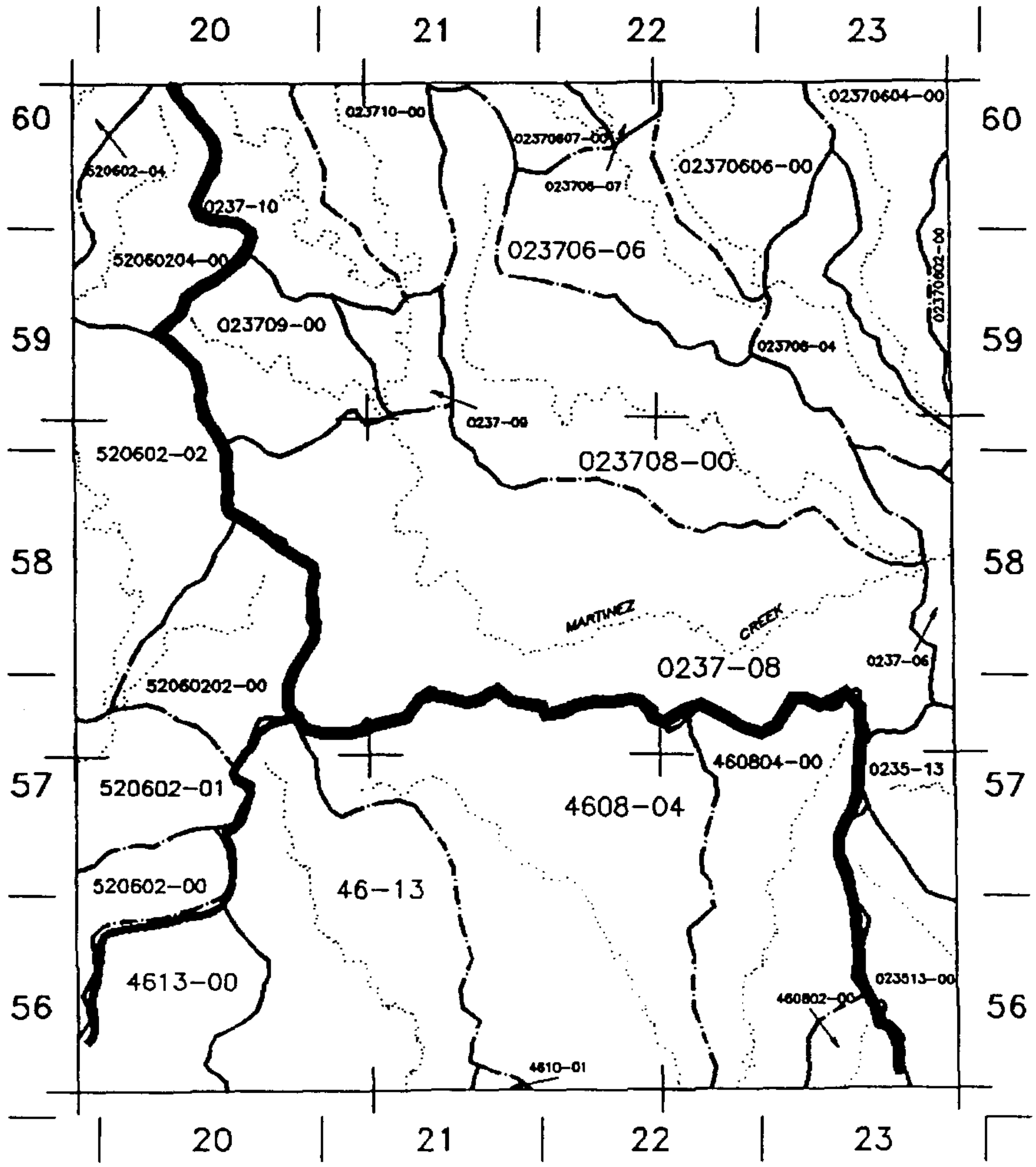
Scale 1:100,000

SCALE (MILES) 0 0.5 1.0 1.5 2.0

Latitude = 29

Longitude = 98

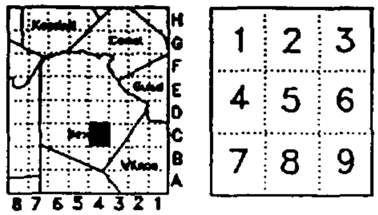
7.5' Area = D3



GAE 1/29/93 44D3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area



Water Well ID 68- 45

Map Name SOUTHTON

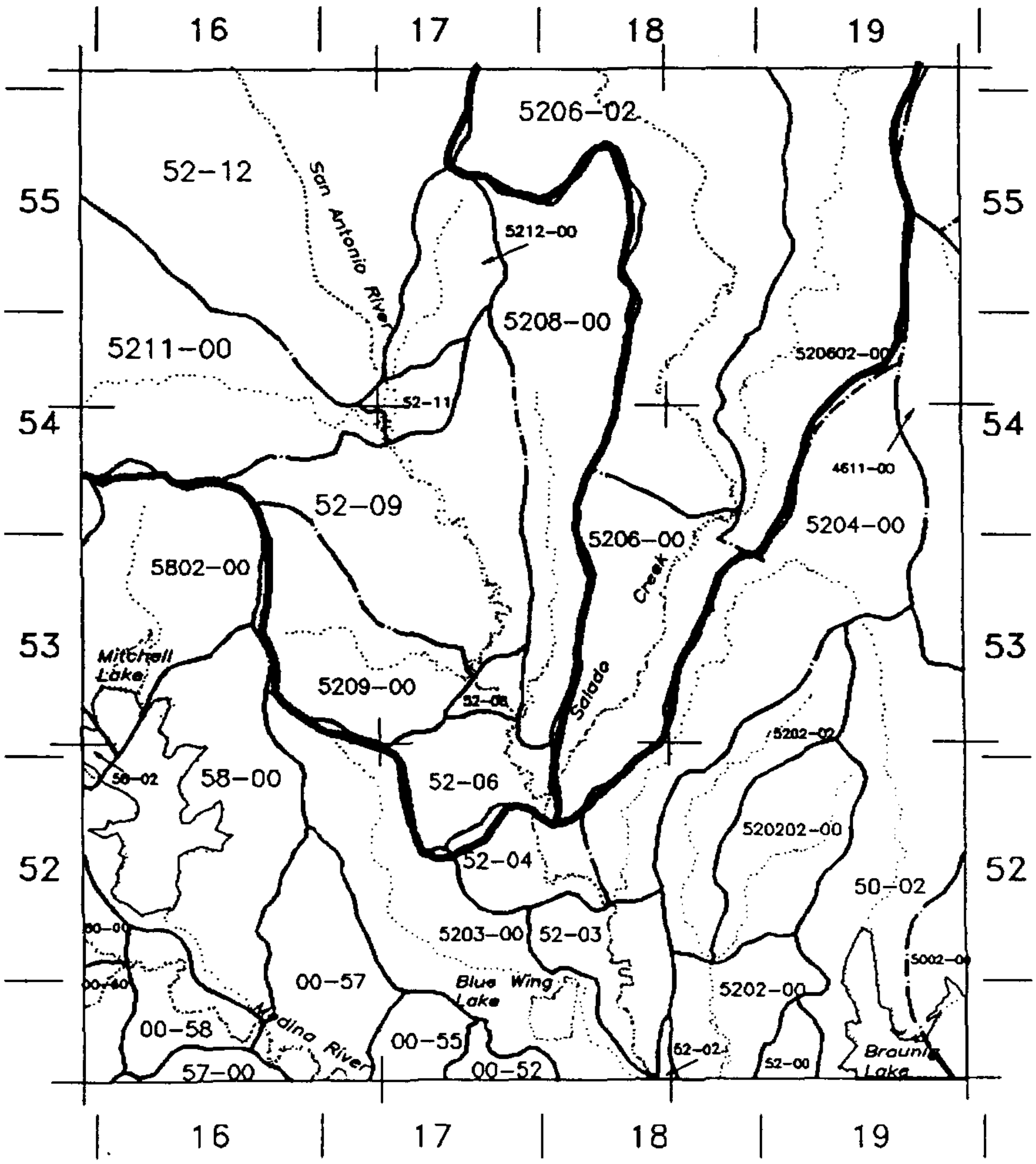
Scale 1:100,000

SCALE (MILES) 0 0.5 1.0 1.5 2.0

Latitude = 29

Longitude = 98

7.5' Area = C4



GAE 1/29/93 44C4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

Report file: q_sws_R
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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado	5206090000- 0	1,745	1,234	1,333	1,390	1,427	2,844
Lower Salado	5206080400- 0	184	150	157	162	187	445
Lower Salado	5206080200- 0	826					1,467
Lower Salado	5206080100- 0	1,194	1,116	1,138	1,196	1,297	3,816
Lower Salado	5206080000- 4	1,469	550	1,418	1,207	1,398	3,739
Lower Salado	5206080000- 2	2,571	2,820	2,893	5,272	3,149	4,007
Lower Salado	5206080000- 1	551	411	421	820	937	1,243
Lower Salado	5206060000- 0	1,194					1,857
Lower Salado	5206020000- 4	551					862
Lower Salado	5206000000- 9	735	760	869	900	906	1,302
Lower Salado	5206000000- 8	275	168	168	223	224	740
Lower Salado	5206000000- 6	918					1,372
Lower Salado		12,213	7,209	8,397	11,170	9,525	23,694

Report file: q_sws_R
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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-3

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado	5206080400- 0	1,377					
Lower Salado	5206080200- 0	459					
Lower Salado	5206080000- 4	184					
Lower Salado	5206080000- 2	275					
Lower Salado	5206060000- 0	92					
Lower Salado	5206020400- 0	92					
Lower Salado	5206020000- 4	367					
Lower Salado		2,847					

Report file: q_sws_R
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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado	5206060000- 0	367	1,331	1,331	1,334	1,332	1,331
Lower Salado	5206050000- 0	1,745	3,376	3,919	3,698	3,609	3,633
Lower Salado	5206030000- 0	1,469	3,389	3,356	3,269	3,266	3,437
Lower Salado	5206020100- 0	918	68	66	65	61	75
Lower Salado	5206020000- 4	1,194	1,286	1,293	1,291	1,293	1,259
Lower Salado	5206020000- 2	3,857	1,957	1,965	2,078	2,190	3,837
Lower Salado	5206020000- 1	367	16	30	39	42	95
Lower Salado	5206020000- 0	2,204	911	1,058	1,280	1,660	2,101
Lower Salado	5206000000- 6	1,010	1,624	1,654	1,804	1,801	2,563
Lower Salado	5206000000- 5	7,805	4,378	5,093	4,529	4,536	4,788
Lower Salado	5206000000- 3	1,377	1,625	1,622	1,758	1,607	1,851
Lower Salado	5206000000- 2	4,500	4,717	4,932	4,970	4,995	5,653
Lower Salado		26,814	24,678	26,319	26,115	26,392	30,623

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-3

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado	5206020400- 0	1,010					
Lower Salado	5206020200- 0	1,286					230
Lower Salado	5206020000- 4	92					
Lower Salado	5206020000- 2	1,745					
Lower Salado	5206020000- 1	643					7
Lower Salado	5206020000- 0	551					85
Lower Salado		5,326					322

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado	5206020000- 0	1,745	42	39	40	39	83
Lower Salado	5206020000- 0	2,112	43	43	40	59	83
Lower Salado	5206000000- 2	4,775	4,630	4,746	4,788	4,894	5,830
Lower Salado	5206000000- 0	4,132	161	161	166	166	501
Lower Salado		12,764	4,876	4,989	5,034	5,158	6,497

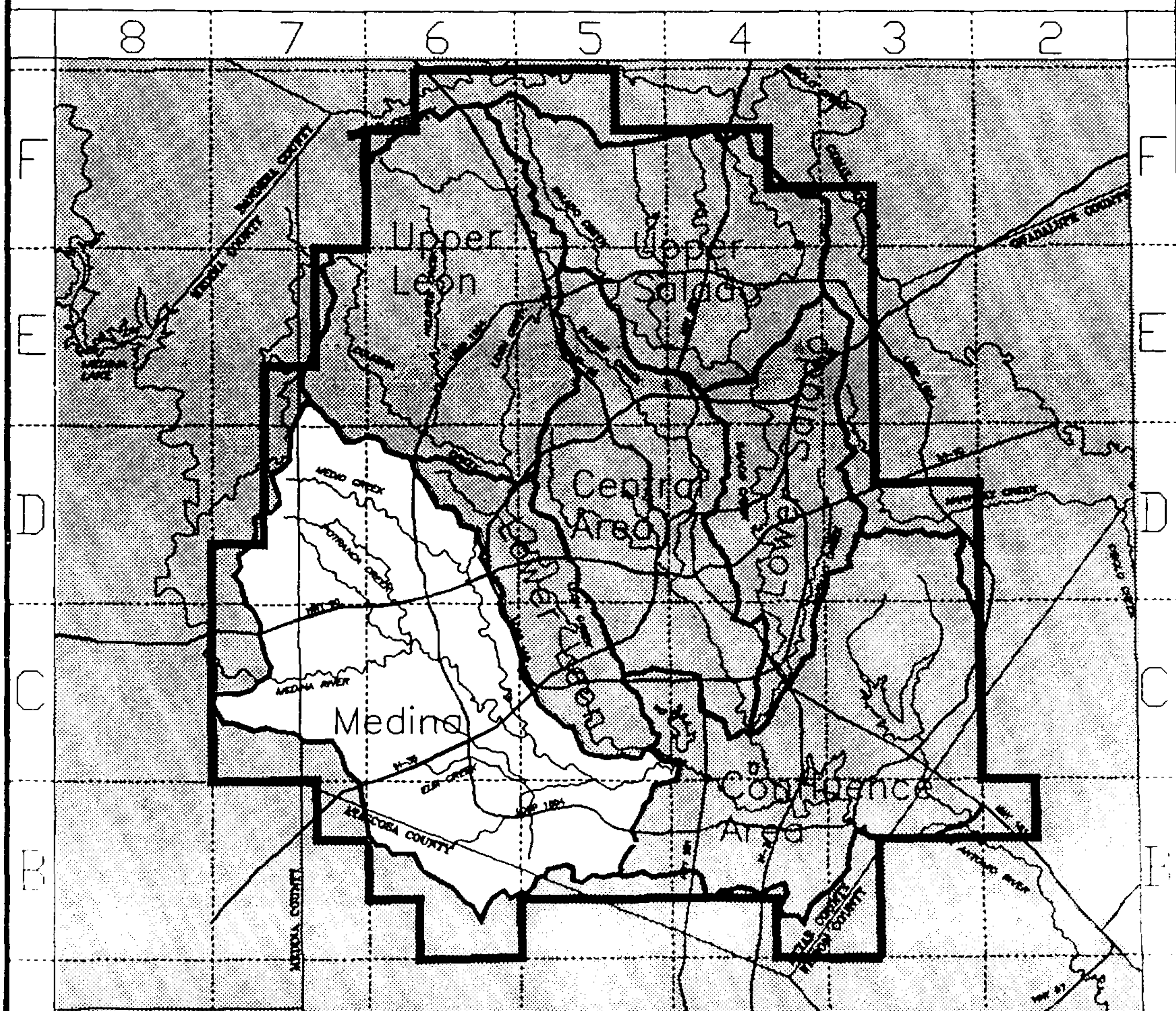
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

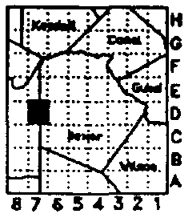
Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Lower Salado	5206090000- 0	1,745	1,234	1,333	1,390	1,427	2,844
Lower Salado	5206080400- 0	1,561	150	157	162	187	445
Lower Salado	5206080200- 0	1,286					1,467
Lower Salado	5206080100- 0	1,194	1,116	1,138	1,196	1,297	3,816
Lower Salado	5206080000- 4	1,653	550	1,418	1,207	1,398	3,739
Lower Salado	5206080000- 2	2,847	2,820	2,893	5,272	3,149	4,007
Lower Salado	5206080000- 1	551	411	421	820	937	1,243
Lower Salado	5206060000- 0	1,653	1,331	1,331	1,334	1,332	3,188
Lower Salado	5206050000- 0	1,745	3,376	3,919	3,698	3,609	3,633
Lower Salado	5206030000- 0	1,469	3,389	3,356	3,269	3,266	3,437
Lower Salado	5206020400- 0	1,102					
Lower Salado	5206020200- 0	1,286					230
Lower Salado	5206020100- 0	918	68	66	65	61	75
Lower Salado	5206020000- 0	1,745	42	39	40	39	83
Lower Salado	5206020000- 4	2,204	1,286	1,293	1,291	1,293	2,121
Lower Salado	5206020000- 2	5,601	1,957	1,965	2,078	2,190	3,837
Lower Salado	5206020000- 1	1,010	16	30	39	42	102
Lower Salado	5206020000- 0	4,867	954	1,101	1,320	1,719	2,269
Lower Salado	5206000000- 9	735	760	869	900	906	1,302
Lower Salado	5206000000- 8	275	168	168	223	224	740
Lower Salado	5206000000- 6	1,928	1,624	1,654	1,804	1,801	3,935
Lower Salado	5206000000- 5	7,805	4,378	5,093	4,529	4,536	4,788
Lower Salado	5206000000- 3	1,377	1,625	1,622	1,758	1,607	1,851
Lower Salado	5206000000- 2	9,275	9,347	9,678	9,758	9,889	11,483
Lower Salado	5206000000- 0	4,132	161	161	166	166	501
Lower Salado		59,963	36,763	39,705	42,319	41,075	61,136

Medina	RESIDENTIAL CONNECTIONS	1976 Thru 1988

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	D - 7	20,294	215	224	235	259	607
Medina	D - 6	22,314	2,691	2,847	3,301	3,778	10,638
Medina	C - 7	12,489	270	281	283	279	384
Medina	C - 6	25,895	1,464	1,699	1,683	1,482	1,597
Medina	C - 5	826	21	22	21	19	26
Medina		81,818	4,661	5,073	5,523	5,817	13,252

New Connections = <u>8,591</u> or <u>6%</u> of all New Connections in Study Area





1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 34

Map Name LA COSTE NE

Scale 1:100,000

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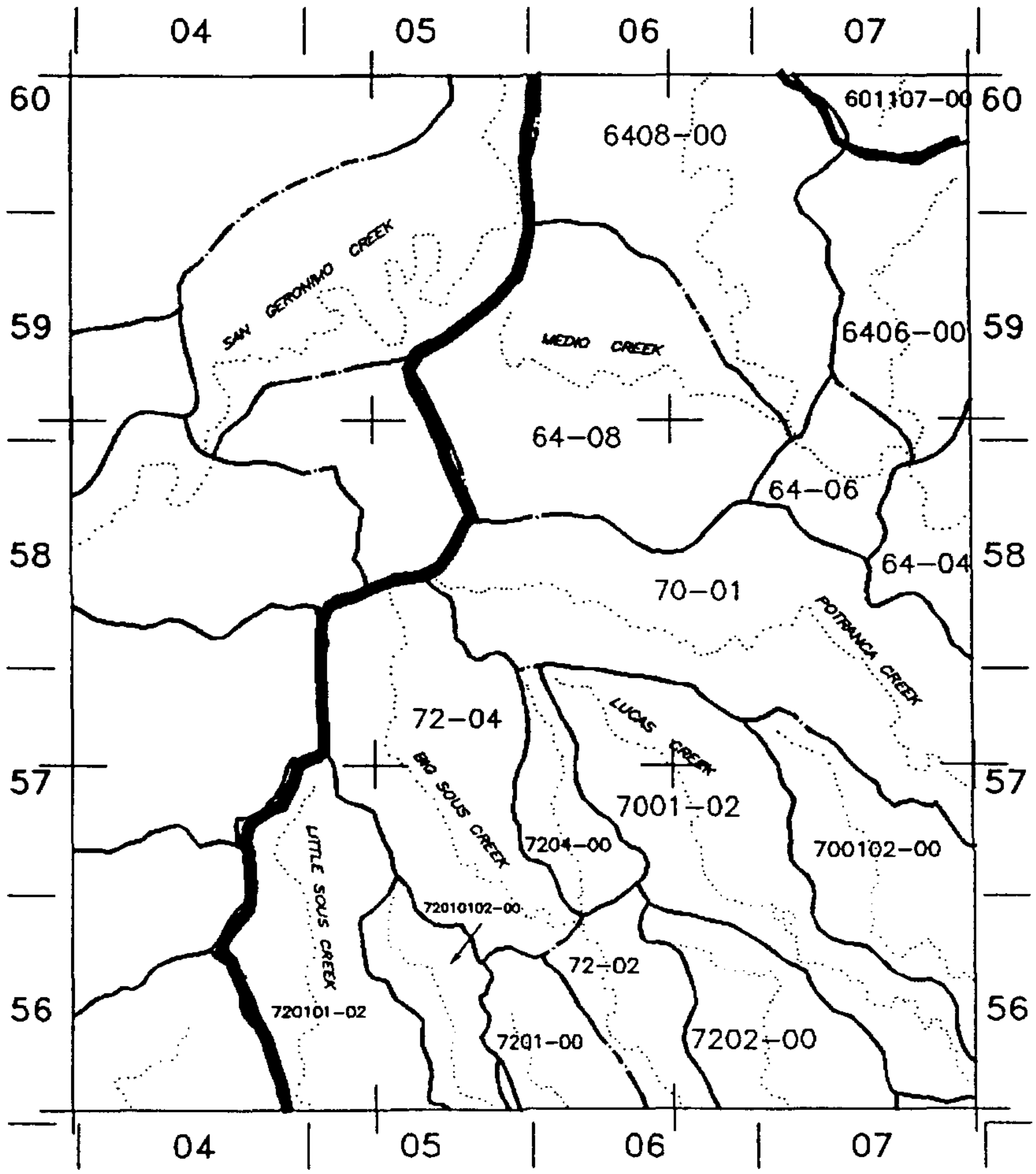
SCALE (MILES)

Latitude = 29

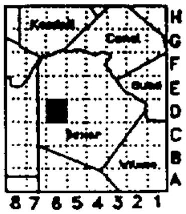
Longitude = 98

7.5' Area = D7



GAE 1/29/93 44D7COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 35

Map Name CULEBRA HILL

Scale 1:100,000

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SCALE (MILES)

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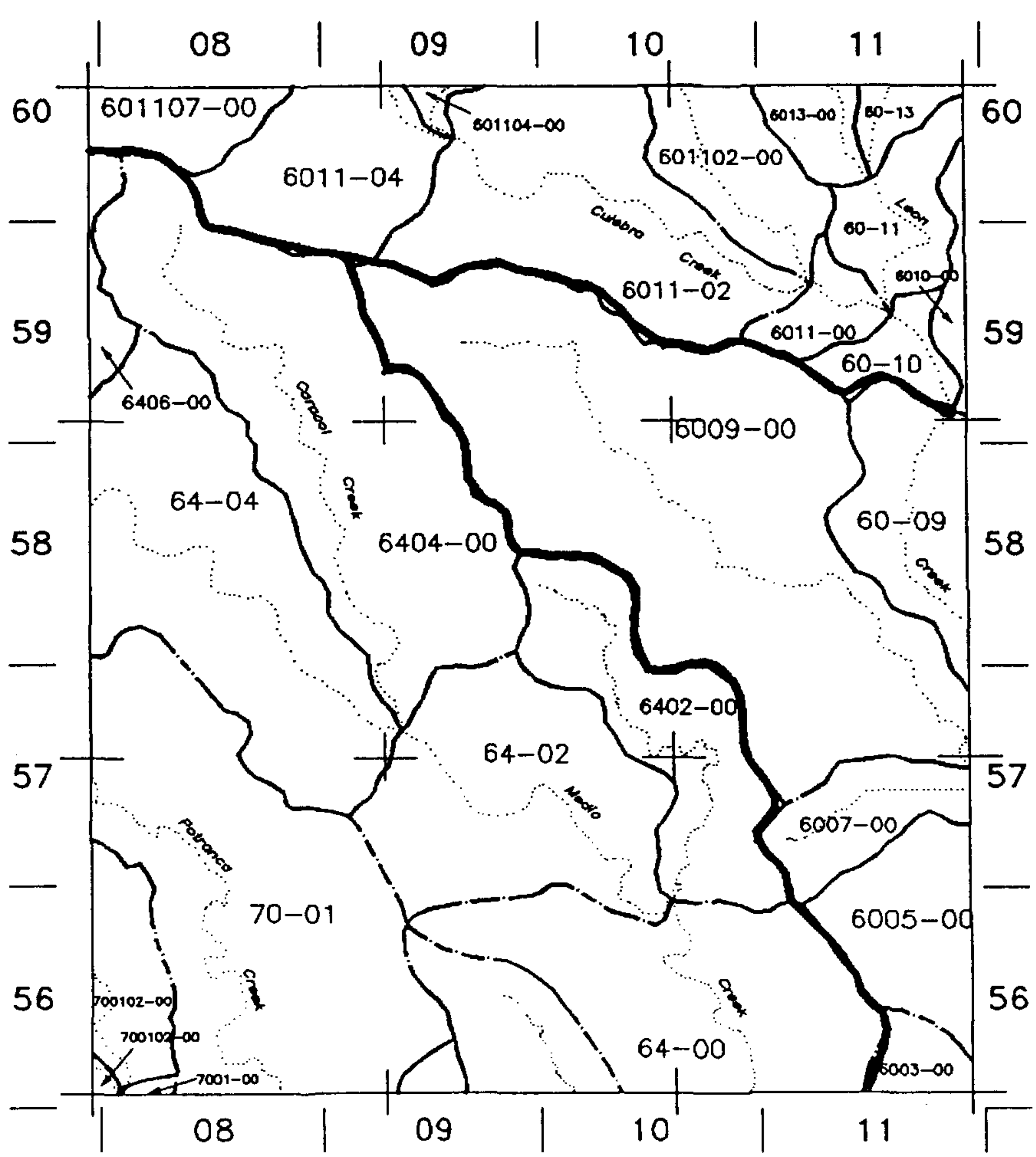
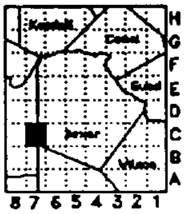
Longitude = 98

7.5' Area = D6



GAE 1/29/93 44D6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 42

Map Name LA COSTE

Scale 1:100,000

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SCALE (MILES)

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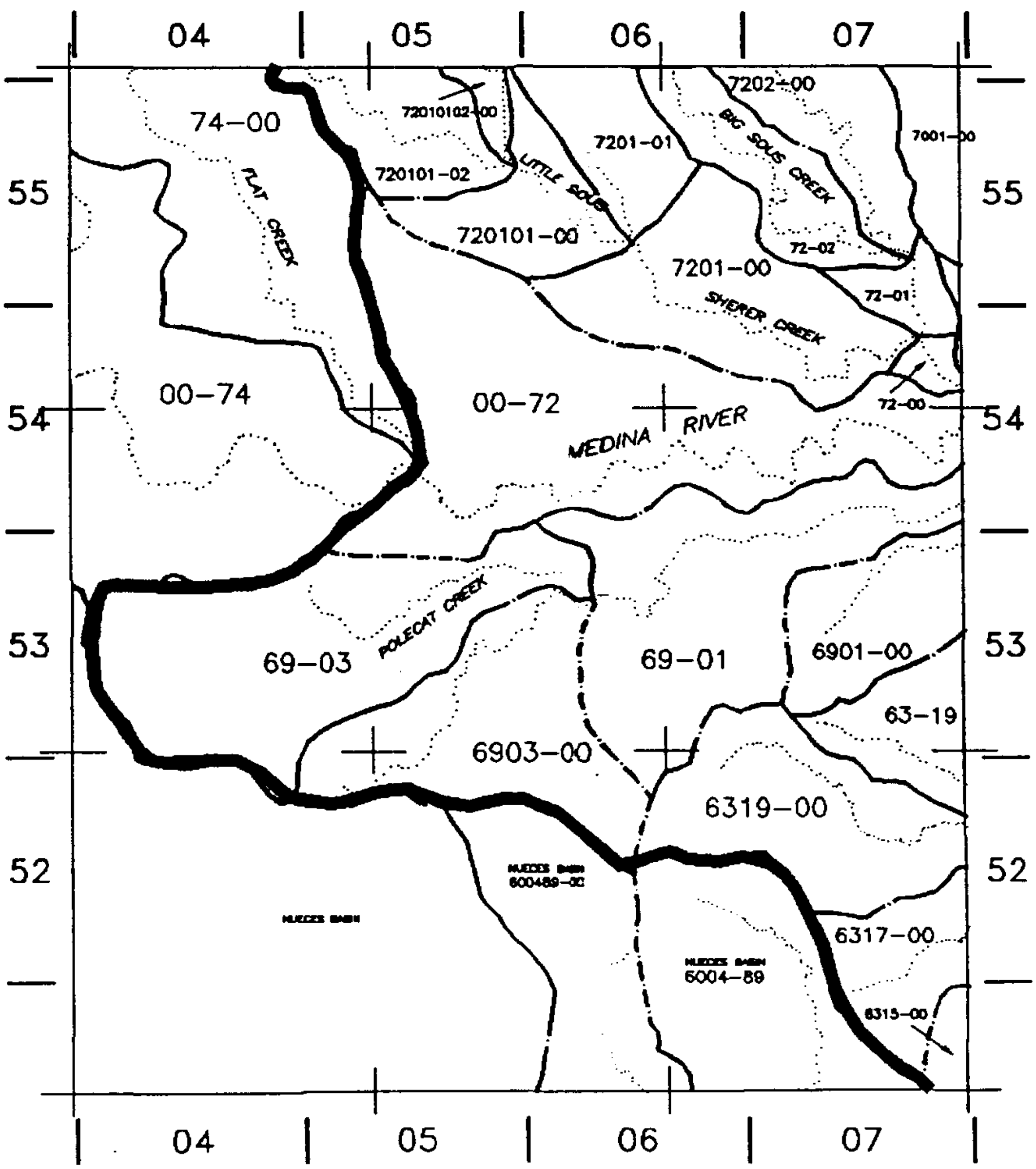
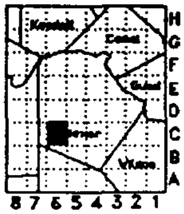
Longitude = 98

7.5' Area = C7



GAE 1/29/93 44C7COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 43

Map Name MACDONA

Scale 1:100,000

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SCALE (MILES)

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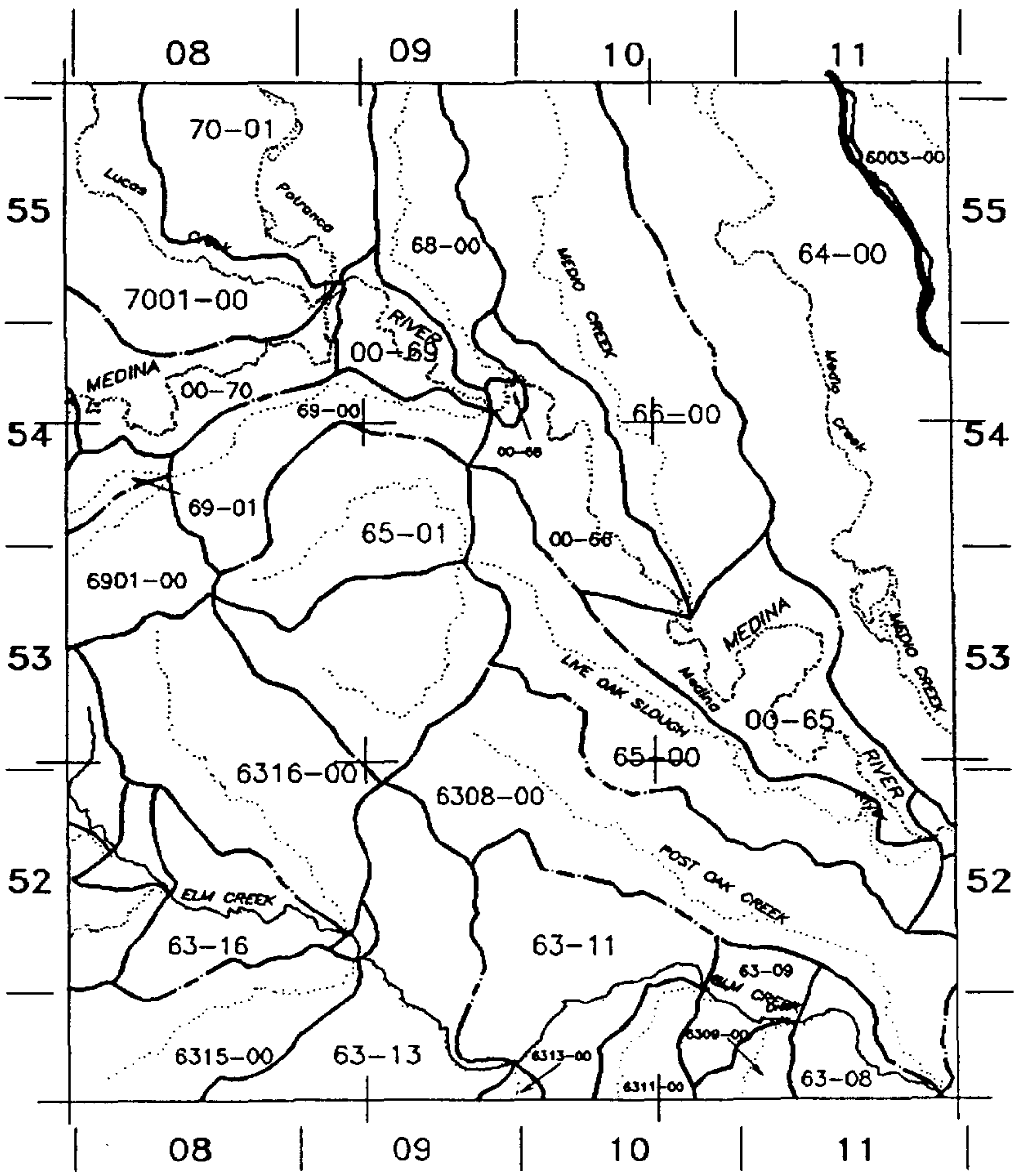
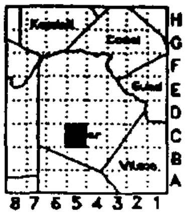
Longitude = 98

7.5' Area = C6





1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 44

Map Name TERREL WELLS

Scale 1:100,000

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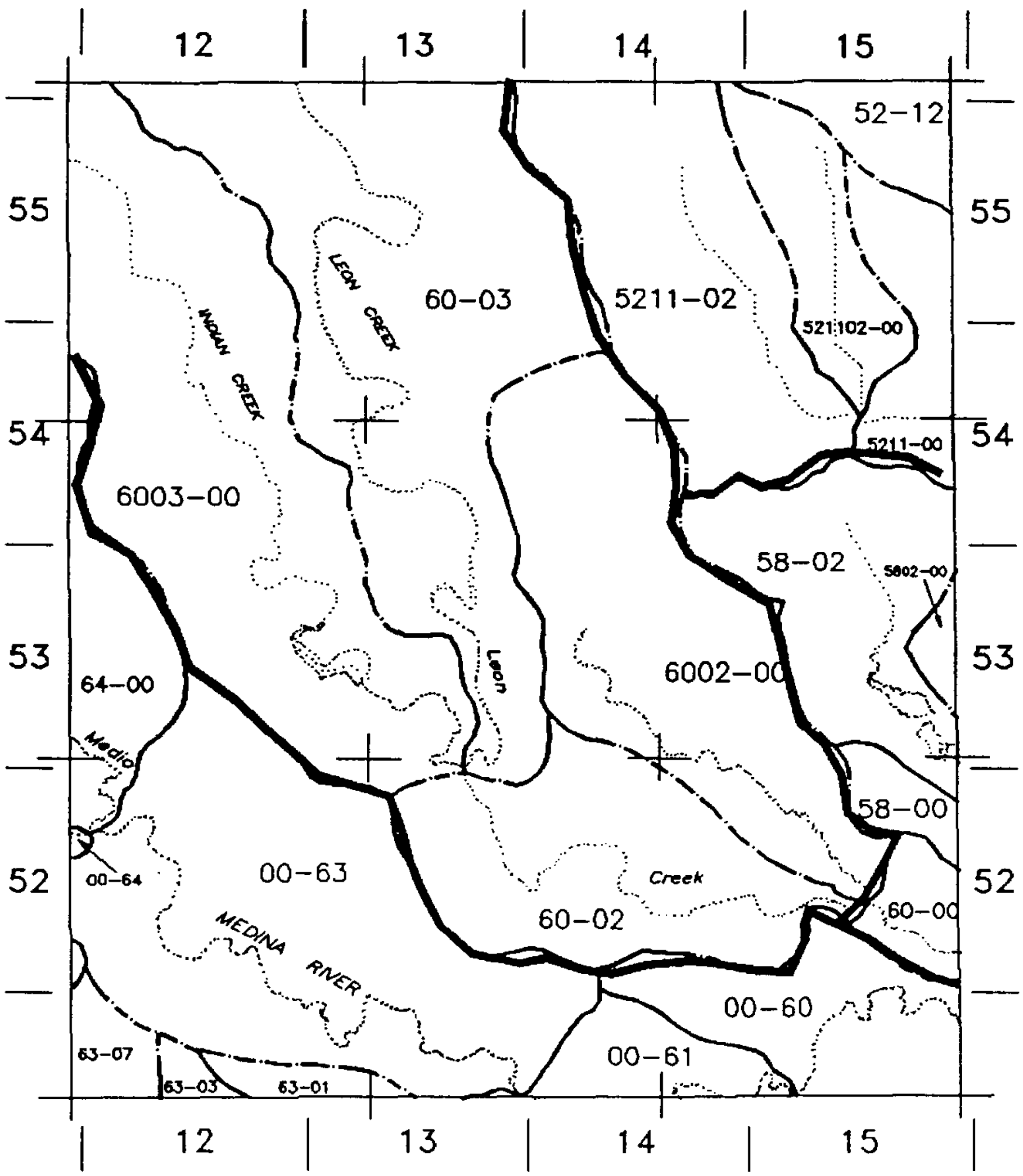
Longitude = 98

7.5' Area = C5



GAE 1/29/93 44C5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-7

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	7202000000- 0	1,928	3	3	3	3	3
Medina	7201000000- 1	184	1	1	1	1	1
Medina	7201000000- 0	275					
Medina	7200000000- 4	92					
Medina	7200000000- 2	1,010	7	8	7	7	57
Medina	7001020000- 0	1,469					1
Medina	7001000000- 2	2,663					
Medina	7001000000- 0	184					
Medina	7000000000- 1	3,489	4	4	5	7	46
Medina	6408000000- 0	3,030	99	107	103	108	201
Medina	6406000000- 0	1,745	20	20	27	27	57
Medina	6400000000- 8	2,571	3	3	3	3	1
Medina	6400000000- 6	735	11	12	16	25	124
Medina	6400000000- 4	918	67	66	70	78	116
Medina		20,294	215	224	235	259	607

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	7001020000- 0	735	1	1	1	1	325
Medina	7000000000- 1	4,500	103	107	110	112	134
Medina	6800000000- 0	92					
Medina	6600000000- 0	1,010	3	3	3	2	166
Medina	6406000000- 0	92	1	1	1	1	1
Medina	6404000000- 0	4,683	24	62	153	205	799
Medina	6402000000- 0	1,653	1,391	1,548	1,745	1,988	4,155
Medina	6400000000- 4	3,581	175	184	192	194	337
Medina	6400000000- 2	2,755	649	597	752	932	2,904
Medina	6400000000- 0	3,214	344	344	344	343	1,817
Medina		22,314	2,691	2,847	3,301	3,778	10,638

Report file: q_sws_R
Page 41   1/28/93 7:55:37 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-7

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	7202000000- 0	826	7	7	7	7	7
Medina	7201010000- 0	459	7	7	8	8	8
Medina	7201000000- 1	826	8	8	5	5	55
Medina	7201000000- 0	1,928	5	5	5	5	6
Medina	7200000000- 2	918	13	13	13	10	21
Medina	7200000000- 1	367					
Medina	7200000000- 0	184					
Medina	7001000000- 0	367	16	17	17	17	23
Medina	6901000000- 0	1,102	45	48	51	51	59
Medina	6900000000- 1	2,847	126	132	132	136	158
Medina	0-72	2,663	43	44	45	40	47
Medina		12,489	270	281	283	279	384

Report file: q_sws_R

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TOTAL RESIDENTIAL CONNECTIONS

1976-1988

7.5' Area : C-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	7001000000- 0	1,653	103	108	111	108	128
Medina	7000000000- 1	1,653	1	1	1	1	5
Medina	6901000000- 0	643	4	4	4	4	10
Medina	6900000000- 1	184	2	2	2	2	2
Medina	6900000000- 0	1,194	24	28	29	31	45
Medina	6800000000- 0	1,102	2	2	2	2	3
Medina	6600000000- 0	3,214	18	18	19	19	18
Medina	6501000000- 0	1,745	62	65	62	65	74
Medina	6500000000- 1	1,377	105	112	104	104	115
Medina	6500000000- 0	2,296	247	251	454	251	304
Medina	6400000000- 0	6,336	769	978	773	769	763
Medina	0-70	1,102	20	21	20	22	25
Medina	0-69	459	3	3	1	1	2
Medina	0-68	92	2	2	2	2	1
Medina	0-66	1,286	14	14	14	14	16
Medina	0-65	1,561	88	90	85	87	86
Medina		25,895	1,464	1,699	1,683	1,482	1,597

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : C-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	6400000000- 0	826	21	22	21	19	26
Medina		826	21	22	21	19	26

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	7202000000- 0	1,928	3	3	3	3	3
Medina	7202000000- 0	826	7	7	7	7	7
Medina	7201010000- 0	459	7	7	8	8	8
Medina	7201000000- 1	184	1	1	1	1	1
Medina	7201000000- 0	275					
Medina	7201000000- 1	826	8	8	5	5	55
Medina	7201000000- 0	1,928	5	5	5	5	6
Medina	7200000000- 4	92					
Medina	7200000000- 2	1,010	7	8	7	7	57
Medina	7200000000- 2	918	13	13	13	10	21
Medina	7200000000- 1	367					
Medina	7200000000- 0	184					
Medina	7001020000- 0	1,469					1
Medina	7001020000- 0	735	1	1	1	1	325
Medina	7001000000- 2	2,663					
Medina	7001000000- 0	184					
Medina	7001000000- 0	2,020	119	125	128	125	151
Medina	7000000000- 1	3,489	4	4	5	7	46
Medina	7000000000- 1	6,152	104	108	111	113	139
Medina	6901000000- 0	1,745	49	52	55	55	69
Medina	6900000000- 1	3,030	128	134	134	138	160
Medina	6900000000- 0	1,194	24	28	29	31	45
Medina	6800000000- 0	1,194	2	2	2	2	3
Medina	6600000000- 0	4,224	21	21	22	21	184
Medina	6501000000- 0	1,745	62	65	62	65	74

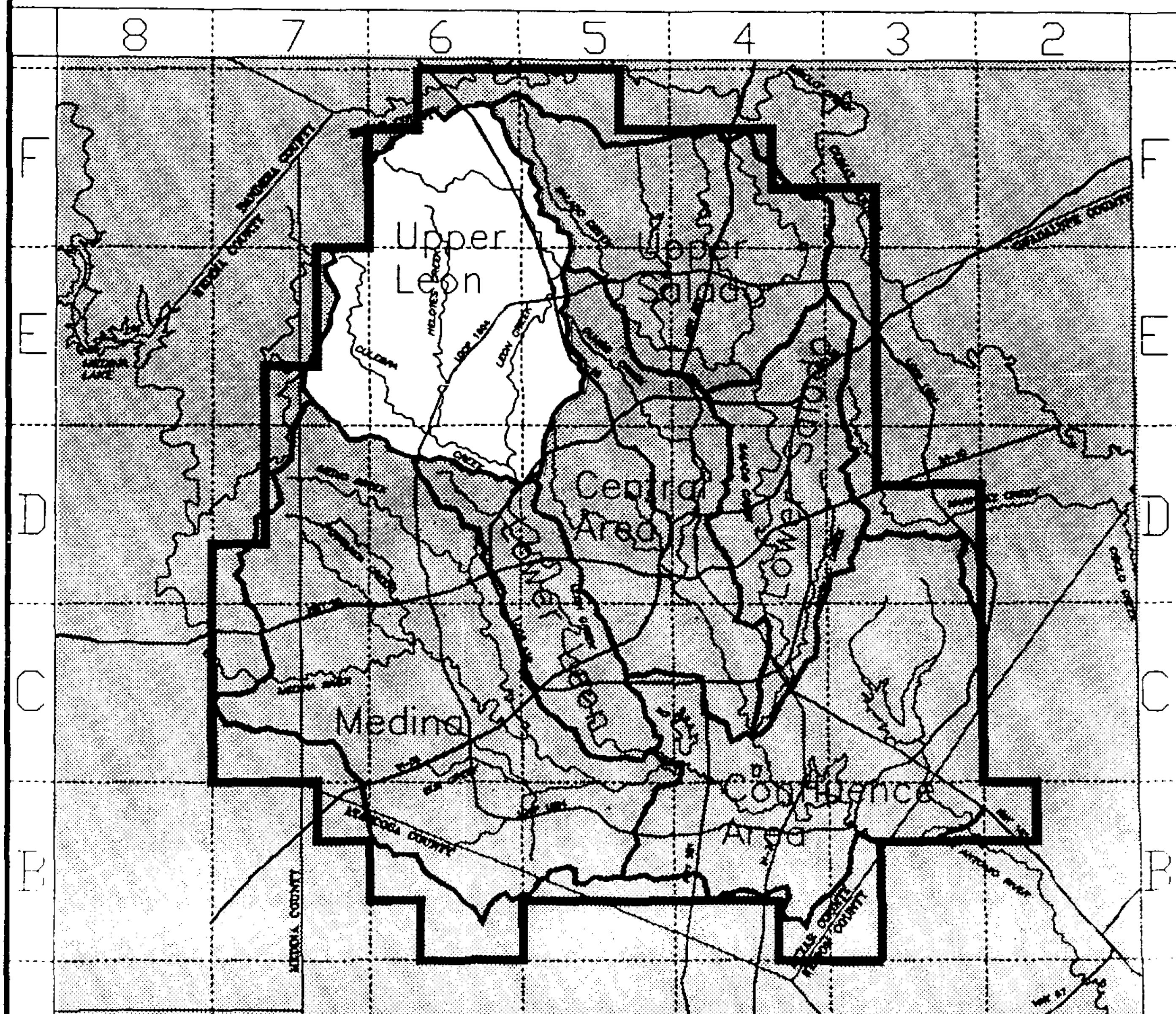
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Medina	6500000000- 1	1,377	105	112	104	104	115
Medina	6500000000- 0	2,296	247	251	454	251	304
Medina	6408000000- 0	3,030	99	107	103	108	201
Medina	6406000000- 0	1,745	20	20	27	27	57
Medina	6406000000- 0	92	1	1	1	1	1
Medina	6404000000- 0	4,683	24	62	153	205	799
Medina	6402000000- 0	1,653	1,391	1,548	1,745	1,988	4,155
Medina	6400000000- 8	2,571	3	3	3	3	1
Medina	6400000000- 6	735	11	12	16	25	124
Medina	6400000000- 4	918	67	66	70	78	116
Medina	6400000000- 4	3,581	175	184	192	194	337
Medina	6400000000- 2	2,755	649	597	752	932	2,904
Medina	6400000000- 0	10,376	1,134	1,344	1,138	1,131	2,606
Medina	0-72	2,663	43	44	45	40	47
Medina	0-70	1,102	20	21	20	22	25
Medina	0-69	459	3	3	1	1	2
Medina	0-68	92	2	2	2	2	1
Medina	0-66	1,286	14	14	14	14	16
Medina	0-65	1,561	88	90	85	87	86
Medina		81,818	4,661	5,073	5,523	5,817	13,252

Upper Leon | *RESIDENTIAL CONNECTIONS* | *1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	F - 6	30,119	951	992	1,090	1,145	1,622
Upper Leon	F - 5	3,214	167	171	171	176	315
Upper Leon	E - 6	41,690	2,233	2,948	3,780	4,613	14,672
Upper Leon	E - 5	11,846	2,339	2,530	2,931	3,475	12,757
Upper Leon	D - 7	643	4	5	10	10	16
Upper Leon	D - 6	8,815	1,346	2,027	7,592	6,693	11,280
Upper Leon	D - 5	826	795	813	851	856	1,194
Upper Leon		97,153	7,835	9,486	16,425	16,968	41,856

New Connections = 34,021 or 23% of all New Connections in Study Area



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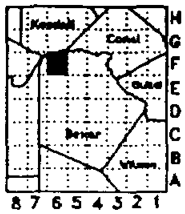
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 19

Map Name Van Raub

Scale 1:100,000

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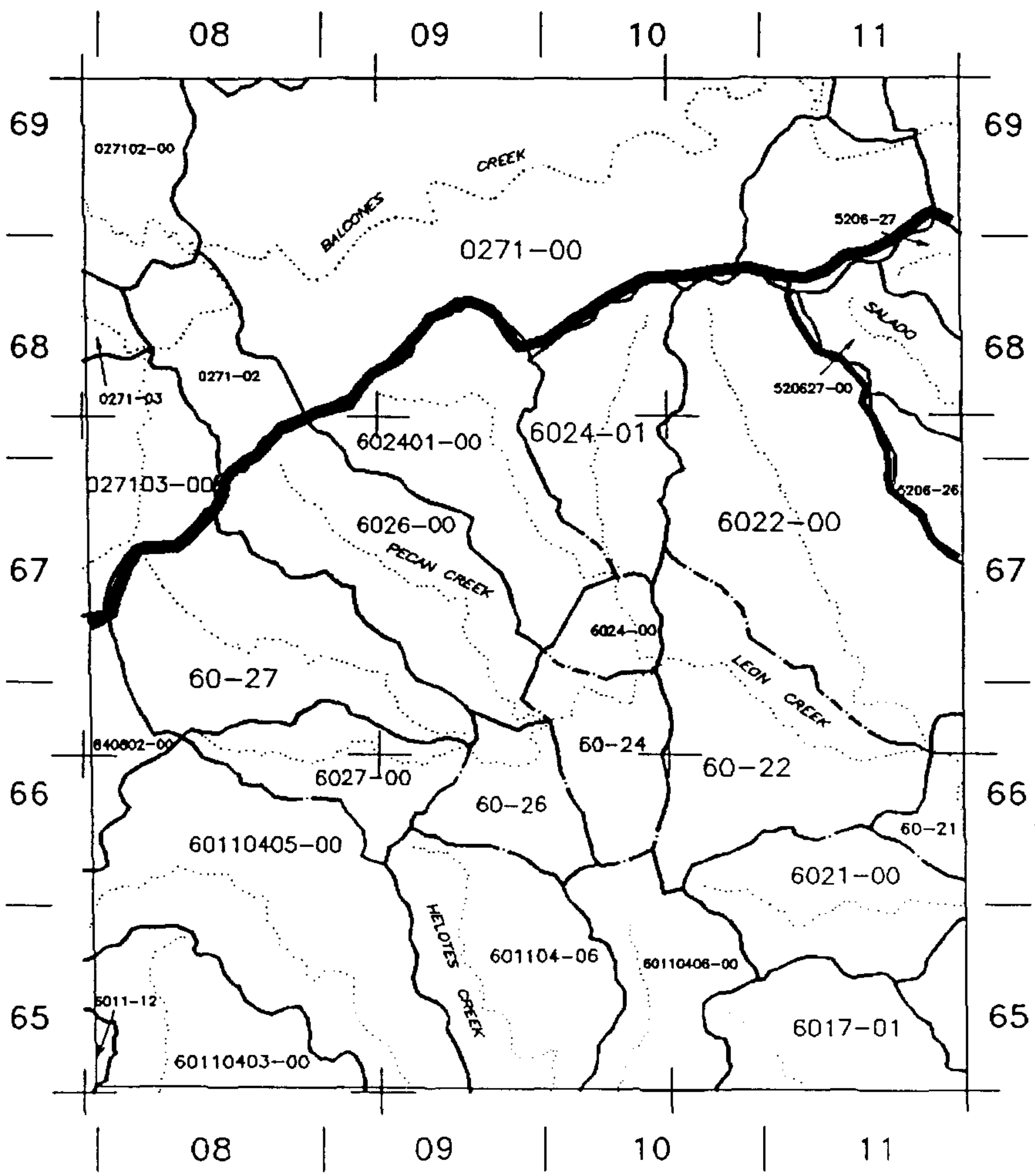
SCALE (MILES)

Latitude = 29

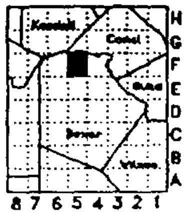
Longitude = 98

7.5' Area = F6



GAE 1/29/93 44F6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 20

Map Name Camp Bullis

Scale 1:100,000

N

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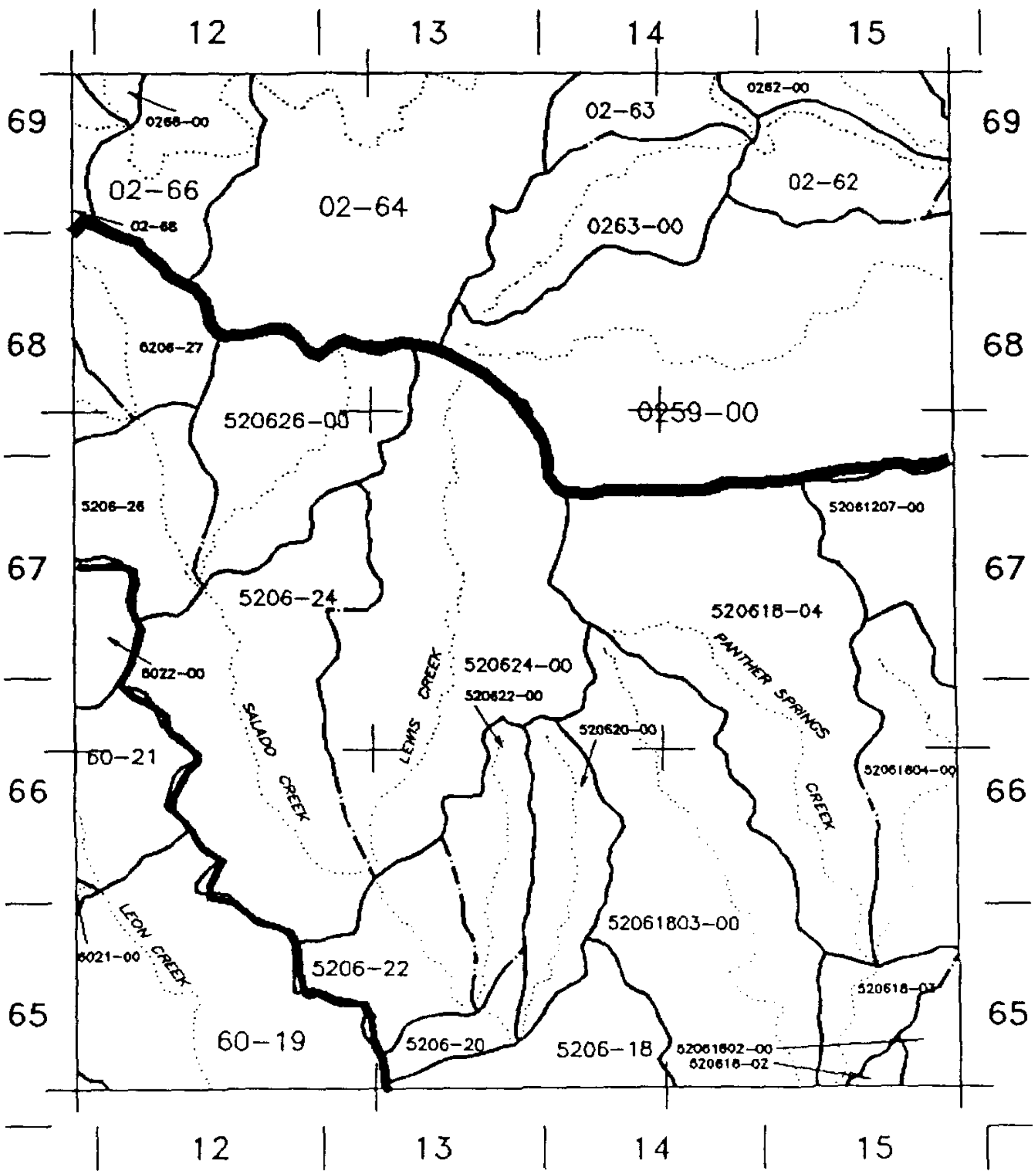
SCALE (MILES)

Latitude = 29

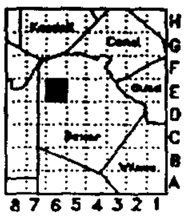
Longitude = 98

7.5' Area = F5



GAE 1/29/93 44F5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 27

Map Name HELOTES

Scale 1:100,000

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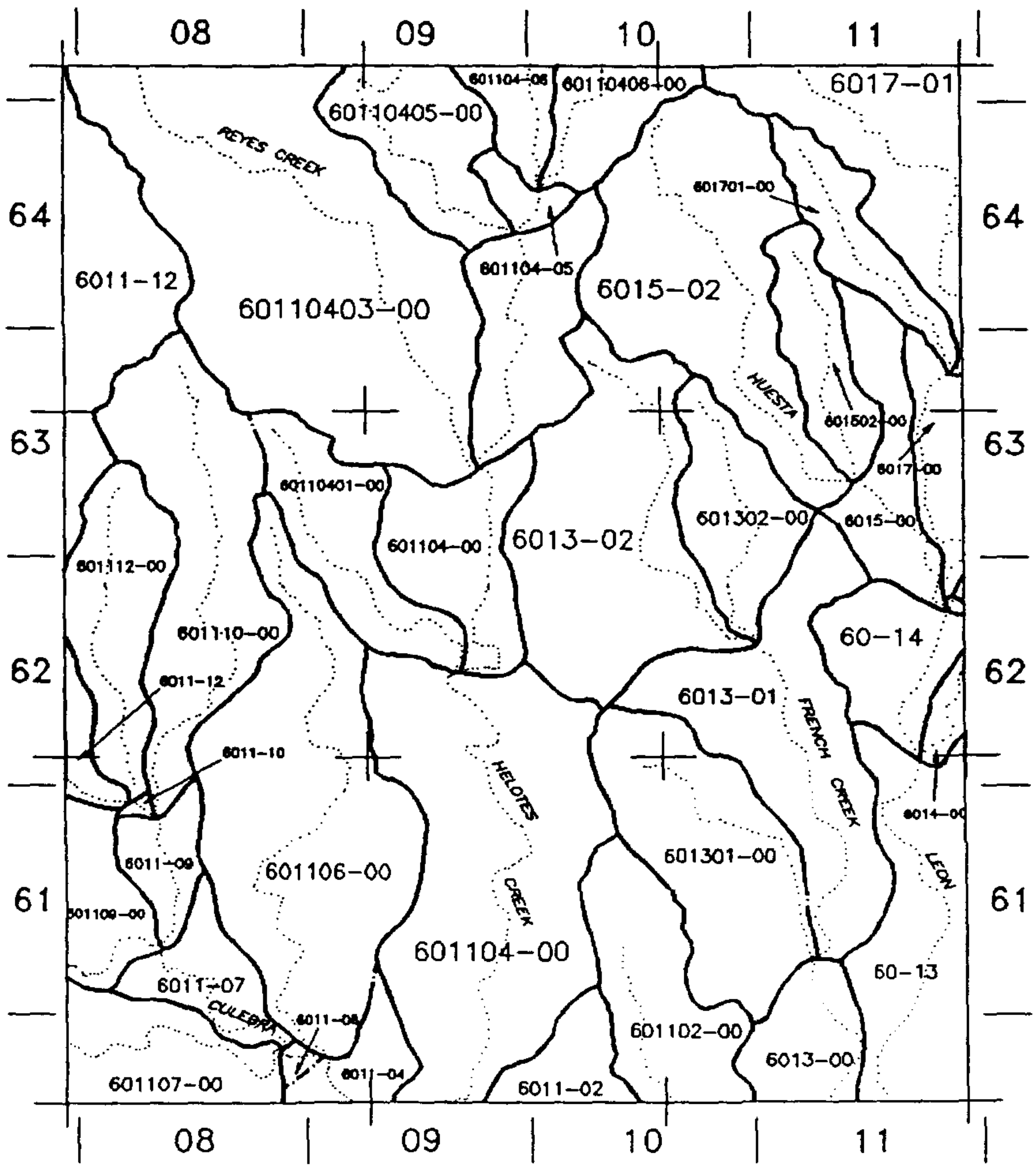
SCALE (MILES)

Latitude = 29

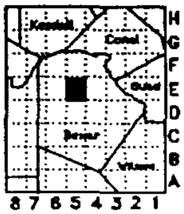
Longitude = 98

7.5' Area = E6



GAE 1/29/93 44E6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

Scale 1:100,000

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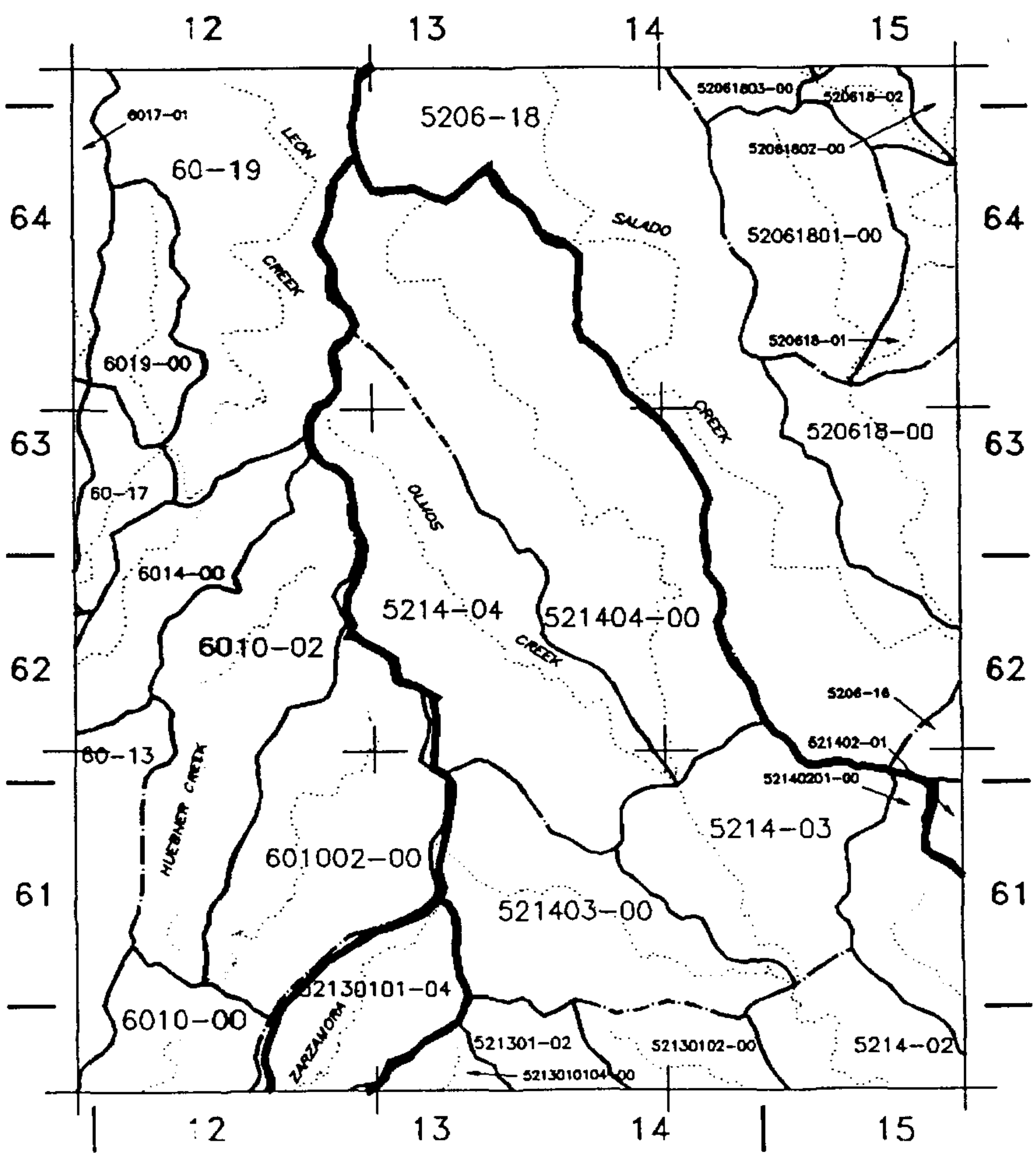
SCALE (MILES)

Latitude = 29

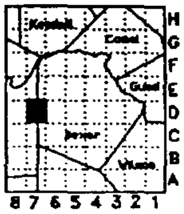
Longitude = 98

7.5' Area = E5



GAE 1/29/93 44E5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 34

Map Name LA COSTE NE

Scale 1:100,000

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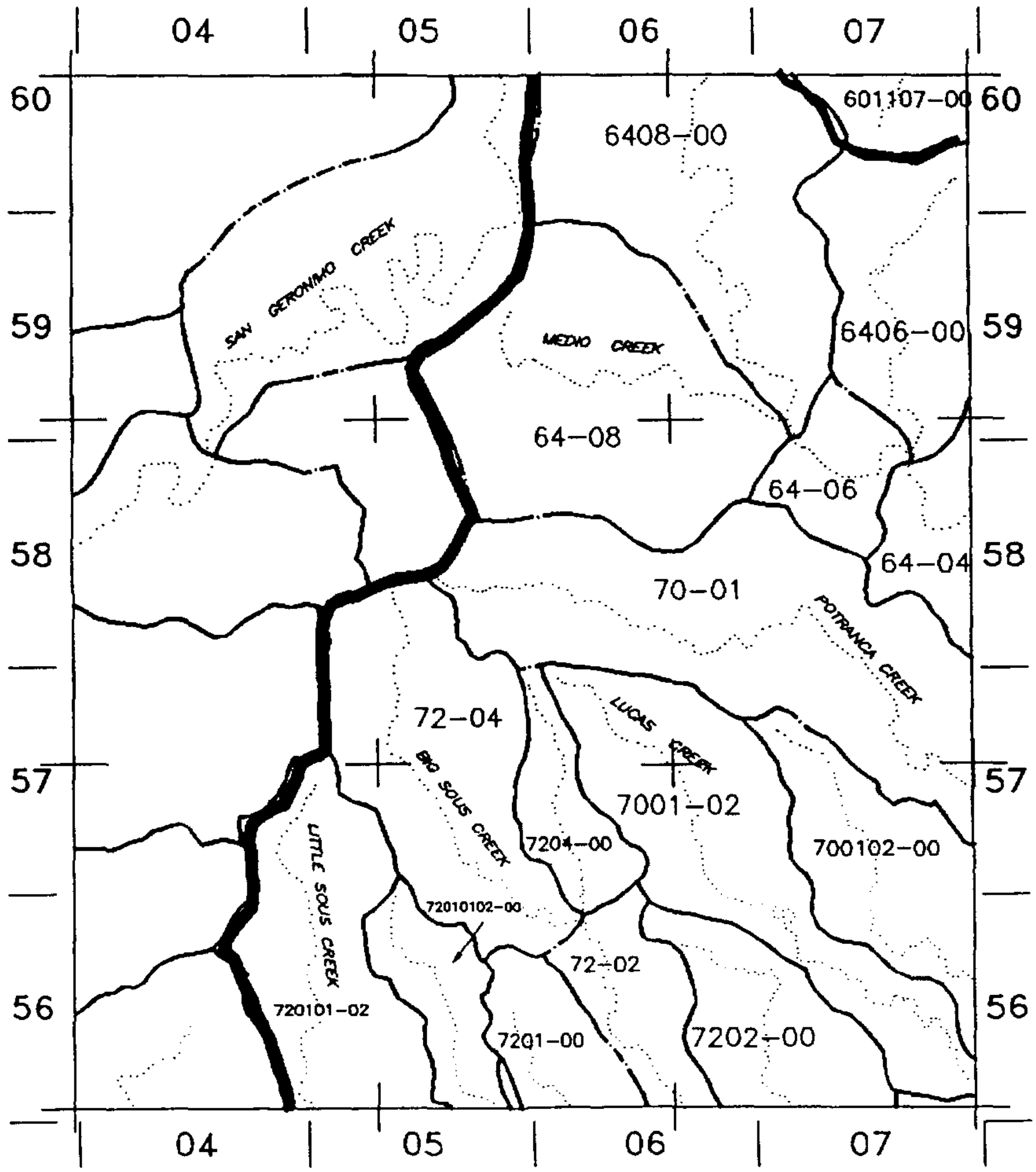
SCALE (MILES)

N

Latitude = 29

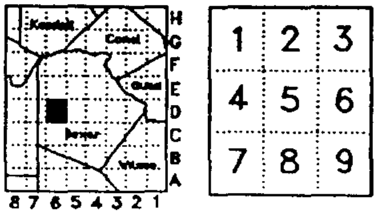
Longitude = 98

7.5' Area = D7



GAE 1/29/93 44D7COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 35

Map Name CULEBRA HILL

Scale 1:100,000

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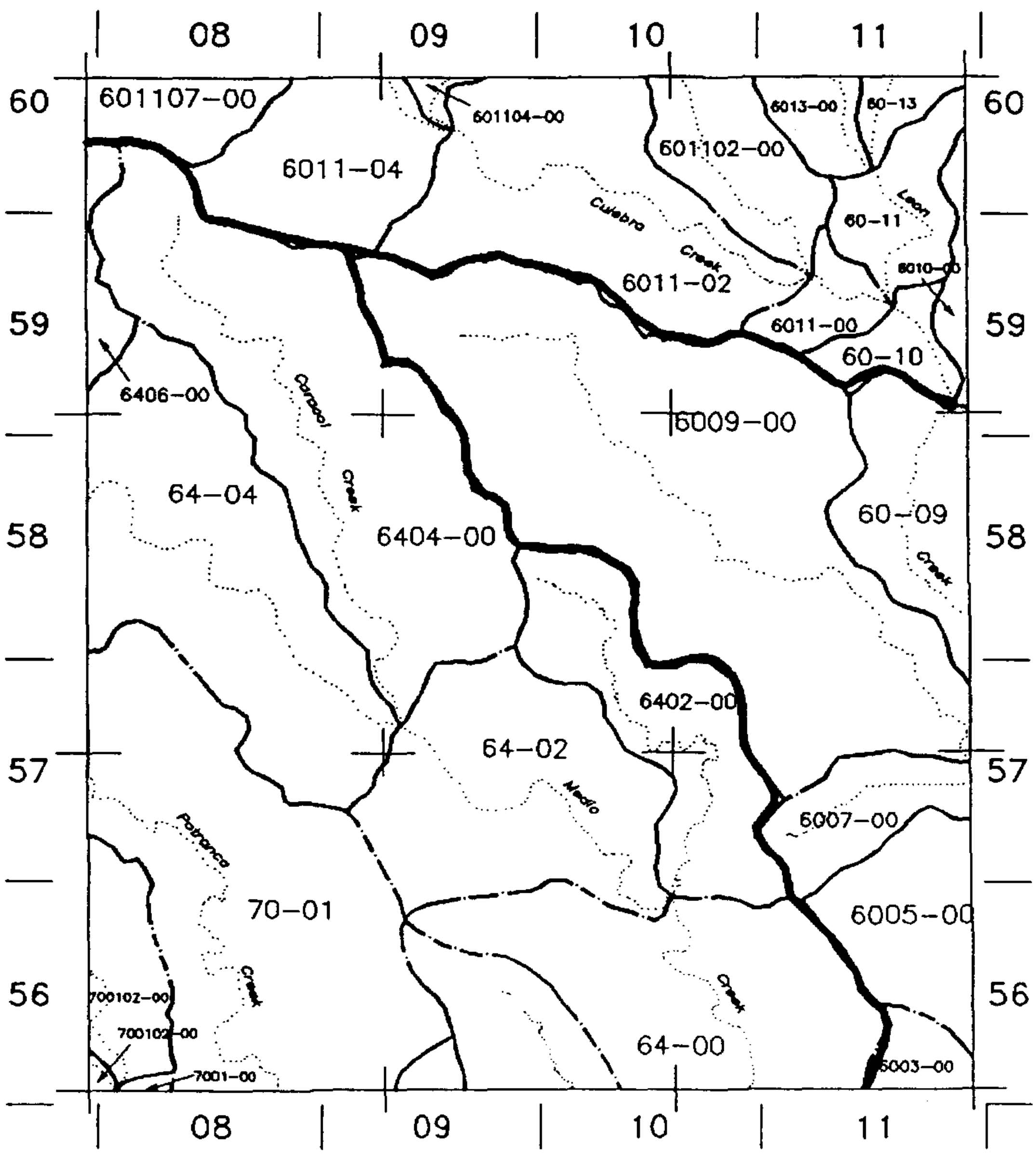
SCALE (MILES)

Latitude = 29

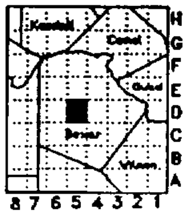
Longitude = 98

7.5' Area = D6



GAE 1/29/93 44D6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 36

Map Name SAN ANTONIO WEST

Scale 1:100,000

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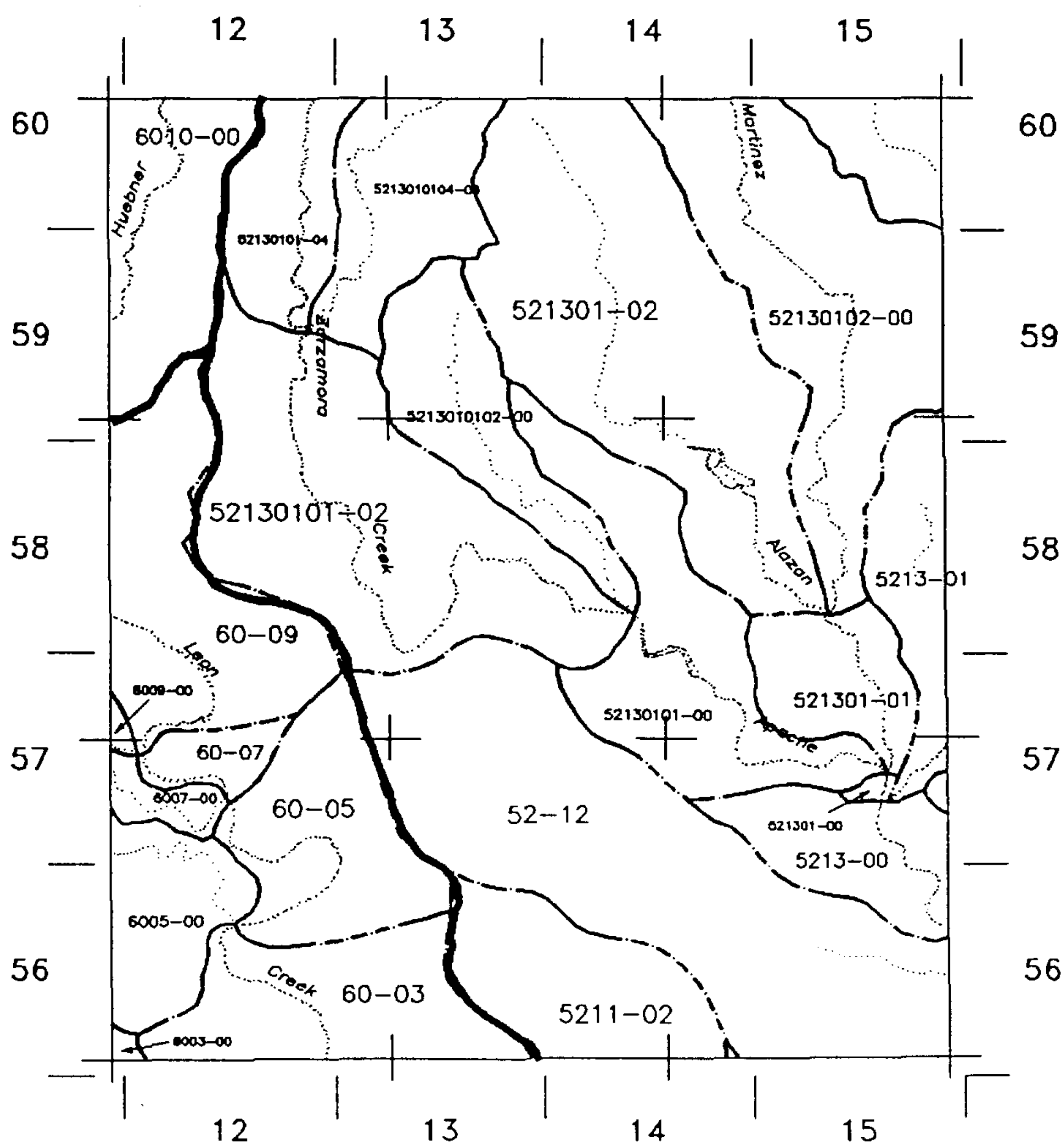
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = D5



GAE 1/29/93 44D5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6027000000- 0	1,010					1
Upper Leon	6026000000- 0	2,112	12	13	14	14	30
Upper Leon	6024010000- 0	2,112	54	56	62	74	134
Upper Leon	6024000000- 1	1,469	72	77	95	98	195
Upper Leon	6024000000- 0	551	61	60	63	61	92
Upper Leon	6022000000- 0	4,224	375	396	450	464	525
Upper Leon	6021000000- 0	1,469	22	40	42	63	52
Upper Leon	6017000000- 1	1,561	14	13	16	13	16
Upper Leon	6011040600- 0	1,561	37	37	37	39	57
Upper Leon	6011040500- 0	3,398	4	4	4	4	17
Upper Leon	6011040300- 0	1,745	4	8	10	11	35
Upper Leon	6011040000- 6	1,837	90	90	93	93	105
Upper Leon	6000000000-27	2,296					3
Upper Leon	6000000000-26	826	2	2	2	2	8
Upper Leon	6000000000-24	918	28	31	33	35	79
Upper Leon	6000000000-22	2,204	127	130	134	138	235
Upper Leon	6000000000-21	367	15	14	14	14	14
Upper Leon	6000000000-19	459	34	21	21	22	24
Upper Leon		30,119	951	992	1,090	1,145	1,622

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6022000000- 0	275					1
Upper Leon	6000000000-21	643					121
Upper Leon	6000000000-19	2,296	167	171	171	176	193
Upper Leon		3,214	167	171	171	176	315

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6017010000- 0	275	13	16	16	16	31
Upper Leon	6017000000- 1	1,377	174	198	197	197	211
Upper Leon	6017000000- 0	551	69	69	70	123	132
Upper Leon	6015020000- 0	643	35	35	35	36	47
Upper Leon	6015000000- 2	2,296	4	4	5	5	7
Upper Leon	6015000000- 0	918	146	149	157	281	691
Upper Leon	6014000000- 0	184	207	212	228	274	593
Upper Leon	6013020000- 0	918	4	7	9	9	12
Upper Leon	6013010000- 0	1,653	173	289	545	648	1,648
Upper Leon	6013000000- 2	2,204	277	287	309	285	373
Upper Leon	6013000000- 1	2,204	168	243	353	445	825
Upper Leon	6013000000- 0	459	8	7	12	64	409
Upper Leon	6011120000- 0	1,194	2	3	3	3	3
Upper Leon	6011100000- 0	1,745	2	2	3	3	12
Upper Leon	6011090000- 0	275					
Upper Leon	6011070000- 0	735	4	4	4	4	5
Upper Leon	6011060000- 0	3,214	69	80	89	94	164
Upper Leon	6011040600- 0	367	65	66	67	67	70
Upper Leon	6011040500- 0	735	13	14	14		21
Upper Leon	6011040300- 0	4,224	141	174	188	151	269
Upper Leon	6011040100- 0	1,010	18	22	30	31	51
Upper Leon	6011040000- 6	184	63	63	62	57	59
Upper Leon	6011040000- 5	184	46	50	49	35	57
Upper Leon	6011040000- 3	826	56	56	59	43	59
Upper Leon	6011040000- 0	6,795	154	164	204	508	3,876
Upper Leon	6011020000- 0	1,286	33	39	59	119	2,357
Upper Leon	6011000000-12	1,010	2	2	2	2	2
Upper Leon	6011000000- 9	551	2	2	2	2	2
Upper Leon	6011000000- 7	643	4	4	4	4	4
Upper Leon	6011000000- 4	367	1	1	1	1	1
Upper Leon	6000000000-14	735	7	7	61	90	816
Upper Leon	6000000000-13	1,928	273	679	943	1,016	1,865
Upper Leon		41,690	2,233	2,948	3,780	4,613	14,672

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6019000000- 0	918					12
Upper Leon	6014000000- 0	918	369	378	431	446	1,312
Upper Leon	6010020000- 0	2,663	279	279	283	555	6,345
Upper Leon	6010000000- 2	2,571	338	421	633	851	2,341
Upper Leon	6010000000- 0	918	1,124	1,219	1,319	1,348	2,081
Upper Leon	6000000000-19	2,847	36	35	35	35	134
Upper Leon	6000000000-17	459	4	5	4	3	2
Upper Leon	6000000000-13	551	189	193	226	237	530
Upper Leon		11,846	2,339	2,530	2,931	3,475	12,757

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Page 24 1/28/93 7:51:50 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-7

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6011070000- 0	643	4	5	10	10	16
Upper Leon		643	4	5	10	10	16

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6013000000- 0	275	3	4	4	23	261
Upper Leon	6011070000- 0	643	2	2	2	2	3
Upper Leon	6011020000- 0	918	36	199	2,641	902	2,658
Upper Leon	6011000000- 4	1,377	5	5	6	5	7
Upper Leon	6011000000- 2	3,214	37	119	555	932	3,694
Upper Leon	6011000000- 0	459	140	311	2,554	568	730
Upper Leon	6010000000- 0	459	295	301	448	453	1,213
Upper Leon	6000000000-13	275	402	515	621	2,973	718
Upper Leon	6000000000-11	643	215	355	530	605	779
Upper Leon	6000000000-10	551	211	216	231	230	1,217
Upper Leon		8,815	1,346	2,027	7,592	6,693	11,280

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : D-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6010000000- 0	826	795	813	851	856	1,194
Upper Leon		826	795	813	851	856	1,194

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6027000000- 0	1,010					1
Upper Leon	6026000000- 0	2,112	12	13	14	14	30
Upper Leon	6024010000- 0	2,112	54	56	62	74	134
Upper Leon	6024000000- 1	1,469	72	77	95	98	195
Upper Leon	6024000000- 0	551	61	60	63	61	92
Upper Leon	6022000000- 0	4,500	375	396	450	464	526
Upper Leon	6021000000- 0	1,469	22	40	42	63	52
Upper Leon	6019000000- 0	918					12
Upper Leon	6017010000- 0	275	13	16	16	16	31
Upper Leon	6017000000- 1	2,938	188	211	213	210	227
Upper Leon	6017000000- 0	551	69	69	70	123	132
Upper Leon	6015020000- 0	643	35	35	35	36	47
Upper Leon	6015000000- 2	2,296	4	4	5	5	7
Upper Leon	6015000000- 0	918	146	149	157	281	691
Upper Leon	6014000000- 0	1,102	576	590	659	720	1,905
Upper Leon	6013020000- 0	918	4	7	9	9	12
Upper Leon	6013010000- 0	1,653	173	289	545	648	1,648
Upper Leon	6013000000- 2	2,204	277	287	309	285	373
Upper Leon	6013000000- 1	2,204	168	243	353	445	825
Upper Leon	6013000000- 0	735	11	11	16	87	670
Upper Leon	6011120000- 0	1,194	2	3	3	3	3
Upper Leon	6011100000- 0	1,745	2	2	3	3	12
Upper Leon	6011090000- 0	275					
Upper Leon	6011070000- 0	2,020	10	11	16	16	24

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon	6011060000- 0	3,214	69	80	89	94	164
Upper Leon	6011040600- 0	1,928	102	103	104	106	127
Upper Leon	6011040500- 0	4,132	17	18	18	4	38
Upper Leon	6011040300- 0	5,969	145	182	198	162	304
Upper Leon	6011040100- 0	1,010	18	22	30	31	51
Upper Leon	6011040000- 6	2,020	153	153	155	150	164
Upper Leon	6011040000- 5	184	46	50	49	35	57
Upper Leon	6011040000- 3	826	56	56	59	43	59
Upper Leon	6011040000- 0	6,795	154	164	204	508	3,876
Upper Leon	6011020000- 0	2,204	69	238	2,700	1,021	5,015
Upper Leon	6011000000-12	1,010	2	2	2	2	2
Upper Leon	6011000000- 9	551	2	2	2	2	2
Upper Leon	6011000000- 7	643	4	4	4	4	4
Upper Leon	6011000000- 4	1,745	6	6	7	6	8
Upper Leon	6011000000- 2	3,214	37	119	555	932	3,694
Upper Leon	6011000000- 0	459	140	311	2,554	568	730
Upper Leon	6010020000- 0	2,663	279	279	283	555	6,345
Upper Leon	6010000000- 2	2,571	338	421	633	851	2,341
Upper Leon	6010000000- 0	2,204	2,214	2,333	2,618	2,657	4,488
Upper Leon	6000000000-27	2,296					3
Upper Leon	6000000000-26	826	2	2	2	2	8
Upper Leon	6000000000-24	918	28	31	33	35	79
Upper Leon	6000000000-22	2,204	127	130	134	138	235
Upper Leon	6000000000-21	1,010	15	14	14	14	135
Upper Leon	6000000000-19	5,601	237	227	227	233	351
Upper Leon	6000000000-17	459	4	5	4	3	2
Upper Leon	6000000000-14	735	7	7	61	90	816
Upper Leon	6000000000-13	2,755	864	1,387	1,790	4,226	3,113
Upper Leon	6000000000-11	643	215	355	530	605	779
Upper Leon	6000000000-10	551	211	216	231	230	1,217

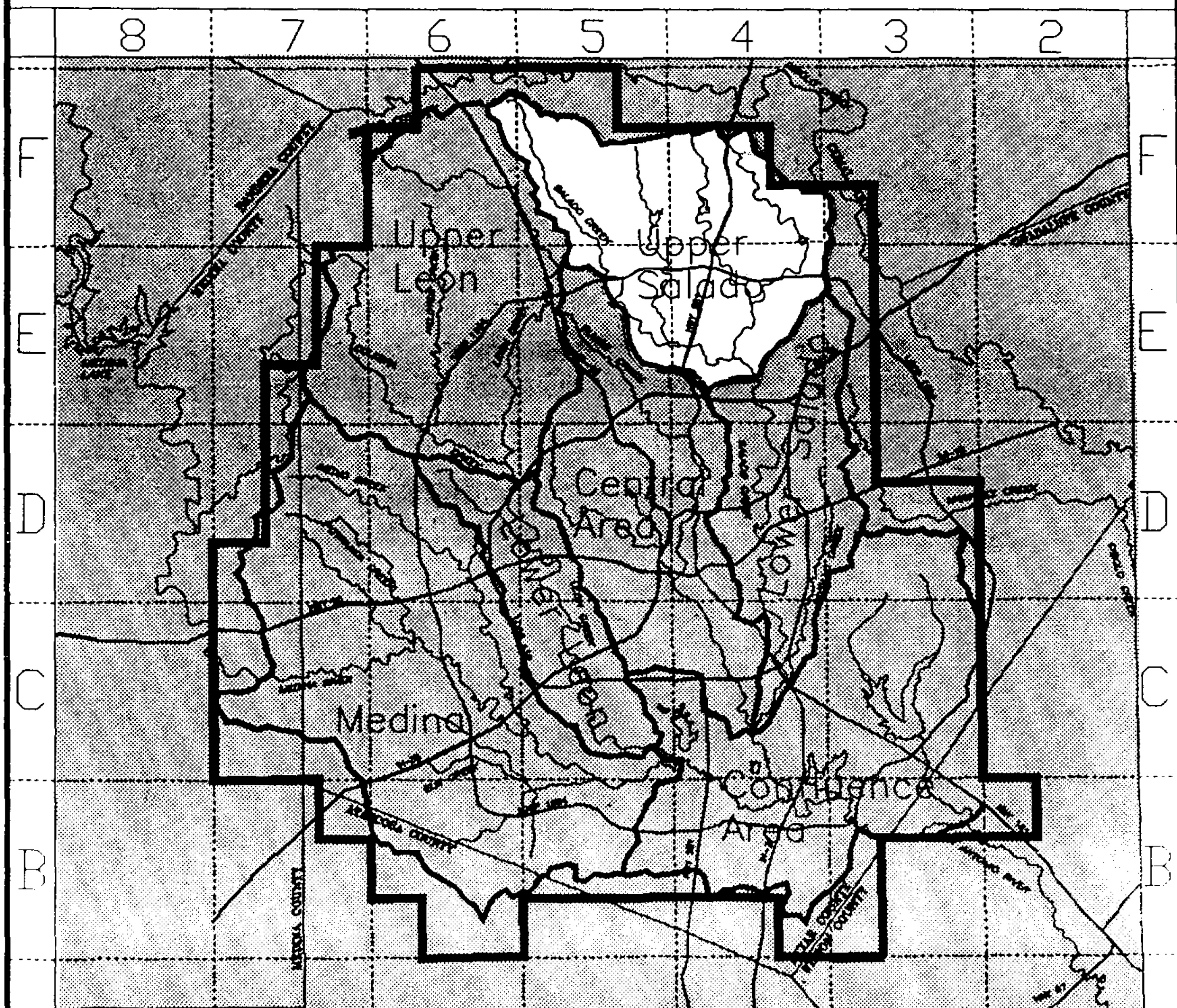
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Leon		97,153	7,835	9,486	16,425	16,968	41,856

Upper Salado	*RESIDENTIAL CONNECTIONS*	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	F - 6	1,561	4	19	61	74	137
Upper Salado	F - 5	25,712	34	41	39	38	332
Upper Salado	F - 4	19,559	93	96	112	119	1,140
Upper Salado	F - 3	92					3
Upper Salado	E - 5	11,019	1,689	1,920	3,311	4,183	13,355
Upper Salado	E - 4	24,702	5,759	6,607	8,531	9,840	23,659
Upper Salado		82,645	7,579	8,683	12,054	14,254	38,626

New Connections = <u>31,047</u> or <u>21%</u> of all New Connections in Study Area



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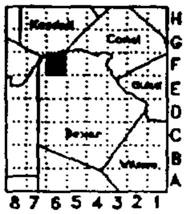
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 19

Map Name Van Raub

Scale 1:100,000

N

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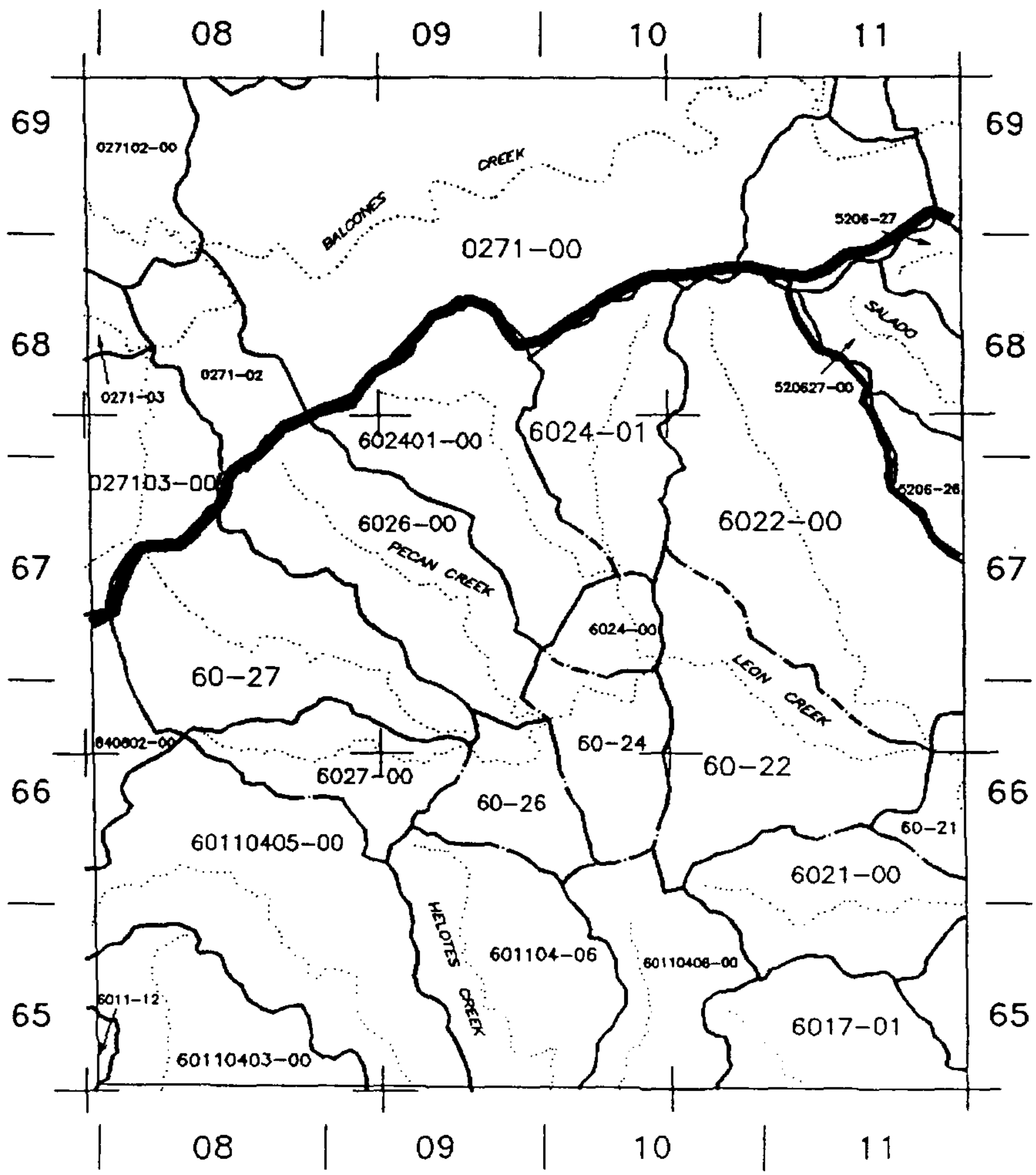
SCALE (MILES)

Latitude = 29

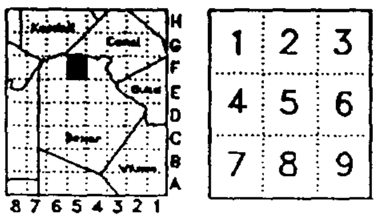
Longitude = 98

7.5' Area = F6



GAE 1/29/93 44F6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

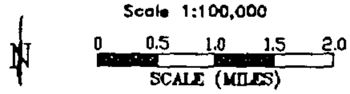


7.5 Minute Area

Water Well ID 68- 20

Map Name Camp Bullis

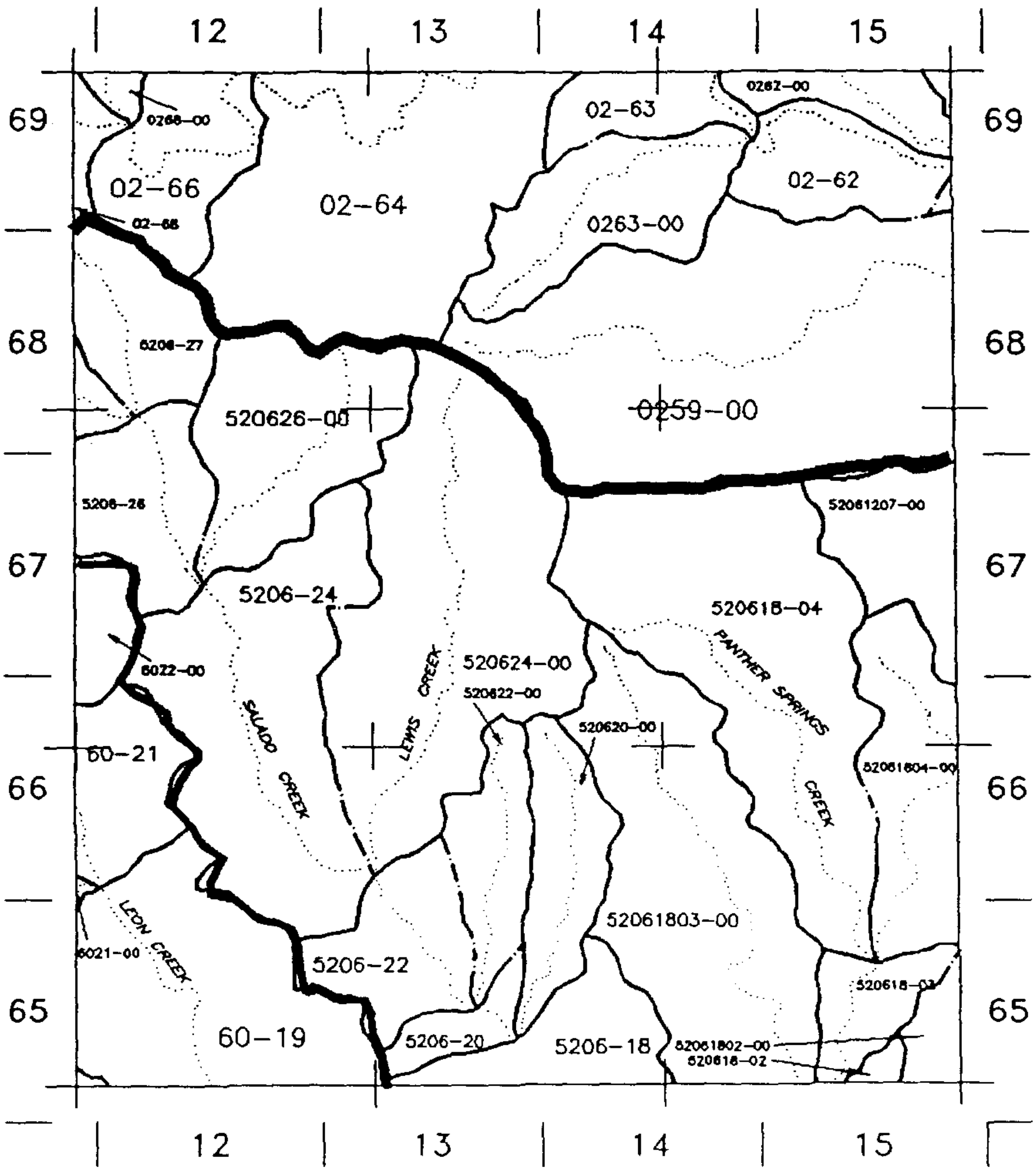
Scale 1:100,000



Latitude = 29

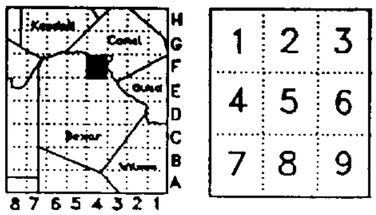
Longitude = 98

7.5' Area = F5



GAE 1/29/93 44F5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 21

Map Name Bulverde

Scale 1:100,000

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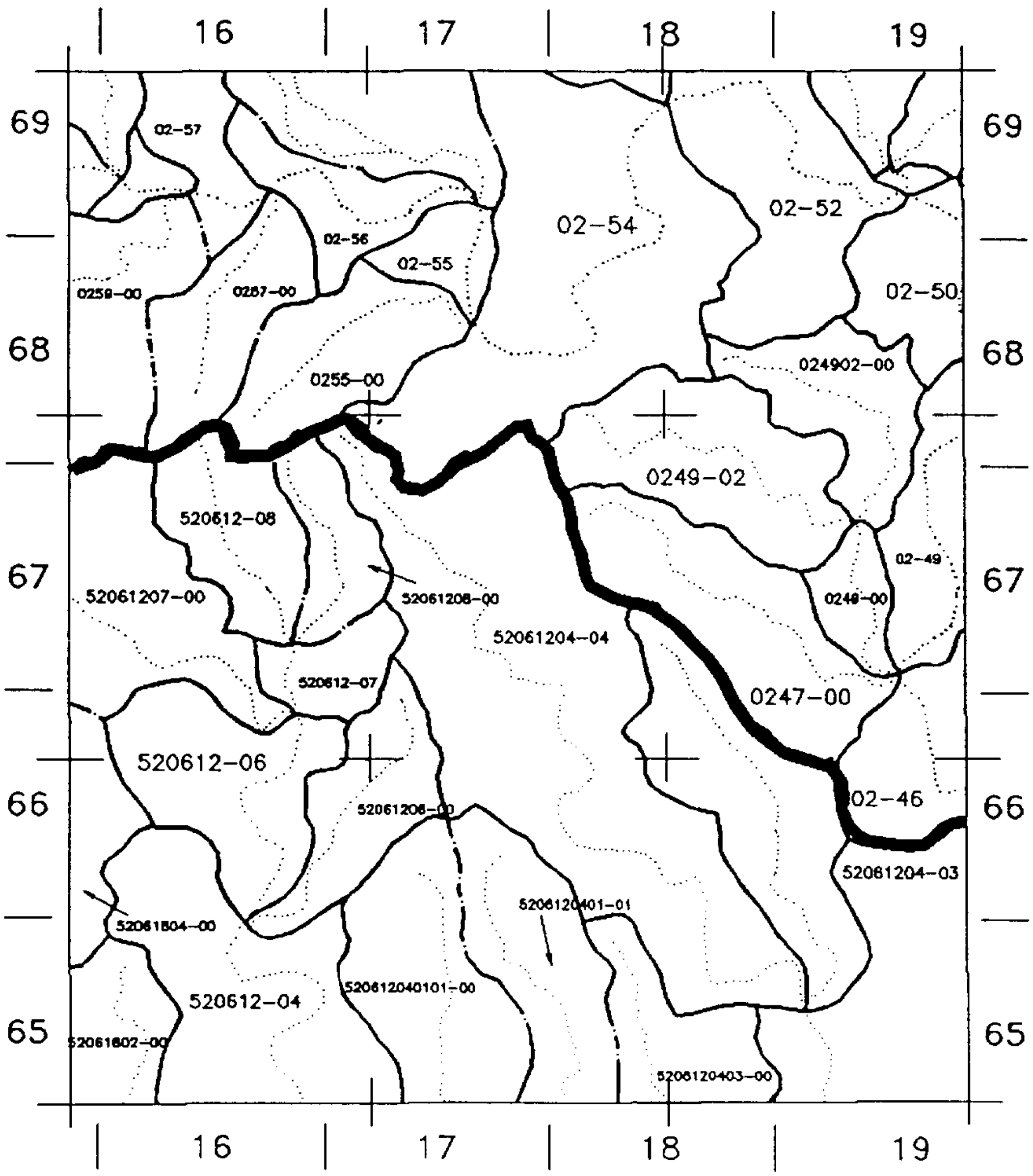
SCALE (MILES)

Latitude = 29

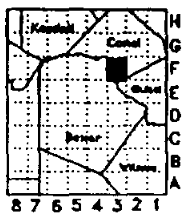
Longitude = 98

7.5' Area = F4



GAE 1/29/93 44F4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 22

Map Name Bat Cave

Scale 1:100,000

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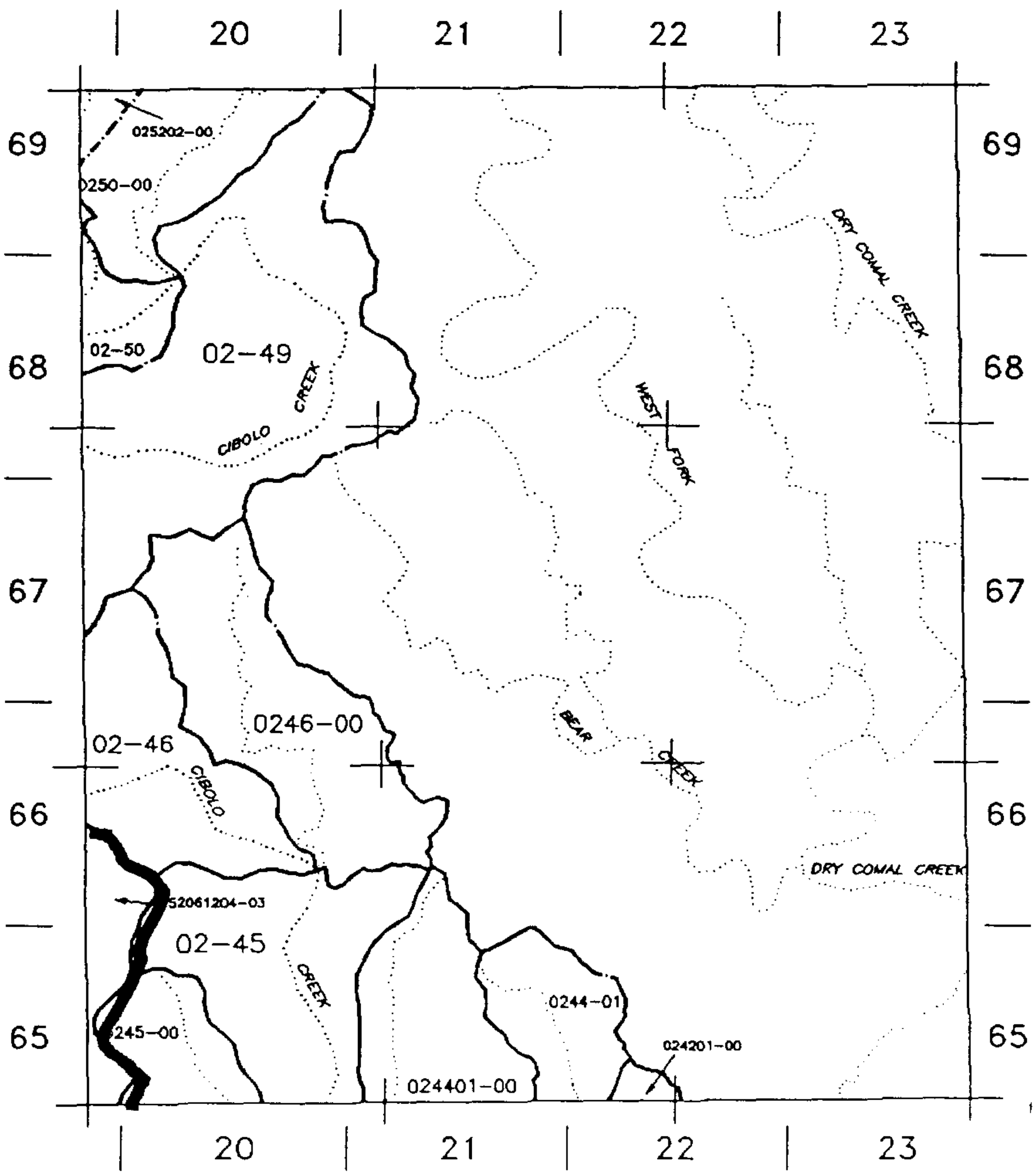
SCALE (MILES)

Latitude = 29

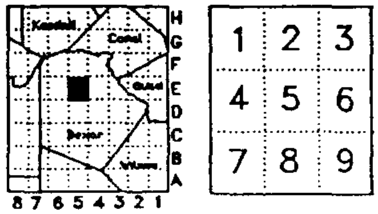
Longitude = 98

7.5' Area = F3



GAE 1/29/93 044F3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

Scale 1:100,000

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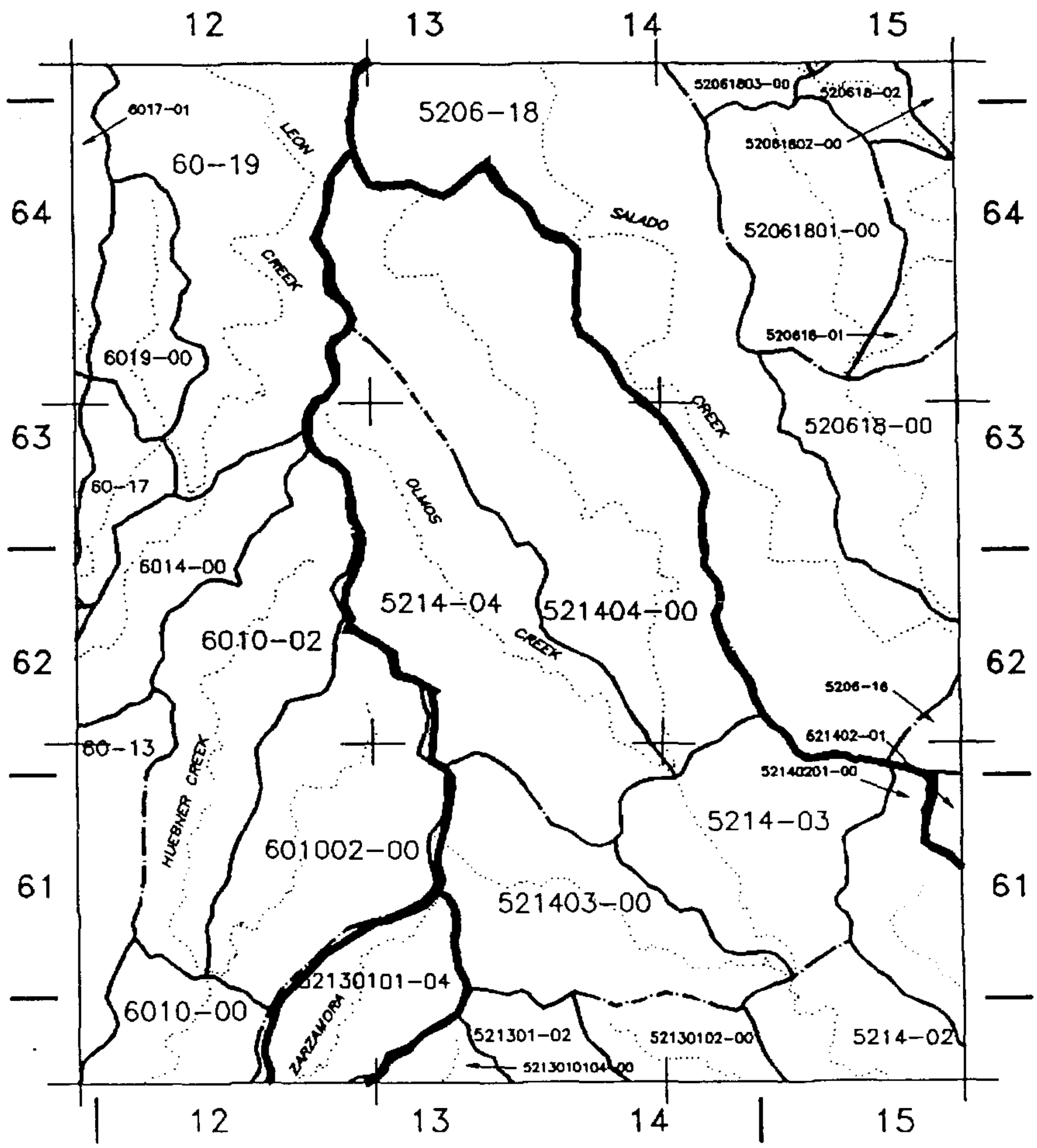
SCALE (MILES)

Latitude = 29

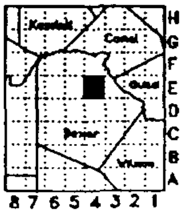
Longitude = 98

7.5' Area = E5



GAE 1/29/93 44E5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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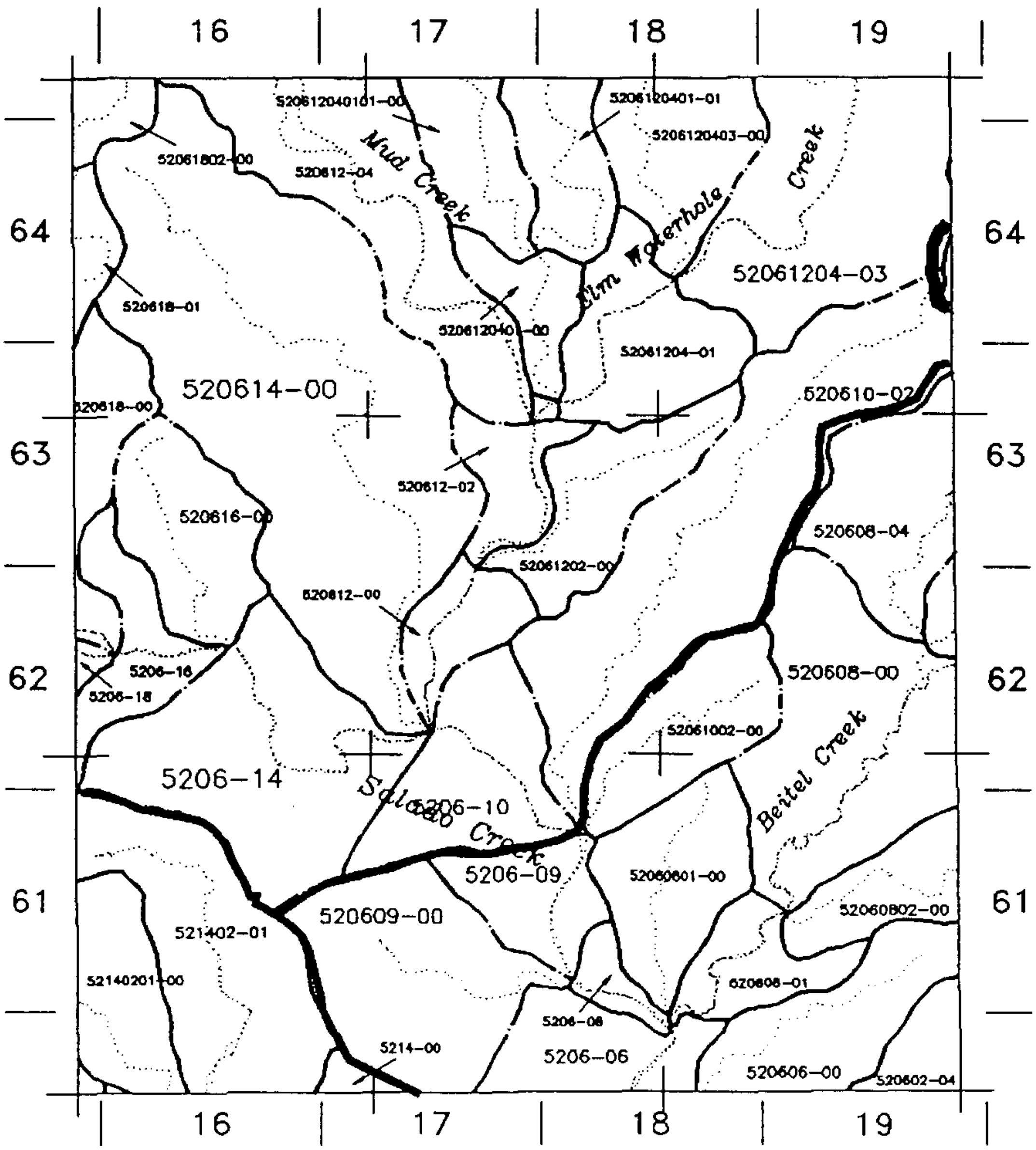
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = E4



GAE 1/29/93 44E4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

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Page 2 1/28/93 7:48:38 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206270000- 0	918	1	13	49	59	114
Upper Salado	5206000000-27	275	2	5	11	13	17
Upper Salado	5206000000-26	367	1	1	1	2	6
Upper Salado		1,561	4	19	61	74	137

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Page 5 1/28/93 7:48:39 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206260000- 0	1,653					
Upper Salado	5206240000- 0	4,040					
Upper Salado	5206220000- 0	918					
Upper Salado	5206200000- 0	826					
Upper Salado	5206180400- 0	1,561	1	1	1	1	153
Upper Salado	5206180300- 0	3,306					0
Upper Salado	5206180200- 0	643		3			57
Upper Salado	5206180000- 4	3,489	15	15	15	15	18
Upper Salado	5206180000- 3	643					0
Upper Salado	5206120700- 0	1,286	17	21	21	20	100
Upper Salado	5206000000-27	735					0
Upper Salado	5206000000-26	1,010					2
Upper Salado	5206000000-24	2,938					
Upper Salado	5206000000-22	735	1	1	1	1	2
Upper Salado	5206000000-20	459			1	1	
Upper Salado	5206000000-18	1,469					0
Upper Salado		25,712	34	41	39	38	332

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TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206180400- 0	92					0
Upper Salado	5206180200- 0	551					206
Upper Salado	5206120800- 0	643					7
Upper Salado	5206120700- 0	1,102			2	4	52
Upper Salado	5206120600- 0	826	2	2	2	3	8
Upper Salado	5206120404- 0	2,020	2	2	2	2	5
Upper Salado	5206120403- 0	1,194	17	18	20	20	26
Upper Salado	5206120401- 0	3,306	5	5	4	9	686
Upper Salado	5206120400- 4	4,775	62	64	76	75	142
Upper Salado	5206120400- 3	2,388	5	5	6	6	8
Upper Salado	5206120000- 4	2,663					
Upper Salado		19,559	93	96	112	119	1,140

Report file: q_sws_R
Page 9 1/28/93 7:48:43 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-3

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206120400- 3	92					3
Upper Salado		92					3

Report file: q_sws_R
Page 15   1/28/93 7:50:36 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206180200- 0	92					3
Upper Salado	5206180100- 0	1,745	8	8	7	7	617
Upper Salado	5206180000- 2	367	1	1	1	1	26
Upper Salado	5206180000- 1	918	134	185	204	178	332
Upper Salado	5206180000- 0	1,653	151	262	418	493	1,563
Upper Salado	5206000000-18	5,969	754	821	2,037	2,858	10,165
Upper Salado	5206000000-16	275	641	643	644	646	649
Upper Salado		11,019	1,689	1,920	3,311	4,183	13,355

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Page 19 1/28/93 7:50:53 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206180000- 0	184	42	43	44	43	43
Upper Salado	5206160000- 0	1,102	197	249	324	570	1,332
Upper Salado	5206140000- 0	5,877	2,928	3,513	4,225	4,608	8,901
Upper Salado	5206120403- 0	643					0
Upper Salado	5206120401- 0	1,745	15	35	15	15	54
Upper Salado	5206120400- 3	2,020	4	4	4	8	669
Upper Salado	5206120400- 1	735	8	8	7	8	220
Upper Salado	5206120400- 0	459	29	42	127	147	239
Upper Salado	5206120200- 0	1,102	69	137	320	427	1,715
Upper Salado	5206120000- 4	1,561	60	134	231	244	725
Upper Salado	5206120000- 2	551	22	33	92	137	1,011
Upper Salado	5206120000- 0	643	9	10	9	12	736
Upper Salado	5206100200- 0	918	421	429	555	575	1,660
Upper Salado	5206100000- 2	2,938	631	860	1,308	1,674	3,845
Upper Salado	5206000000-16	643	69	71	69	152	312
Upper Salado	5206000000-14	2,296	676	462	501	520	1,227
Upper Salado	5206000000-10	1,286	579	577	700	700	970
Upper Salado		24,702	5,759	6,607	8,531	9,840	23,659

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206270000- 0	918	1	13	49	59	114
Upper Salado	5206260000- 0	1,653					
Upper Salado	5206240000- 0	4,040					
Upper Salado	5206220000- 0	918					
Upper Salado	5206200000- 0	826					
Upper Salado	5206180400- 0	1,653	1	1	1	1	153
Upper Salado	5206180300- 0	3,306					0
Upper Salado	5206180200- 0	1,286		3			266
Upper Salado	5206180100- 0	1,745	8	8	7	7	617
Upper Salado	5206180000- 4	3,489	15	15	15	15	18
Upper Salado	5206180000- 3	643					0
Upper Salado	5206180000- 2	367	1	1	1	1	26
Upper Salado	5206180000- 1	918	134	185	204	178	332
Upper Salado	5206180000- 0	1,837	193	305	462	536	1,606
Upper Salado	5206160000- 0	1,102	197	249	324	570	1,332
Upper Salado	5206140000- 0	5,877	2,928	3,513	4,225	4,608	8,901
Upper Salado	5206120800- 0	643					7
Upper Salado	5206120700- 0	2,388	17	21	23	24	152
Upper Salado	5206120600- 0	826	2	2	2	3	8
Upper Salado	5206120404- 0	2,020	2	2	2	2	5
Upper Salado	5206120403- 0	1,837	17	18	20	20	26
Upper Salado	5206120401- 0	5,051	20	40	19	24	740
Upper Salado	5206120400- 4	4,775	62	64	76	75	142
Upper Salado	5206120400- 3	4,500	9	9	10	14	680

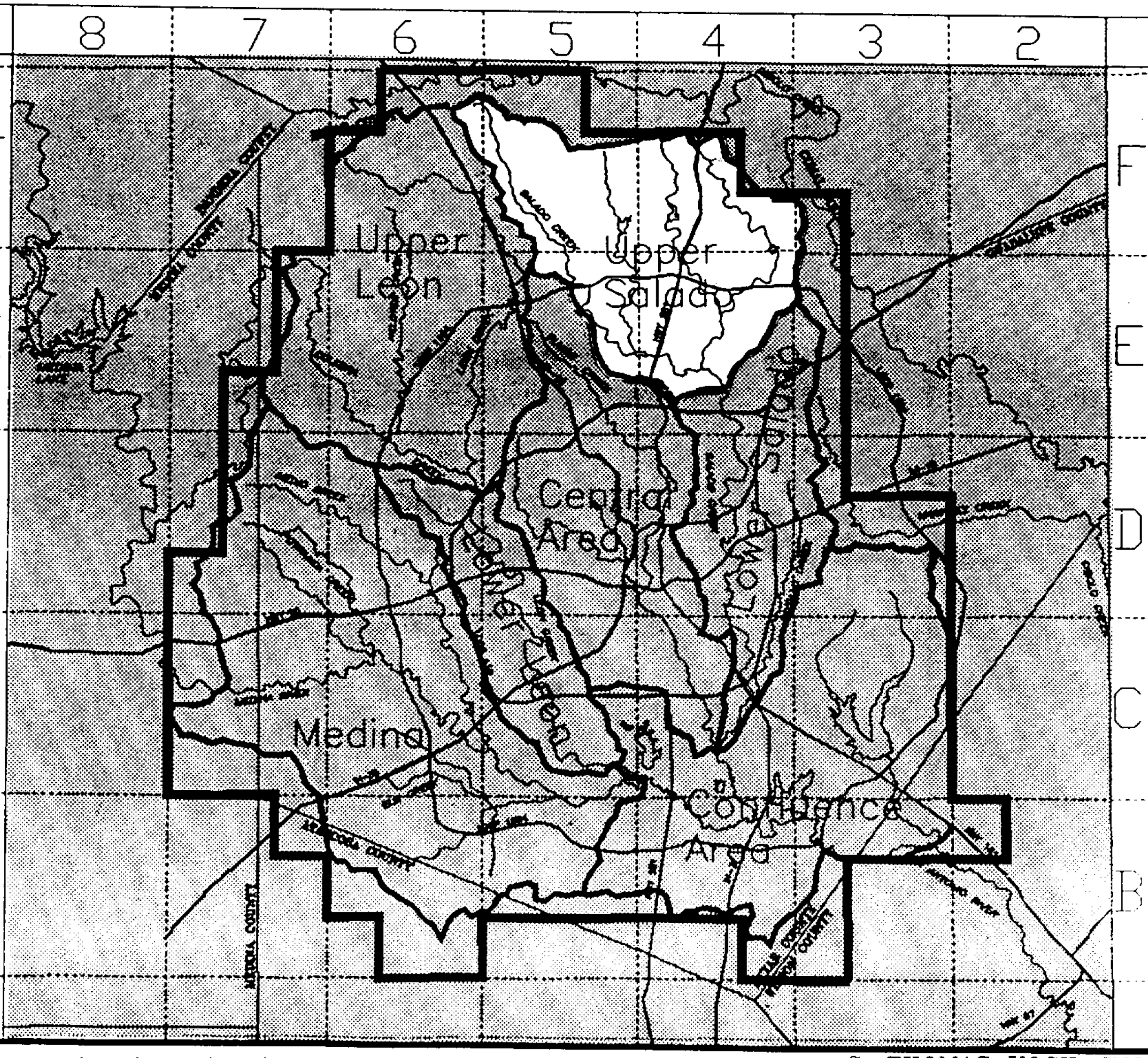
TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206120400- 1	735	8	8	7	8	220
Upper Salado	5206120400- 0	459	29	42	127	147	239
Upper Salado	5206120200- 0	1,102	69	137	320	427	1,715
Upper Salado	5206120000- 4	4,224	60	134	231	244	725
Upper Salado	5206120000- 2	551	22	33	92	137	1,011
Upper Salado	5206120000- 0	643	9	10	9	12	736
Upper Salado	5206100200- 0	918	421	429	555	575	1,660
Upper Salado	5206100000- 2	2,938	631	860	1,308	1,674	3,845
Upper Salado	5206000000-27	1,010	2	5	11	13	17
Upper Salado	5206000000-26	1,377	1	1	1	2	8
Upper Salado	5206000000-24	2,938					
Upper Salado	5206000000-22	735	1	1	1	1	2
Upper Salado	5206000000-20	459			1	1	
Upper Salado	5206000000-18	7,438	754	821	2,037	2,858	10,165
Upper Salado	5206000000-16	918	710	714	713	798	961
Upper Salado	5206000000-14	2,296	676	462	501	520	1,227
Upper Salado	5206000000-10	1,286	579	577	700	700	970
Upper Salado		82,645	7,579	8,683	12,054	14,254	38,626

Upper Salado	*RESIDENTIAL CONNECTIONS*	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	F - 6	1,561	4	19	61	74	137
Upper Salado	F - 5	25,712	34	41	39	38	332
Upper Salado	F - 4	19,559	93	96	112	119	1,140
Upper Salado	F - 3	92					3
Upper Salado	E - 5	11,019	1,689	1,920	3,311	4,183	13,355
Upper Salado	E - 4	24,702	5,759	6,607	8,531	9,840	23,659
Upper Salado		82,645	7,579	8,683	12,054	14,254	38,626

New Connections = <u>31,047</u> or <u>21%</u> of all New Connections in Study Area



C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area

Water Well ID 68- 19

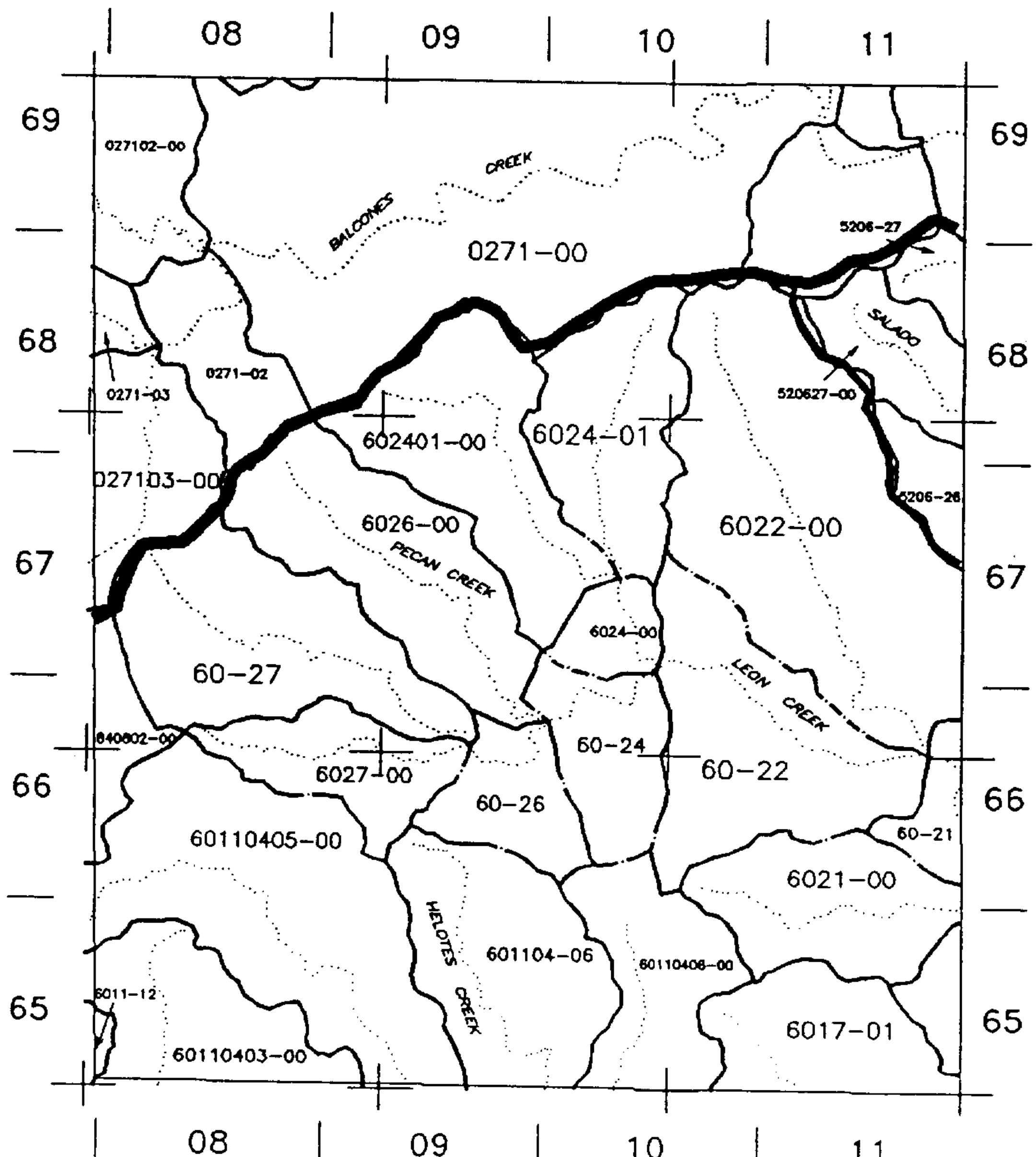
Map Name Van Raub

Scale 1:100,000

Latitude = 29

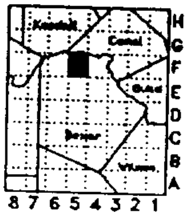
Longitude = 98

7.5' Area = F6



GAE 1/29/93 44F6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 20

Map Name Camp Bullis

Scale 1:100,000

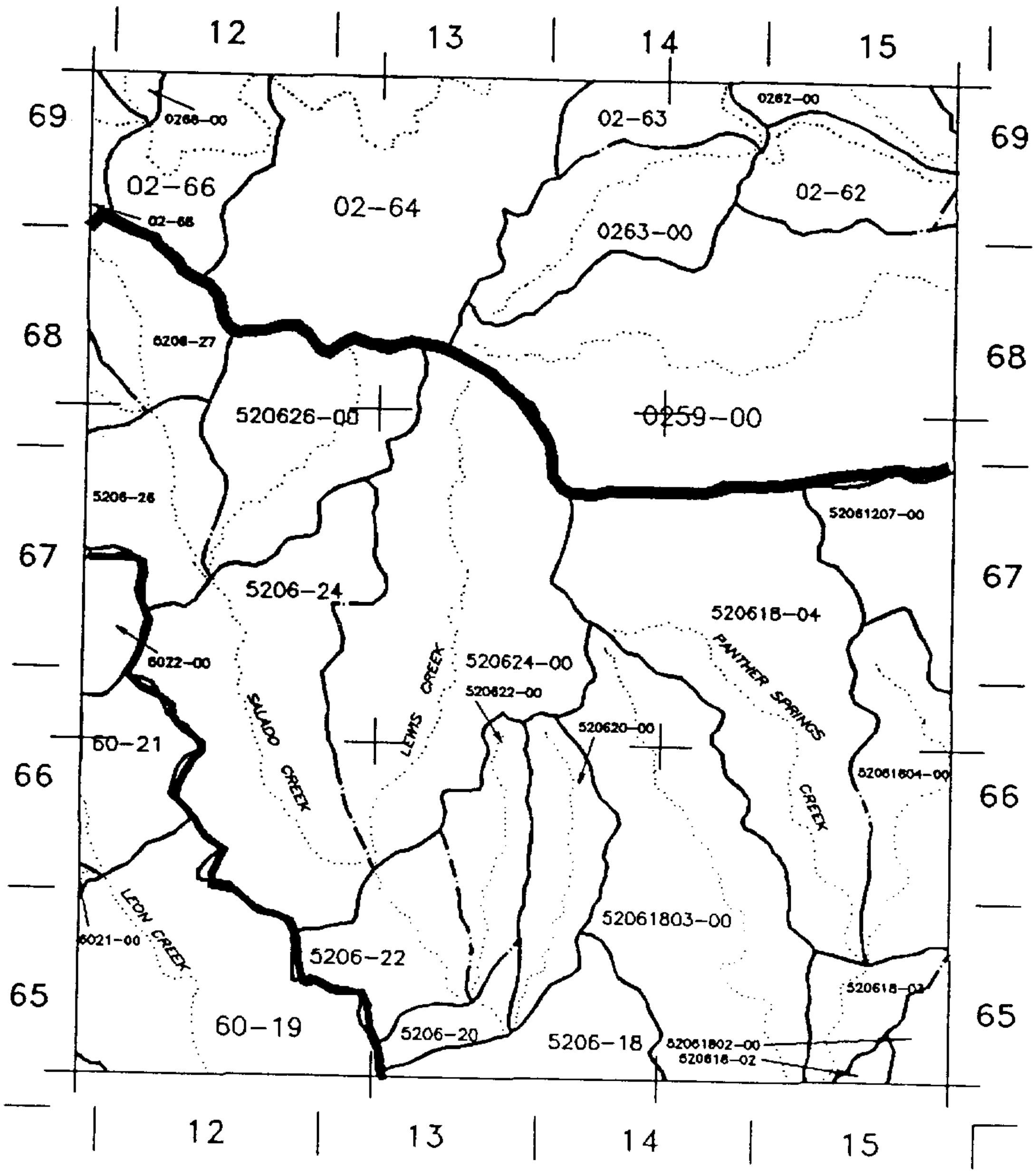
0 0.5 1.0 1.5 2.0

SCALE (MILES)

Latitude = 29

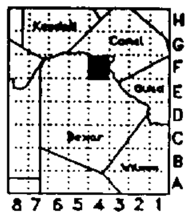
Longitude = 98

7.5' Area = F5



GAE 1/29/93 44F5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 21

Map Name Bulverde

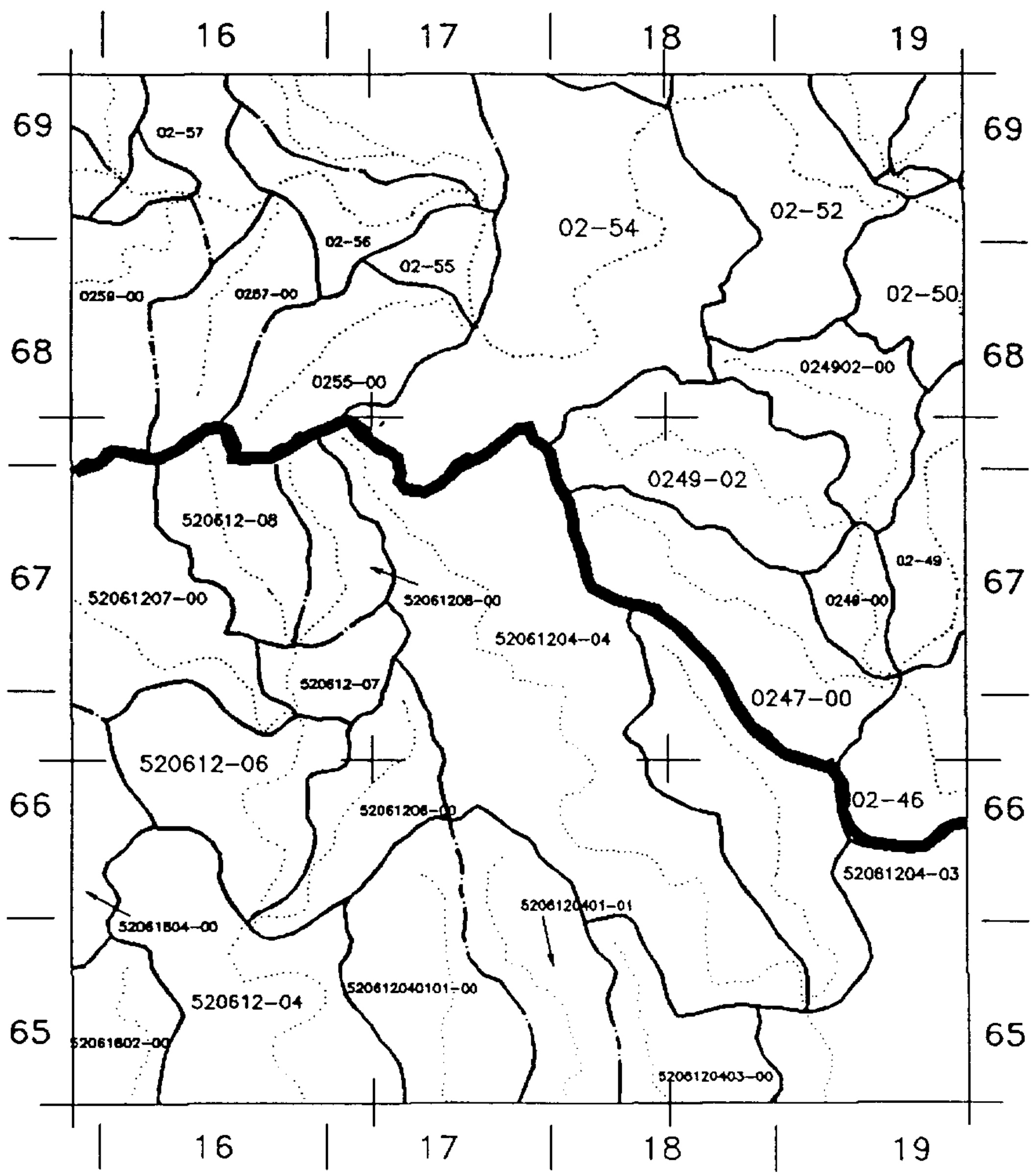
Scale 1:100,000

SCALE (MILES): 0 0.5 1.0 1.5 2.0

Latitude = 29

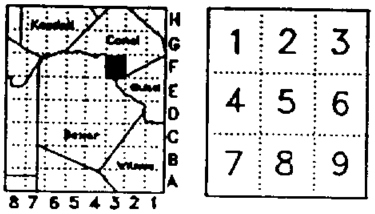
Longitude = 98

7.5' Area = F4



GAE 1/29/93 44F4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 22

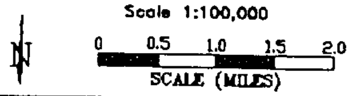
Map Name Bat Cave

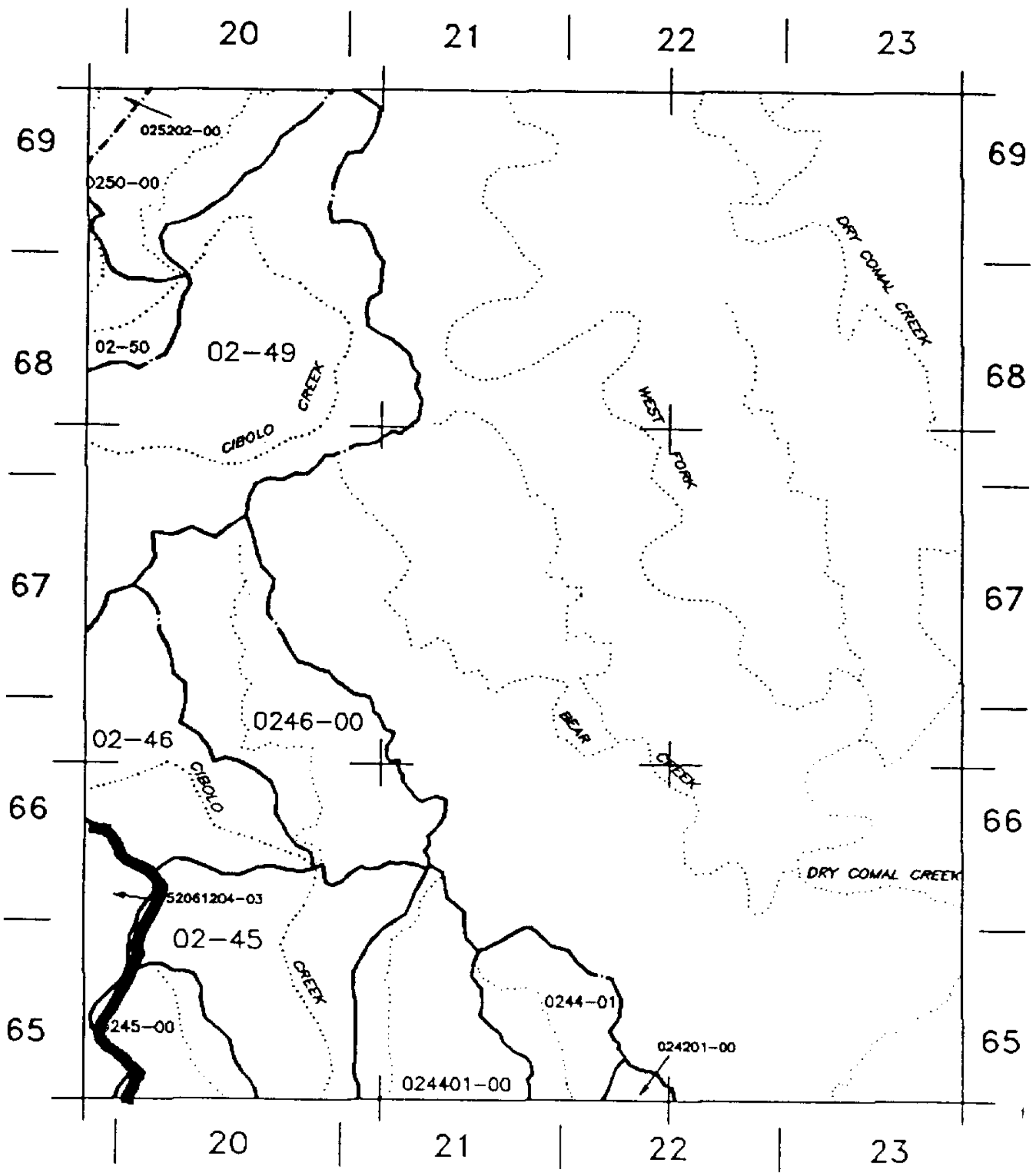
Scale 1:100,000

Latitude = 29

Longitude = 98

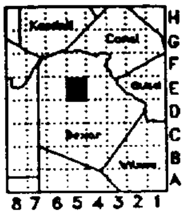
7.5' Area = F3





GAE 1/29/93 044F3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

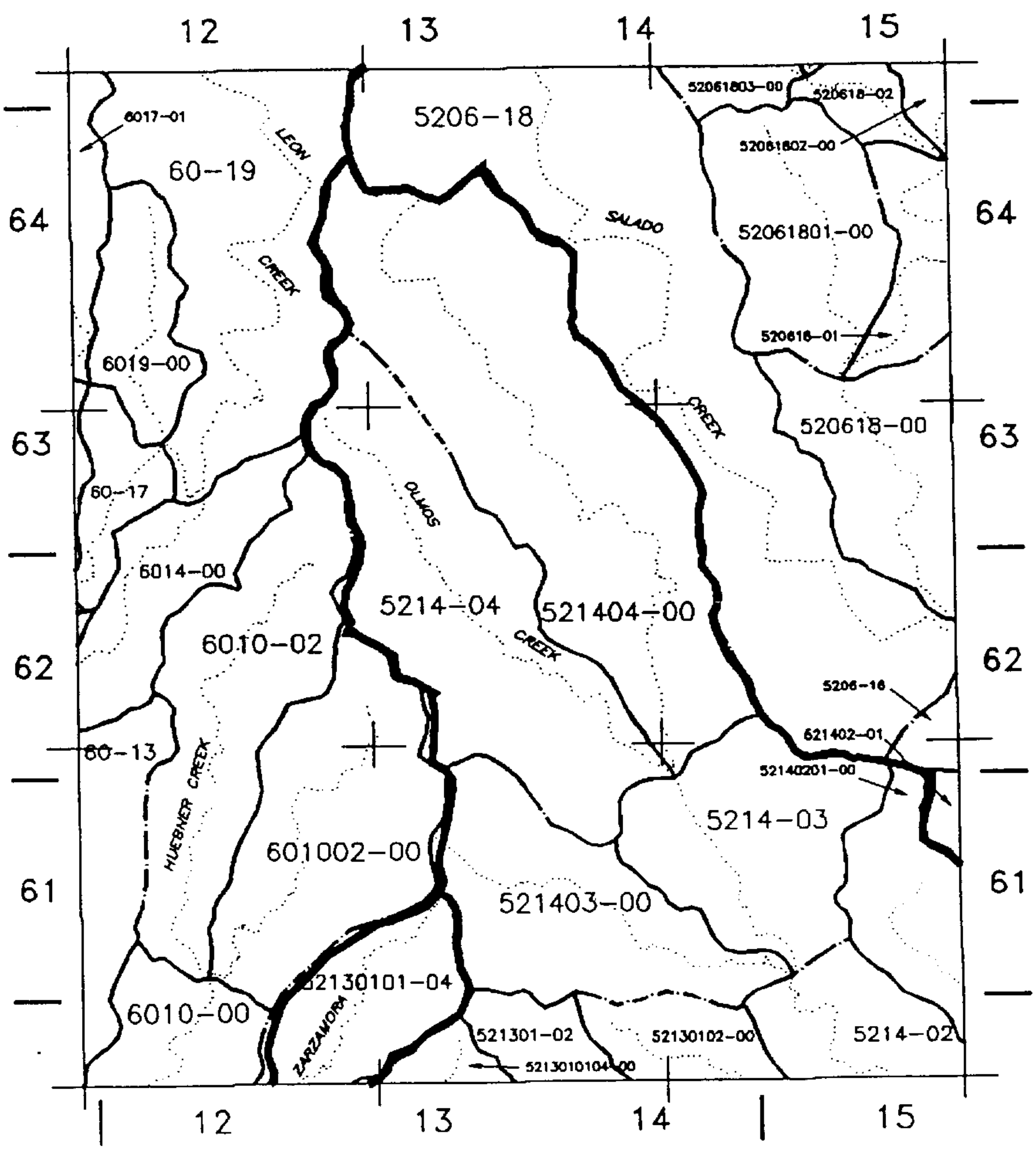
Scale 1:100,000

0 0.5 1.0 1.5 2.0
SCALE (MILES)

Latitude = 29

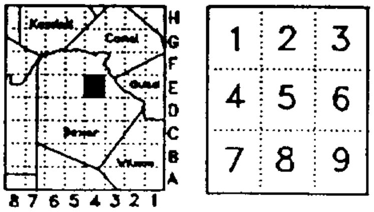
Longitude = 98

7.5' Area = E5



GAE 1/29/93 44E5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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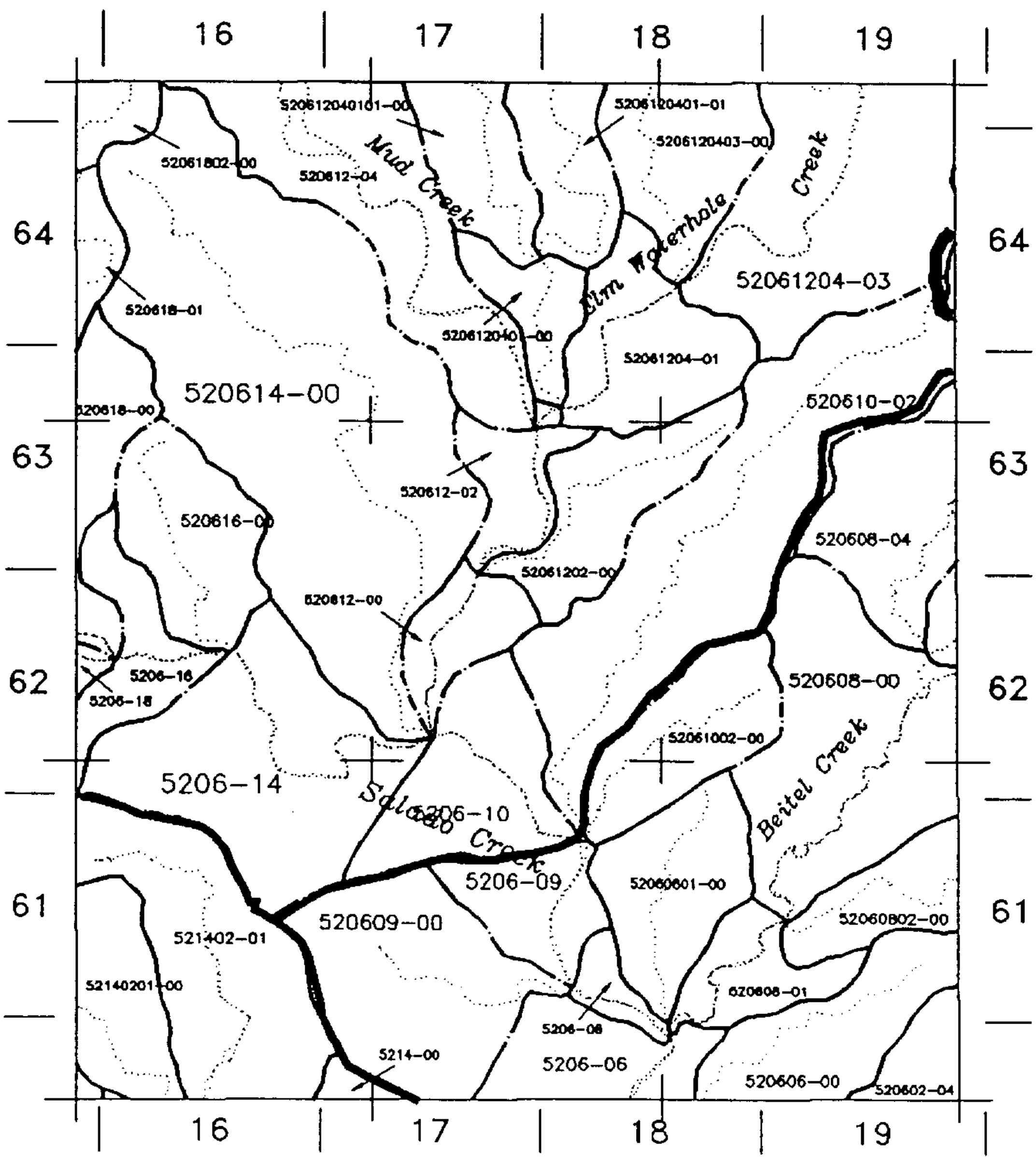
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = E4



GAE 1/29/93 44E4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

Report file: q_sws_R

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TOTAL RESIDENTIAL CONNECTIONS

1976-1988

7.5' Area : F-6

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206270000- 0	918	1	13	49	59	114
Upper Salado	5206000000-27	275	2	5	11	13	17
Upper Salado	5206000000-26	367	1	1	1	2	6
Upper Salado		1,561	4	19	61	74	137

Report file: q_sws_R
Page 5 1/28/93 7:48:39 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206260000- 0	1,653					
Upper Salado	5206240000- 0	4,040					
Upper Salado	5206220000- 0	918					
Upper Salado	5206200000- 0	826					
Upper Salado	5206180400- 0	1,561	1	1	1	1	153
Upper Salado	5206180300- 0	3,306					0
Upper Salado	5206180200- 0	643		3			57
Upper Salado	5206180000- 4	3,489	15	15	15	15	18
Upper Salado	5206180000- 3	643					0
Upper Salado	5206120700- 0	1,286	17	21	21	20	100
Upper Salado	5206000000-27	735					0
Upper Salado	5206000000-26	1,010					2
Upper Salado	5206000000-24	2,938					
Upper Salado	5206000000-22	735	1	1	1	1	2
Upper Salado	5206000000-20	459			1	1	
Upper Salado	5206000000-18	1,469					0
Upper Salado		25,712	34	41	39	38	332

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206180400- 0	92					0
Upper Salado	5206180200- 0	551					206
Upper Salado	5206120800- 0	643					7
Upper Salado	5206120700- 0	1,102			2	4	52
Upper Salado	5206120600- 0	826	2	2	2	3	8
Upper Salado	5206120404- 0	2,020	2	2	2	2	5
Upper Salado	5206120403- 0	1,194	17	18	20	20	26
Upper Salado	5206120401- 0	3,306	5	5	4	9	686
Upper Salado	5206120400- 4	4,775	62	64	76	75	142
Upper Salado	5206120400- 3	2,388	5	5	6	6	8
Upper Salado	5206120000- 4	2,663					
Upper Salado		19,559	93	96	112	119	1,140

Report file: q_sws_R
Page 9 1/28/93 7:48:43 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : F-3

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206120400- 3	92					3
Upper Salado		92					3

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Page 15 1/28/93 7:50:36 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206180200- 0	92					3
Upper Salado	5206180100- 0	1,745	8	8	7	7	617
Upper Salado	5206180000- 2	367	1	1	1	1	26
Upper Salado	5206180000- 1	918	134	185	204	178	332
Upper Salado	5206180000- 0	1,653	151	262	418	493	1,563
Upper Salado	5206000000-18	5,969	754	821	2,037	2,858	10,165
Upper Salado	5206000000-16	275	641	643	644	646	649
Upper Salado		11,019	1,689	1,920	3,311	4,183	13,355

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Page 19 1/28/93 7:50:53 pm

TOTAL RESIDENTIAL CONNECTIONS
1976-1988
7.5' Area : E-4

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206180000- 0	184	42	43	44	43	43
Upper Salado	5206160000- 0	1,102	197	249	324	570	1,332
Upper Salado	5206140000- 0	5,877	2,928	3,513	4,225	4,608	8,901
Upper Salado	5206120403- 0	643					0
Upper Salado	5206120401- 0	1,745	15	35	15	15	54
Upper Salado	5206120400- 3	2,020	4	4	4	8	669
Upper Salado	5206120400- 1	735	8	8	7	8	220
Upper Salado	5206120400- 0	459	29	42	127	147	239
Upper Salado	5206120200- 0	1,102	69	137	320	427	1,715
Upper Salado	5206120000- 4	1,561	60	134	231	244	725
Upper Salado	5206120000- 2	551	22	33	92	137	1,011
Upper Salado	5206120000- 0	643	9	10	9	12	736
Upper Salado	5206100200- 0	918	421	429	555	575	1,660
Upper Salado	5206100000- 2	2,938	631	860	1,308	1,674	3,845
Upper Salado	5206000000-16	643	69	71	69	152	312
Upper Salado	5206000000-14	2,296	676	462	501	520	1,227
Upper Salado	5206000000-10	1,286	579	577	700	700	970
Upper Salado		24,702	5,759	6,607	8,531	9,840	23,659

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206270000- 0	918	1	13	49	59	114
Upper Salado	5206260000- 0	1,653					
Upper Salado	5206240000- 0	4,040					
Upper Salado	5206220000- 0	918					
Upper Salado	5206200000- 0	826					
Upper Salado	5206180400- 0	1,653	1	1	1	1	153
Upper Salado	5206180300- 0	3,306					0
Upper Salado	5206180200- 0	1,286		3			266
Upper Salado	5206180100- 0	1,745	8	8	7	7	617
Upper Salado	5206180000- 4	3,489	15	15	15	15	18
Upper Salado	5206180000- 3	643					0
Upper Salado	5206180000- 2	367	1	1	1	1	26
Upper Salado	5206180000- 1	918	134	185	204	178	332
Upper Salado	5206180000- 0	1,837	193	305	462	536	1,606
Upper Salado	5206160000- 0	1,102	197	249	324	570	1,332
Upper Salado	5206140000- 0	5,877	2,928	3,513	4,225	4,608	8,901
Upper Salado	5206120800- 0	643					7
Upper Salado	5206120700- 0	2,388	17	21	23	24	152
Upper Salado	5206120600- 0	826	2	2	2	3	8
Upper Salado	5206120404- 0	2,020	2	2	2	2	5
Upper Salado	5206120403- 0	1,837	17	18	20	20	26
Upper Salado	5206120401- 0	5,051	20	40	19	24	740
Upper Salado	5206120400- 4	4,775	62	64	76	75	142
Upper Salado	5206120400- 3	4,500	9	9	10	14	680

TOTAL RESIDENTIAL CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 RES	1977 RES	1979 RES	1980 RES	1988 RES
Upper Salado	5206120400- 1	735	8	8	7	8	220
Upper Salado	5206120400- 0	459	29	42	127	147	239
Upper Salado	5206120200- 0	1,102	69	137	320	427	1,715
Upper Salado	5206120000- 4	4,224	60	134	231	244	725
Upper Salado	5206120000- 2	551	22	33	92	137	1,011
Upper Salado	5206120000- 0	643	9	10	9	12	736
Upper Salado	5206100200- 0	918	421	429	555	575	1,660
Upper Salado	5206100000- 2	2,938	631	860	1,308	1,674	3,845
Upper Salado	5206000000-27	1,010	2	5	11	13	17
Upper Salado	5206000000-26	1,377	1	1	1	2	8
Upper Salado	5206000000-24	2,938					
Upper Salado	5206000000-22	735	1	1	1	1	2
Upper Salado	5206000000-20	459			1	1	
Upper Salado	5206000000-18	7,438	754	821	2,037	2,858	10,165
Upper Salado	5206000000-16	918	710	714	713	798	961
Upper Salado	5206000000-14	2,296	676	462	501	520	1,227
Upper Salado	5206000000-10	1,286	579	577	700	700	970
Upper Salado		82,645	7,579	8,683	12,054	14,254	38,626

2 of 8

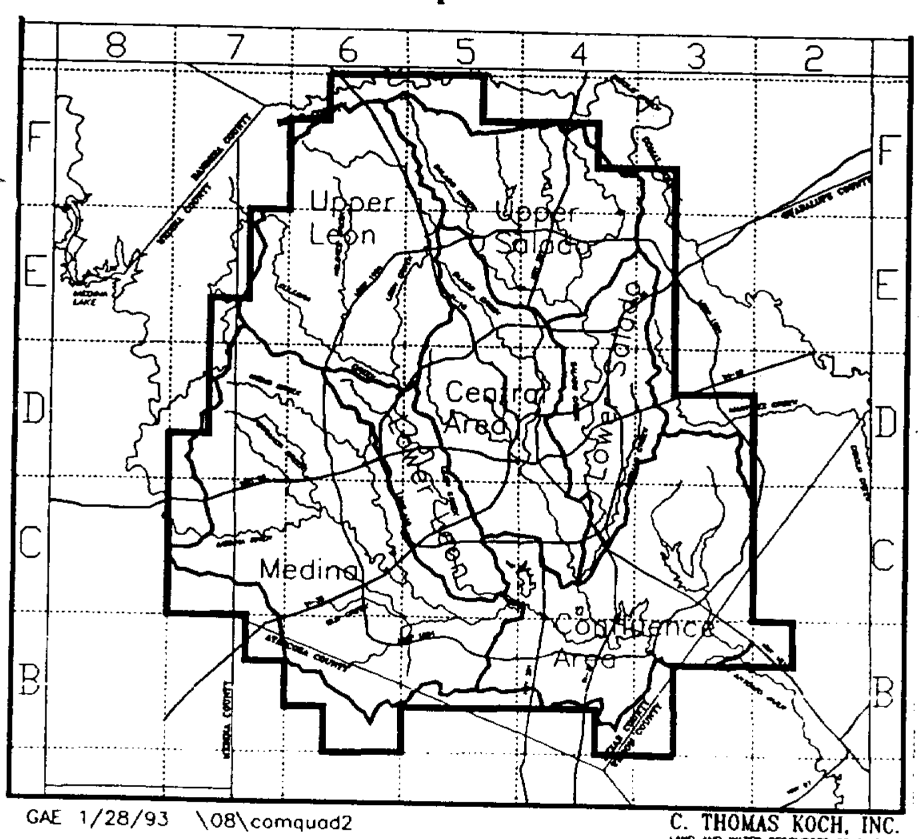
San Antonio Water System

WATER RESOURCES PLANNING PROCESS

DEVELOPMENT TRENDS

BUSINESS CONNECTIONS
by Watershed Planning Area

Report No. 2



Prepared for:

Texas Water Development Board

January 1993

twdbjan2.tc

Summary

Central

Confluence

Lower Leon

Lower Salado

Medina

Upper Leon

Upper Salado

SAN ANTONIO WATER SYSTEM

P.O. Box 2449, San Antonio, Texas 78298-2449 210/225-7461

February 1, 1993

MR. CURTIS JOHNSON
TEXAS WATER DEVELOPMENT BOARD
P.O. Box 13231, Capitol Station
Austin, Texas 78711-3231

RE: REPORT NO. 2 - DEVELOPMENT TRENDS
BUSINESS CONNECTIONS BY WATERSHED PLANNING AREA
(TWDB Contract Number 9-483-722)

Dear Curtis:

Today we are providing you with copies of eight documents which give you a status report on the planning process we are implementing for the San Antonio Water System through partial funding provided by your agency. A brief description of each of the other reports is contained in a separate letter to you dated today.

Report No. 2 provides computer listings and maps showing the number of business connections located within each of the seven watershed planning areas. An analysis of all utility connections have been provided for the following years: 1976, 1977, 1979, 1980, 1988.

A companion document (Report No. 4) provides the same listings. However, the historical utility connection data is first aggregated by 7.5 minute USGS maps and then disaggregated into watersheds. This allows our staff to use USGS maps as a base to record information and to better coordinate our efforts with State agencies such as yours.

I am sure you will have many questions concerning these data. Since these data serve as the launching platform for all other reports, I am suggesting that our staffs have a working session sometime during the week of February 22-26 to allow submittal of computer disks and programs to you and thereby reduce the amount of paper while increasing the amount of information conveyed to you.

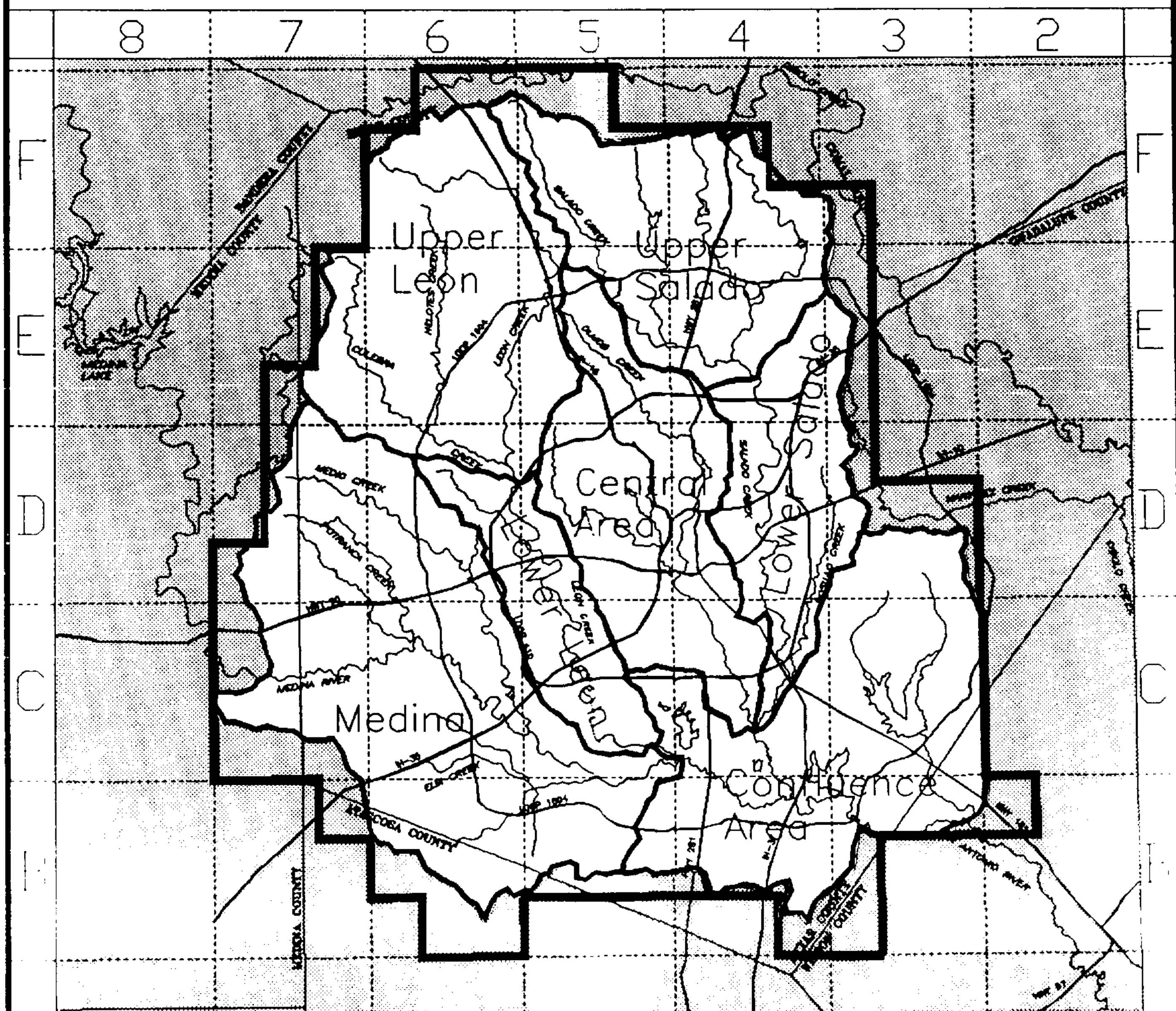
Very truly yours,

Jim Daniels/for
JOE A. ACEVES
President and Chief Executive Officer
JA:lk
twdb2.fl

PLANNING AREA	***BUSINESS CONNECTIONS***	*1976 Thru 1988*

Watershed	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	93,113	16,980	16,943	18,092	18,485	21,714
Confluence	110,285	501	518	541	594	747
Lower Leon	32,691	1,024	1,258	1,106	1,107	1,674
Lower Salado	59,963	2,983	3,264	3,295	3,713	6,624
Medina	81,818	334	335	372	372	817
Upper Leon	97,153	731	822	935	988	3,112
Upper Salado	82,645	1,223	1,363	1,646	1,922	4,328
	557,668	23,776	24,503	25,987	27,181	39,016

New Connections = 15,240 or 100% of all New Connections in Study Area



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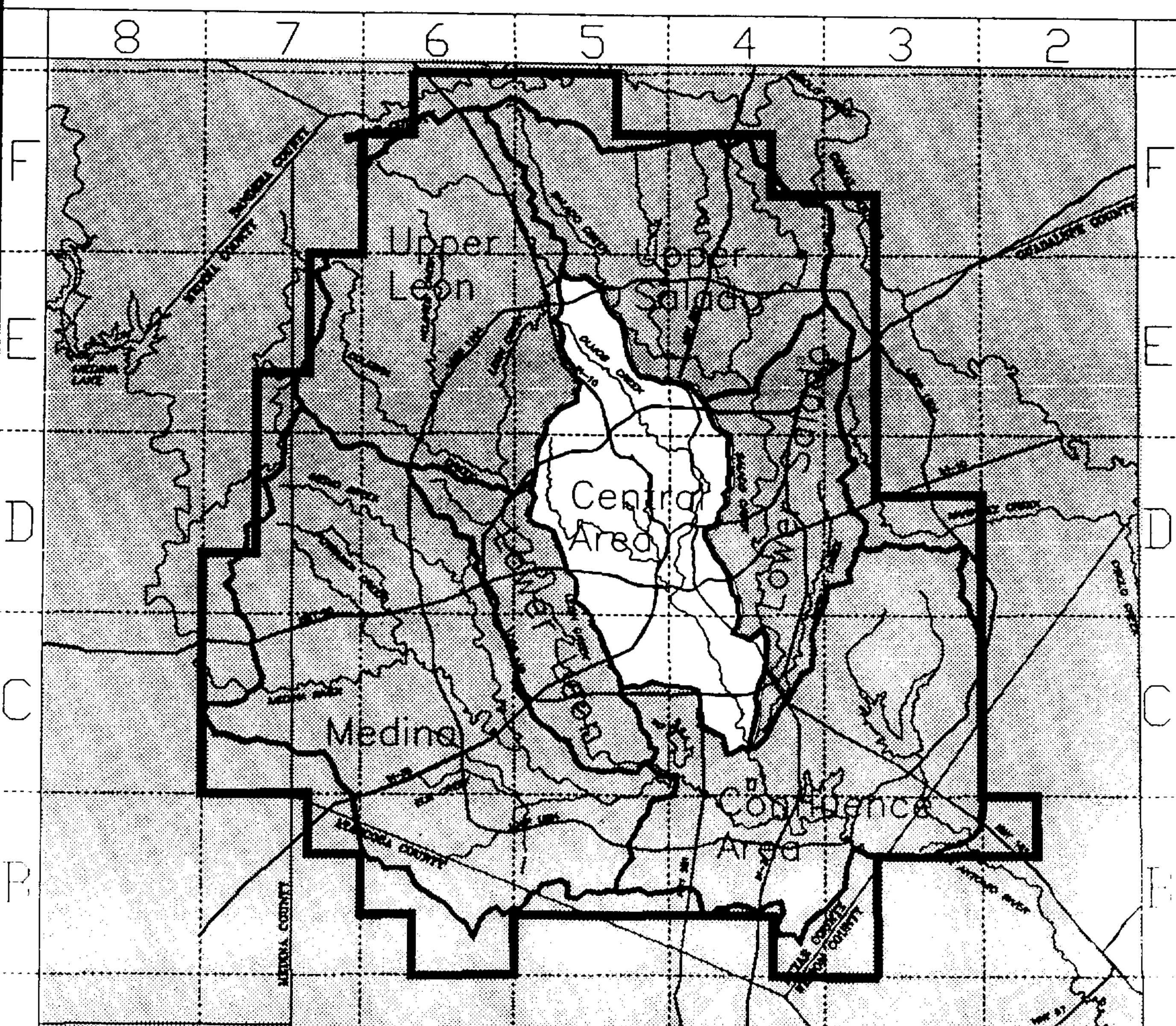
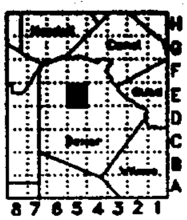
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

Central	***BUSINESS CONNECTIONS***	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	E - 5	17,631	937	1,061	1,338	1,390	3,573
Central	E - 4	2,571	440	479	592	607	925
Central	D - 5	31,864	8,293	8,069	8,116	9,019	9,292
Central	D - 4	14,141	5,270	5,256	5,907	5,323	5,197
Central	D - 2	459	52	52	58	55	186
Central	C - 5	6,520	1,205	1,240	1,272	1,285	1,503
Central	C - 4	19,927	783	786	809	806	1,038
	Central	93,113	16,980	16,943	18,092	18,485	21,714

New Connections = <u>4,734</u> or <u>31%</u> of all New Connections in Study Area





1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

Scale 1:100,000

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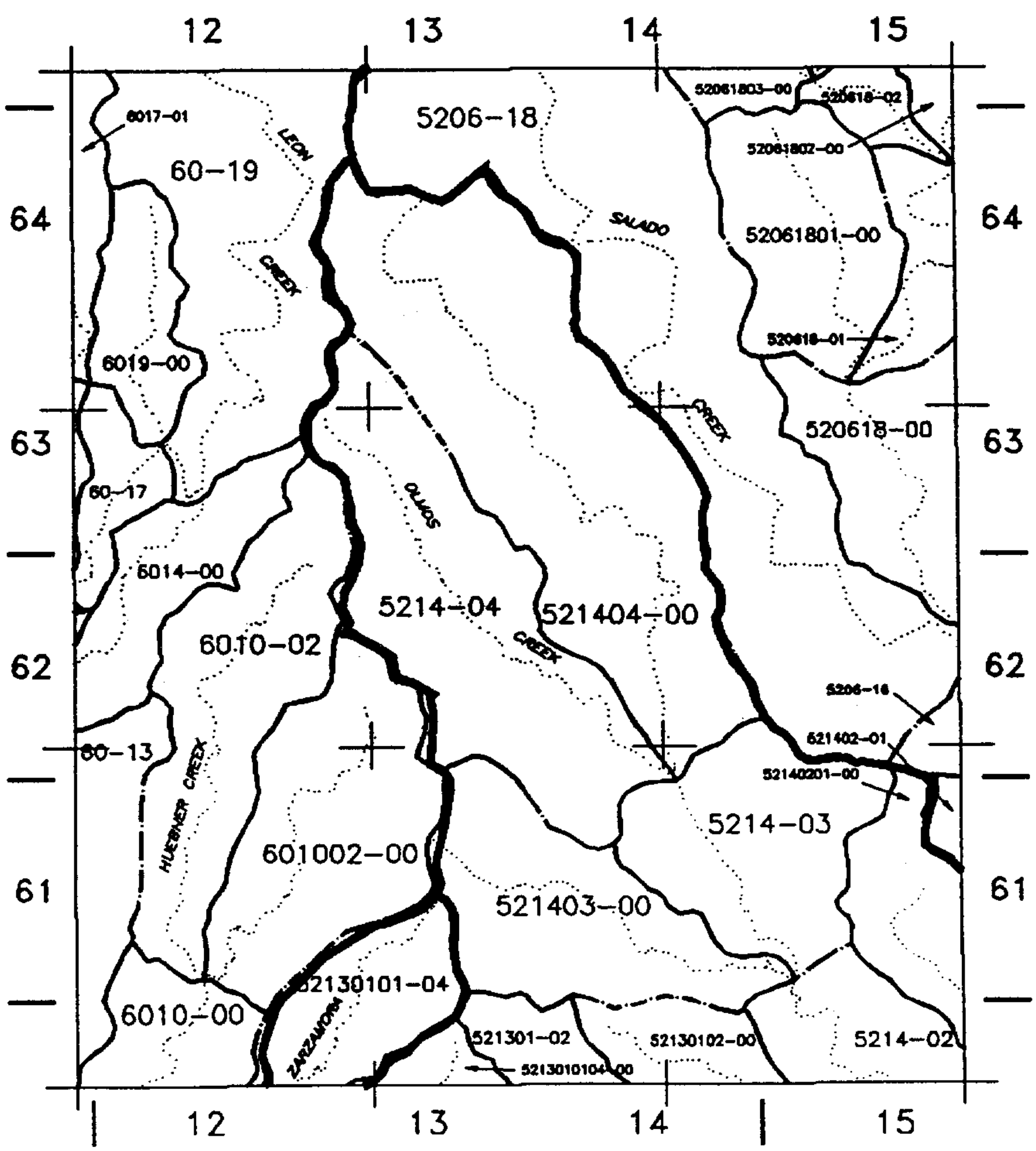
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = E5



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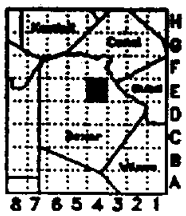
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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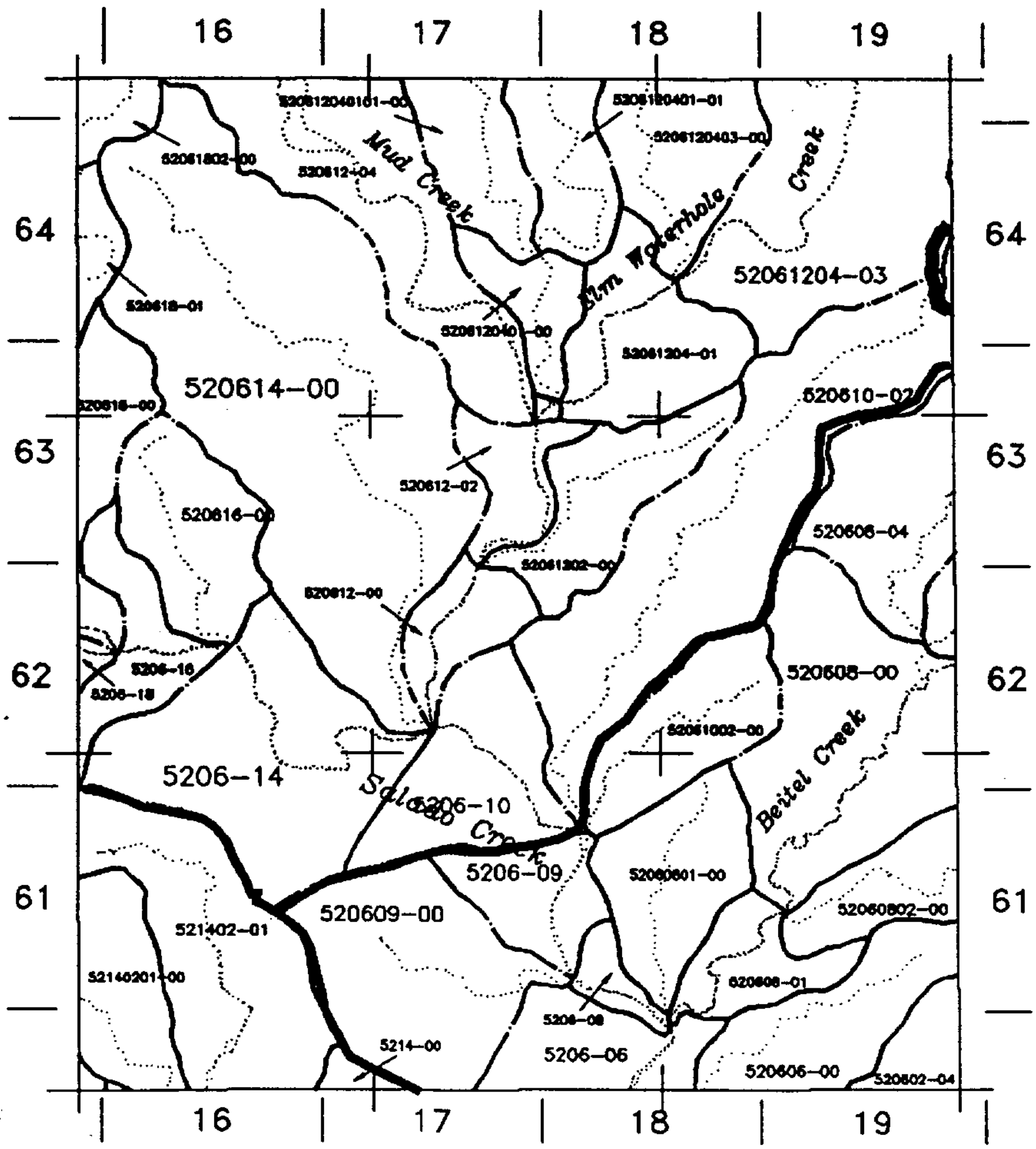
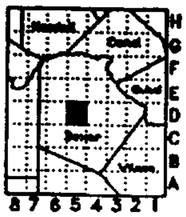
7.5' Area = E4



GAE 1/29/93 44E4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 36

Map Name SAN ANTONIO WEST

Scale 1:100,000

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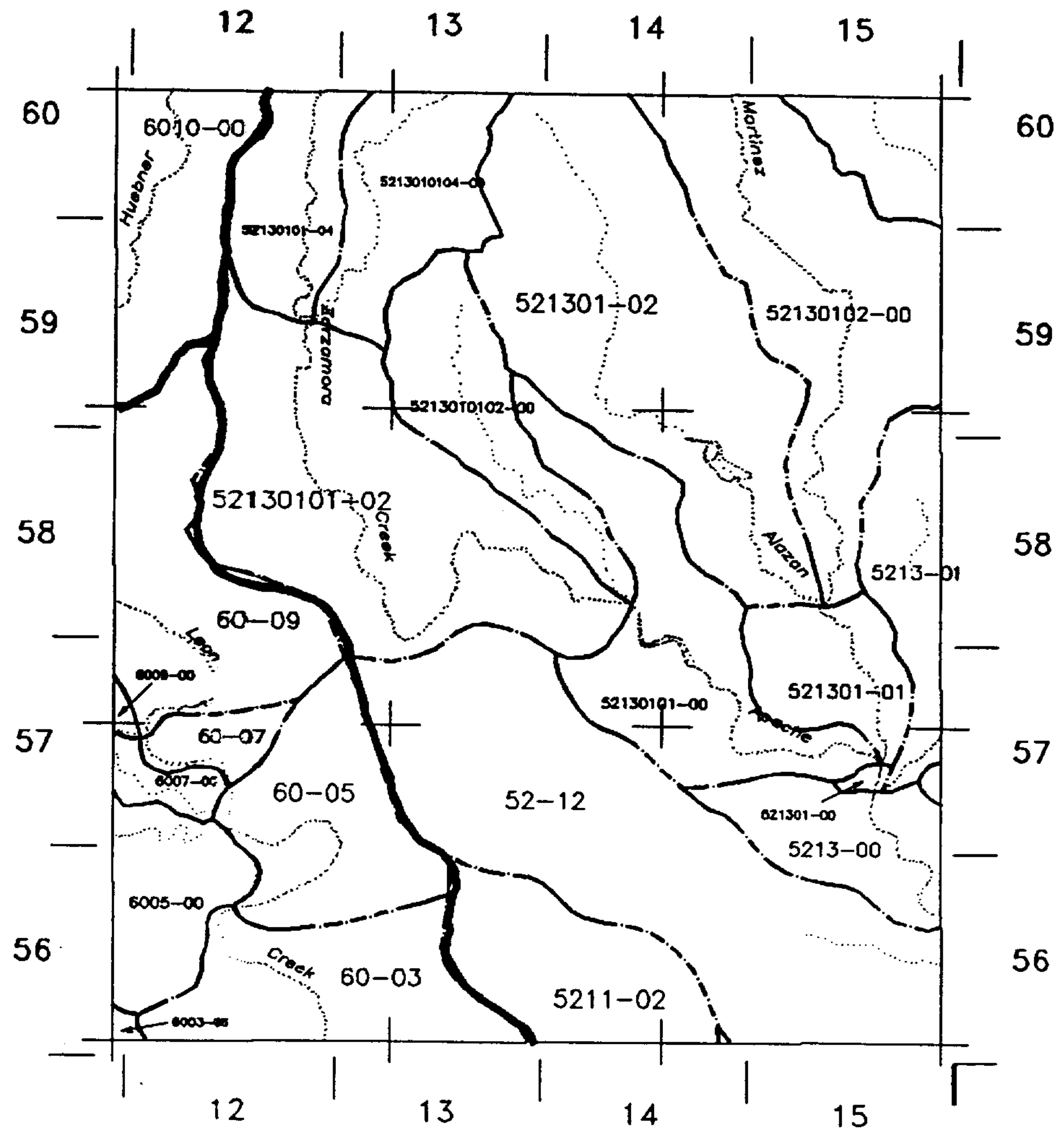
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = D5



GAE 1/29/93 44D5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area

Water Well ID 68- 37

Map Name SAN ANTONIO EAST

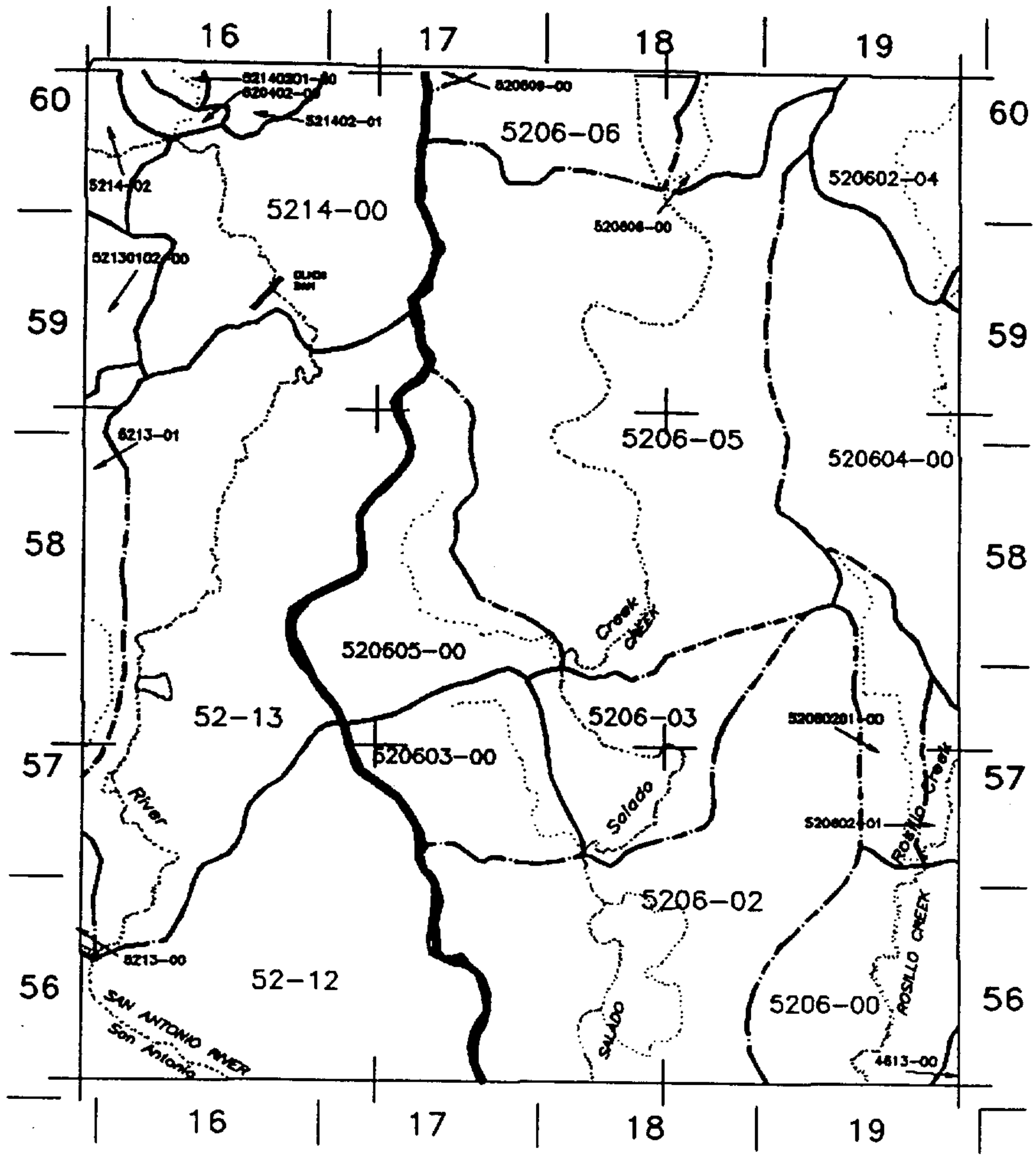
Scale 1:100,000

SCALE (MILES)

Latitude = 29

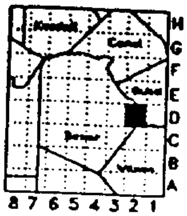
Longitude = 98

7.5' Area = D4



GAE 1/29/93 44D4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68-39

Map Name Saint Hedwig

Scale 1:100,000

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SCALE (MILES)

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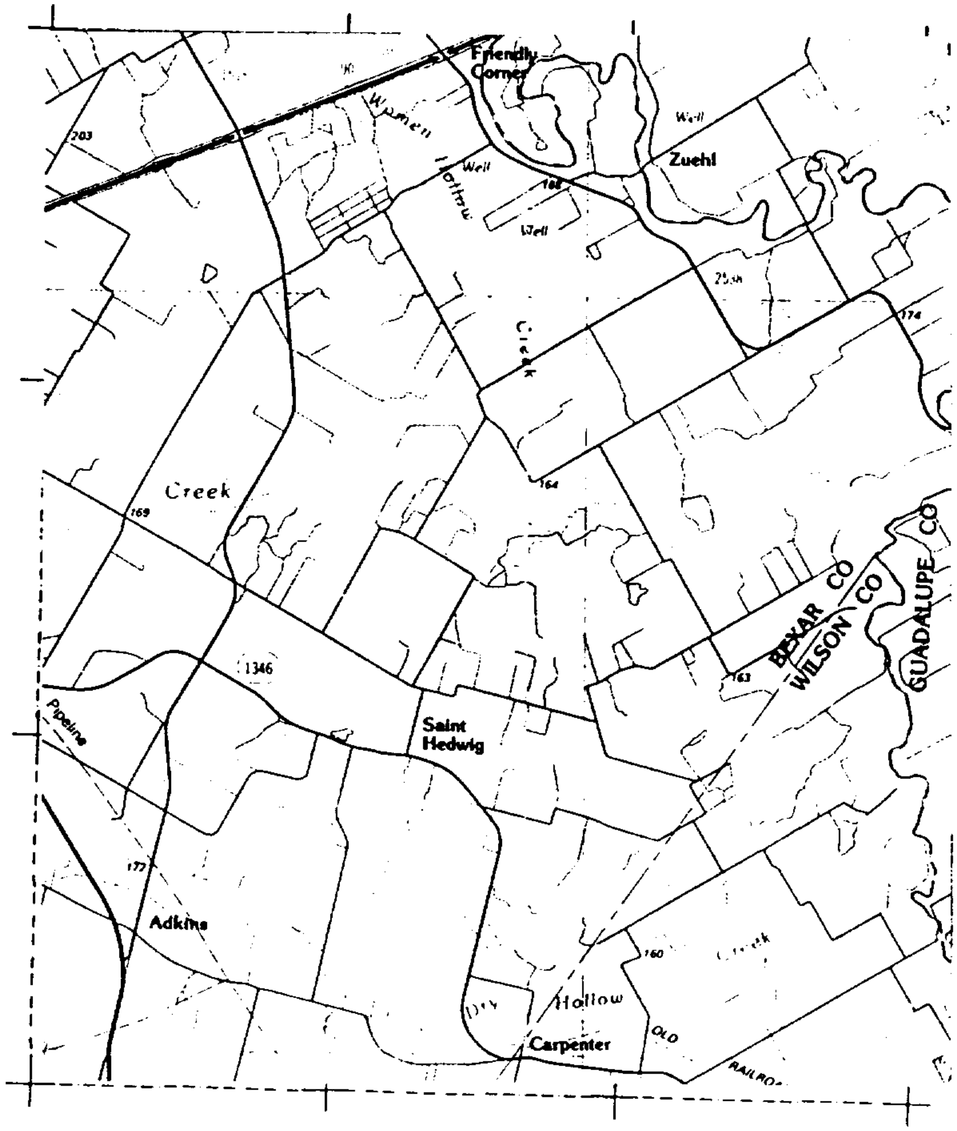
Longitude = 98

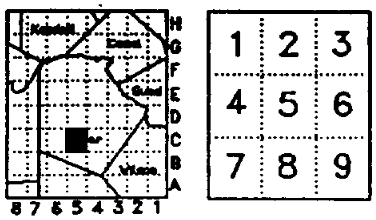
7.5' Area = D2



GAE 1/18/93 038FRAME.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area



Water Well ID	68- 44
Map Name	TERREL WELLS

Scale 1:100,000

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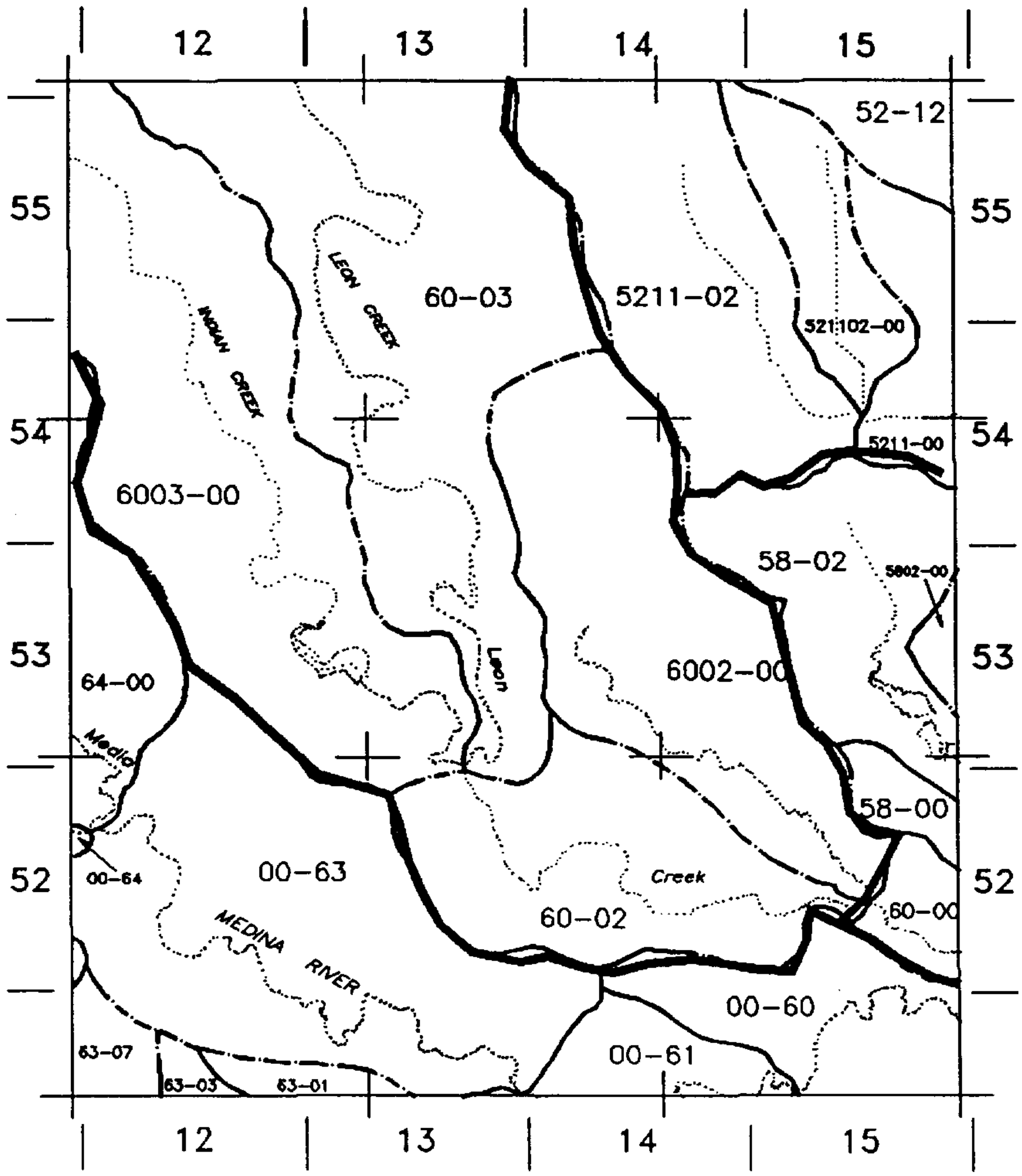
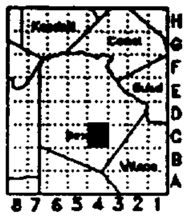
Longitude	= 98
7.5' Area	= C5



GAE 1/29/93 44C5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 45

Map Name SOUTHTON

Scale 1:100,000

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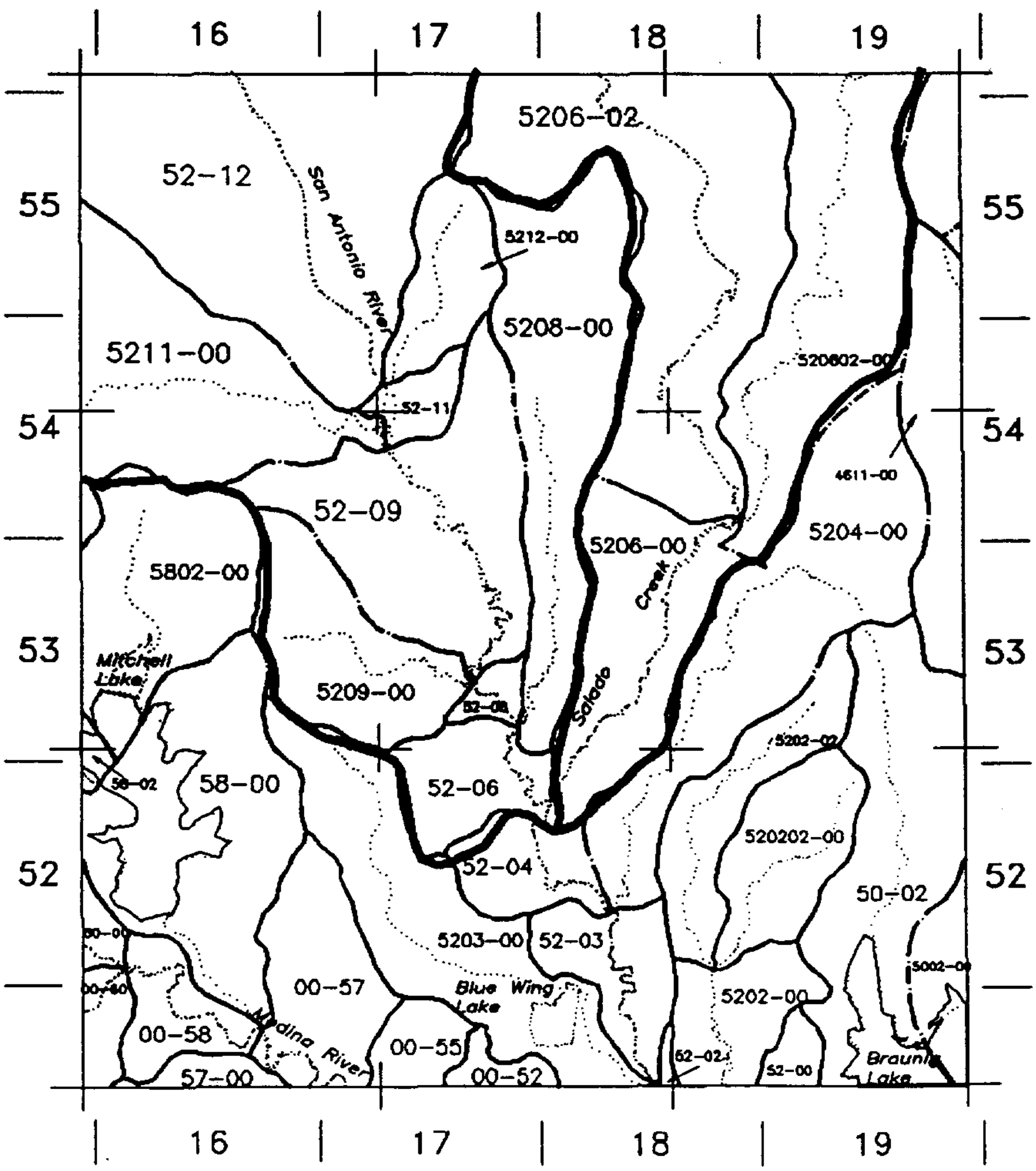
Longitude = 98

7.5' Area = C4



GAE 1/29/93 44C4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5214040000- 0	5,418	39	46	58	61	222
Central	5214030000- 0	2,112	330	377	494	522	906
Central	5214020100- 0	1,102	249	270	312	318	446
Central	5214020000- 1	184	38	40	61	59	76
Central	5214000000- 4	3,398	98	114	180	187	461
Central	5214000000- 3	1,928	167	195	211	211	363
Central	5214000000- 2	1,010	2	2	2	2	287
Central	5213010200- 0	643					68
Central	5213010104- 0	184					37
Central	5213010100- 4	1,102	14	17	20	30	358
Central	5213010000- 2	551					349
Central		17,631	937	1,061	1,338	1,390	3,573

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5214000000- 2	826	339	350	354	356	428
Central	5213010200- 0	3,765	1,223	1,230	1,281	1,272	1,352
Central	5213010104- 0	1,561	126	139	181	398	336
Central	5213010102- 0	1,653	190	189	211	216	316
Central	5213010100- 2	4,408	431	464	459	474	579
Central	5213010100- 0	3,030	1,205	826	859	850	896
Central	5213010000- 2	5,051	1,322	1,410	1,420	1,401	1,669
Central	5213010000- 1	1,102	732	735	698	697	932
Central	5213000000- 1	1,286	885	877	860	1,552	853
Central	5213000000- 0	1,469	521	523	524	525	541
Central	5211000000- 2	1,653	120	120	126	126	141
Central	5200000000-12	6,061	1,199	1,206	1,143	1,152	1,249
Central		31,864	8,293	8,069	8,116	9,019	9,292

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TOTAL BUSINESS CONNECTIONS

1976-1988

7.5' Area : D-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5214020000- 0	184	19	22	22	24	27
Central	5214000000- 2	184	10	10	11	10	20
Central	5214000000- 0	3,122	471	489	512	533	588
Central	5213000000- 1	367	421	412	1,120	403	394
Central	5200000000-13	5,601	3,219	3,188	3,130	3,103	3,041
Central	5200000000-12	4,683	1,130	1,135	1,112	1,250	1,127
Central		14,141	5,270	5,256	5,907	5,323	5,197

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-2

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5213010100- 4	459	52	52	58	55	186
Central		459	52	52	58	55	186

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5211020000- 0	1,286	192	195	199	203	277
Central	5211000000- 2	3,398	574	592	613	599	686
Central	5211000000- 0	1,377	349	362	371	385	433
Central	5200000000-12	459	90	91	89	98	107
Central		6,520	1,205	1,240	1,272	1,285	1,503

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Page 50   1/28/93 7:30:08 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5212000000- 0	643					
Central	5212000000- 0	643	17	16	18	19	26
Central	5211000000- 0	1,653					
Central	5211000000- 0	1,837	111	118	118	118	172
Central	5209000000- 0	1,102	9	11	30	11	20
Central	5208000000- 0	643					
Central	5208000000- 0	2,204	67	64	66	71	105
Central	5200000000-12	6,979	524	522	523	528	646
Central	5200000000-11	735	15	16	14	15	13
Central	5200000000- 9	2,571	31	31	33	39	45
Central	5200000000- 8	184	0	0	0	0	0
Central	5200000000- 6	735	9	8	7	5	11
Central		19,927	783	786	809	806	1,038

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Page 1 1/29/93 12:16:06 p

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5214040000- 0	5,418	39	46	58	61	222
Central	5214030000- 0	2,112	330	377	494	522	906
Central	5214020100- 0	1,745	358	397	442	448	606
Central	5214020000- 1	2,112	369	392	523	536	841
Central	5214020000- 0	184	19	22	22	24	27
Central	5214000000- 4	3,398	98	114	180	187	461
Central	5214000000- 3	1,928	167	195	211	211	363
Central	5214000000- 2	2,020	351	362	367	368	735
Central	5214000000- 0	3,122	471	489	512	533	588
Central	5213010200- 0	4,408	1,223	1,230	1,281	1,272	1,420
Central	5213010104- 0	1,745	126	139	181	398	373
Central	5213010102- 0	1,653	190	189	211	216	316
Central	5213010100- 4	459	52	52	58	55	186
Central	5213010100- 4	1,102	14	17	20	30	358
Central	5213010100- 2	4,408	431	464	459	474	579
Central	5213010100- 0	3,030	1,205	826	859	850	896
Central	5213010000- 2	5,601	1,322	1,410	1,420	1,401	2,018
Central	5213010000- 1	1,102	732	735	698	697	932
Central	5213000000- 1	1,653	1,306	1,289	1,980	1,955	1,247
Central	5213000000- 0	1,469	521	523	524	525	541
Central	5212000000- 0	643					
Central	5212000000- 0	643	17	16	18	19	26
Central	5211020000- 0	1,286	192	195	199	203	277
Central	5211000000- 0	1,653					
Central	5211000000- 2	5,051	694	712	739	725	827
Central	5211000000- 0	3,214	460	480	489	503	605

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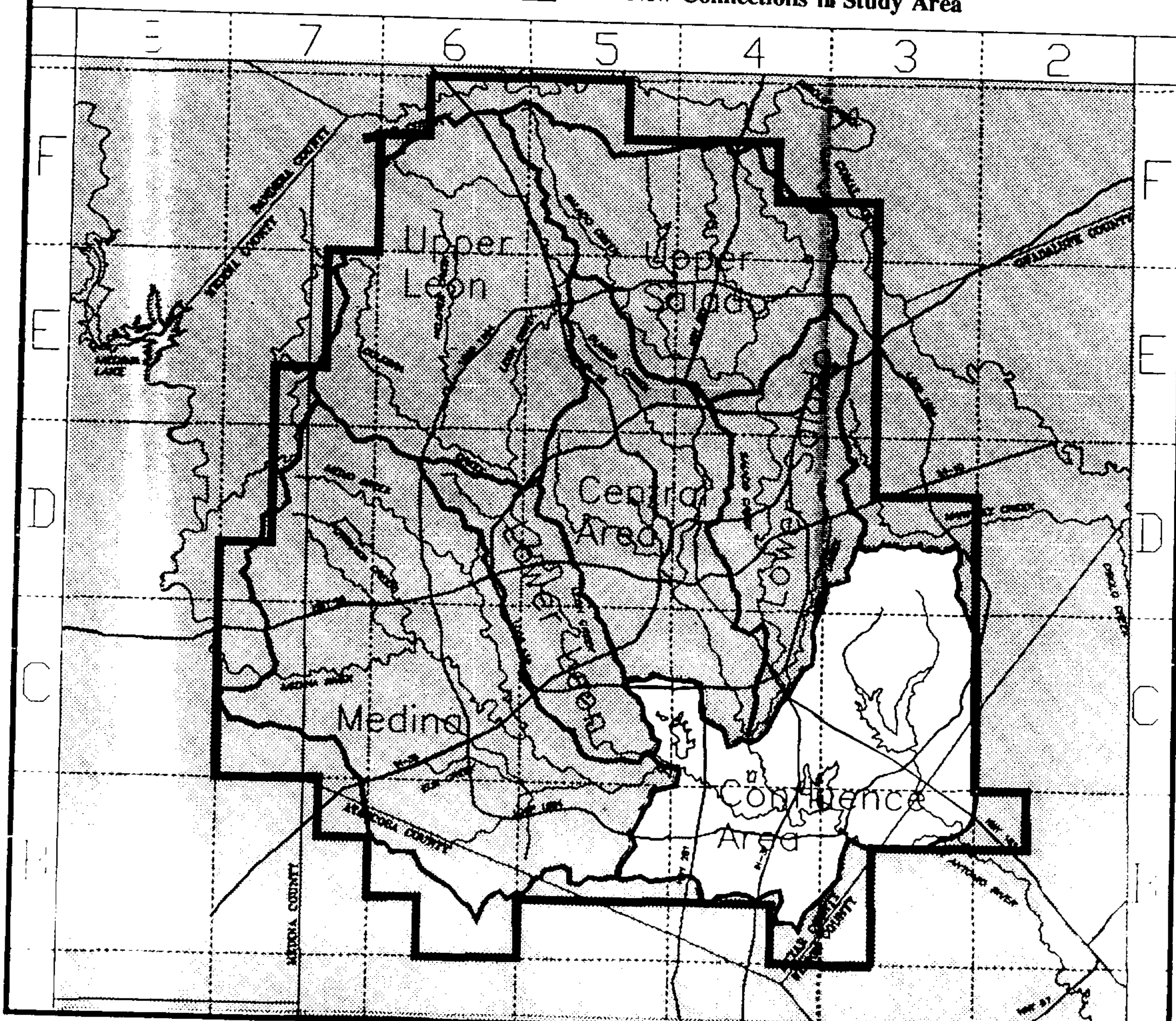
TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Central	5209000000- 0	1,102	9	11	30	11	20
Central	5208000000- 0	643					
Central	5208000000- 0	2,204	67	64	66	71	105
Central	5200000000-13	5,601	3,219	3,188	3,130	3,103	3,041
Central	5200000000-12	18,182	2,943	2,954	2,867	3,028	3,129
Central	5200000000-11	735	15	16	14	15	13
Central	5200000000- 9	2,571	31	31	33	39	45
Central	5200000000- 8	184	0	0	0	0	0
Central	5200000000- 6	735	9	8	7	5	11
Central		93,113	16,980	16,943	18,092	18,485	21,714

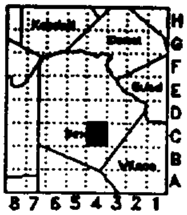
Confluence	**BUSINESS CONNECTIONS**	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	C - 4	19,835	171	173	186	207	227
Confluence	C - 3	40,129	180	186	189	206	266
Confluence	C - 2	4,408	9	7	13	11	
Confluence	B - 5	4,683	20	22	23	28	48
Confluence	B - 4	26,905	112	122	123	127	192
Confluence	B - 3	13,774	9	8	6	15	14
Confluence	B - 2	459					
Confluence	-	92	0	0	1	0	
Confluence		110,285	501	518	541	594	747

New Connections = 246 or 2% of all New Connections in Study Area



C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 45

Map Name SOUTHTON

Scale 1:100,000

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SCALE (MILES)

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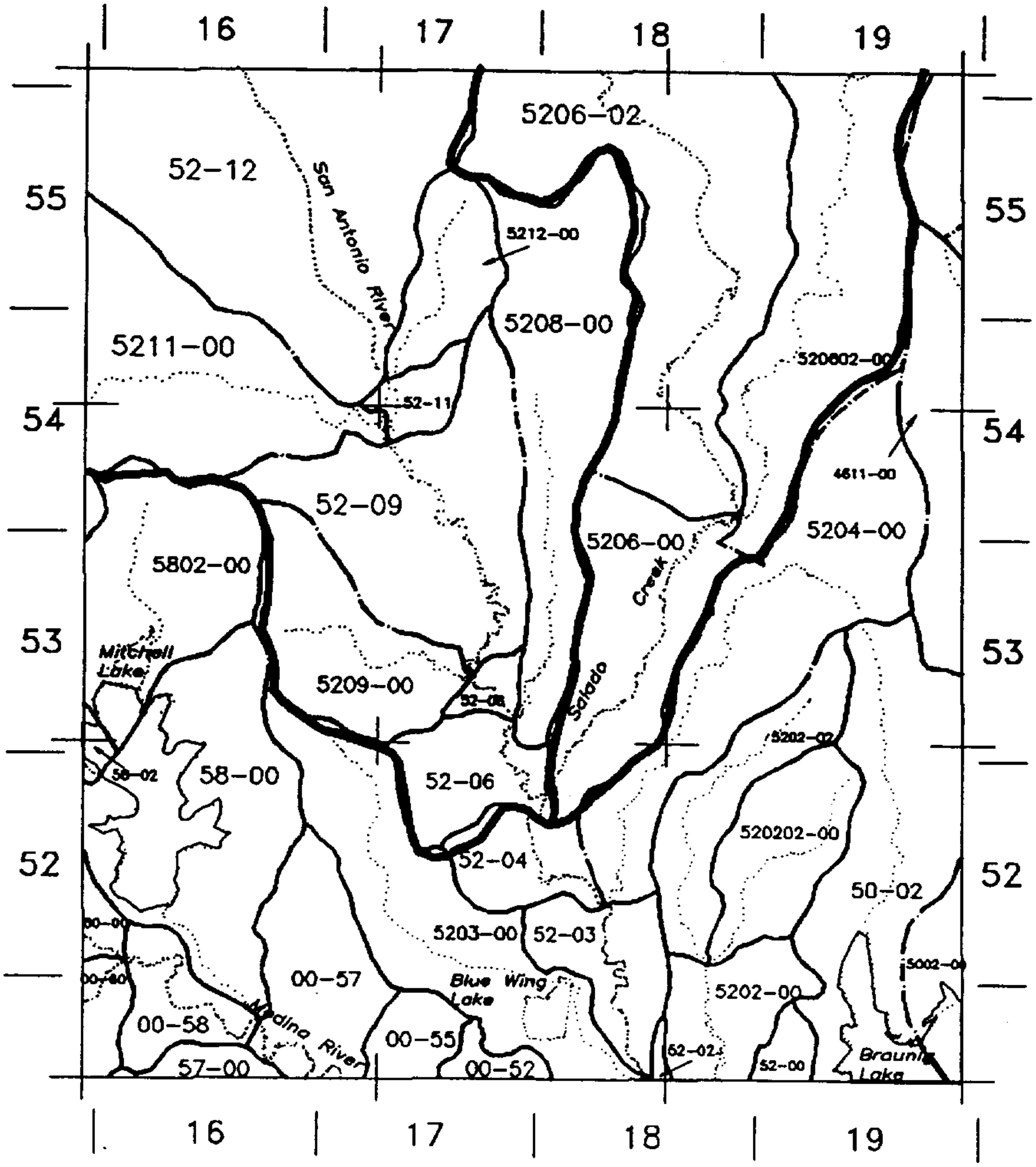
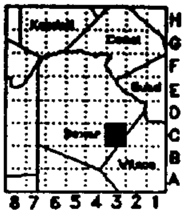
Longitude = 98

7.5' Area = C4



GAE 1/29/93 44C4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 46

Map Name ELMENDORF

Scale 1:100,000

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SCALE (MILES)

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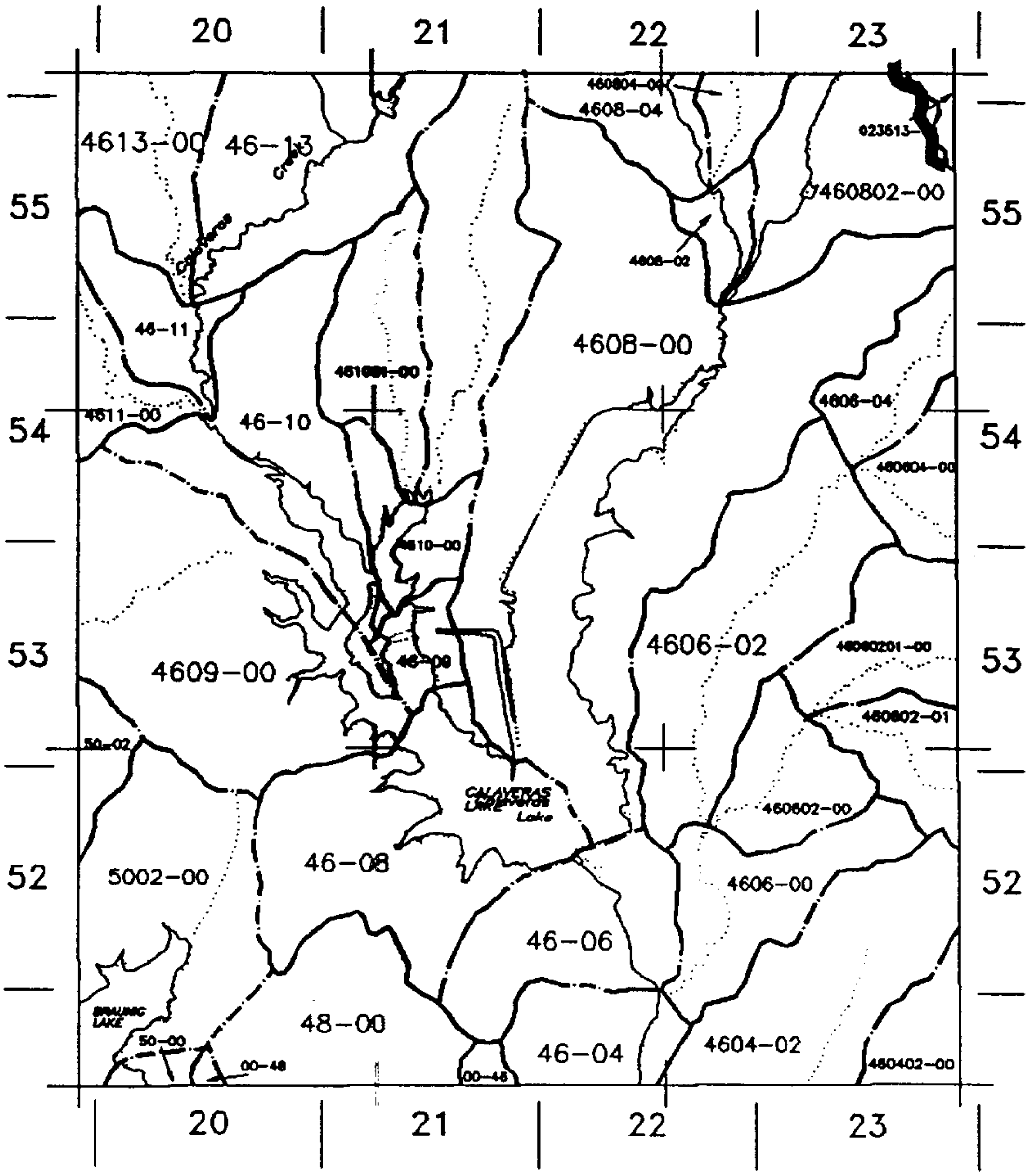
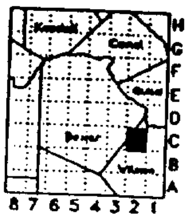
Longitude = 98

7.5' Area = C3



GAE 1/29/93 44C3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68-47

Map Name La Vernia SW

Scale 1:100,000

N

0 0.5 1.0 1.5 2.0

SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = C2

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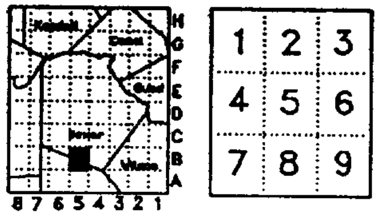


7.5 Minute Area

Water Well ID 68- 52

Map Name THELMA

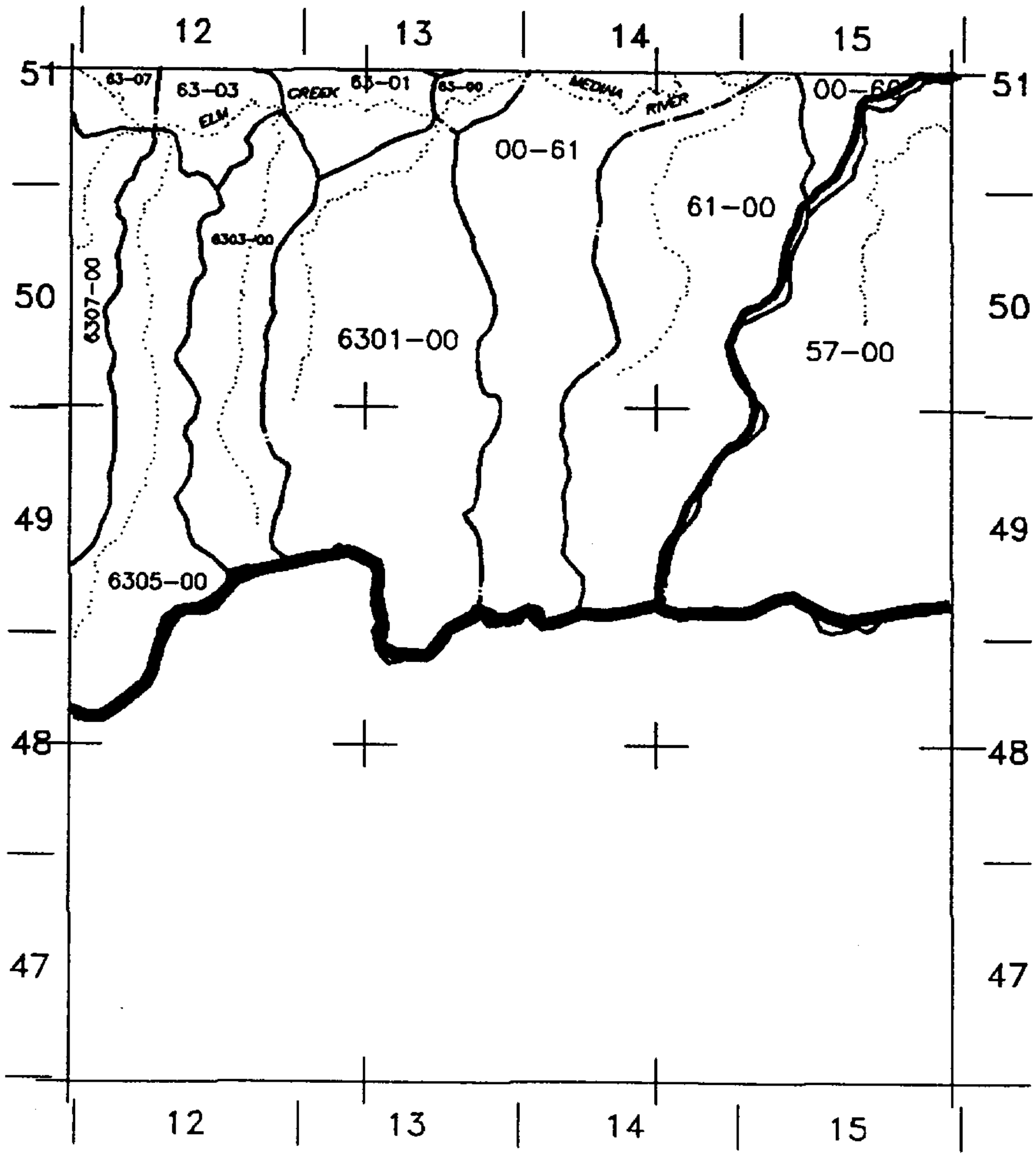
Scale 1:100,000

SCALE (MILES) 0 0.5 1.0 1.5 2.0

Latitude = 29

Longitude = 98

7.5' Area = B5



GAE 1/29/93 44B5COMP.DWG

C. THOMAS KOCH, INC.
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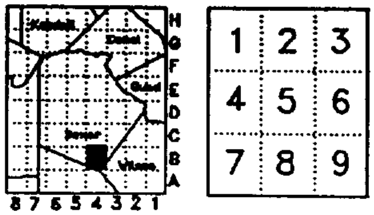

7.5 Minute Area

Water Well ID 68- 53

Map Name LOSOYA

Scale 1:100,000

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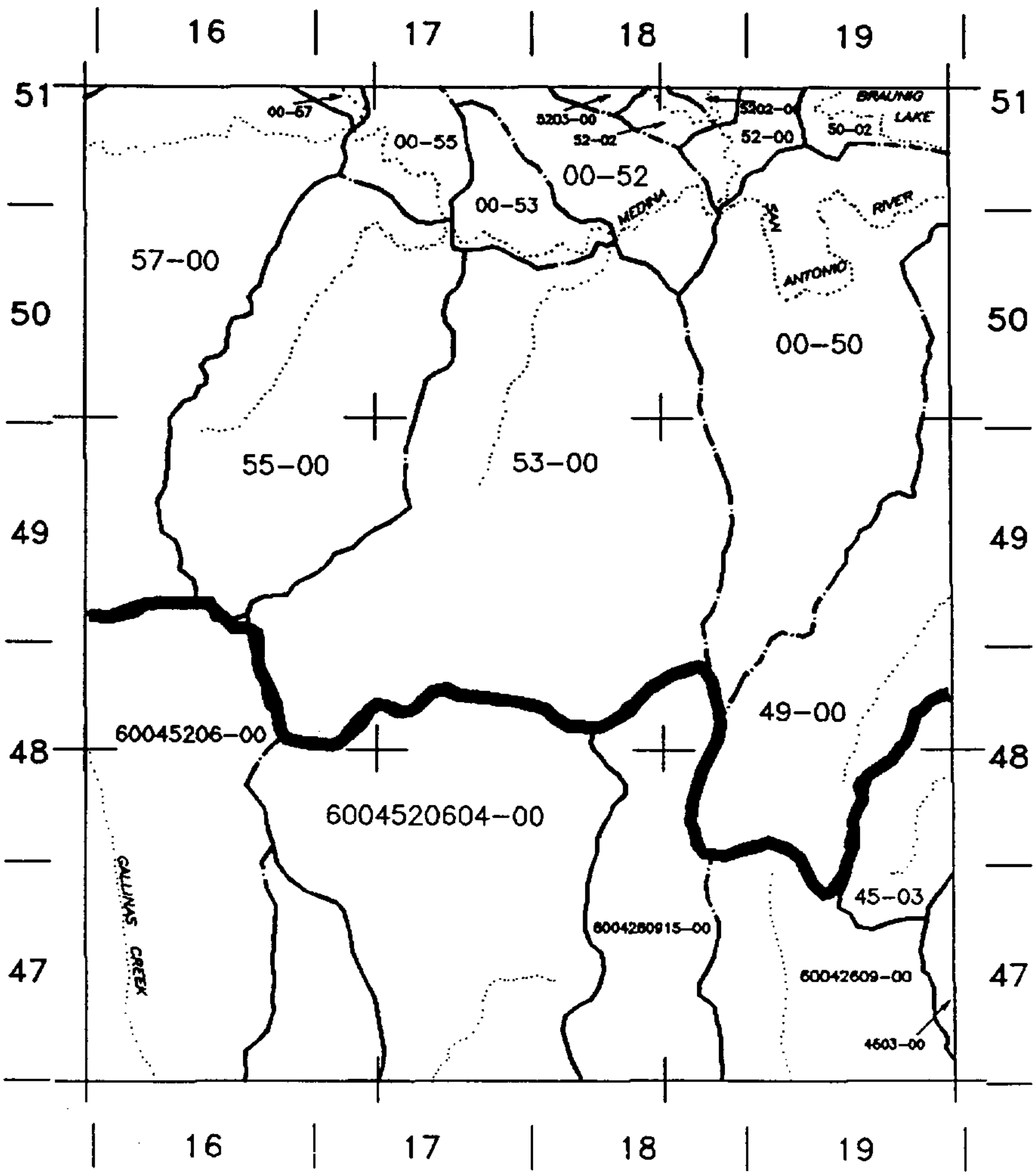
SCALE (MILES)

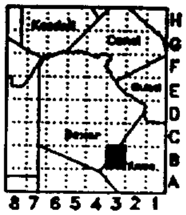
Latitude = 29

Longitude = 98

7.5' Area = B4



C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 54

Map Name SASPAMCO

Scale 1:100,000

N

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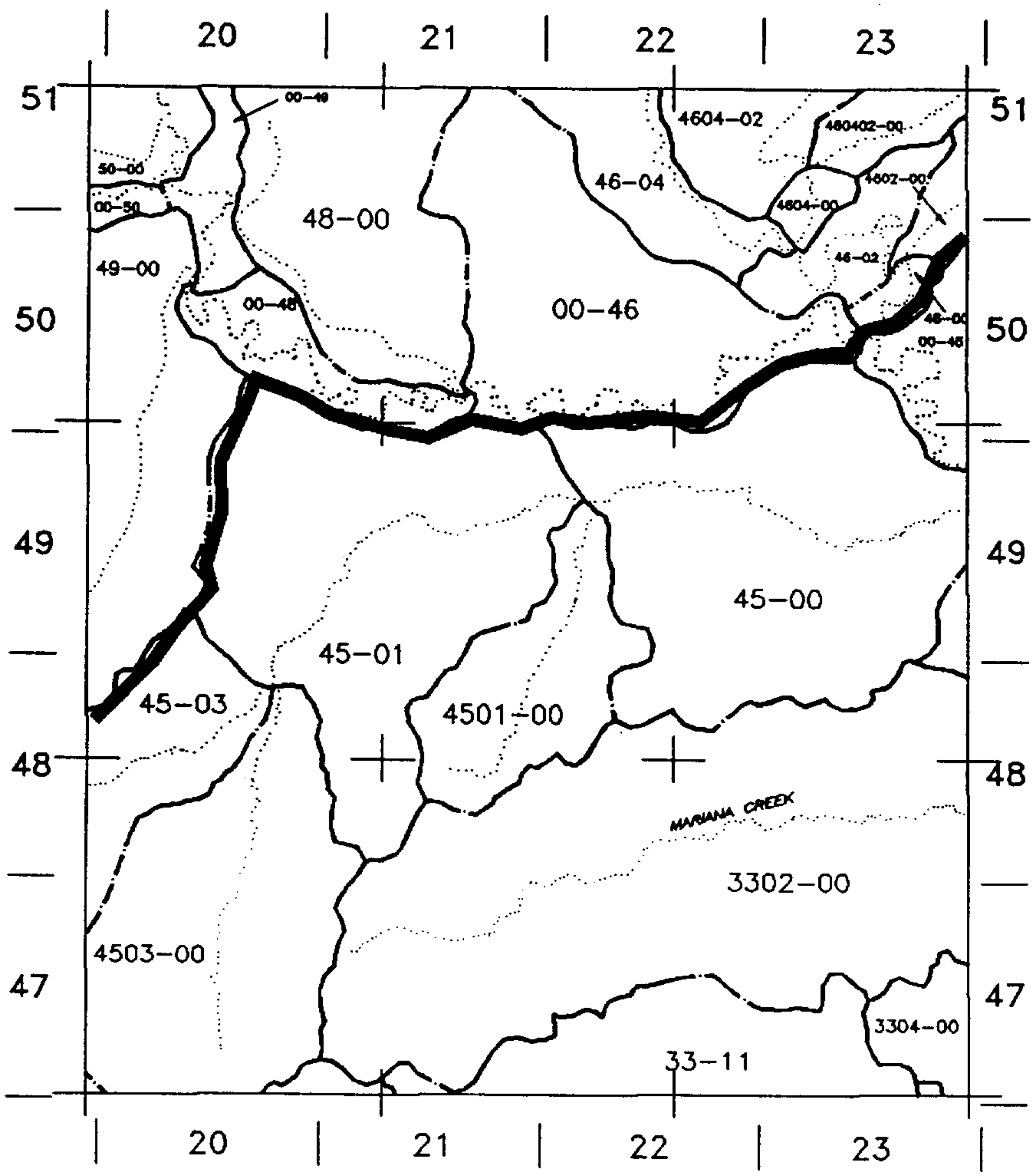
SCALE (MILES)

Latitude = 29

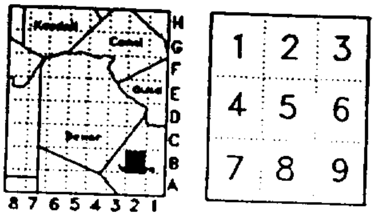
Longitude = 98

7.5' Area = B3



GAE 1/29/93 44B3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68-55

Map Name Floresville

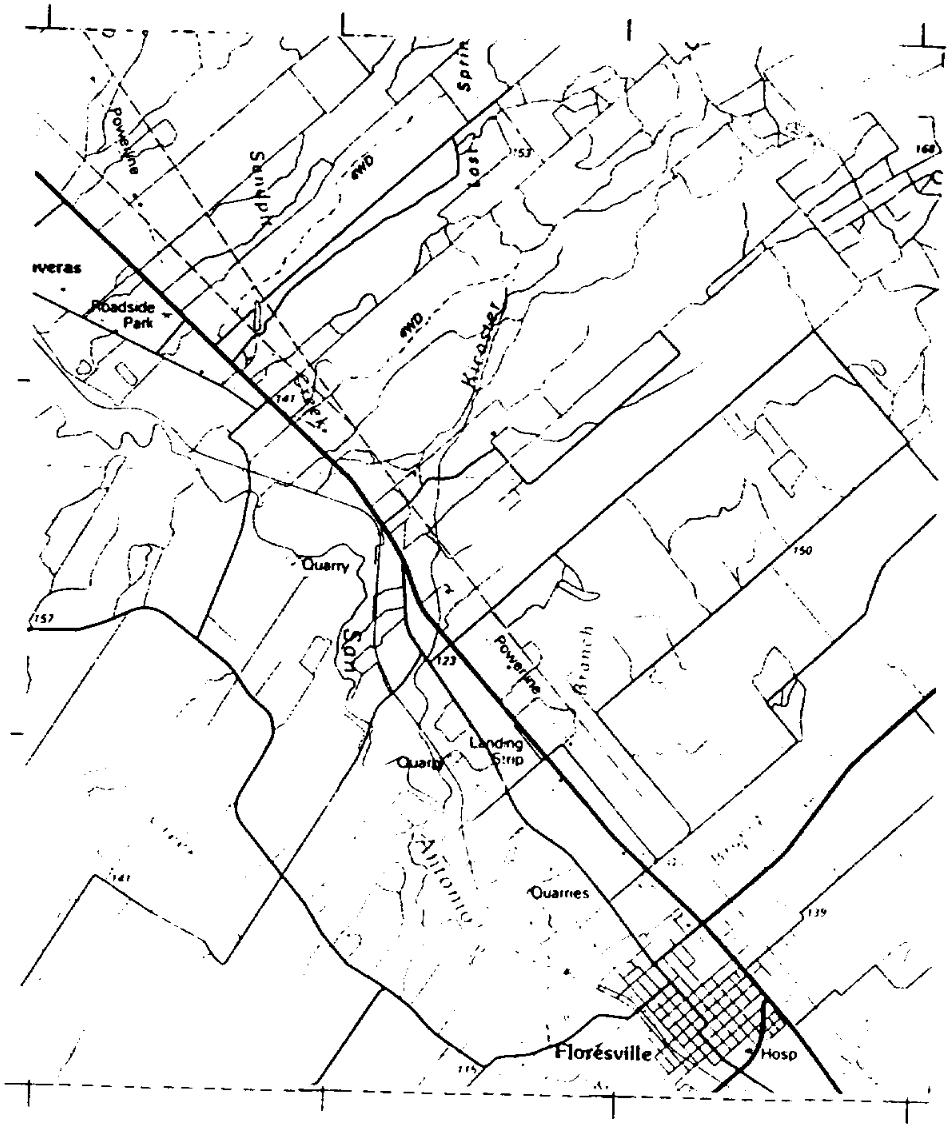
Scale 1:100,000

SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = B2



GAE 1/18/93 038FRAME.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	6000000000- 0	184	0	0	0	0	
Confluence	5802000000- 0	92					
Confluence	5802000000- 0	1,653	57	54	57	80	59
Confluence	5800000000- 0	2,388	2	2	2	2	3
Confluence	5700000000- 0	92	0	0	0	0	2
Confluence	5204000000- 0	2,571	38	35	37	36	43
Confluence	5203000000- 0	2,204	14	15	21	22	19
Confluence	5202020000- 0	918	2	3	5	4	9
Confluence	5202000000- 2	918	4	4	4	4	3
Confluence	5202000000- 0	735	1	1	1	1	1
Confluence	5200000000- 4	459	1	1	1	0	2
Confluence	5200000000- 3	826	3	3	2	2	7
Confluence	5200000000- 0	92	0	0	0	0	0
Confluence	5002000000- 0	643	0	0	0	1	2
Confluence	5000000000- 2	2,388	16	21	22	21	31
Confluence	4613000000- 0	551	4	4	4	4	3
Confluence	4611000000- 0	918	10	10	10	10	10
Confluence	4609000000- 0	551	1	1	1	1	5
Confluence	0-58	367	2	3	2	2	3
Confluence	0-57	1,010	14	14	15	15	22
Confluence	0-55	275	2	2	2	2	3
Confluence		19,835	171	173	186	207	227

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-3

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	5002000000- 0	1,928	4	4	4	4	7
Confluence	5000000000- 2	92	1	1	1	1	2
Confluence	5000000000- 0	92	0	0	0	0	
Confluence	4800000000- 0	1,377	20	20	20	22	22
Confluence	4613000000- 0	643	4	4	4	4	8
Confluence	4611000000- 0	184	2	2	2	2	3
Confluence	4610010000- 0	826	4	4	3	3	4
Confluence	4610000000- 0	2,479	3	3	4	5	5
Confluence	4609000000- 0	3,306	28	30	29	29	43
Confluence	4608040000- 0	184	1	1	1	1	1
Confluence	4608020000- 0	1,286	8	8	7	7	9
Confluence	4608000000- 4	459	4	4	4	7	15
Confluence	4608000000- 2	275	0	0	0	0	0
Confluence	4608000000- 0	7,530	29	29	29	34	36
Confluence	4606040000- 0	735	2	2	4	4	3
Confluence	4606020100- 0	1,102	0	0	0	0	0
Confluence	4606020000- 1	735	0	1	1	1	1
Confluence	4606020000- 0	826	3	4	4	3	0
Confluence	4606000000- 4	551	2	2	2	2	2
Confluence	4606000000- 2	2,479	6	6	9	9	12
Confluence	4606000000- 0	1,286	5	5	5	5	5
Confluence	4604020000- 0	551	0	0	0	0	
Confluence	4604000000- 2	1,561	2	2	2	2	5
Confluence	4604000000- 0	184	0	0	0	0	
Confluence	4600000000-13	1,837	7	7	8	8	13
Confluence	4600000000-11	551	3	3	3	3	4
Confluence	4600000000-10	2,020	6	7	6	6	9
Confluence	4600000000- 9	367	1	0	0	0	2
Confluence	4600000000- 8	2,571	27	29	29	33	42
Confluence	4600000000- 6	1,286	8	8	8	11	13
Confluence	4600000000- 4	735	0	0	0	0	
Confluence	0-46	92	0	0	0	0	
Confluence		40,129	180	186	189	206	266

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-2

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	4606040000- 0	1,377	8	6	10	9	
Confluence	4606020100- 0	275	0	0	0	0	
Confluence	4606020000- 1	1,377	0	0	0	0	
Confluence	4606000000- 4	735	1	1	3	2	
Confluence	4604020000- 0	459					
Confluence	4602000000- 0	184					
Confluence		4,408	9	7	13	11	

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : B-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	5700000000- 0	4,683	20	22	23	28	48
Confluence		4,683	20	22	23	28	48

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : B-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	5700000000- 0	3,673	42	42	40	45	70
Confluence	5500000000- 0	3,765	32	37	38	36	44
Confluence	5300000000- 0	7,530	11	15	12	13	18
Confluence	5203000000- 0	92	0	0	0	0	
Confluence	5202000000- 0	92	0	0	0	0	
Confluence	5200000000- 2	275	1	1	1	1	3
Confluence	5200000000- 0	367	0	1	2	2	2
Confluence	5000000000- 2	735	3	3	3	3	4
Confluence	4900000000- 0	3,489	2	2	2	3	3
Confluence	0-57	92	0	0	0	0	
Confluence	0-55	551	7	7	6	6	10
Confluence	0-53	735	1	1	1	1	4
Confluence	0-52	1,194	1	1	3	3	8
Confluence	0-50	4,316	12	12	15	14	26
Confluence		26,905	112	122	123	127	192

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : B-3

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	5000000000- 0	367	0	0	0	0	
Confluence	4900000000- 0	1,837	1	1	2	2	1
Confluence	4800000000- 0	2,663	5	4	1	3	7
Confluence	4604020000- 0	459					
Confluence	4604000000- 0	918	0	0	0	0	
Confluence	4602000000- 0	367					
Confluence	4600000000- 4	1,102	0	0	0	0	0
Confluence	4600000000- 0	918					
Confluence	0-50	92	0	0	0	0	
Confluence	0-48	1,377	0	0	0	0	1
Confluence	0-46	3,673	3	3	3	10	5
Confluence		13,774	9	8	6	15	14

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : B-2

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	4602000000- 0	459					
Confluence		459					

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TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	6000000000- 0	184	0	0	0	0	
Confluence	5802000000- 0	92					
Confluence	5802000000- 0	1,653	57	54	57	80	59
Confluence	5800000000- 0	2,388	2	2	2	2	3
Confluence	5700000000- 0	8,448	62	64	63	73	120
Confluence	5500000000- 0	3,765	32	37	38	36	44
Confluence	5300000000- 0	7,530	11	15	12	13	18
Confluence	5204000000- 0	2,571	38	35	37	36	43
Confluence	5203000000- 0	2,296	14	15	21	22	19
Confluence	5202020000- 0	918	2	3	5	4	9
Confluence	5202000000- 2	918	4	4	4	4	3
Confluence	5202000000- 0	826	1	1	1	1	1
Confluence	5200000000- 4	459	1	1	1	0	2
Confluence	5200000000- 3	826	3	3	2	2	7
Confluence	5200000000- 2	275	1	1	1	1	3
Confluence	5200000000- 0	459	0	1	2	2	2
Confluence	5002000000- 0	2,571	4	4	4	5	9
Confluence	5000000000- 2	3,214	20	25	26	25	37
Confluence	5000000000- 0	459	0	0	0	0	
Confluence	4900000000- 0	5,326	3	3	4	5	4
Confluence	4800000000- 0	4,040	25	24	21	25	29
Confluence	4613000000- 0	1,194	8	8	8	8	11
Confluence	4611000000- 0	1,102	12	12	12	12	13
Confluence	4610010000- 0	826	4	4	3	3	4

Report file: WPA_swsB

Page 5 1/29/93 12:16:16 p

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	4600000000-13	1,837	7	7	8	8	13
Confluence	4600000000-11	551	3	3	3	3	4
Confluence	4600000000-10	2,020	6	7	6	6	9
Confluence	4600000000- 9	367	1	0	0	0	2
Confluence	4600000000- 8	2,571	27	29	29	33	42
Confluence	4600000000- 6	1,286	8	8	8	11	13
Confluence	4600000000- 4	1,837	0	0	0	0	0
Confluence	4600000000- 0	918					
Confluence	0-58	367	2	3	2	2	3
Confluence	0-57	1,102	14	14	15	15	22
Confluence	0-55	826	9	9	8	8	13
Confluence	0-53	735	1	1	1	1	4
Confluence	0-52	1,194	1	1	3	3	8
Confluence	0-50	4,408	12	12	15	14	26
Confluence	0-48	1,377	0	0	0	0	1
Confluence	0-46	3,765	3	3	3	10	5
Confluence		110,285	501	518	541	594	747

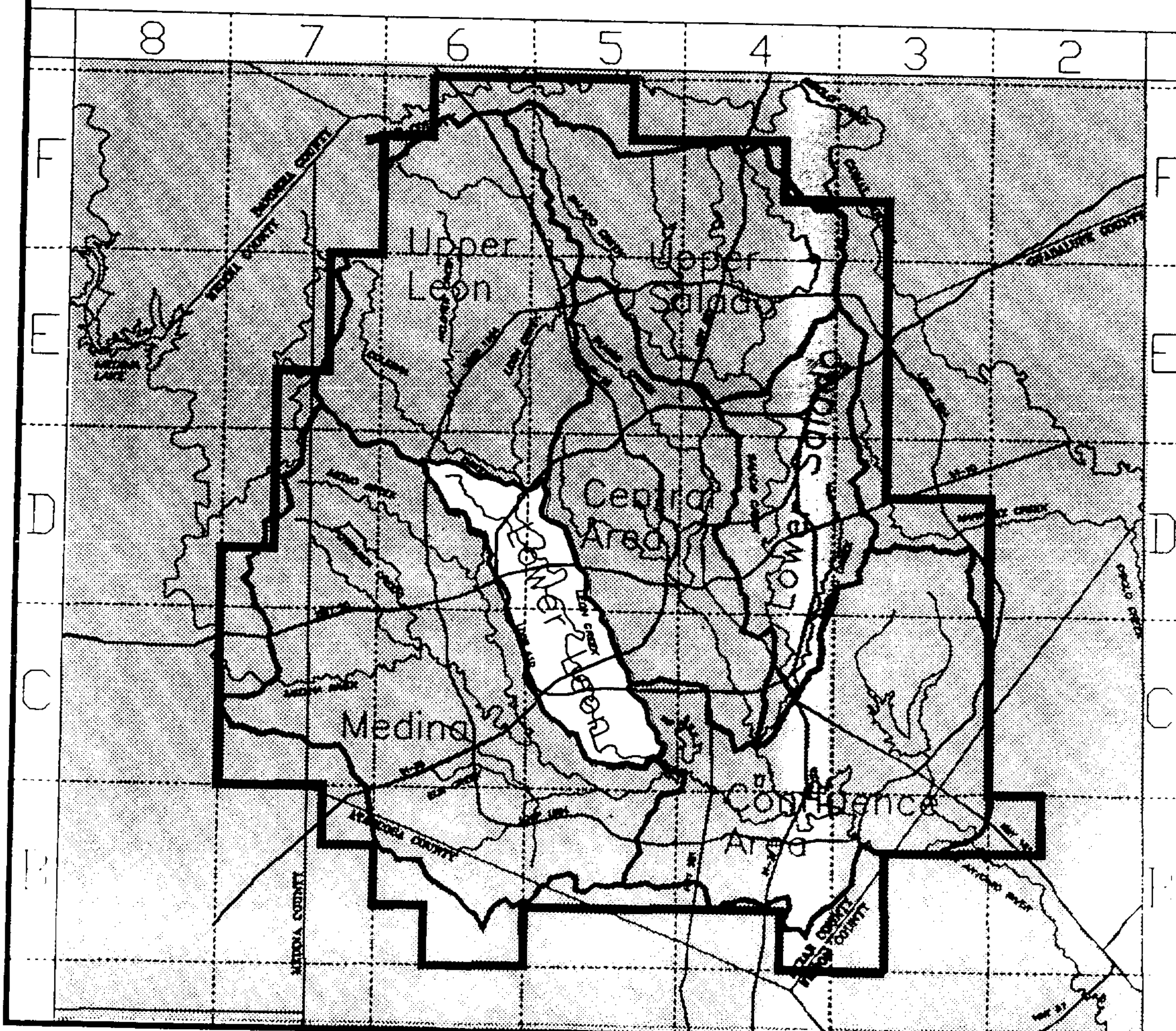
TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Confluence	4610000000- 0	2,479	3	3	4	5	5
Confluence	4609000000- 0	3,857	29	31	30	30	48
Confluence	4608040000- 0	184	1	1	1	1	1
Confluence	4608020000- 0	1,286	8	8	7	7	9
Confluence	4608000000- 4	459	4	4	4	7	15
Confluence	4608000000- 2	275	0	0	0	0	0
Confluence	4608000000- 0	7,530	29	29	29	34	36
Confluence	4606040000- 0	1,377	8	6	10	9	
Confluence	4606040000- 0	735	2	2	4	4	3
Confluence	4606020100- 0	275	0	0	0	0	
Confluence	4606020100- 0	1,102	0	0	0	0	0
Confluence	4606020000- 1	1,377	0	0	0	0	
Confluence	4606020000- 1	735	0	1	1	1	1
Confluence	4606020000- 0	826	3	4	4	3	0
Confluence	4606000000- 4	735	1	1	3	2	
Confluence	4606000000- 4	551	2	2	2	2	2
Confluence	4606000000- 2	2,571	6	6	10	9	12
Confluence	4606000000- 0	1,286	5	5	5	5	5
Confluence	4604020000- 0	459					
Confluence	4604020000- 0	1,010	0	0	0	0	
Confluence	4604000000- 2	1,561	2	2	2	2	5
Confluence	4604000000- 0	1,102	0	0	0	0	
Confluence	4602000000- 0	643					
Confluence	4602000000- 0	367					

Lower Leon	BUSINESS CONNECTIONS	1976 Thru 1988

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Leon	D - 6	11,019	397	411	458	451	894
Lower Leon	D - 5	8,081	217	222	218	232	323
Lower Leon	C - 6	735	10	11	13	12	15
Lower Leon	C - 5	12,856	400	614	417	412	442
Lower Leon		32,691	1,024	1,258	1,106	1,107	1,674

New Connections = 650 or 4% of all New Connections in Study Area



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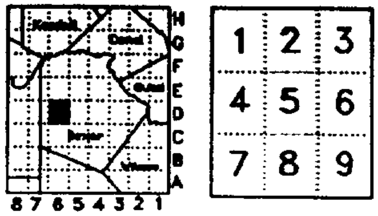

7.5 Minute Area

Water Well ID 68- 35

Map Name CULEBRA HILL

Scale 1:100,000

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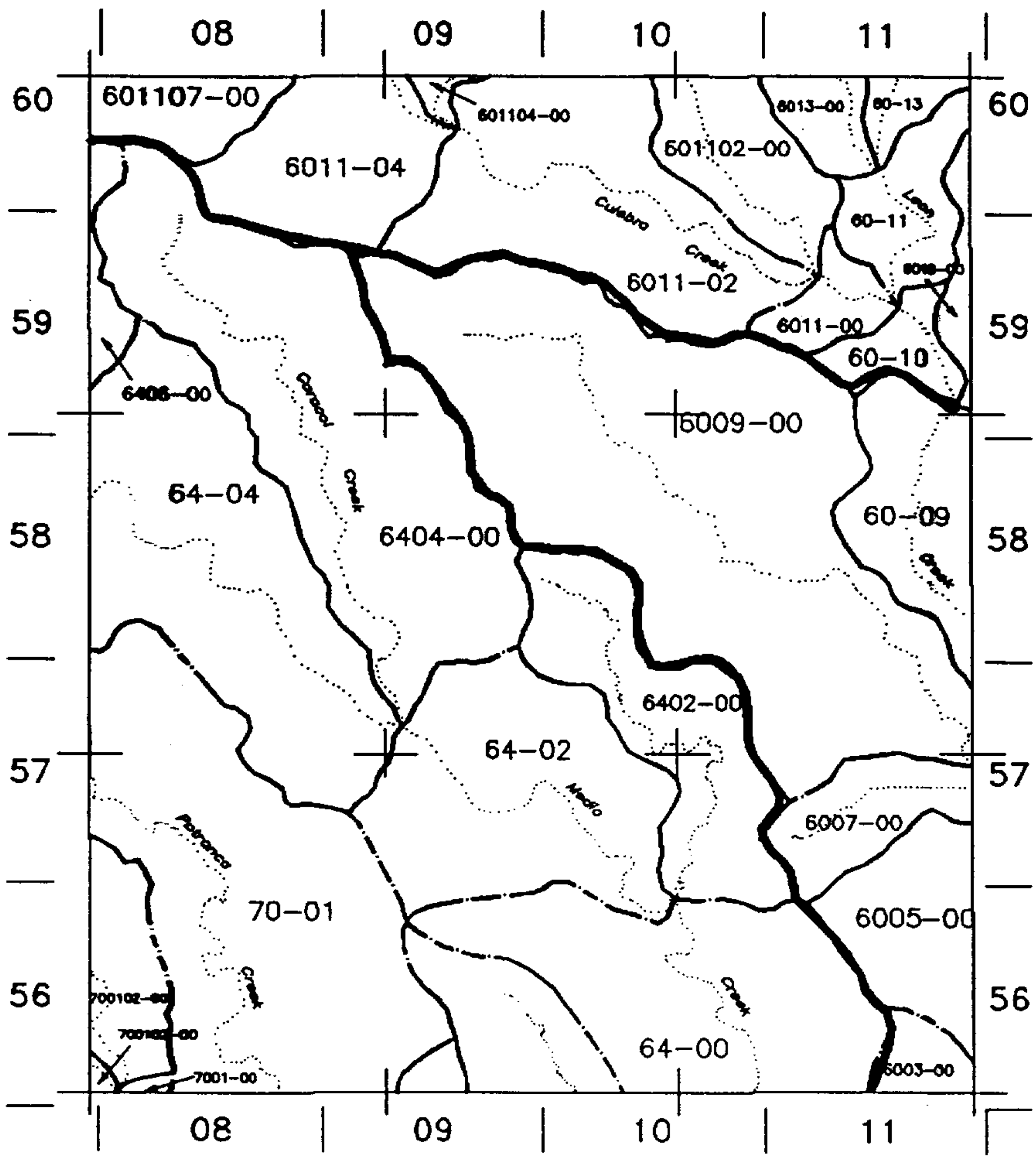
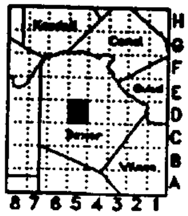
Longitude = 98

7.5' Area = D6



GAE 1/29/93 44D6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 36

Map Name SAN ANTONIO WEST

Scale 1:100,000

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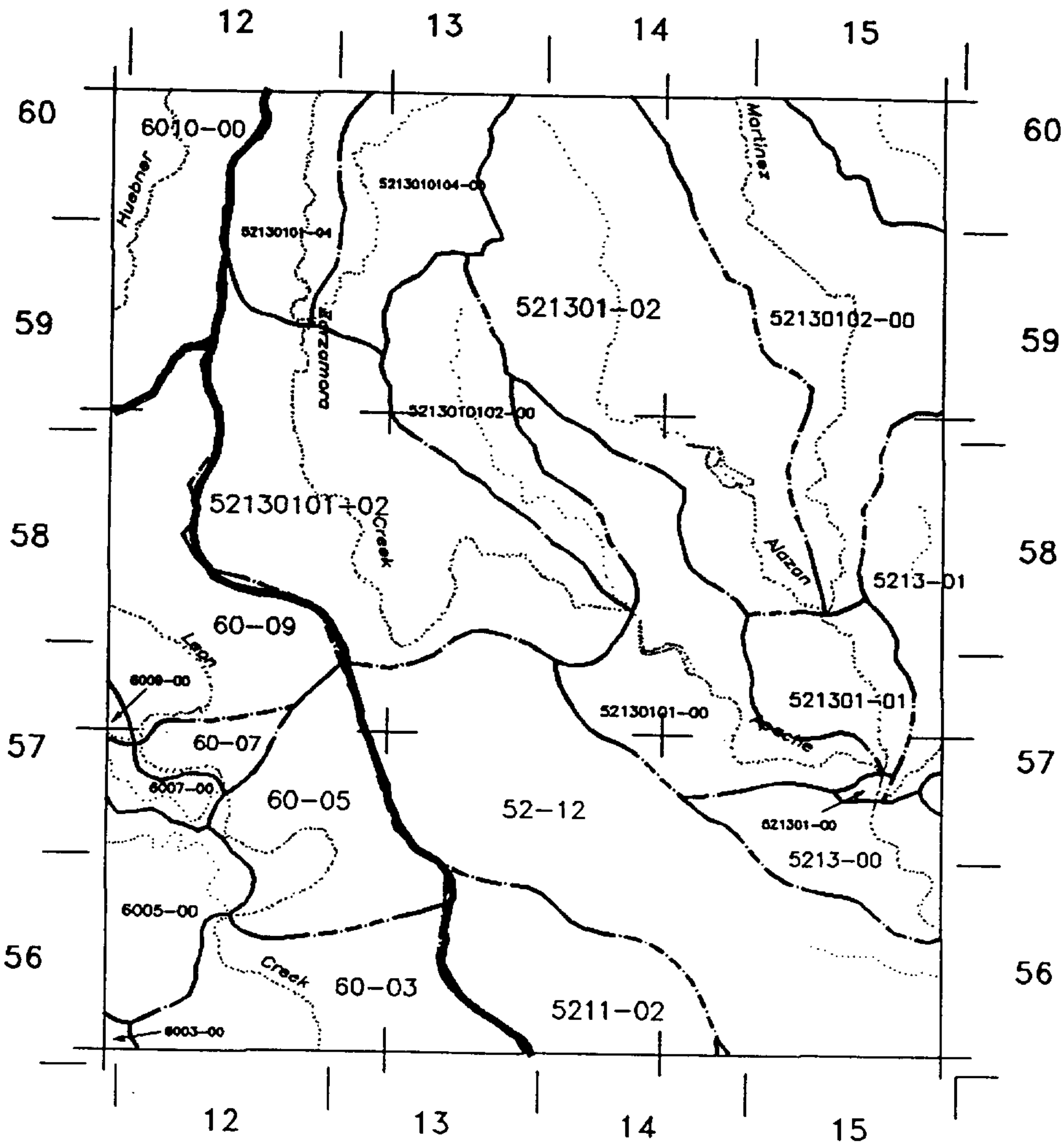
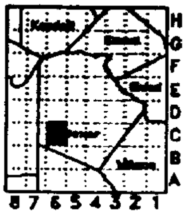
Longitude = 98

7.5' Area = D5



GAE 1/29/93 44D5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 43

Map Name MACDONA

Scale 1:100,000

N

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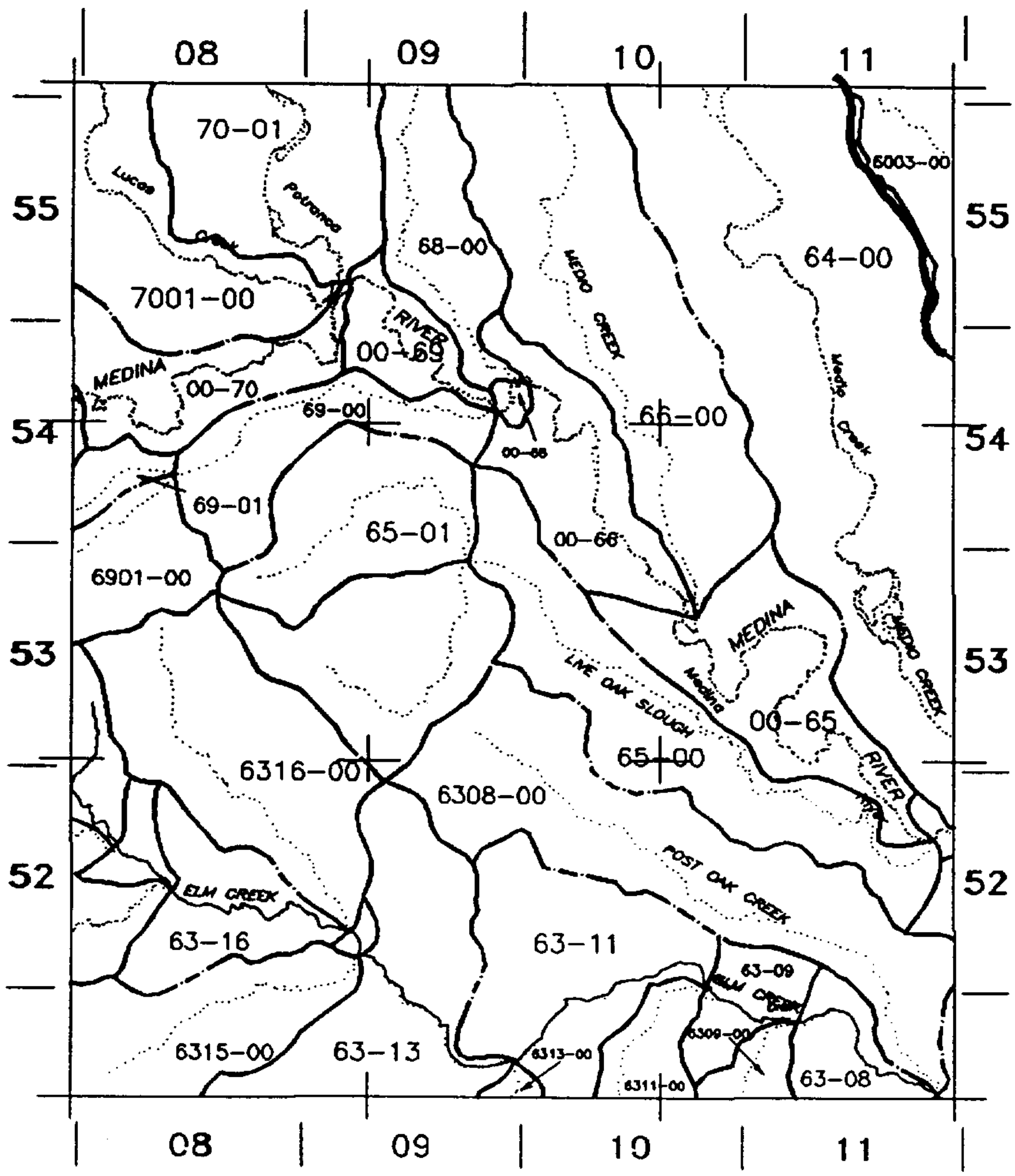
SCALE (MILES)

Latitude = 29

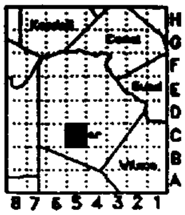
Longitude = 98

7.5' Area = C6



GAE 1/29/93 44C6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 44

Map Name TERREL WELLS

Scale 1:100,000

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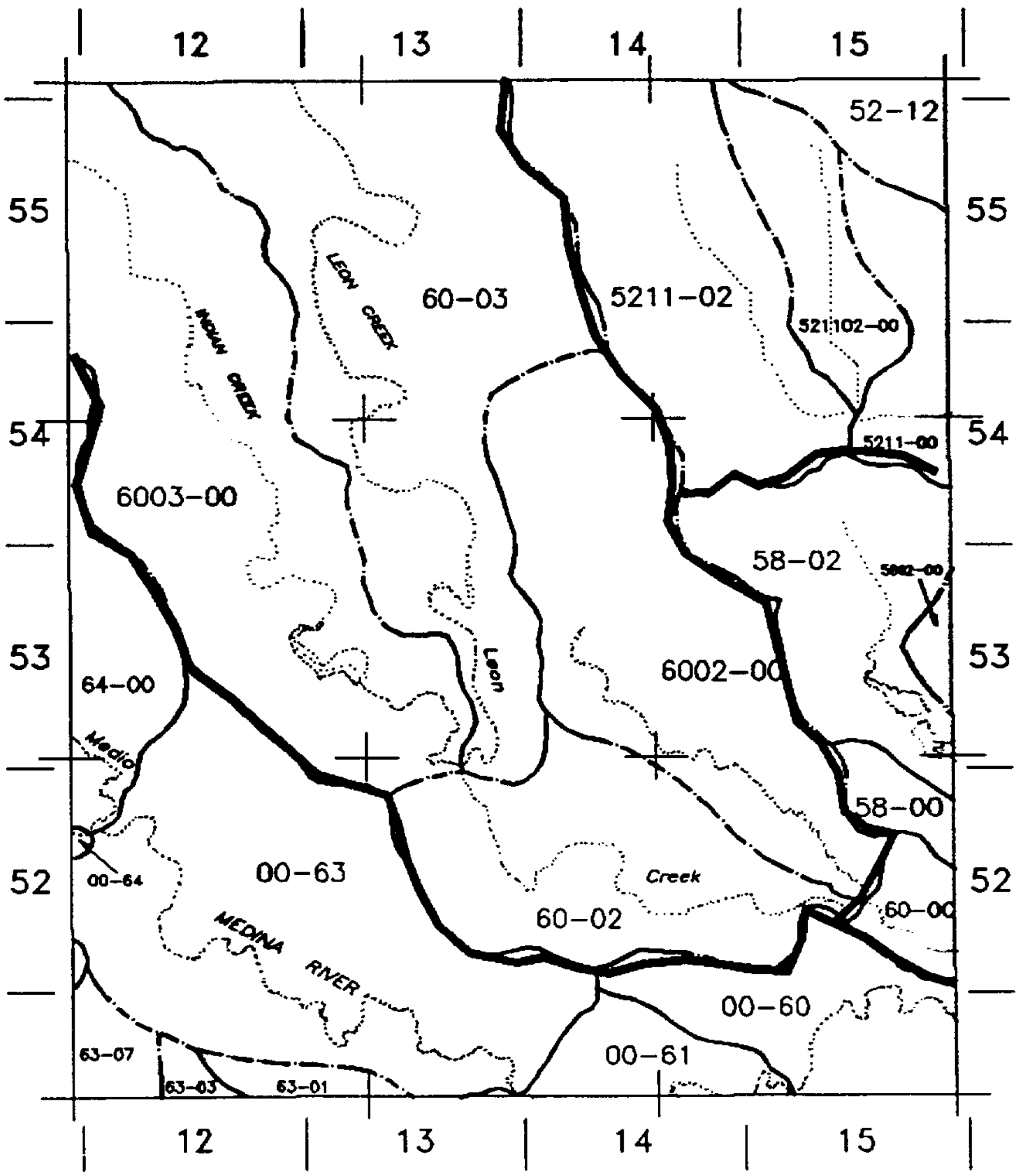
Longitude = 98

7.5' Area = C5



GAE 1/29/93 44C5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

Report file: q_sws_8
Page 26 1/28/93 7:24:41 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Leon	6009000000- 0	7,163	122	125	135	144	372
Lower Leon	6007000000- 0	918	161	170	182	182	219
Lower Leon	6005000000- 0	1,286	96	95	93	96	191
Lower Leon	6003000000- 0	367					9
Lower Leon	6000000000- 9	1,286	18	21	48	29	103
Lower Leon		11,019	397	411	458	451	894

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Leon	6007000000- 0	184	36	34	32	30	26
Lower Leon	6005000000- 0	918	26	25	26	26	25
Lower Leon	6000000000- 9	2,388	25	29	29	27	106
Lower Leon	6000000000- 7	275	11	10	14	14	13
Lower Leon	6000000000- 5	2,020	93	99	91	110	99
Lower Leon	6000000000- 3	2,296	26	25	26	25	54
Lower Leon		8,081	217	222	218	232	323

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Leon	6003000000- 0	735	10	11	13	12	15
Lower Leon		735	10	11	13	12	15

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Leon	6003000000- 0	6,336	78	87	91	89	142
Lower Leon	6000000000- 3	6,520	322	527	326	323	300
Lower Leon		12,856	400	614	417	412	442

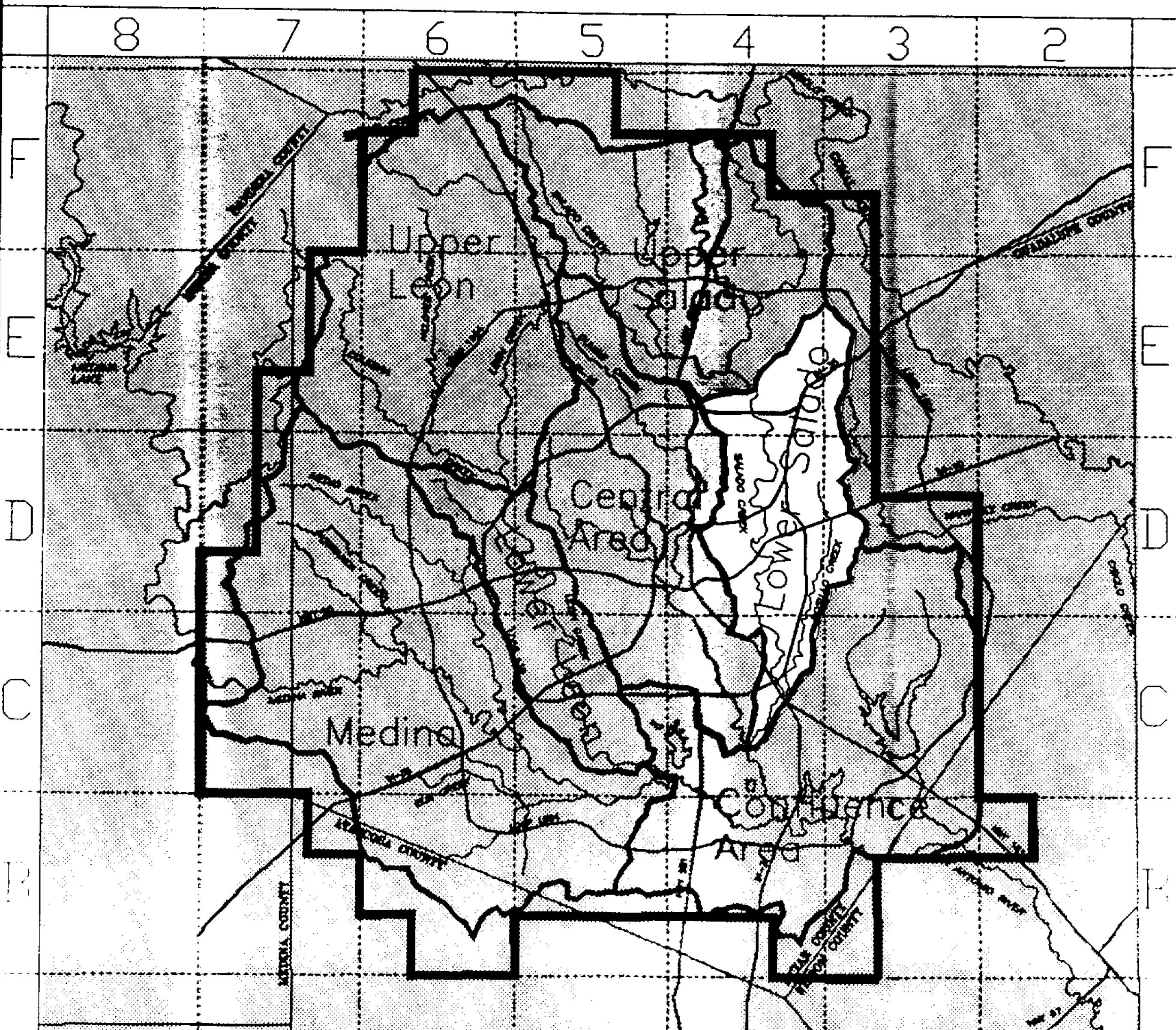
TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Leon	6009000000- 0	7,163	122	125	135	144	372
Lower Leon	6007000000- 0	1,102	197	204	214	212	245
Lower Leon	6005000000- 0	2,204	122	120	119	122	216
Lower Leon	6003000000- 0	7,438	88	98	104	101	166
Lower Leon	6000000000- 9	3,673	43	50	77	56	209
Lower Leon	6000000000- 7	275	11	10	14	14	13
Lower Leon	6000000000- 5	2,020	93	99	91	110	99
Lower Leon	6000000000- 3	8,815	348	552	352	348	354
Lower Leon		32,691	1,024	1,258	1,106	1,107	1,674

Lower Salado	***BUSINESS CONNECTIONS***	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	E - 4	12,213	656	730	871	984	3,167
Lower Salado	E - 3	2,847					
Lower Salado	D - 4	26,814	2,172	2,375	2,271	2,563	3,202
Lower Salado	D - 3	5,326					39
Lower Salado	C - 4	12,764	155	159	153	166	216
Lower Salado		59,963	2,983	3,264	3,295	3,713	6,624

New Connections = 3,641 or 24% of all New Connections in Study Area



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C. THOMAS KOCH, INC.
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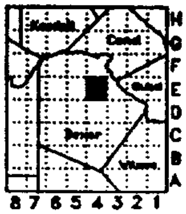

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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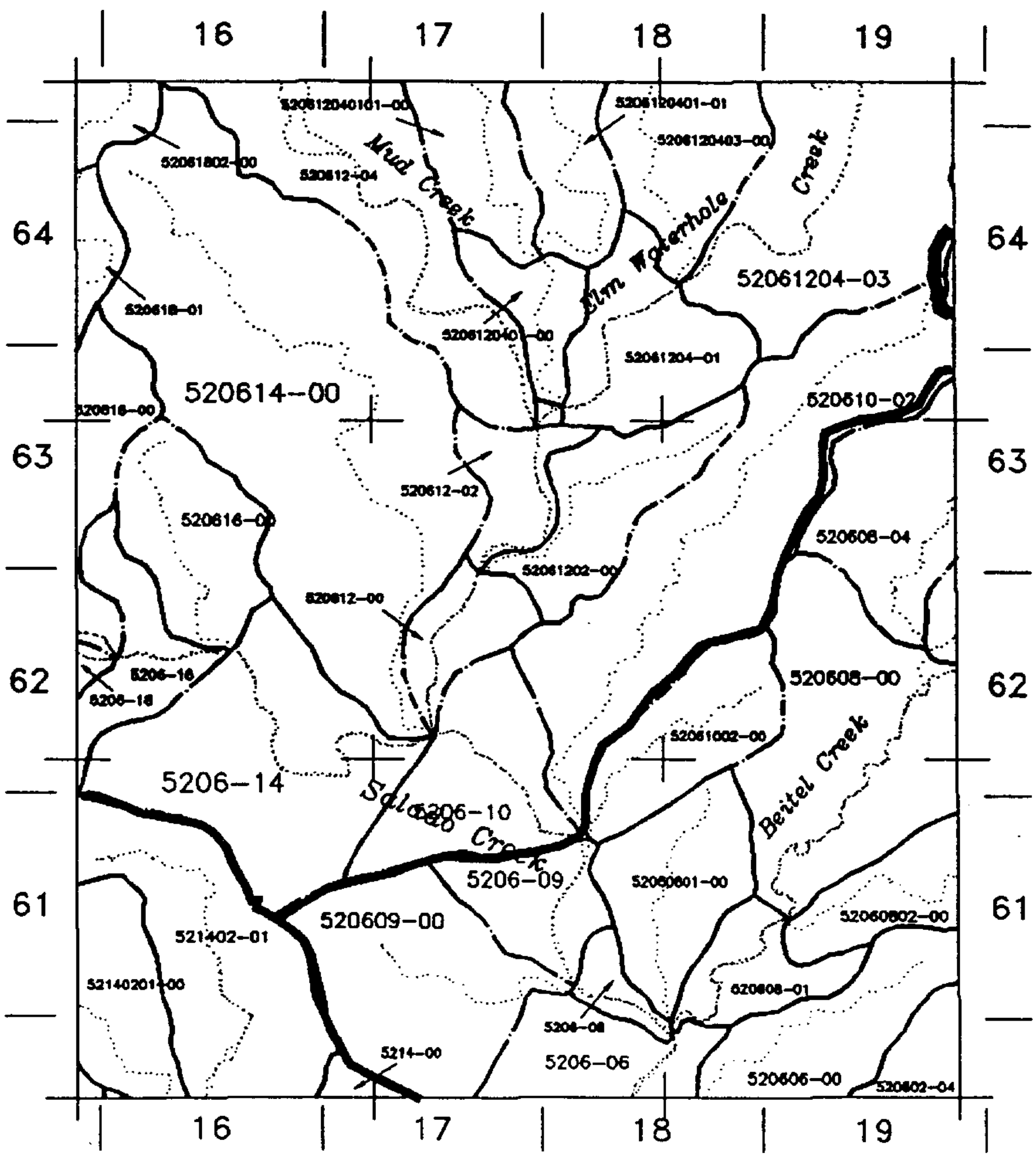
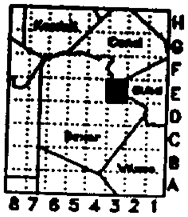
Longitude = 98

7.5' Area = E4



GAE 1/29/93 44E4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 30

Map Name SCHERTZ

Scale 1:100,000

N

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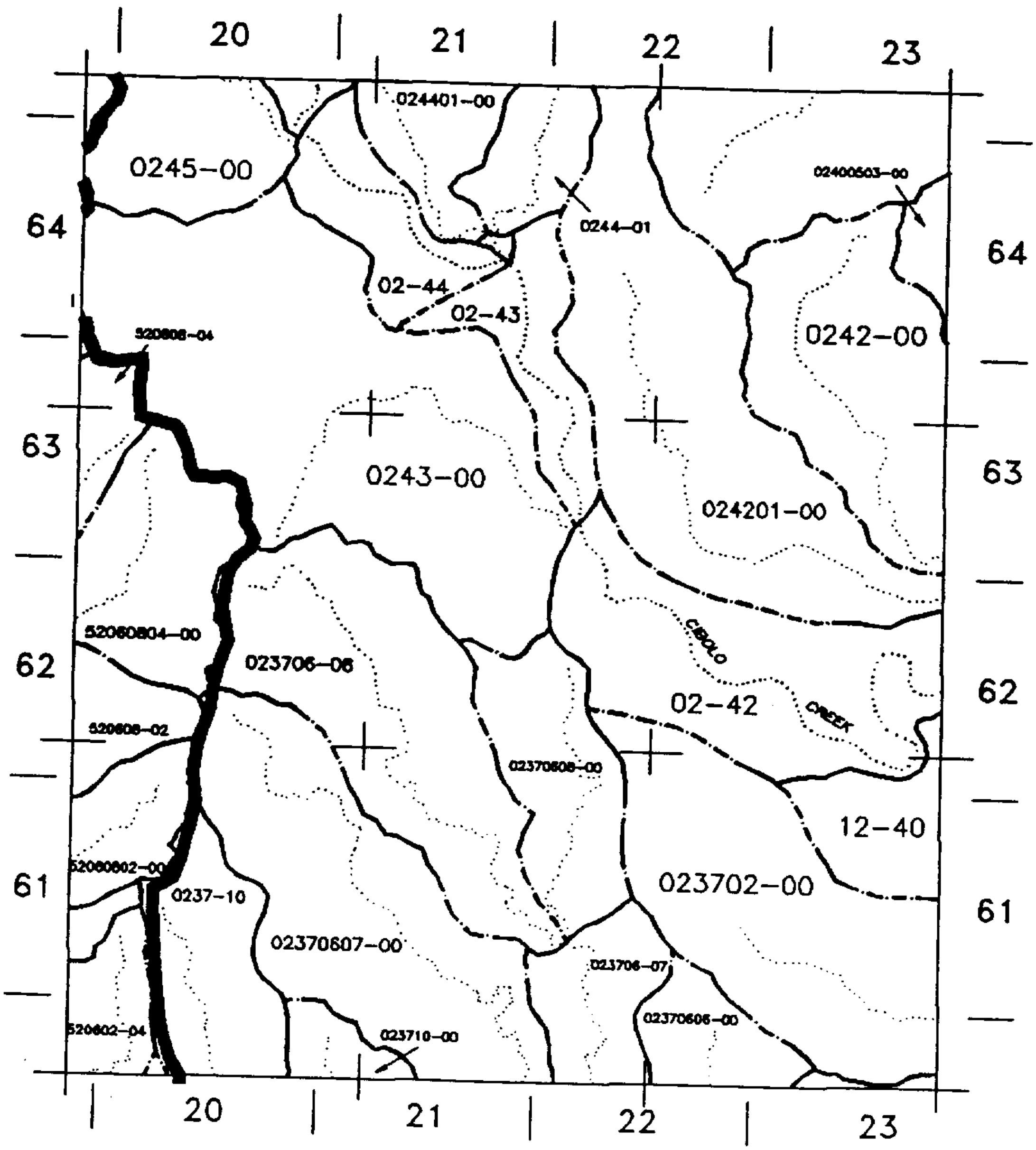
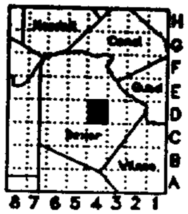
Longitude = 98

7.5' Area = E3



GAE 1/29/93 44E3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 37

Map Name SAN ANTONIO EAST

Scale 1:100,000

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SCALE (MILES)

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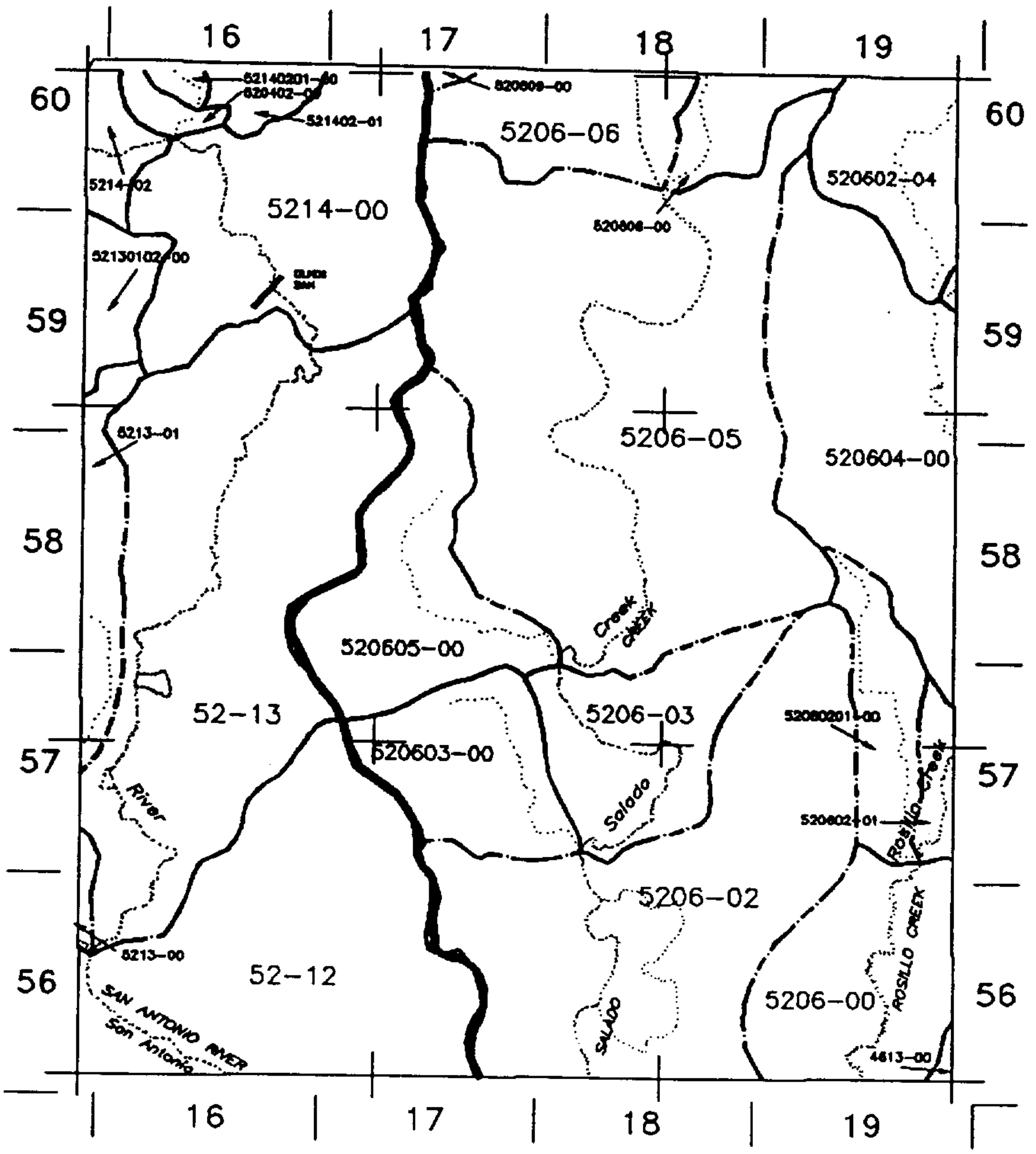
Longitude = 98

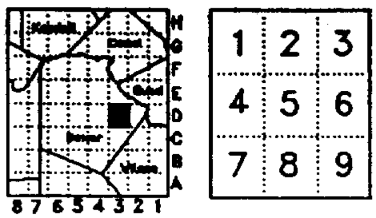
7.5' Area = D4



GAE 1/29/93 44D4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area



Water Well ID 68- 38

Map Name MARTINEZ

Scale 1:100,000

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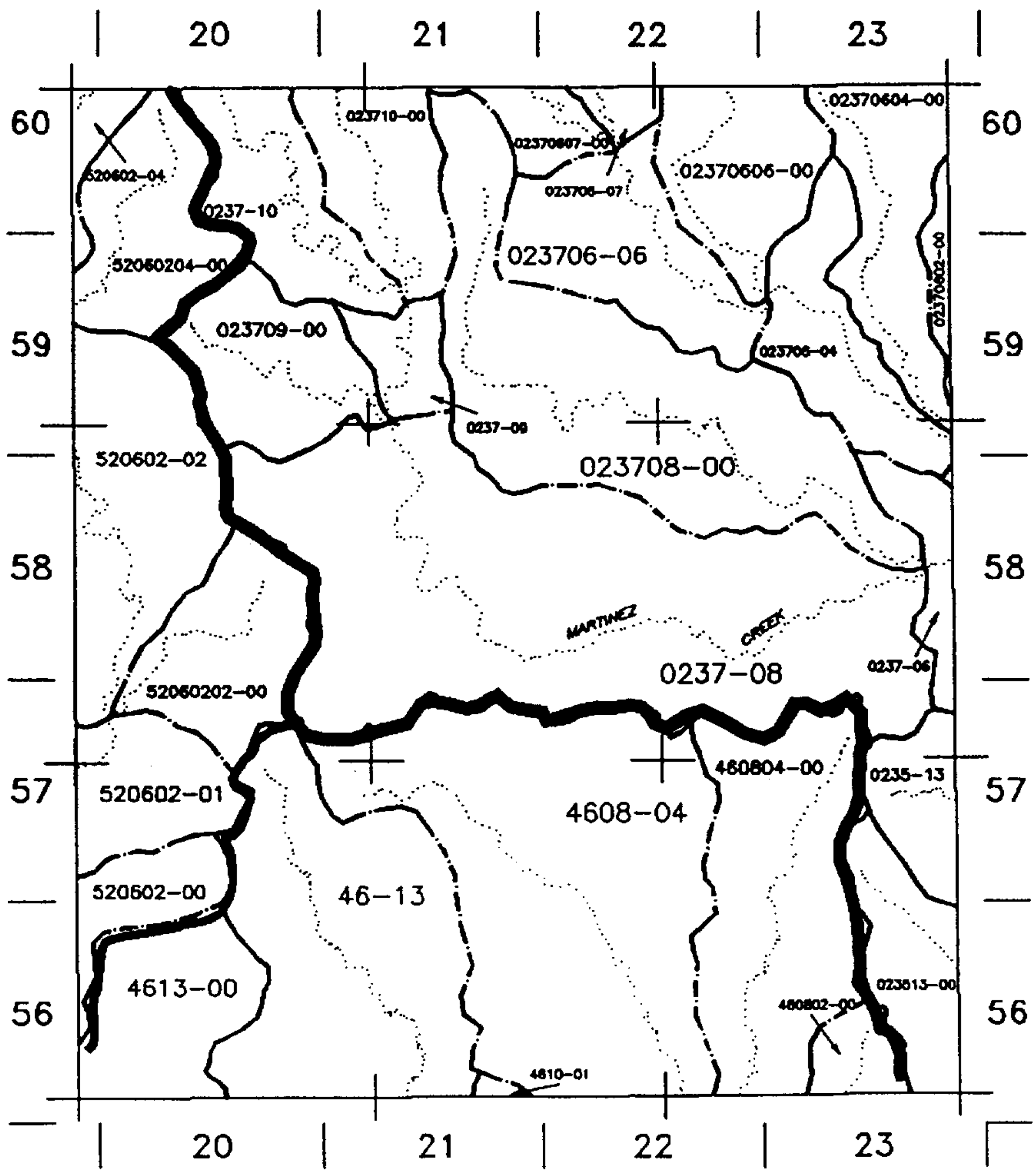
SCALE (MILES)

Latitude = 29

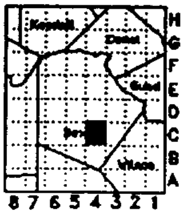
Longitude = 98

7.5' Area = D3



GAE 1/29/93 44D3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 45

Map Name SOUTHTON

Scale 1:100,000

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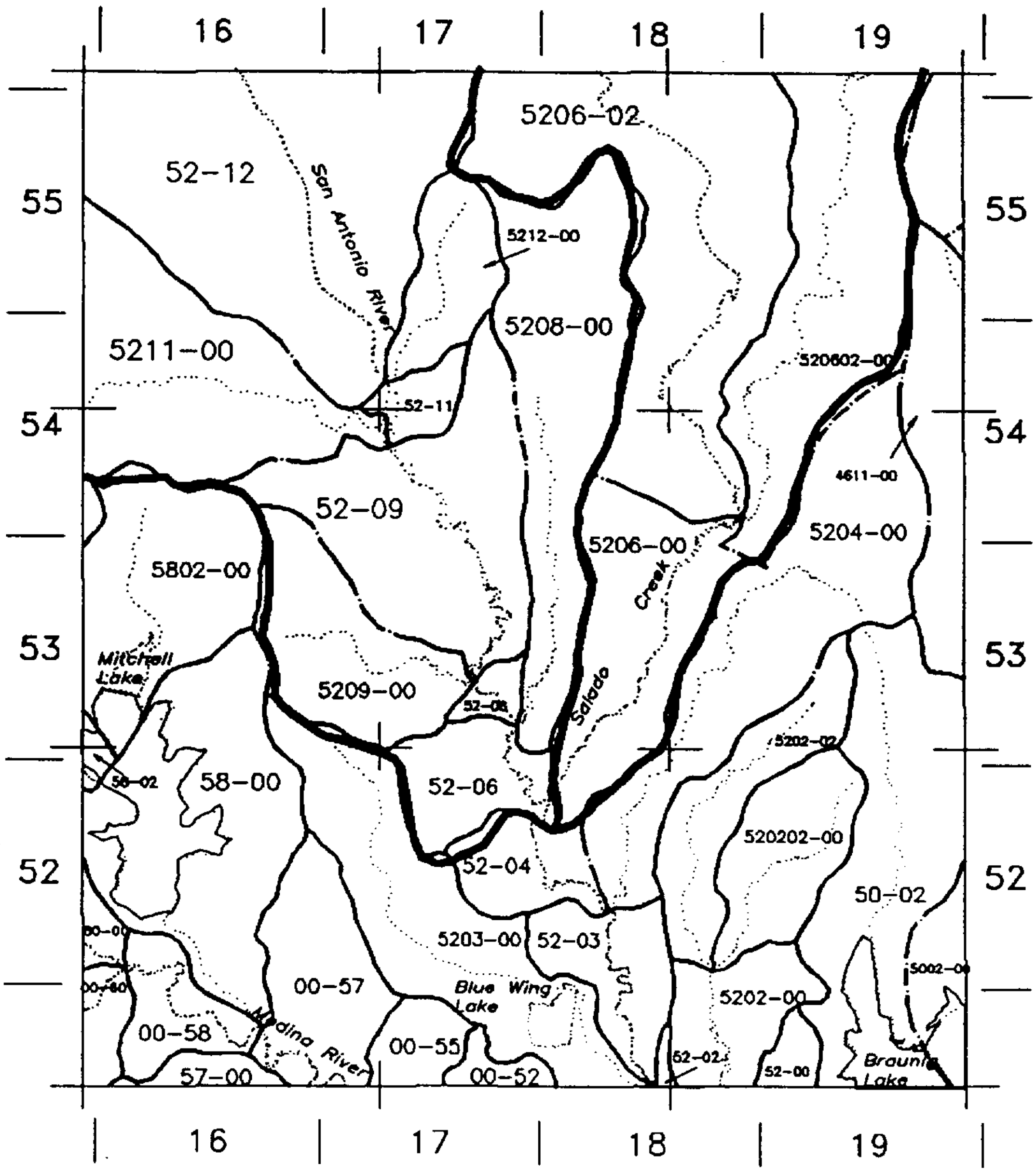
Latitude = 29

Longitude = 98

7.5' Area = C4



GAE 1/29/93 44C4COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

Report file: q_sws_8
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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	5206090000- 0	1,745	304	331	356	388	504
Lower Salado	5206080400- 0	184	1	2	2	4	5
Lower Salado	5206080200- 0	826					109
Lower Salado	5206080100- 0	1,194	84	91	114	139	596
Lower Salado	5206080000- 4	1,469	13	13	14	23	286
Lower Salado	5206080000- 2	2,571	112	123	137	150	490
Lower Salado	5206080000- 1	551	40	53	117	148	331
Lower Salado	5206060000- 0	1,194					303
Lower Salado	5206020000- 4	551					96
Lower Salado	5206000000- 9	735	79	95	102	100	171
Lower Salado	5206000000- 8	275	23	22	29	32	102
Lower Salado	5206000000- 6	918					174
Lower Salado		12,213	656	730	871	984	3,167

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-3

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	5206080400- 0	1,377					
Lower Salado	5206080200- 0	459					
Lower Salado	5206080000- 4	184					
Lower Salado	5206080000- 2	275					
Lower Salado	5206060000- 0	92					
Lower Salado	5206020400- 0	92					
Lower Salado	5206020000- 4	367					
Lower Salado		2,847					

Report file: q_sws_B
Page 35   1/28/93 7:26:50 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	5206060000- 0	367	21	20	16	19	20
Lower Salado	5206050000- 0	1,745	309	305	299	295	298
Lower Salado	5206030000- 0	1,469	350	499	286	294	301
Lower Salado	5206020100- 0	918	15	10	16	17	29
Lower Salado	5206020000- 4	1,194	32	29	30	31	58
Lower Salado	5206020000- 2	3,857	239	272	316	331	542
Lower Salado	5206020000- 1	367					1
Lower Salado	5206020000- 0	2,204	59	66	66	91	132
Lower Salado	5206000000- 6	1,010	189	195	213	215	317
Lower Salado	5206000000- 5	7,805	554	568	592	613	921
Lower Salado	5206000000- 3	1,377	133	124	125	130	161
Lower Salado	5206000000- 2	4,500	271	287	312	527	422
Lower Salado		26,814	2,172	2,375	2,271	2,563	3,202

Report file: q_sws_B
Page 37 1/28/93 7:27:17 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-3

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	5206020400- 0	1,010					
Lower Salado	5206020200- 0	1,286					10
Lower Salado	5206020000- 4	92					
Lower Salado	5206020000- 2	1,745					
Lower Salado	5206020000- 1	643					11
Lower Salado	5206020000- 0	551					18
Lower Salado		5,326					39

Report file: q_sws_B

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	5206020000- 0	1,745					
Lower Salado	5206020000- 0	2,112	6	7	5	7	14
Lower Salado	5206000000- 2	4,775	125	126	122	126	159
Lower Salado	5206000000- 0	4,132	24	26	26	33	43
Lower Salado		12,764	155	159	153	166	216

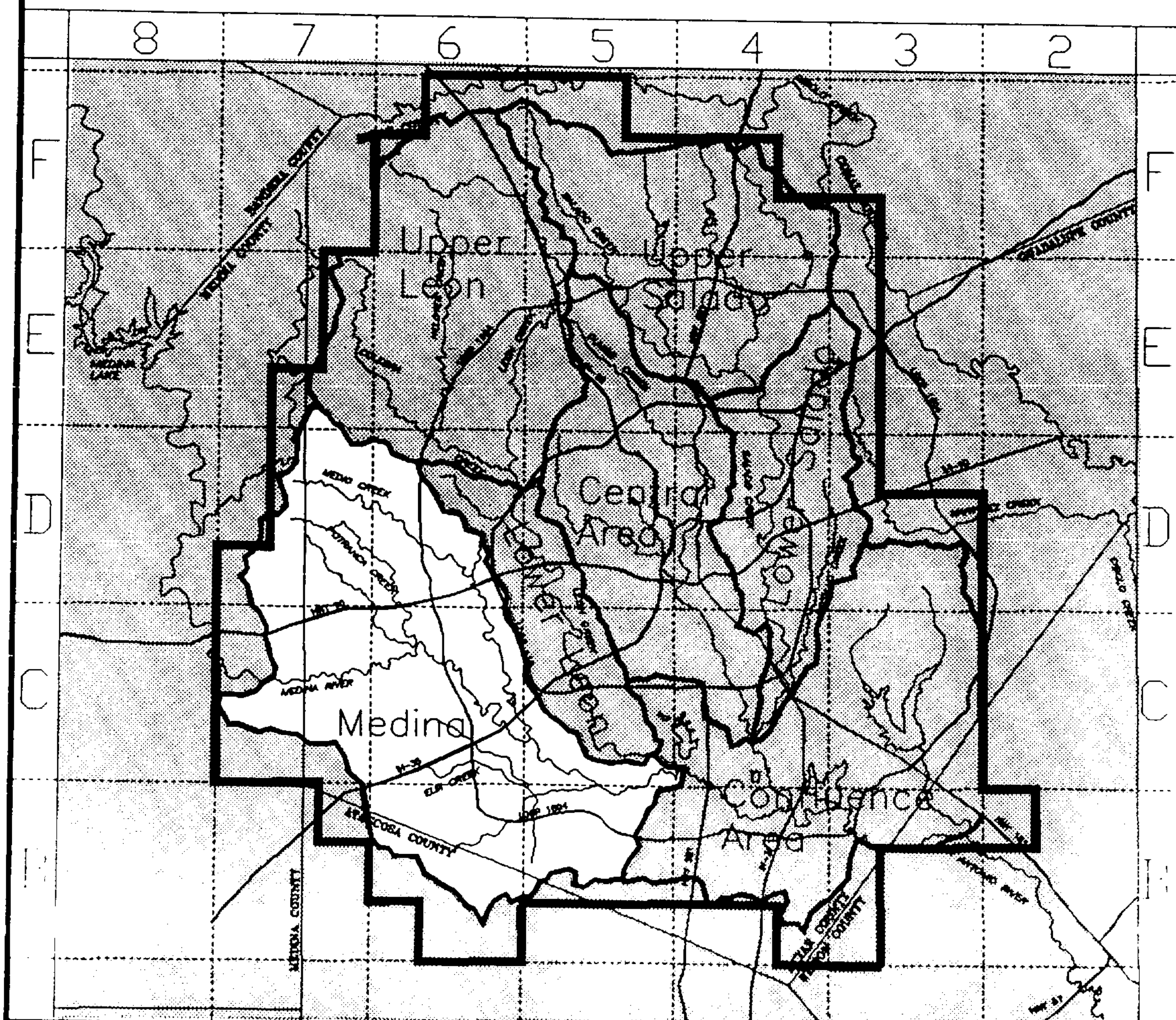
TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Lower Salado	5206090000- 0	1,745	304	331	356	388	504
Lower Salado	5206080400- 0	1,561	1	2	2	4	5
Lower Salado	5206080200- 0	1,286					109
Lower Salado	5206080100- 0	1,194	84	91	114	139	596
Lower Salado	5206080000- 4	1,653	13	13	14	23	286
Lower Salado	5206080000- 2	2,847	112	123	137	150	490
Lower Salado	5206080000- 1	551	40	53	117	148	331
Lower Salado	5206060000- 0	1,653	21	20	16	19	323
Lower Salado	5206050000- 0	1,745	309	305	299	295	298
Lower Salado	5206030000- 0	1,469	350	499	286	294	301
Lower Salado	5206020400- 0	1,102					
Lower Salado	5206020200- 0	1,286					10
Lower Salado	5206020100- 0	918	15	10	16	17	29
Lower Salado	5206020000- 0	1,745					
Lower Salado	5206020000- 4	2,204	32	29	30	31	154
Lower Salado	5206020000- 2	5,601	239	272	316	331	542
Lower Salado	5206020000- 1	1,010					12
Lower Salado	5206020000- 0	4,867	65	73	71	98	164
Lower Salado	5206000000- 9	735	79	95	102	100	171
Lower Salado	5206000000- 8	275	23	22	29	32	102
Lower Salado	5206000000- 6	1,928	189	195	213	215	491
Lower Salado	5206000000- 5	7,805	554	568	592	613	921
Lower Salado	5206000000- 3	1,377	133	124	125	130	161
Lower Salado	5206000000- 2	9,275	396	413	434	653	581
Lower Salado	5206000000- 0	4,132	24	26	26	33	43
Lower Salado		59,963	2,983	3,264	3,295	3,713	6,624

Medina	*BUSINESS CONNECTIONS*	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	D - 7	20,294	21	21	24	23	35
Medina	D - 6	22,314	81	83	96	98	420
Medina	C - 7	12,489	44	42	50	50	67
Medina	C - 6	25,895	179	180	189	189	272
Medina	C - 5	826	9	9	13	12	23
Medina		81,818	334	335	372	372	817

New Connections = 483 or 3% of all New Connections in Study Area



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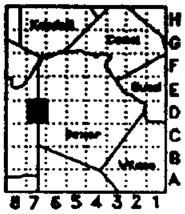
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 34

Map Name LA COSTE NE

Scale 1:100,000

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SCALE (MILES)

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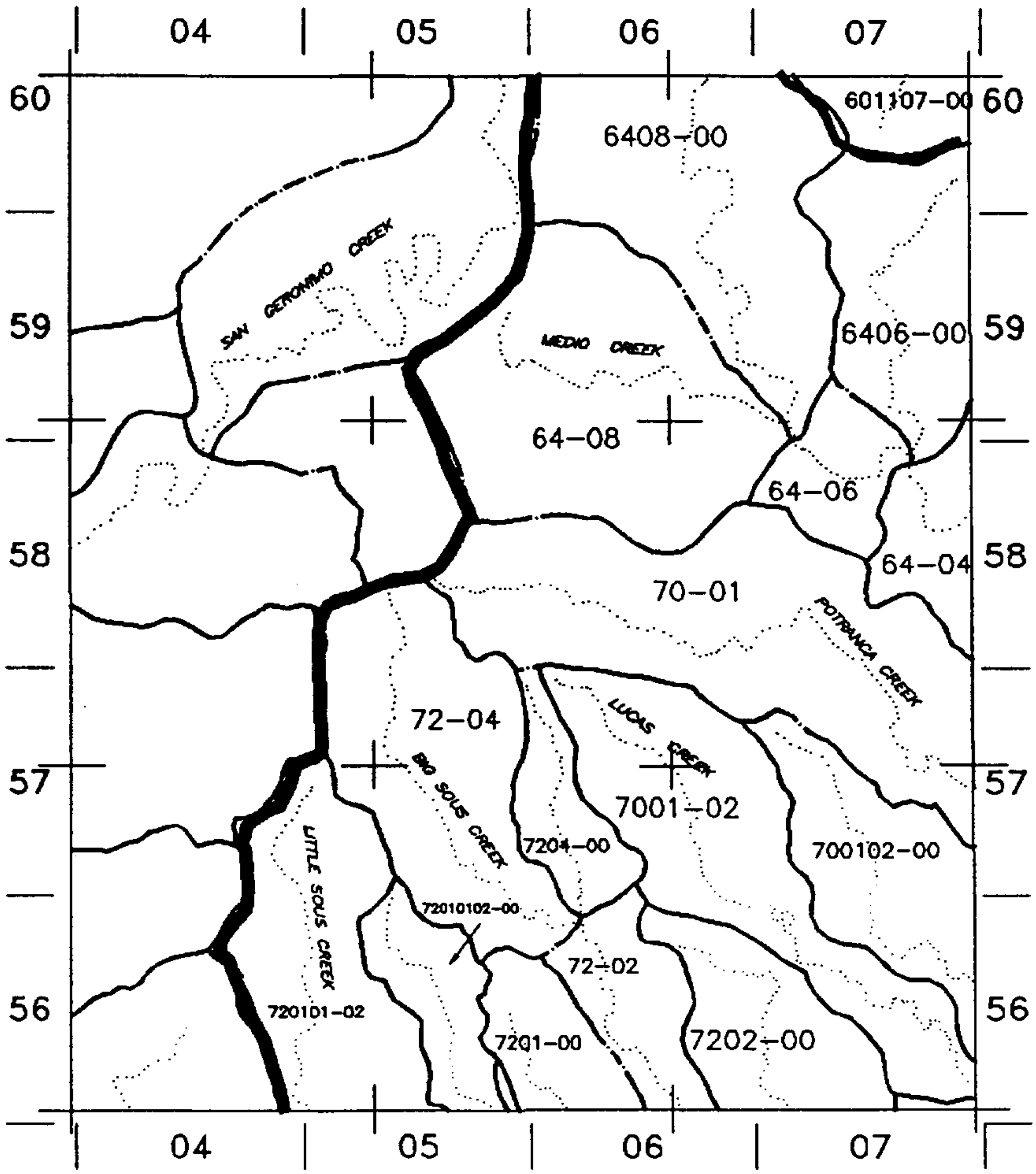
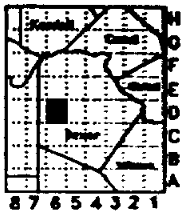
Longitude = 98

7.5' Area = D7



GAE 1/29/93 44D7COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 35

Map Name CULEBRA HILL

Scale 1:100,000

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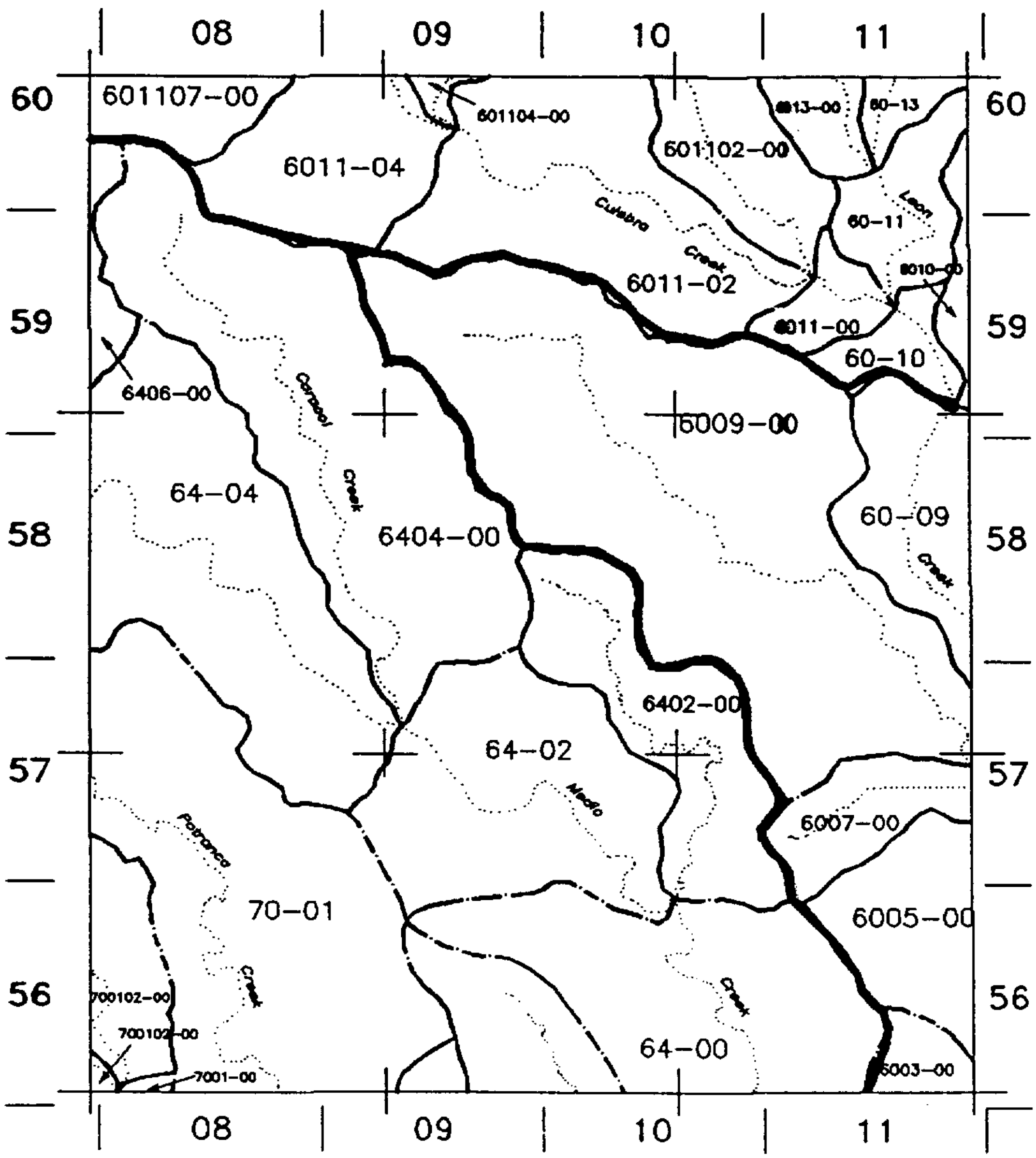
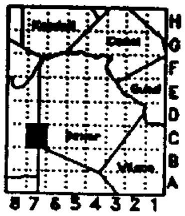
Longitude = 98

7.5' Area = D6



GAE 1/29/93 44D6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 42

Map Name LA COSTE

Scale 1:100,000

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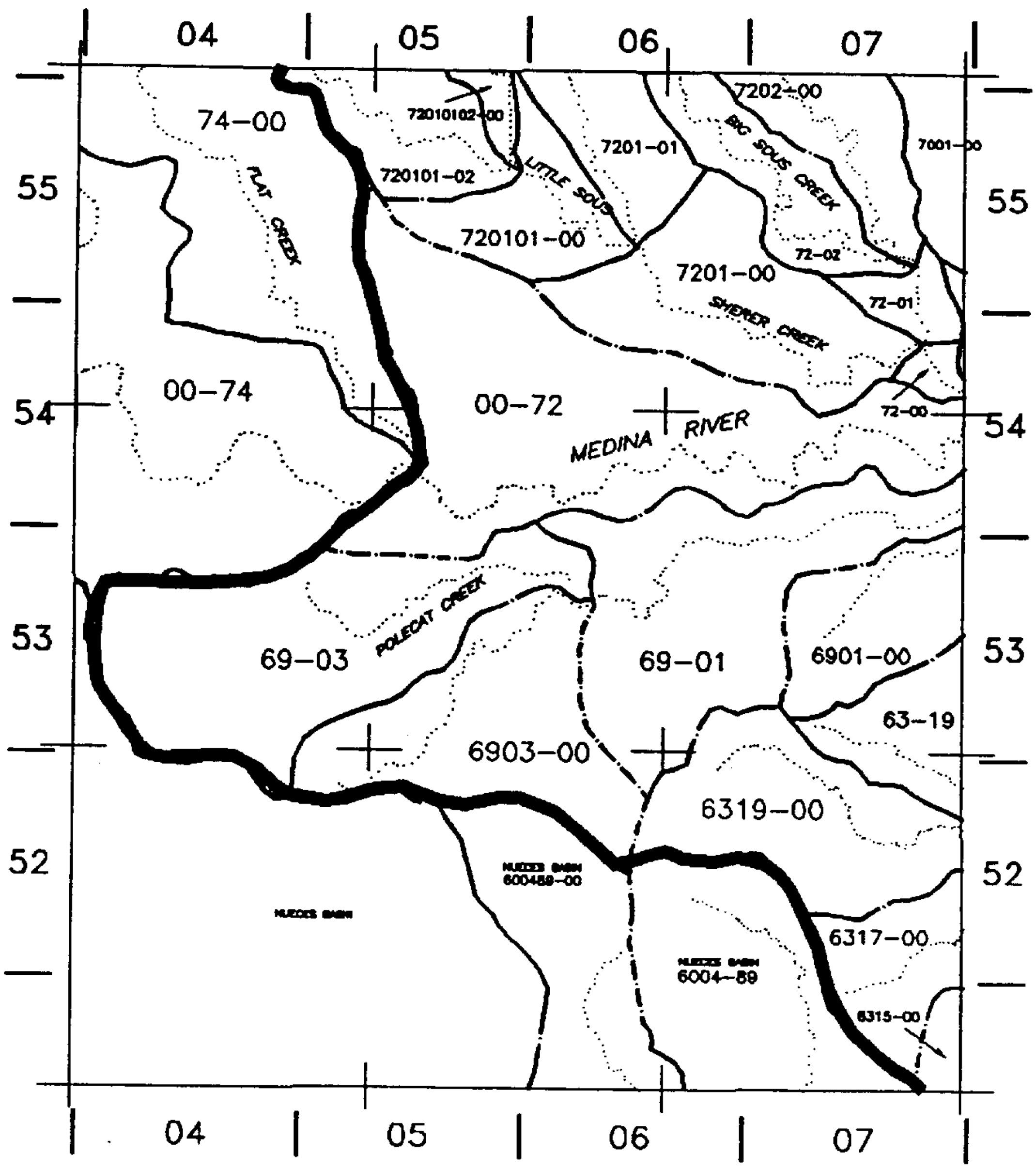
SCALE (MILES)

Latitude = 29

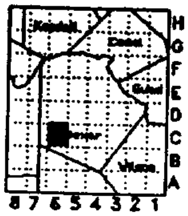
Longitude = 98

7.5' Area = C7



GAE 1/29/93 44C7COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 43

Map Name MACDONA

Scale 1:100,000

N

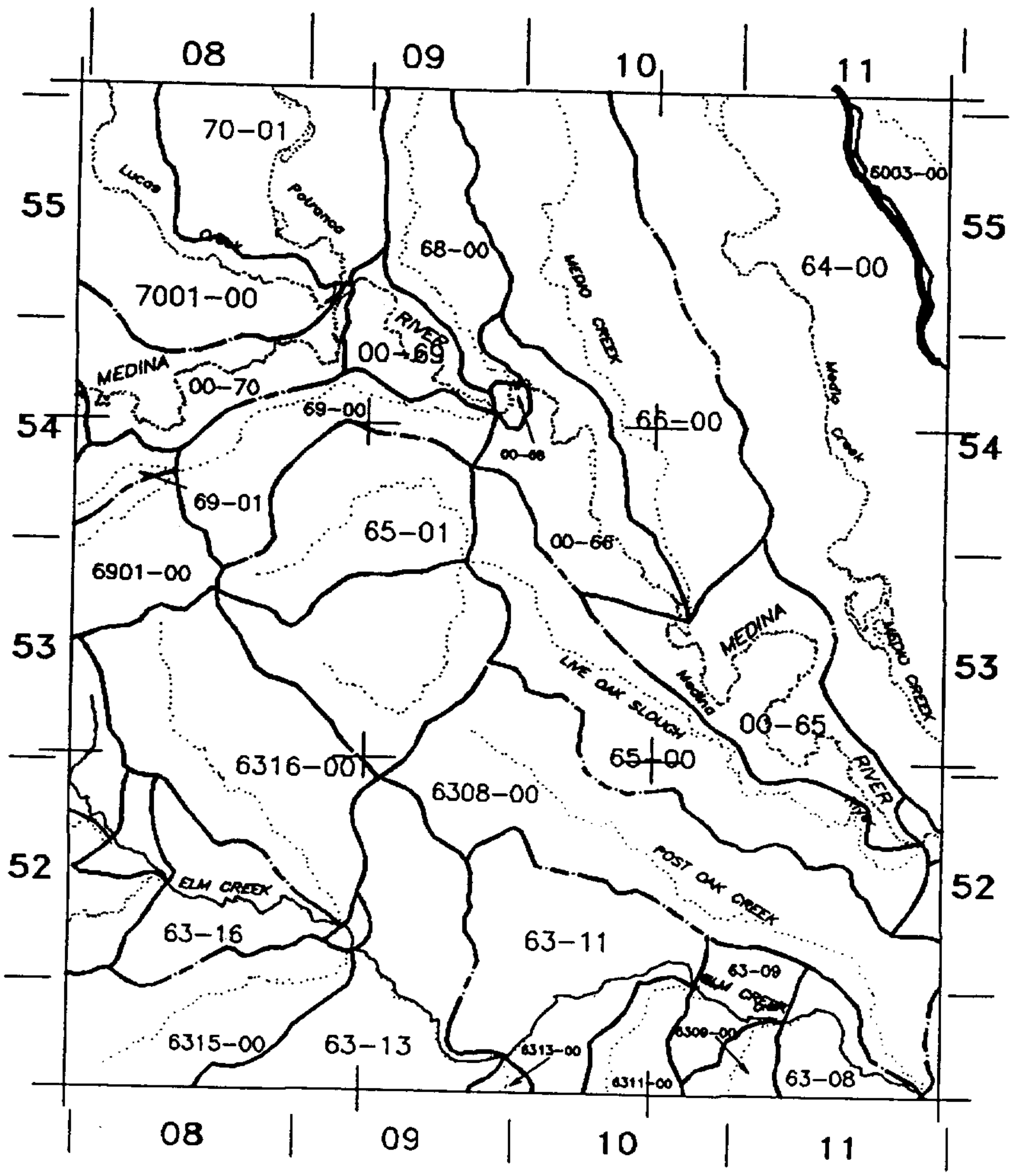
0 0.5 1.0 1.5 2.0

SCALE (MILES)

Latitude = 29

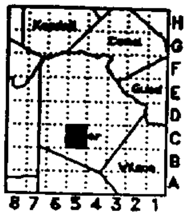
Longitude = 98

7.5' Area = C6



GAE 1/29/93 44C6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



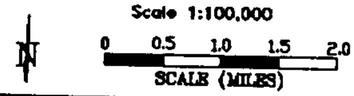
1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 44

Map Name TERREL WELLS

Scale 1:100,000



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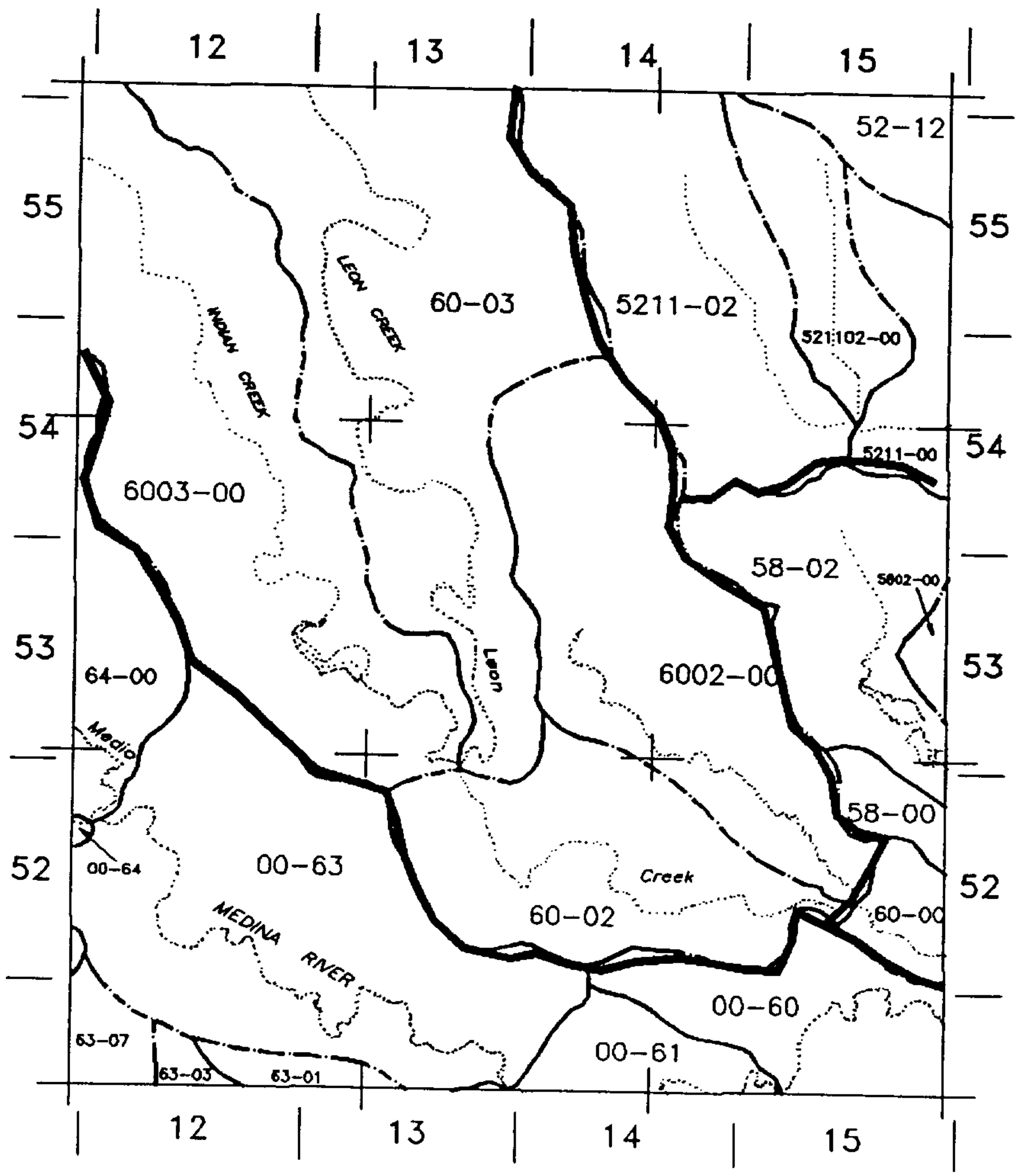
7.5' Area = C5



GAE 1/29/93 44C5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-7

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	7202000000- 0	1,928	4	3	2	2	3
Medina	7201000000- 1	184					
Medina	7201000000- 0	275					
Medina	7200000000- 4	92					
Medina	7200000000- 2	1,010	1	1	1	1	2
Medina	7001020000- 0	1,469					
Medina	7001000000- 2	2,663					1
Medina	7001000000- 0	184	2	1	1	1	
Medina	7000000000- 1	3,489		1	2	1	3
Medina	6408000000- 0	3,030	5	6	8	8	8
Medina	6406000000- 0	1,745	3	4	3	3	7
Medina	6400000000- 8	2,571	2	2	2	2	4
Medina	6400000000- 6	735	1	1	2	2	3
Medina	6400000000- 4	918	3	2	3	3	4
Medina		20,294	21	21	24	23	35

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	7001020000- 0	735	1	1	1	1	6
Medina	7000000000- 1	4,500	13	13	13	14	22
Medina	6800000000- 0	92					
Medina	6600000000- 0	1,010					4
Medina	6406000000- 0	92					0
Medina	6404000000- 0	4,683	7	8	13	12	32
Medina	6402000000- 0	1,653	16	17	17	18	131
Medina	6400000000- 4	3,581	14	16	16	17	32
Medina	6400000000- 2	2,755	13	13	16	18	55
Medina	6400000000- 0	3,214	17	15	20	18	138
Medina		22,314	81	83	96	98	420

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-7

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	7202000000- 0	826	2	2	2	2	1
Medina	7201010000- 0	459	1	2	2	2	2
Medina	7201000000- 1	826	3	3	5	7	9
Medina	7201000000- 0	1,928	7	7	7	7	7
Medina	7200000000- 2	918	5	5	5	5	6
Medina	7200000000- 1	367					
Medina	7200000000- 0	184					
Medina	7001000000- 0	367	2	2	2	2	
Medina	6901000000- 0	1,102	6	5	5	5	17
Medina	6900000000- 1	2,847	15	13	17	15	20
Medina	0-72	2,663	3	3	5	5	5
Medina		12,489	44	42	50	50	67

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	7001000000- 0	1,653	13	16	17	17	19
Medina	7000000000- 1	1,653	1	1	1	1	2
Medina	6901000000- 0	643	1	1	1	1	4
Medina	6900000000- 1	184	1	1	1	1	2
Medina	6900000000- 0	1,194	3	4	5	3	8
Medina	6800000000- 0	1,102					4
Medina	6600000000- 0	3,214	5	5	9	9	10
Medina	6501000000- 0	1,745	5	5	6	6	15
Medina	6500000000- 1	1,377	13	12	12	13	20
Medina	6500000000- 0	2,296	70	65	66	65	78
Medina	6400000000- 0	6,336	37	38	36	33	52
Medina	0-70	1,102	6	7	8	9	12
Medina	0-69	459			1	3	5
Medina	0-68	92					0
Medina	0-66	1,286	4	4	3	3	7
Medina	0-65	1,561	20	21	23	25	34
Medina		25,895	179	180	189	189	272

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : C-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	6400000000- 0	826	9	9	13	12	23
Medina		826	9	9	13	12	23

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	7202000000- 0	1,928	4	3	2	2	3
Medina	7202000000- 0	826	2	2	2	2	1
Medina	7201010000- 0	459	1	2	2	2	2
Medina	7201000000- 1	184					
Medina	7201000000- 0	275					
Medina	7201000000- 1	826	3	3	5	7	9
Medina	7201000000- 0	1,928	7	7	7	7	7
Medina	7200000000- 4	92					
Medina	7200000000- 2	1,010	1	1	1	1	2
Medina	7200000000- 2	918	5	5	5	5	6
Medina	7200000000- 1	367					
Medina	7200000000- 0	184					
Medina	7001020000- 0	1,469					
Medina	7001020000- 0	735	1	1	1	1	6
Medina	7001000000- 2	2,663					1
Medina	7001000000- 0	184	2	1	1	1	
Medina	7001000000- 0	2,020	15	18	19	19	19
Medina	7000000000- 1	3,489		1	2	1	3
Medina	7000000000- 1	6,152	14	14	14	15	24
Medina	6901000000- 0	1,745	7	6	6	6	21
Medina	6900000000- 1	3,030	16	14	18	16	22
Medina	6900000000- 0	1,194	3	4	5	3	8
Medina	6800000000- 0	1,194					4
Medina	6600000000- 0	4,224	5	5	9	9	14
Medina	6501000000- 0	1,745	5	5	6	6	15

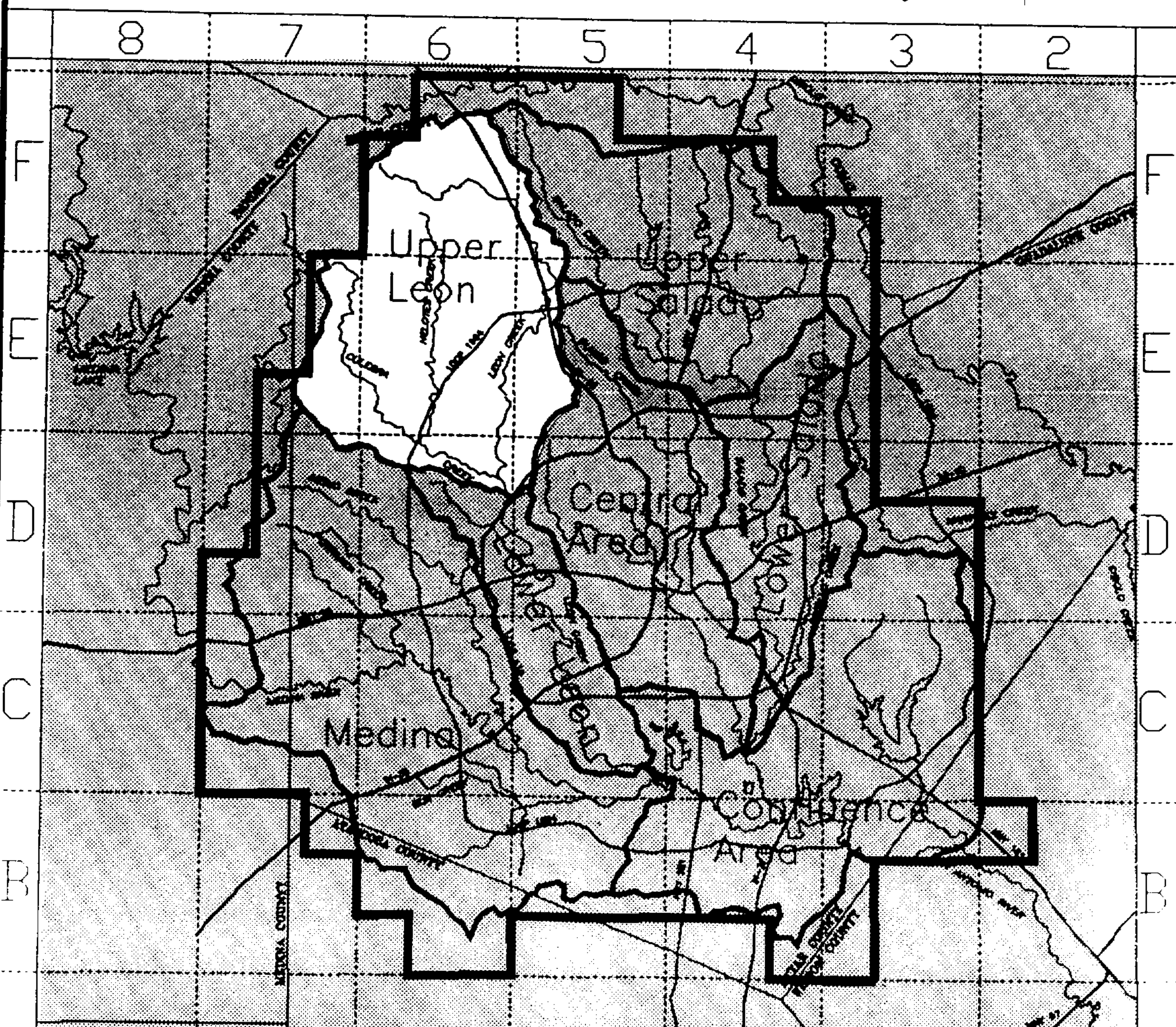
TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Medina	6500000000- 1	1,377	13	12	12	13	20
Medina	6500000000- 0	2,296	70	65	66	65	78
Medina	6408000000- 0	3,030	5	6	8	8	8
Medina	6406000000- 0	1,745	3	4	3	3	7
Medina	6406000000- 0	92					0
Medina	6404000000- 0	4,683	7	8	13	12	32
Medina	6402000000- 0	1,653	16	17	17	18	131
Medina	6400000000- 8	2,571	2	2	2	2	4
Medina	6400000000- 6	735	1	1	2	2	3
Medina	6400000000- 4	918	3	2	3	3	4
Medina	6400000000- 4	3,581	14	16	16	17	32
Medina	6400000000- 2	2,755	13	13	16	18	55
Medina	6400000000- 0	10,376	63	62	69	63	213
Medina	0-72	2,663	3	3	5	5	5
Medina	0-70	1,102	6	7	8	9	12
Medina	0-69	459			1	3	5
Medina	0-68	92					0
Medina	0-66	1,286	4	4	3	3	7
Medina	0-65	1,561	20	21	23	25	34
Medina		81,818	334	335	372	372	817

Upper Leon	***BUSINESS CONNECTIONS***	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	F - 6	30,119	102	123	132	152	231
Upper Leon	F - 5	3,214	37	38	37	36	70
Upper Leon	E - 6	41,690	244	275	339	352	969
Upper Leon	E - 5	11,846	178	222	232	240	1,012
Upper Leon	D - 7	643					
Upper Leon	D - 6	8,815	75	86	111	122	668
Upper Leon	D - 5	826	95	78	84	86	162
Upper Leon		97,153	731	822	935	988	3,112

New Connections = <u>2,381</u> or <u>16%</u> of all New Connections in Study Area



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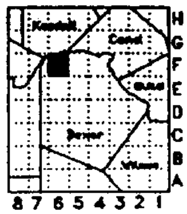
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 19

Map Name Van Raub

Scale 1:100,000

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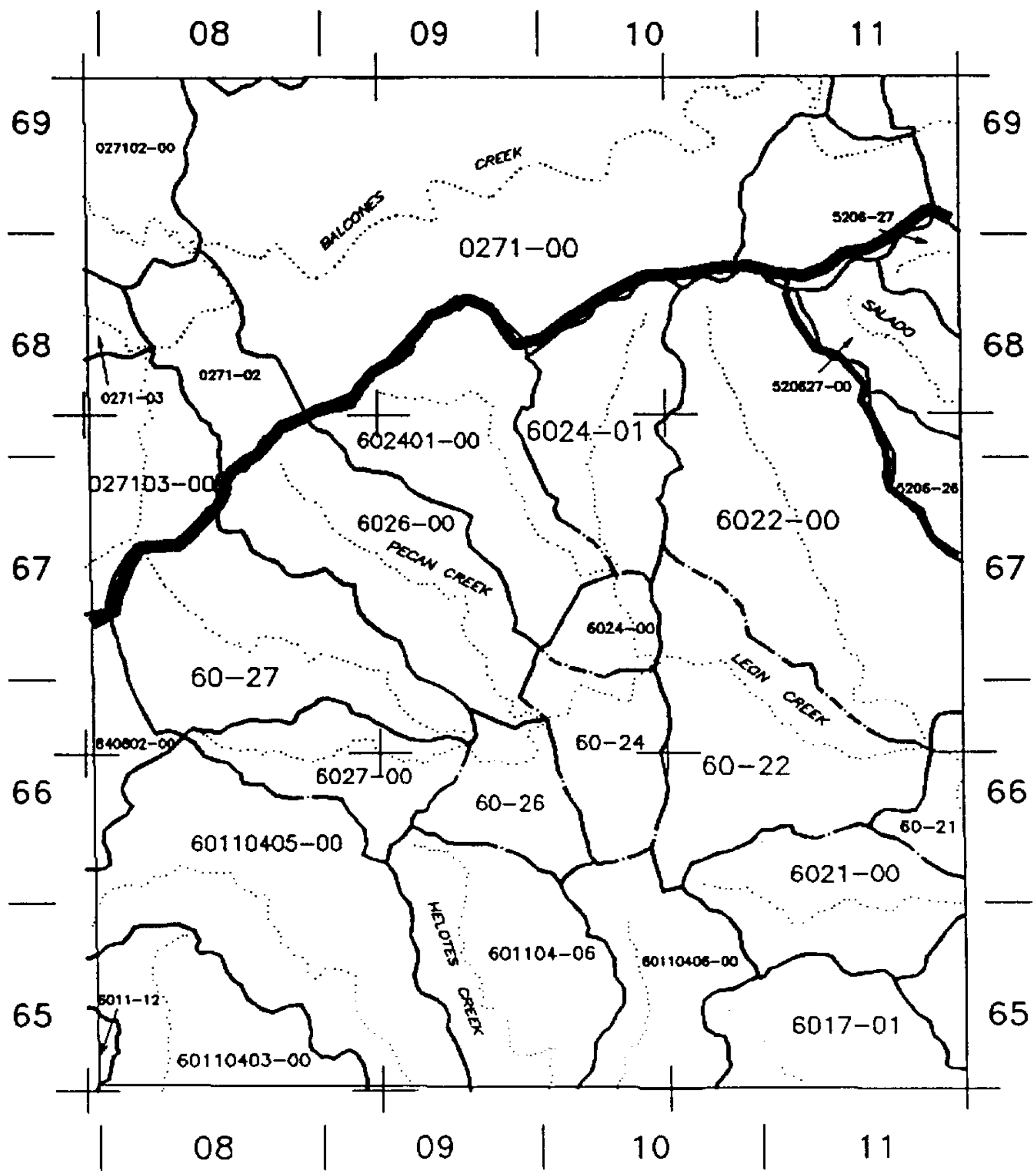
SCALE (MILES)

Latitude = 29

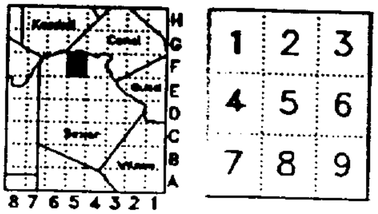
Longitude = 98

7.5' Area = F6



GAE 1/29/93 44F6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 20

Map Name Camp Bullis

Scale 1:100,000

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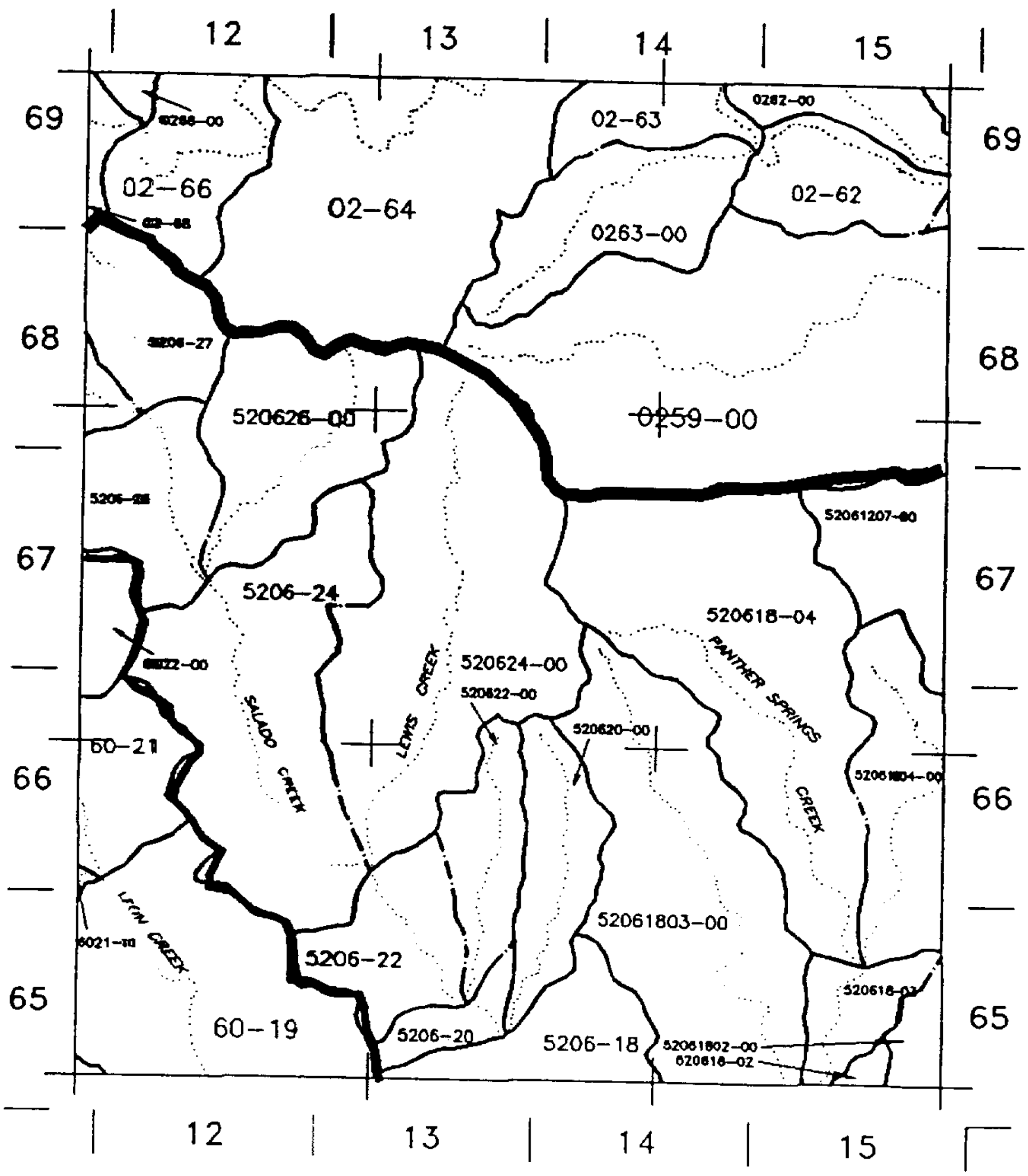
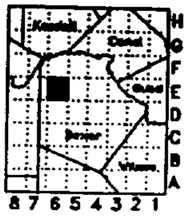
7.5' Area = F5



GAE 1/29/93 44F5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



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4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 27

Map Name HELOTES

Scale 1:100,000

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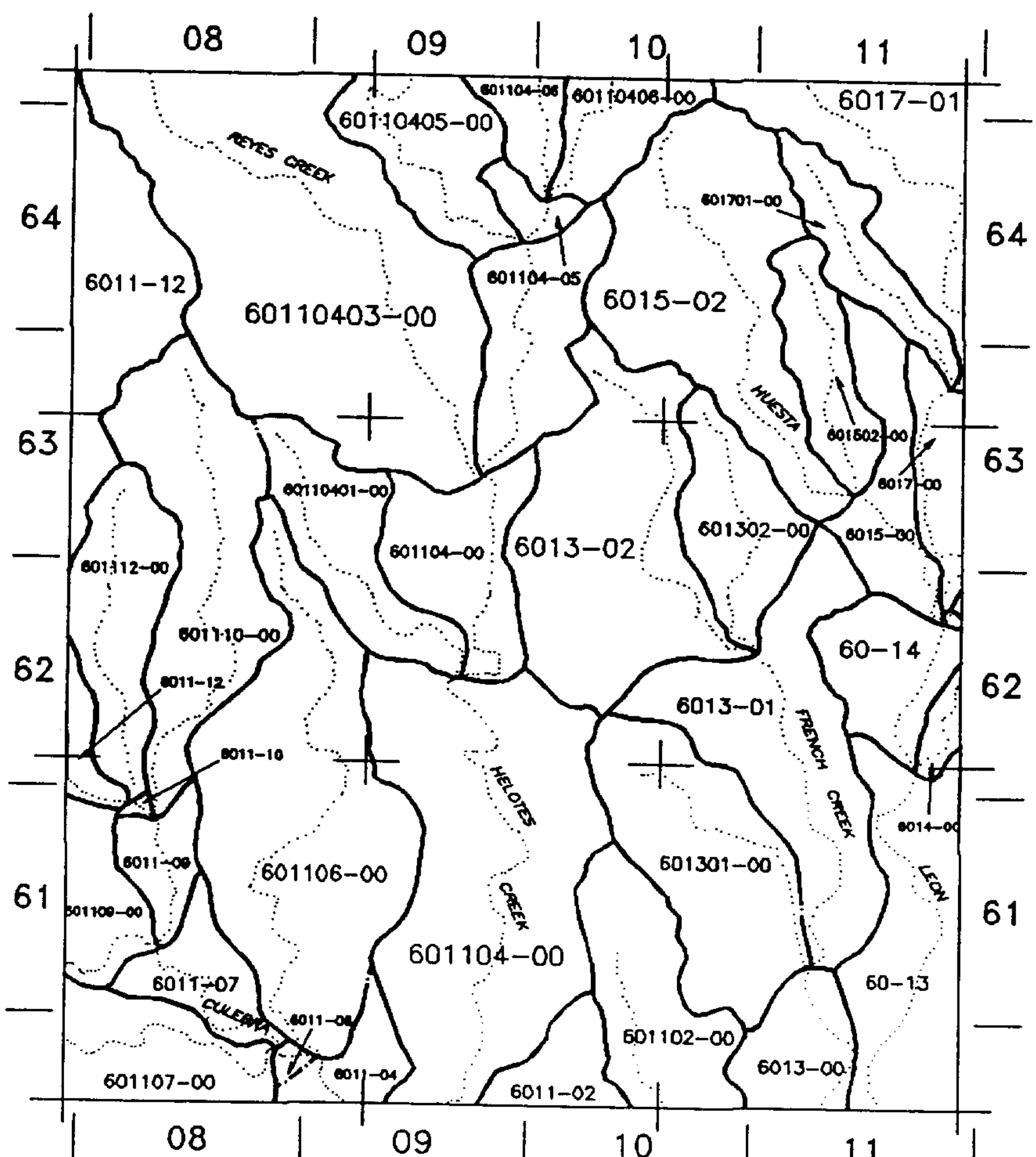
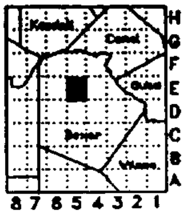
Longitude = 98

7.5' Area = E6



GAE 1/29/93 44E6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

Scale 1:100,000

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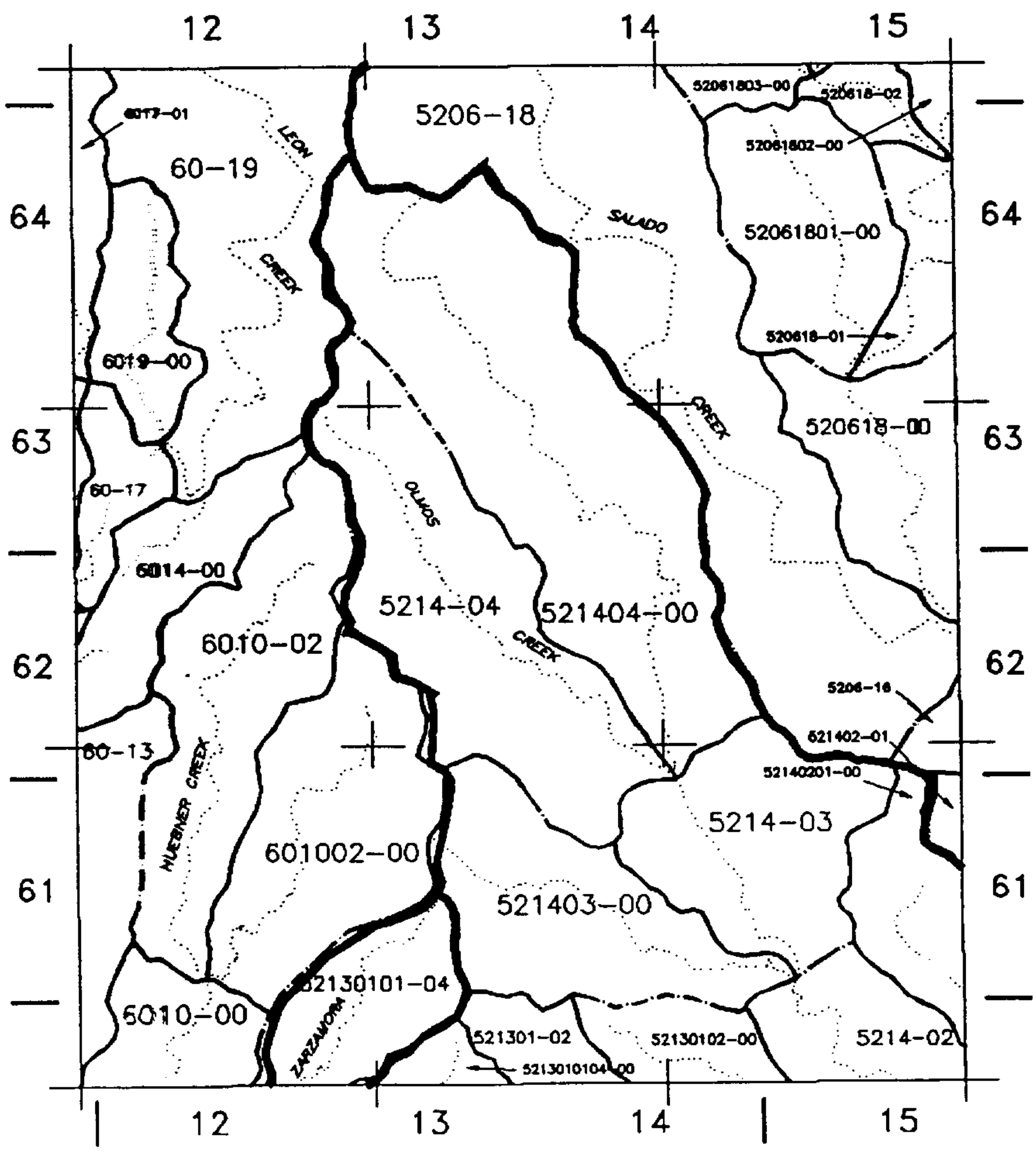
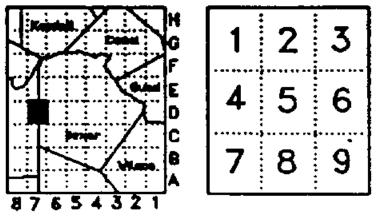
Longitude = 98

7.5' Area = E5



GAE 1/29/93 44E5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

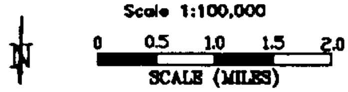


7.5 Minute Area

Water Well ID 68- 34

Map Name LA COSTE NE

Scale 1:100,000



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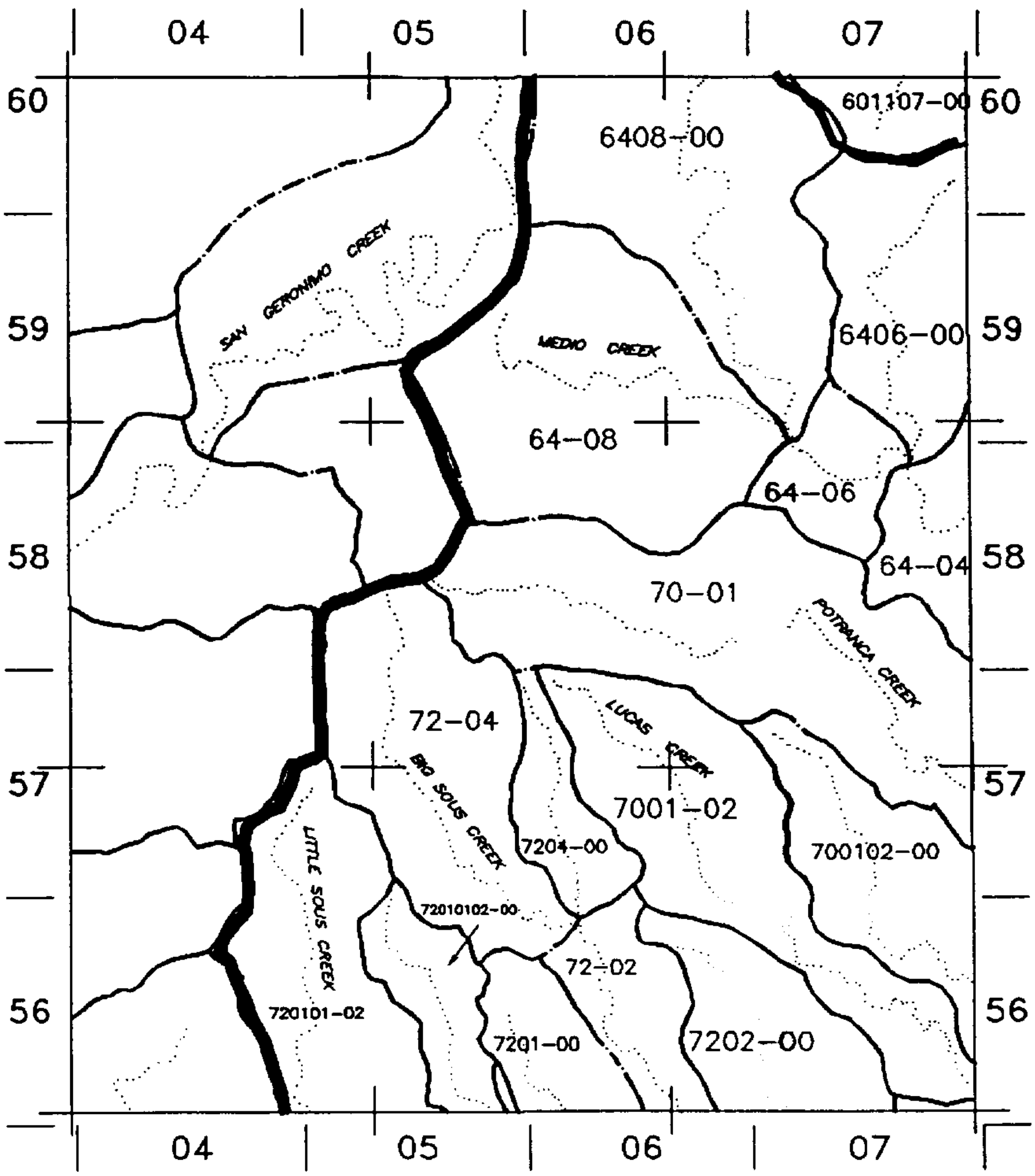
Longitude = 98

7.5' Area = D7



GAE 1/29/93 44D7COMP.DWG

C. THOMAS KOCH, INC.
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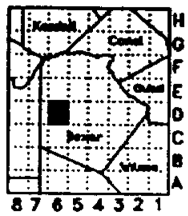

1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 35

Map Name CULEBRA HILL

Scale 1:100,000

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SCALE (MILES)

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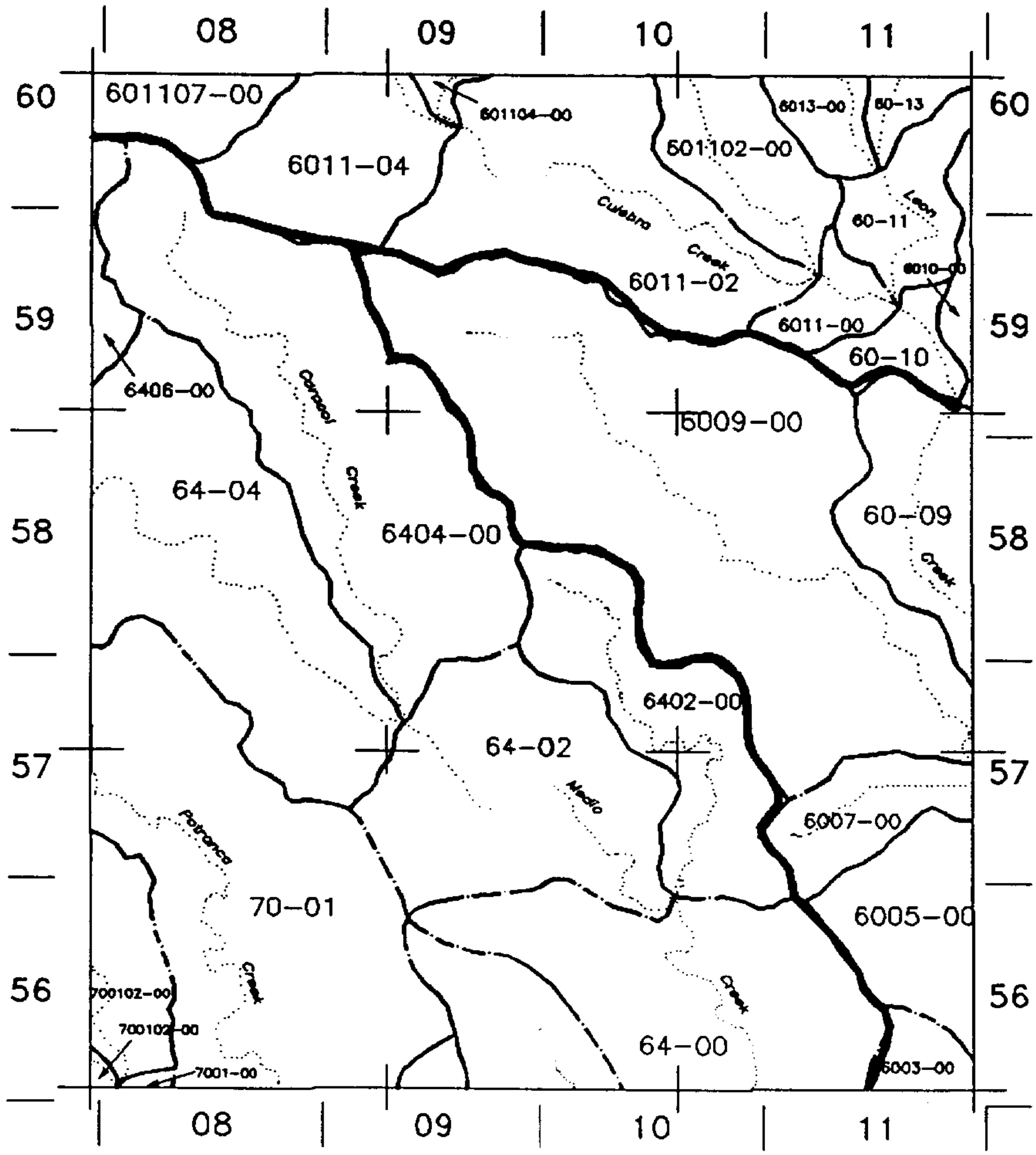
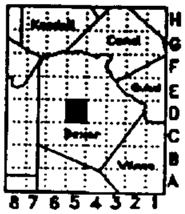
Longitude = 98

7.5' Area = D6



GAE 1/29/93 44D6COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 36

Map Name SAN ANTONIO WEST

Scale 1:100,000

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SCALE (MILES)

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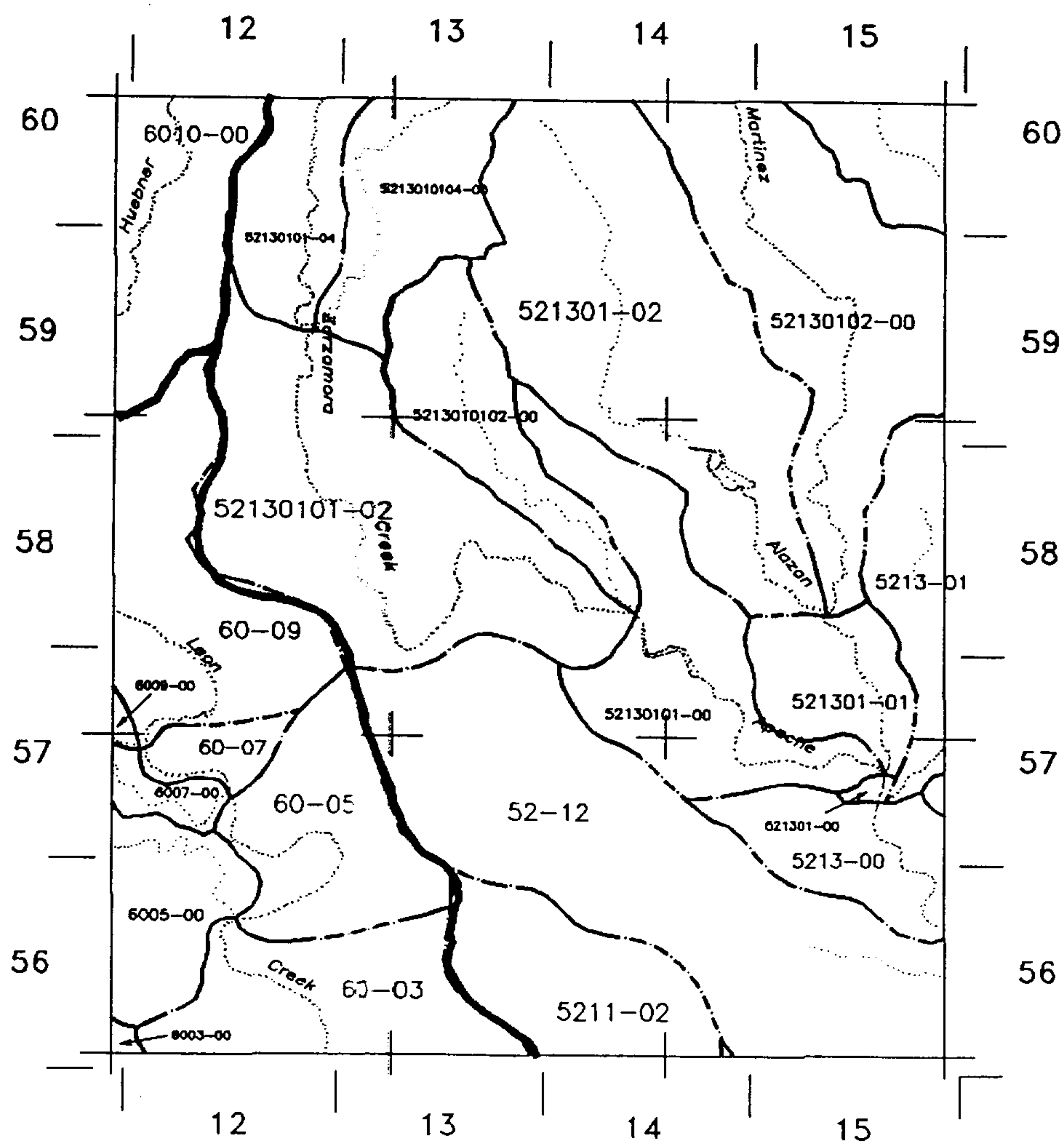
Longitude = 98

7.5' Area = D5



GAE 1/29/93 44D5COMP.DWG

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : F-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6027000000- 0	1,010					0
Upper Leon	6026000000- 0	2,112	6	7	7	7	8
Upper Leon	6024010000- 0	2,112	2	2	4	4	13
Upper Leon	6024000000- 1	1,469	4	5	5	5	10
Upper Leon	6024000000- 0	551	11	14	16	16	19
Upper Leon	6022000000- 0	4,224	18	25	27	31	57
Upper Leon	6021000000- 0	1,469	4	6	3	3	3
Upper Leon	6017000000- 1	1,561	2	2	2	2	4
Upper Leon	6011040600- 0	1,561	5	6	6	6	8
Upper Leon	6011040500- 0	3,398	3	3	9	30	11
Upper Leon	6011040300- 0	1,745	4	8	7	1	10
Upper Leon	6011040000- 6	1,837	8	9	10	10	9
Upper Leon	6000000000-27	2,296					5
Upper Leon	6000000000-26	826					2
Upper Leon	6000000000-24	918	4	4	4	4	7
Upper Leon	6000000000-22	2,204	24	24	23	24	42
Upper Leon	6000000000-21	367	5	6	6	6	16
Upper Leon	6000000000-19	459	2	2	3	3	7
Upper Leon		30,119	102	123	132	152	231

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : F-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6022000000- 0	275					0
Upper Leon	6000000000-21	643					3
Upper Leon	6000000000-19	2,296	37	38	37	36	67
Upper Leon		3,214	37	38	37	36	70

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6017010000- 0	275		1	1	1	3
Upper Leon	6017000000- 1	1,377	5	17	18	18	21
Upper Leon	6017000000- 0	551	4	8	10	11	11
Upper Leon	6015020000- 0	643					0
Upper Leon	6015000000- 2	2,296	2	3	3	2	2
Upper Leon	6015000000- 0	918	12	11	10	10	45
Upper Leon	6014000000- 0	184				2	0
Upper Leon	6013020000- 0	918	2	2	2	2	4
Upper Leon	6013010000- 0	1,653	9	11	11	9	24
Upper Leon	6013000000- 2	2,204	36	43	42	43	60
Upper Leon	6013000000- 1	2,204	22	23	30	31	72
Upper Leon	6013000000- 0	459	2	2	2	1	11
Upper Leon	6011120000- 0	1,194					0
Upper Leon	6011100000- 0	1,745					0
Upper Leon	6011090000- 0	275					
Upper Leon	6011070000- 0	735	1	1	1	1	6
Upper Leon	6011060000- 0	3,214	8	7	7	8	15
Upper Leon	6011040600- 0	367	3	3	3	3	3
Upper Leon	6011040500- 0	735	4	4	4		4
Upper Leon	6011040300- 0	4,224	27	29	35	29	55
Upper Leon	6011040100- 0	1,010	1	2	2	2	3
Upper Leon	6011040000- 6	184	7	7	6	4	6
Upper Leon	6011040000- 5	184					2
Upper Leon	6011040000- 3	826	13	15	15	16	25
Upper Leon	6011040000- 0	6,795	38	38	48	52	104
Upper Leon	6011020000- 0	1,286	3	3	4	6	55
Upper Leon	6011000000-12	1,010					0
Upper Leon	6011000000- 9	551					0
Upper Leon	6011000000- 7	643					0
Upper Leon	6011000000- 4	367	2	2	3	3	3
Upper Leon	6000000000-14	735	2	2	3	3	5
Upper Leon	6000000000-13	1,928	41	41	79	95	430
Upper Leon		41,690	244	275	339	352	969

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6019000000- 0	918	2	2	2	2	4
Upper Leon	6014000000- 0	918	9	35	36	36	60
Upper Leon	6010020000- 0	2,663	71	72	75	75	695
Upper Leon	6010000000- 2	2,571	36	47	50	51	116
Upper Leon	6010000000- 0	918	14	19	21	28	62
Upper Leon	6000000000-19	2,847	35	35	34	35	53
Upper Leon	6000000000-17	459	3	3	3	3	5
Upper Leon	6000000000-13	551	8	9	11	10	17
Upper Leon		11,846	178	222	232	240	1,012

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-7

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6011070000- 0	643					
Upper Leon		643					

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6013000000- 0	275	2	3	3	2	3
Upper Leon	6011070000- 0	643	1	1			2
Upper Leon	6011020000- 0	918	3	5	4	3	51
Upper Leon	6011000000- 4	1,377	13	13	14	14	23
Upper Leon	6011000000- 2	3,214	11	15	25	27	122
Upper Leon	6011000000- 0	459	4	8	12	22	41
Upper Leon	6010000000- 0	459	13	13	10	7	112
Upper Leon	6000000000-13	275	4	4	4	3	5
Upper Leon	6000000000-11	643	12	13	27	26	104
Upper Leon	6000000000-10	551	12	11	12	18	205
Upper Leon		8,815	75	86	111	122	668

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : D-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6010000000- 0	826	95	78	84	86	162
Upper Leon		826	95	78	84	86	162

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6027000000- 0	1,010					0
Upper Leon	6026000000- 0	2,112	6	7	7	7	8
Upper Leon	6024010000- 0	2,112	2	2	4	4	13
Upper Leon	6024000000- 1	1,469	4	5	5	5	10
Upper Leon	6024000000- 0	551	11	14	16	16	19
Upper Leon	6022000000- 0	4,500	18	25	27	31	57
Upper Leon	6021000000- 0	1,469	4	6	3	3	3
Upper Leon	6019000000- 0	918	2	2	2	2	4
Upper Leon	6017010000- 0	275		1	1	1	3
Upper Leon	6017000000- 1	2,938	7	19	20	20	25
Upper Leon	6017000000- 0	551	4	8	10	11	11
Upper Leon	6015020000- 0	643					0
Upper Leon	6015000000- 2	2,296	2	3	3	2	2
Upper Leon	6015000000- 0	918	12	11	10	10	45
Upper Leon	6014000000- 0	1,102	9	35	36	38	60
Upper Leon	6013020000- 0	918	2	2	2	2	4
Upper Leon	6013010000- 0	1,653	9	11	11	9	24
Upper Leon	6013000000- 2	2,204	36	43	42	43	60
Upper Leon	6013000000- 1	2,204	22	23	30	31	72
Upper Leon	6013000000- 0	735	4	5	5	3	14
Upper Leon	6011120000- 0	1,194					0
Upper Leon	6011100000- 0	1,745					0
Upper Leon	6011090000- 0	275					
Upper Leon	6011070000- 0	2,020	2	2	1	1	8

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon	6011060000- 0	3,214	8	7	7	8	15
Upper Leon	6011040600- 0	1,928	8	9	9	9	11
Upper Leon	6011040500- 0	4,132	7	7	13	30	15
Upper Leon	6011040300- 0	5,969	31	37	42	30	65
Upper Leon	6011040100- 0	1,010	1	2	2	2	3
Upper Leon	6011040000- 6	2,020	15	16	16	14	15
Upper Leon	6011040000- 5	184					2
Upper Leon	6011040000- 3	826	13	15	15	16	25
Upper Leon	6011040000- 0	6,795	38	38	48	52	104
Upper Leon	6011020000- 0	2,204	6	8	8	9	106
Upper Leon	6011000000-12	1,010					0
Upper Leon	6011000000- 9	551					0
Upper Leon	6011000000- 7	643					0
Upper Leon	6011000000- 4	1,745	15	15	17	17	26
Upper Leon	6011000000- 2	3,214	11	15	25	27	122
Upper Leon	6011000000- 0	459	4	8	12	22	41
Upper Leon	6010020000- 0	2,663	71	72	75	75	695
Upper Leon	6010000000- 2	2,571	36	47	50	51	116
Upper Leon	6010000000- 0	2,204	122	110	115	121	336
Upper Leon	6000000000-27	2,296					5
Upper Leon	6000000000-26	826					2
Upper Leon	6000000000-24	918	4	4	4	4	7
Upper Leon	6000000000-22	2,204	24	24	23	24	42
Upper Leon	6000000000-21	1,010	5	6	6	6	19
Upper Leon	6000000000-19	5,601	74	75	74	74	127
Upper Leon	6000000000-17	459	3	3	3	3	5
Upper Leon	6000000000-14	735	2	2	3	3	5
Upper Leon	6000000000-13	2,755	53	54	94	108	452
Upper Leon	6000000000-11	643	12	13	27	26	104
Upper Leon	6000000000-10	551	12	11	12	18	205

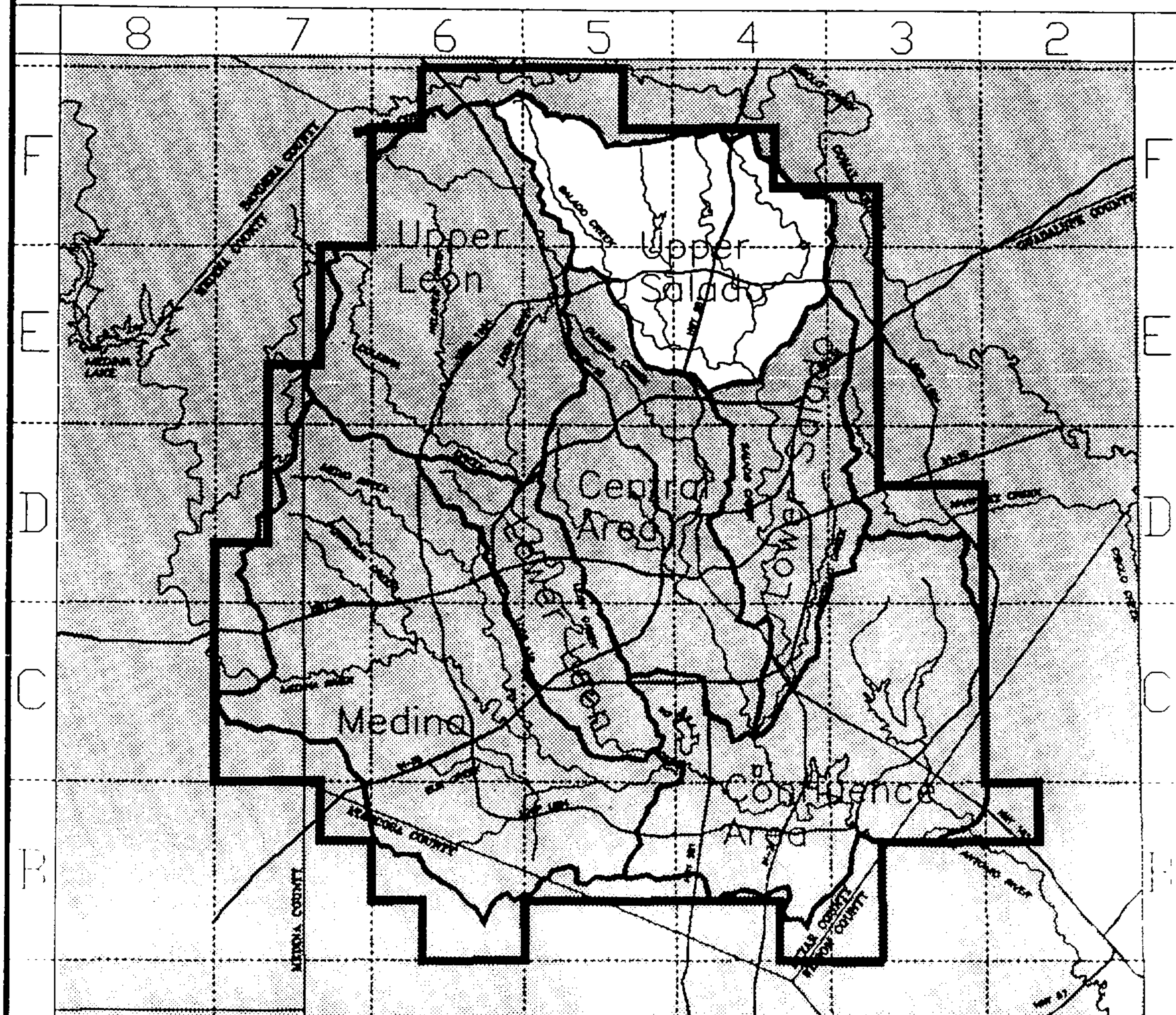
TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Leon		97,153	731	822	935	988	3,112

Upper Salado	**BUSINESS CONNECTIONS**	*1976 Thru 1988*

Watershed	7.5' Area	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	F - 6	1,561	2	5	7	7	15
Upper Salado	F - 5	25,712	20	17	18	17	48
Upper Salado	F - 4	19,559	19	24	27	30	81
Upper Salado	F - 3	92					0
Upper Salado	E - 5	11,019	311	348	481	498	1,377
Upper Salado	E - 4	24,702	871	969	1,113	1,370	2,807
Upper Salado		82,645	1,223	1,363	1,646	1,922	4,328

New Connections = <u>3,105</u> or <u>20%</u> of all New Connections in Study Area



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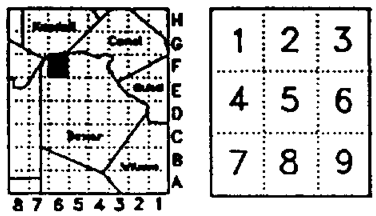
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 19

Map Name Van Raub

Scale 1:100,000

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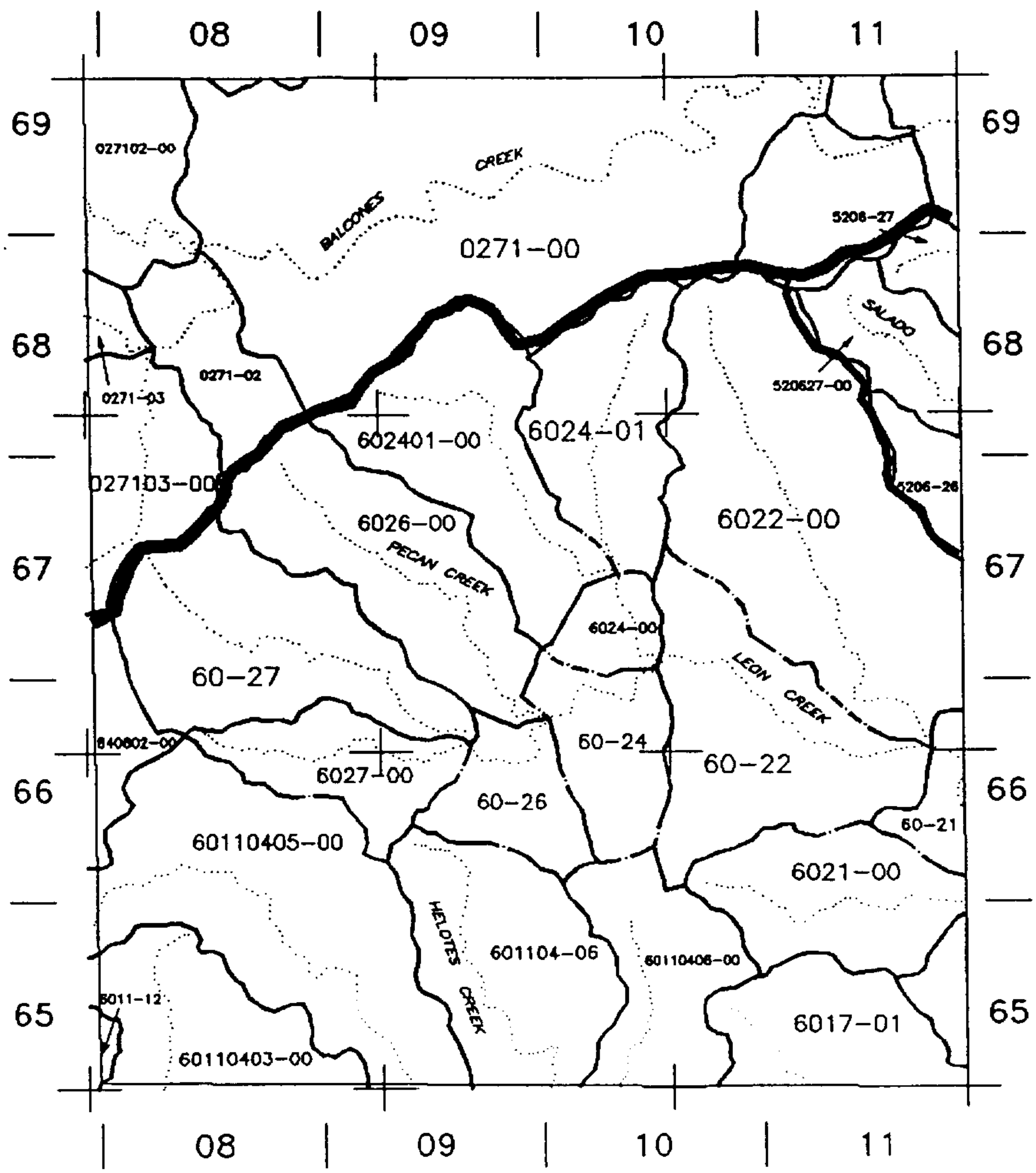
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = F6



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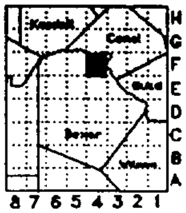
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 21

Map Name Bulverde

Scale 1:100,000

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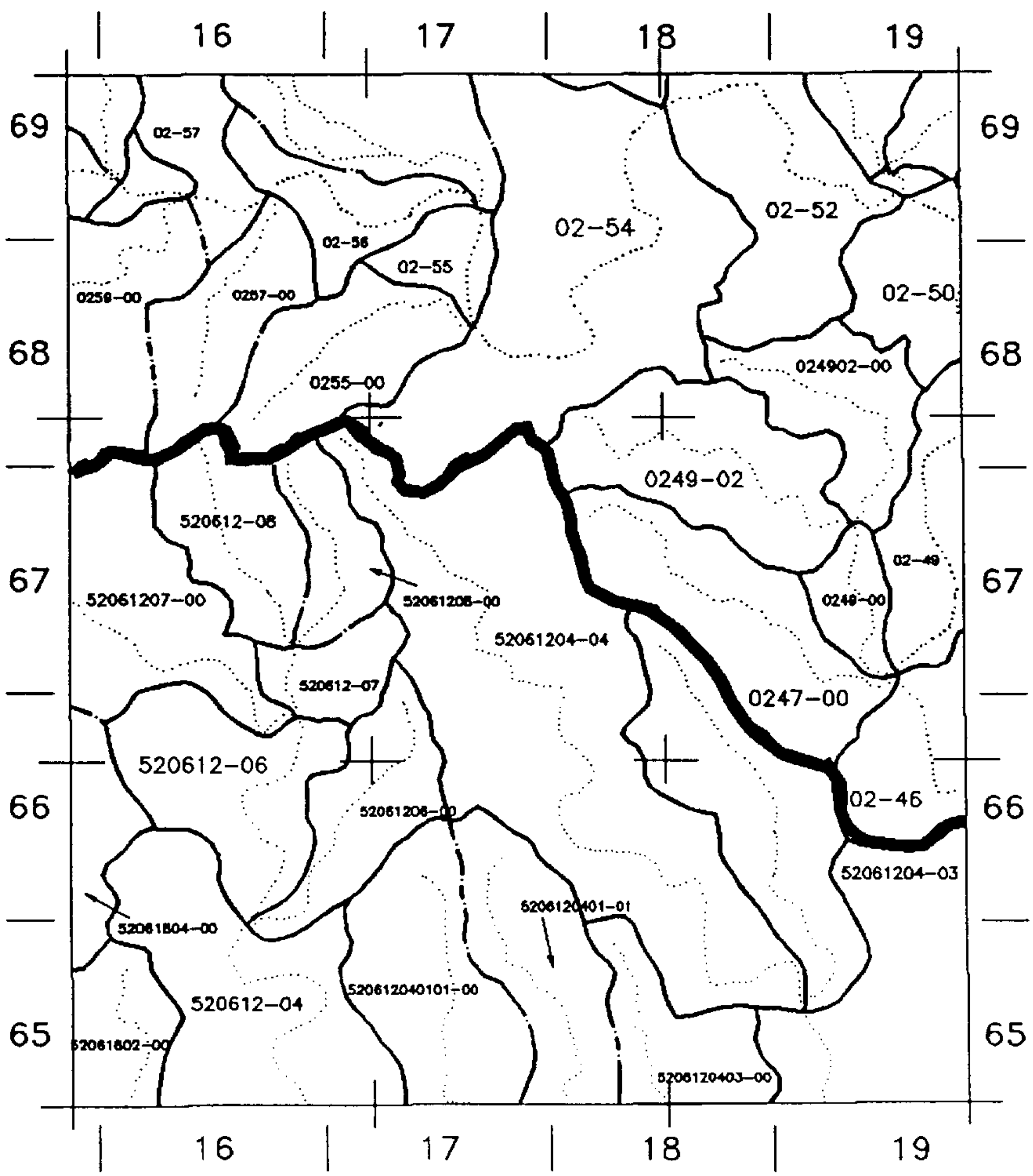
Latitude = 29

Longitude = 98

7.5' Area = F4



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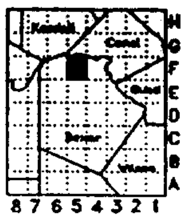
C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



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7	8	9

7.5 Minute Area

Water Well ID 68- 20

Map Name Camp Bullis

Scale 1:100,000

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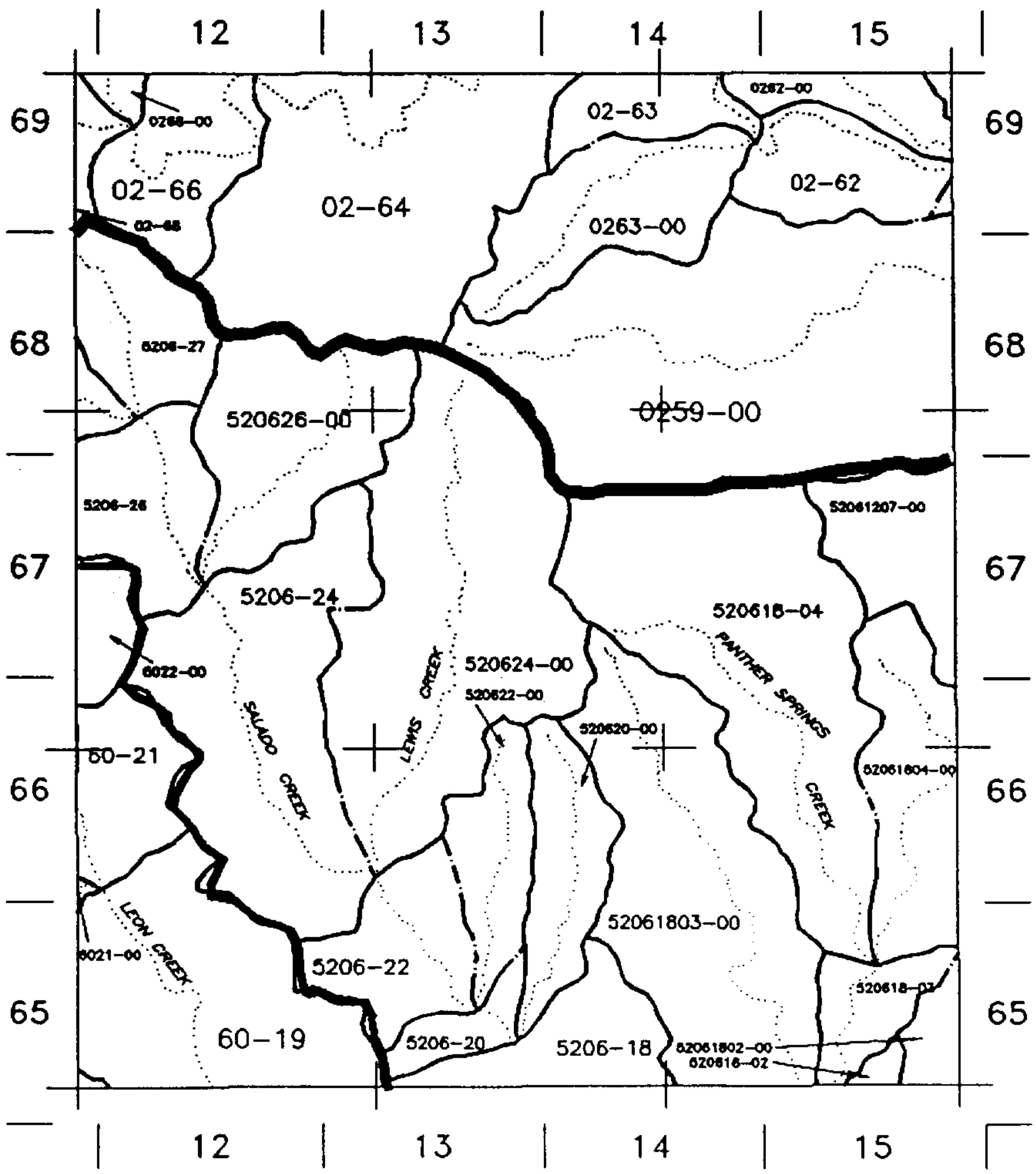
SCALE (MILES)

Latitude = 29

Longitude = 98

7.5' Area = F5



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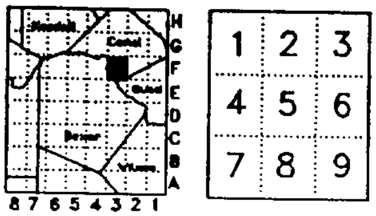
LAND AND WATER RESOURCES CONSULTANT



7.5 Minute Area

Water Well ID 68- 22

Map Name Bat Cave

Scale 1:100,000

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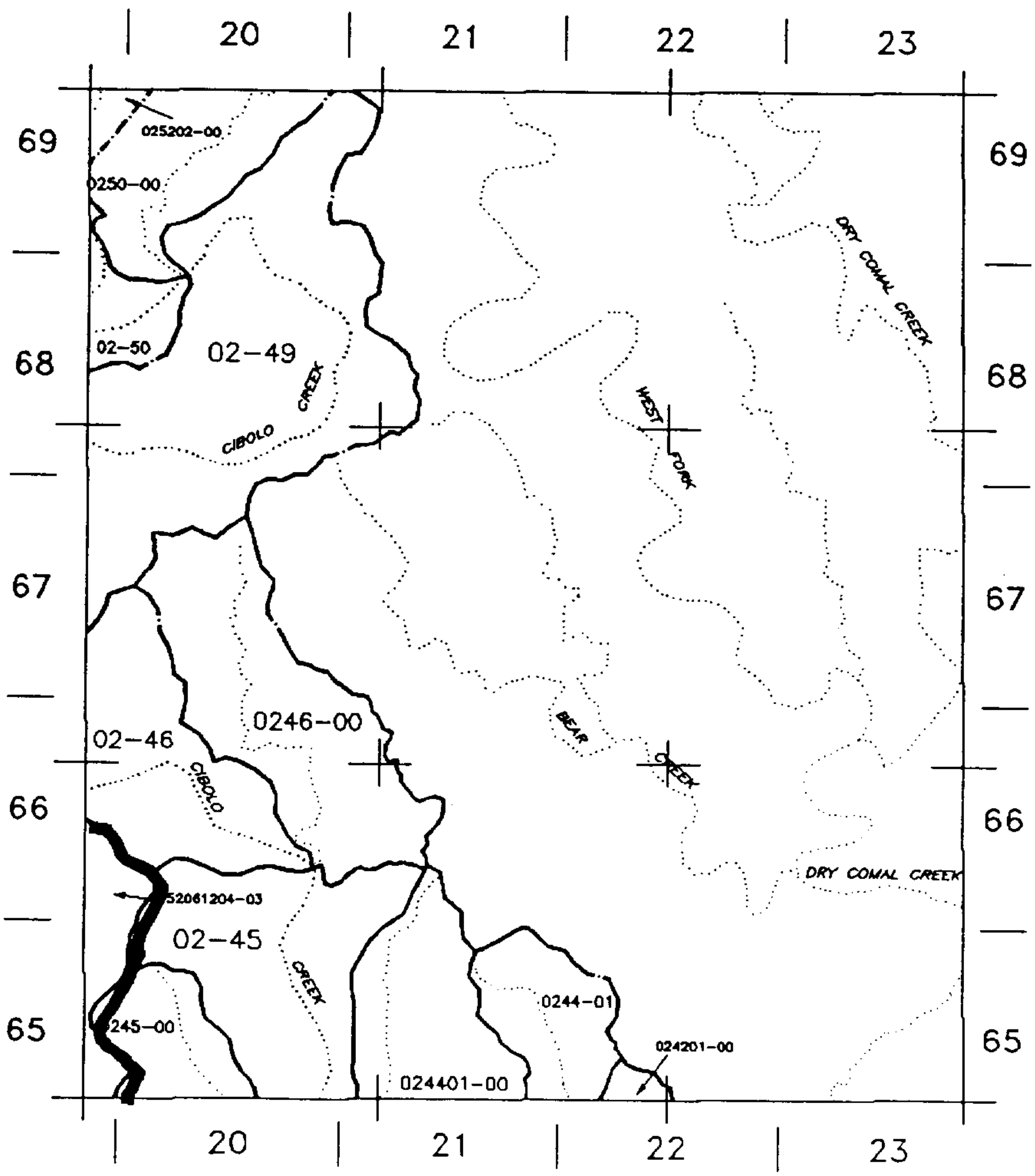
Longitude = 98

7.5' Area = F3



GAE 1/29/93 044F3COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

7.5 Minute Area

Water Well ID 68- 28

Map Name CASTLE HILLS

Scale 1:100,000

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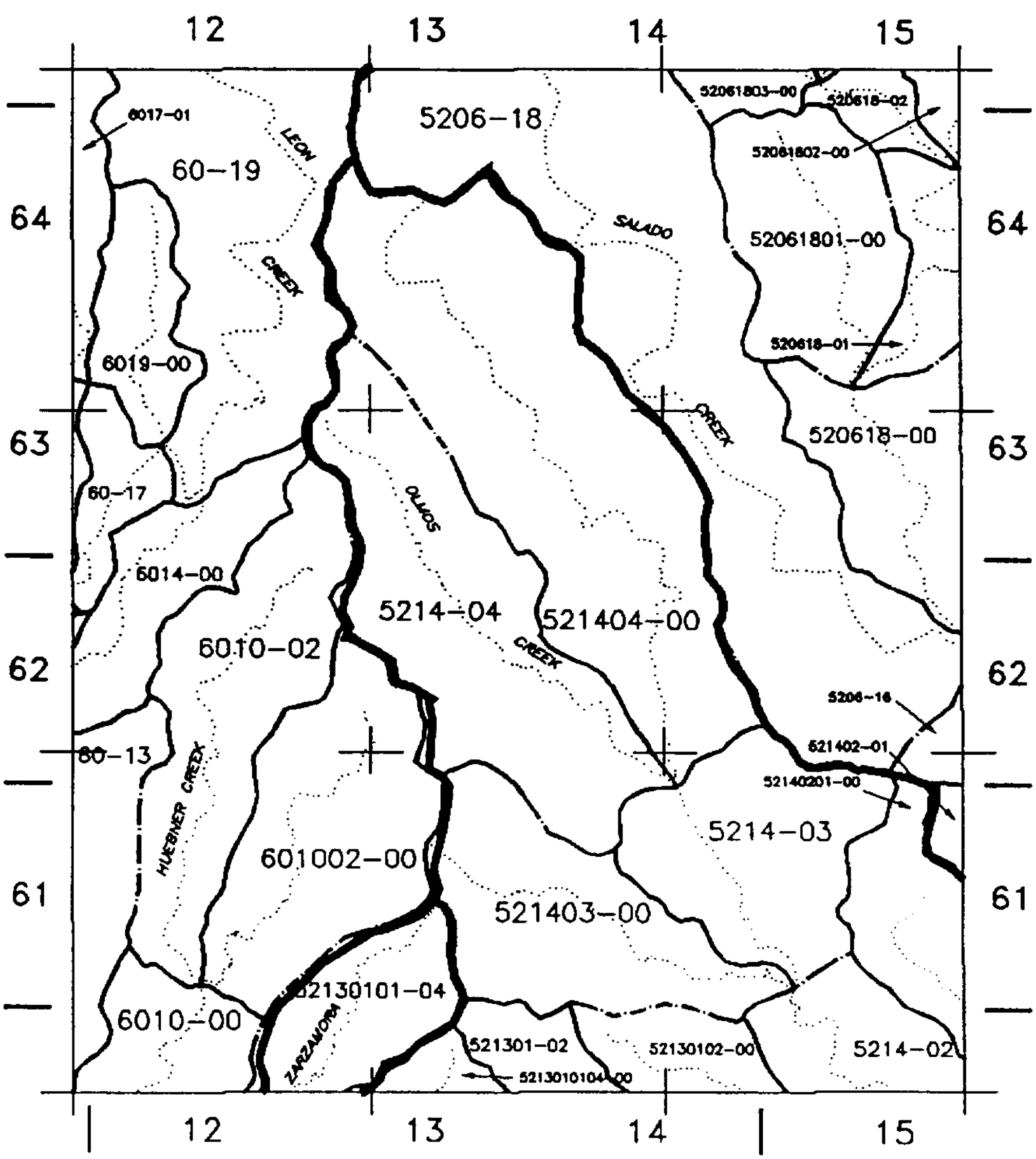
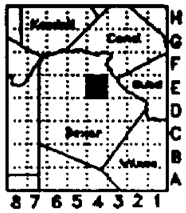
Longitude = 98

7.5' Area = E5



GAE 1/29/93 44E5COMP.DWG

C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT



1	2	3
4	5	6
7	8	9

7.5 Minute Area

Water Well ID 68- 29

Map Name LONGHORN

Scale 1:100,000

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SCALE (MILES)

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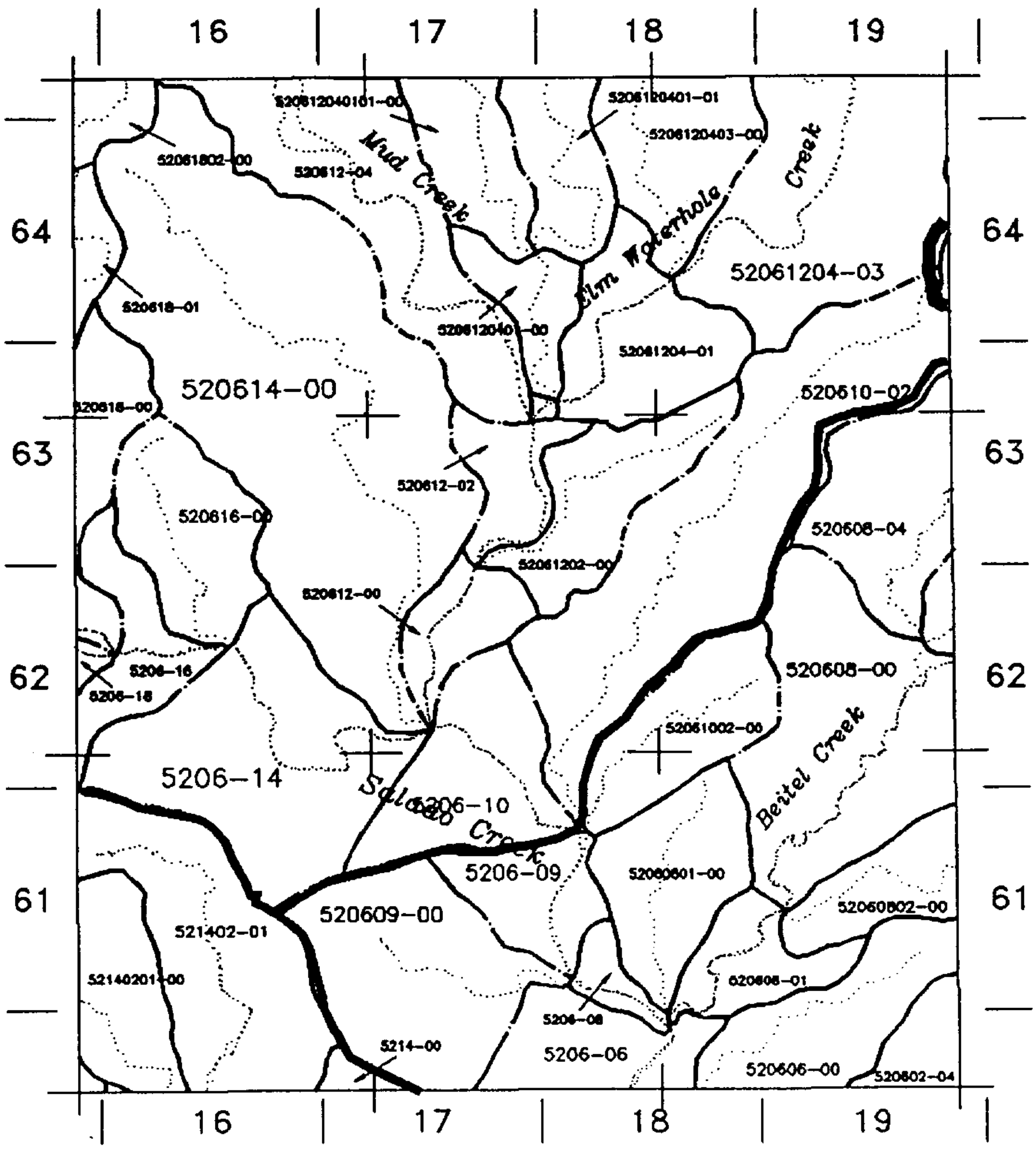
Latitude = 29

Longitude = 98

7.5' Area = E4



C. THOMAS KOCH, INC.
LAND AND WATER RESOURCES CONSULTANT

Report file: q_sws_B
Page 2 1/28/93 7:21:02 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : F-6

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206270000- 0	918	1	3	4	4	9
Upper Salado	5206000000-27	275	1	2	3	3	5
Upper Salado	5206000000-26	367					1
Upper Salado		1,561	2	5	7	7	15

Report file: q_sws_B
Page 5   1/28/93 7:21:02 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : F-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206260000- 0	1,653					
Upper Salado	5206240000- 0	4,040	1	1	1	1	
Upper Salado	5206220000- 0	918					
Upper Salado	5206200000- 0	826					
Upper Salado	5206180400- 0	1,561	2	1	1	1	2
Upper Salado	5206180300- 0	3,306	3	3	3	1	9
Upper Salado	5206180200- 0	643					22
Upper Salado	5206180000- 4	3,489	7	6	6	7	6
Upper Salado	5206180000- 3	643	3	3	3	3	2
Upper Salado	5206120700- 0	1,286	4	3	4	4	4
Upper Salado	5206000000-27	735					1
Upper Salado	5206000000-26	1,010					0
Upper Salado	5206000000-24	2,938					
Upper Salado	5206000000-22	735					0
Upper Salado	5206000000-20	459					
Upper Salado	5206000000-18	1,469					2
Upper Salado		25,712	20	17	18	17	48

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : F-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206180400- 0	92					1
Upper Salado	5206180200- 0	551					17
Upper Salado	5206120800- 0	643					0
Upper Salado	5206120700- 0	1,102				1	7
Upper Salado	5206120600- 0	826	3	3	3	3	5
Upper Salado	5206120404- 0	2,020					1
Upper Salado	5206120403- 0	1,194					0
Upper Salado	5206120401- 0	3,306	4	4	4	5	13
Upper Salado	5206120400- 4	4,775	11	13	14	14	28
Upper Salado	5206120400- 3	2,388	1	4	6	7	9
Upper Salado	5206120000- 4	2,663					
Upper Salado		19,559	19	24	27	30	81

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Page 9   1/28/93 7:21:06 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : F-3

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206120400- 3	92					0
Upper Salado		92					0

Report file: q_sws_B
Page 15 1/28/93 7:22:21 pm

TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-5

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206180200- 0	92					8
Upper Salado	5206180100- 0	1,745	6	6	8	8	67
Upper Salado	5206180000- 2	367		1	1	1	13
Upper Salado	5206180000- 1	918	18	17	17	18	57
Upper Salado	5206180000- 0	1,653	12	11	16	15	100
Upper Salado	5206000000-18	5,969	235	270	395	412	1,088
Upper Salado	5206000000-16	275	40	43	44	44	44
Upper Salado		11,019	311	348	481	498	1,377

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TOTAL BUSINESS CONNECTIONS
1976-1988
7.5' Area : E-4

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206180000- 0	184	1	1	1	1	2
Upper Salado	5206160000- 0	1,102	53	63	63	76	229
Upper Salado	5206140000- 0	5,877	125	142	153	176	592
Upper Salado	5206120403- 0	643	1	1	1	1	1
Upper Salado	5206120401- 0	1,745	6	10	8	10	20
Upper Salado	5206120400- 3	2,020	9	12	12	12	86
Upper Salado	5206120400- 1	735	5	1	5	5	24
Upper Salado	5206120400- 0	459	3	4	5	4	6
Upper Salado	5206120200- 0	1,102	4	4	13	126	31
Upper Salado	5206120000- 4	1,561	6	6	6	5	41
Upper Salado	5206120000- 2	551	2	3	5	6	53
Upper Salado	5206120000- 0	643	2	2	3	3	3
Upper Salado	5206100200- 0	918	175	194	232	283	555
Upper Salado	5206100000- 2	2,938	38	40	44	52	210
Upper Salado	5206000000-16	643	230	244	255	256	295
Upper Salado	5206000000-14	2,296	170	187	196	210	368
Upper Salado	5206000000-10	1,286	41	55	111	144	291
Upper Salado		24,702	871	969	1,113	1,370	2,807

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206270000- 0	918	1	3	4	4	9
Upper Salado	5206260000- 0	1,653					
Upper Salado	5206240000- 0	4,040	1	1	1	1	
Upper Salado	5206220000- 0	918					
Upper Salado	5206200000- 0	826					
Upper Salado	5206180400- 0	1,653	2	1	1	1	3
Upper Salado	5206180300- 0	3,306	3	3	3	1	9
Upper Salado	5206180200- 0	1,286					47
Upper Salado	5206180100- 0	1,745	6	6	8	8	67
Upper Salado	5206180000- 4	3,489	7	6	6	7	6
Upper Salado	5206180000- 3	643	3	3	3	3	2
Upper Salado	5206180000- 2	367		1	1	1	13
Upper Salado	5206180000- 1	918	18	17	17	18	57
Upper Salado	5206180000- 0	1,837	13	12	17	16	102
Upper Salado	5206160000- 0	1,102	53	63	63	76	229
Upper Salado	5206140000- 0	5,877	125	142	153	176	592
Upper Salado	5206120800- 0	643					0
Upper Salado	5206120700- 0	2,388	4	3	4	5	11
Upper Salado	5206120600- 0	826	3	3	3	3	5
Upper Salado	5206120404- 0	2,020					1
Upper Salado	5206120403- 0	1,837	1	1	1	1	1
Upper Salado	5206120401- 0	5,051	10	14	12	15	33
Upper Salado	5206120400- 4	4,775	11	13	14	14	28
Upper Salado	5206120400- 3	4,500	10	16	18	19	95

TOTAL BUSINESS CONNECTIONS
1976-1988

Watershed	Stream Segment	Acres	1976 BUS	1977 BUS	1979 BUS	1980 BUS	1988 BUS
Upper Salado	5206120400- 1	735	5	1	5	5	24
Upper Salado	5206120400- 0	459	3	4	5	4	6
Upper Salado	5206120200- 0	1,102	4	4	13	126	31
Upper Salado	5206120000- 4	4,224	6	6	6	5	41
Upper Salado	5206120000- 2	551	2	3	5	6	53
Upper Salado	5206120000- 0	643	2	2	3	3	3
Upper Salado	5206100200- 0	918	175	194	232	283	555
Upper Salado	5206100000- 2	2,938	38	40	44	52	210
Upper Salado	5206000000-27	1,010	1	2	3	3	6
Upper Salado	5206000000-26	1,377					1
Upper Salado	5206000000-24	2,938					
Upper Salado	5206000000-22	735					0
Upper Salado	5206000000-20	459					
Upper Salado	5206000000-18	7,438	235	270	395	412	1,090
Upper Salado	5206000000-16	918	270	287	299	300	339
Upper Salado	5206000000-14	2,296	170	187	196	210	368
Upper Salado	5206000000-10	1,286	41	55	111	144	291
Upper Salado		82,645	1,223	1,363	1,646	1,922	4,328

9-483-722

9-483-722
Tech V-9

PROJECT CONTROL

PROJECT CONTROL
3427 Northeast Parkway
San Antonio, Texas 78218

BEXAR COUNTY

WATER SUPPLY PROJECTS

August 1990

Advisory Technical Water Committee
(Greater San Antonio Metropolitan Area)

Independent
Project Management
Consultants

INDEX

Project Control of Texas

Kenneth R. Rector
PRESIDENT

August 10, 1990

The Honorable Weir Labatt
Councilman
100 Military Plaza
San Antonio, Texas 78205

Re: Advisory Technical Water Committee
Preliminary Report

Dear Weir:

Enclosed please find the Final Report (August 1990) for recommended future water supply projects.

The City Water Board, City Public Service, City of San Antonio, The Alamo Conservation and Reuse District, large private well owners, Bexar County Water Purveyors, and members of the local engineering community participated in the preparation of this report.

We have studied all relevant projects presented in previous reports including the San Antonio Water Resource Study (1986), The Edwards Aquifer: Perspectives for Local and Regional Action (1987), The Regional Water Plan (1988), The Water Management Plan Using Braunig and Calavaras Lakes (1990), and Texas Water Development Board Studies (1989 and 1990).

The unanimous opinion of the committee is the immediate need to vigorously pursue concurrently the four projects listed for completion prior to the year 2010 and the projects listed for completion after 2010 and before 2040.

Very truly yours,

Kenneth R. Rector
Committee Moderator

KRR:je

Enclosure

3427 Northeast Parkway ▪ San Antonio, Texas 78218-3329 ▪ (512) 824-4308

BEXAR COUNTY

TECHNICAL WATER PLANNING COMMITTEE

PROJECT DIRECTORY

REPRESENTING:

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San Antonio, Texas 78283-3966

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Councilman
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Telephone: 922-5133 FAX: 924-9229

CIBOLO CREEK MUNICIPAL AUTHORITY:

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VICKREY & ASSOCIATES:	**Mr. Ken Vickrey** 7334 Blanco Road, Suite 109 San Antonio, Texas 78216 Telephone: 349-3271 FAX: 349-2561
LEE WILSON & ASSOCIATES:	**Mr. Lee Wilson** 105 Cienega St. P. O. Box 931 Santa Fe, New Mexico 87504 Telephone: 505/988-9811 FAX: 505/986-0092

ASSUMPTIONS

A. The Applewhite Reservoir will be completed and in operation by 1995. It provides an essential component of the surface and ground water system to serve the Greater San Antonio Metropolitan Area (GSAMA) by providing storage, treatment and distribution capability for this and other water projects.

B. The planning period used for this report is the 50-year period from 1990 to 2040.

C. The amount of water that is presently being pumped from the Edwards Aquifer by wells located in GSAMA for both potable and non-potable use is approximately 325,000 acre feet per year. In addition, approximately 40,000 acre feet per year of non-potable water is being provided by surface water and reuse.

D. The Edwards Aquifer will become subject to regulation which establishes a maximum amount of water that can be pumped from the Aquifer by wells located in GSAMA. The report assumes a reduction from the Aquifer to 300,000 acre feet per year by the year 2010.

E. The Texas Water Development Board projects that the water demand in Bexar County by the year 2040 will be approximately 670,000 acre feet per year, which is an additional 330,000 acre feet per year. The water demand projected for the year 2010 is 413,000 acre feet per year, which is an additional 73,000 acre feet per year. These projections are based upon a high population growth rate, average per capita use and the existence of conservation measures (TWDB Study dated November 20, 1989).

F. Yield and cost figures are provided by the Texas Water Development Board (TWDB Unit Cost Comparison for Alternative Water Supplies for Bexar County dated May 1990). Cost estimates should not be relied upon for individual project costs but are for comparison purposes to be used in identifying the most promising means for additional water sources.

CONCLUSIONS

A. The Greater San Antonio Metropolitan Area (GSAMA) cannot continue to rely upon the Edwards Aquifer as its primary source of water for potable and non-potable use.

B. Additional water sources are essential for the continued economic development of GSAMA.

C. Adequate water sources for GSAMA are available and feasible for immediate development through the year 2010 from the following:

1. Conservation lifestyle
2. Reuse waste water for potable and non-potable uses
3. Additional surface water
4. Additional ground water

D. It is imperative that the water projects and engineering studies recommended be pursued by GSAMA vigorously and without delay to provide an adequate water supply.

RECOMMENDATIONS

The following projects are recommended for immediate and concurrent implementation:

A. Average per capita consumption in GSAMA must be reduced through conservation measures to 165 metered gallons per person per day.

B. Waste Water Reuse:

   1. Develop 50,000 acre feet of reuse water. The first uses of this water will be non-potable with a transition and testing period for potable uses.

   2. Increase the yield of surface reservoirs, including Applewhite, by acceptance of upstream discharges.

C. Medina Canal Water (Bexar/Medina/Atascosa Irrigation District): Acquire 15,000 acre feet per year.

D. Carrizo Wilcox Aquifer Wells: Pump 40,000 acre feet per year into the San Antonio finished water distribution system.

E. Garwood/Texana: Obtain rights to 45,000 acre feet per year.

F. Begin engineering studies and permitting process for the following projects to be on line prior to the year 2040.

   1. Additional Reuse

   2. Cuero I

   3. Lindenau

   4. Goliad

G. Summary Table of Projects Recommended for Immediate Development. (Costs from the Texas Water Development Board Report dated May 1990)

Project	Yield Acre/Ft/Yr.	Cost $/Acre/Ft.	Total Annualized Cost
Reuse I	50,000	$292	$14,600,000
Medina Canal	15,000	$273	$ 4,095,000
Carrizo Wells	40,000	$310	$12,400,000
Garwood/Texana	45,000	$428	$19,260,000
SUB TOTAL (immediate development)	150,000		$50,355,000

H. Summary of Projects Recommended for Long Range Development:

1. Reuse II: Additional 50,000 acre feet per year of reuse; costs the same as listed above.

2. Cuero I, Lindenau and Goliad should all be pursued. It is assumed all will be constructed for regional water distribution with GSAMA sharing to a projected need of 130,000 acre feet per year at an average cost in the area of about $500 per acre foot; or, one or two will be constructed to provide the same result.

I. <u>1990 Current Rates</u> (present rates for 1,500 cubic feet of water per person per month):

San Antonio	$12.37 + $2.40 for Applewhite
Austin	$26.30
Corpus Christi	$16.91
Dallas	$14.41
Fort Worth	$22.25
Houston	$27.37

The costs for water in the years 2010 and 2040 in GSAMA will still be less than other major metropolitan areas in the state of Texas.

RELATIVE COSTS OF TREATED WATER DELIVERED TO BEXAR COUNTY UTILITY DISTRIBUTION SYSTEMS

	ALTERNATIVE	YIELD (AC-FT/YR)	COST ($/1000 GAL)	COST ($/AC-FT)	VIABILITY	WATER RIGHTS (YEARS)	CONSTRUCTION & LEAD TIME (YEARS)	INTERACTION WITH OTHER PROJECTS
1.	Applewhite Reservoir (Average Yield)	48,000	$1.15	$376.17	1 – A	0	5	
2.a)	Purchase of Medina Irrigation Water	15,000	$0.84	$272.55	1 – A	2	2	1.
3.a)	Transfer of Water by Pipeline to San Antonio from Town Lake or Lake Travis (LCRA)	50,000	$1.32	$428.30	1 – A	2	5	
3.b)	Pumpover from Lake Travis to Canyon Reservoir, with Recapture at McQueeny Lake (LCRA)	50,000	$1.34	$434.79	1 – A	2	5	
*4.	Purchase of Texas Water Development Board share of Texana Reservoir, and Conveyance to San Antonio	43,000	$1.89	$613.25	1 – A	2	5	
*5.	Purchase of Water from Garwood Irrigation District	30,000	$1.32	$428.30	1 – A	2	5	4.
**6.	Carrizo-Wilcox Aquifer Wells Pumping to the San Antonio Finished Water Distribution System	40,000	$0.95	$309.56	1 – A	1-5	2	
***7.	Canyon Lake Reservoir	5,000	N/A	N/A	1 – A	1-2	5	
8.a)	Western Region Reuse	4,000	N/A	N/A	1 – A	1-2	5	1.
9.a)	Edwards Aquifer – Obtain Additional Rights		N/A	N/A	1 – A	1-2	0	2.a)
9.b)	Edwards Aquifer – Purchase of 1 – 10 ac. in Uvalde County, West of Knippa Gap	80,000	$0.50	$162.70	1 – A	1-2	2	
****10.a)	Wastewater Reuse (20K ac-ft:nonpotable)	20,000	$0.90	$292.02	1 – A	0	1-5	1.
****10.b)	Wastewater Reuse (30K ac-ft:nonpotable/potable)	30,000	$0.90	$292.02	1 – A	0	1-5	
2.b)	Purchase of Medina Lake & Recharge	15K – 30K	$0.84	$272.55	1 – B	2	2	9.a)
****10.c)	Wastewater Reuse (2nd 50K ac-ft)	50,000	$0.90	$292.02	1 – B	0	1-5	
8.b)	Eastern Region Reuse	5,000	N/A	N/A	1 – B	1-2	5	
11.	Cuero I Reservoir	141,000	$1.49	$483.46	1 – B	1-5	18	
12.	Goliad without Cibolo Reservoir, Including a Conveyance System from Goliad to Applewhite	148,000	$1.48	$480.22	1 – B	1-5	18	1.
13.	Lindenau Reservoir	107,000	$1.83	$593.78	1 – B	1-5	18	

N/A – Information not available.

* With a firm contract for water rights from one or both of these alternatives, there would be a possibility of contracting with GBRA to trade for Canyon downstream rights. It is assumed that between these 2 projects, 45,000 ac-ft/yr would be available to GSAWA.

** The 40,000 ac-ft/yr yield from Carrizo-Wilcox Aquifer would require approximately 2,000 – 3,000 acres of land and could be brought on line in increments of 5,000 ac-ft/yr.

*** Canyon Regional Water Authority presently in negotiations.

**** Reuse projects are based on the current availability of 100,000 ac-ft/yr of effluent which could increase by another 50,000 ac-ft/yr by the year 2040.

VIABILITY KEY

1 – Feasible   A – Before the year 2000
2 – Questionable   B – After the year 2000

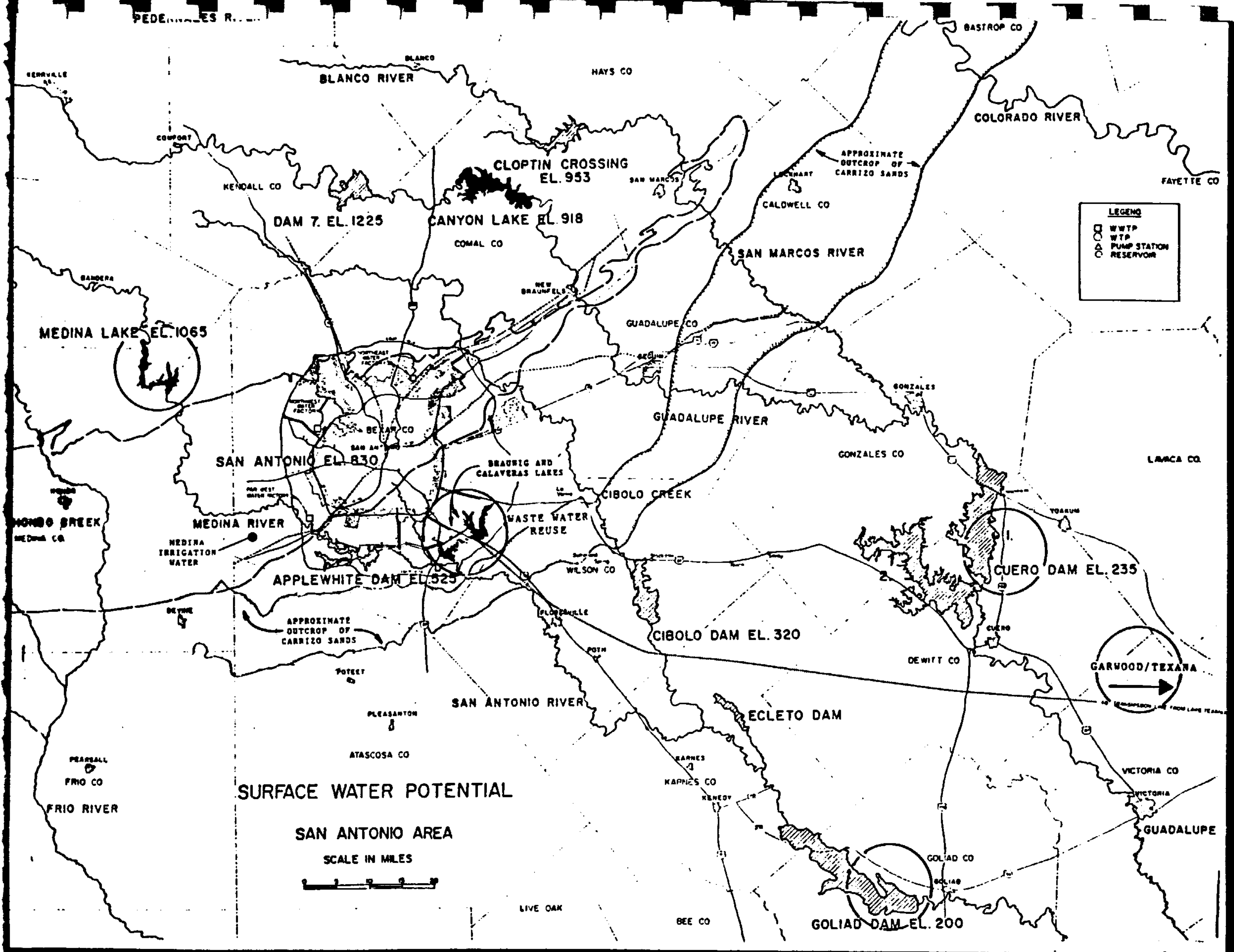
NOTE: Total time for project implementation is the sum of "WATER RIGHTS" and "CONSTRUCTION & LEAD TIME"

PROJECTS CONSIDERED BUT SUBSEQUENTLY DELETED

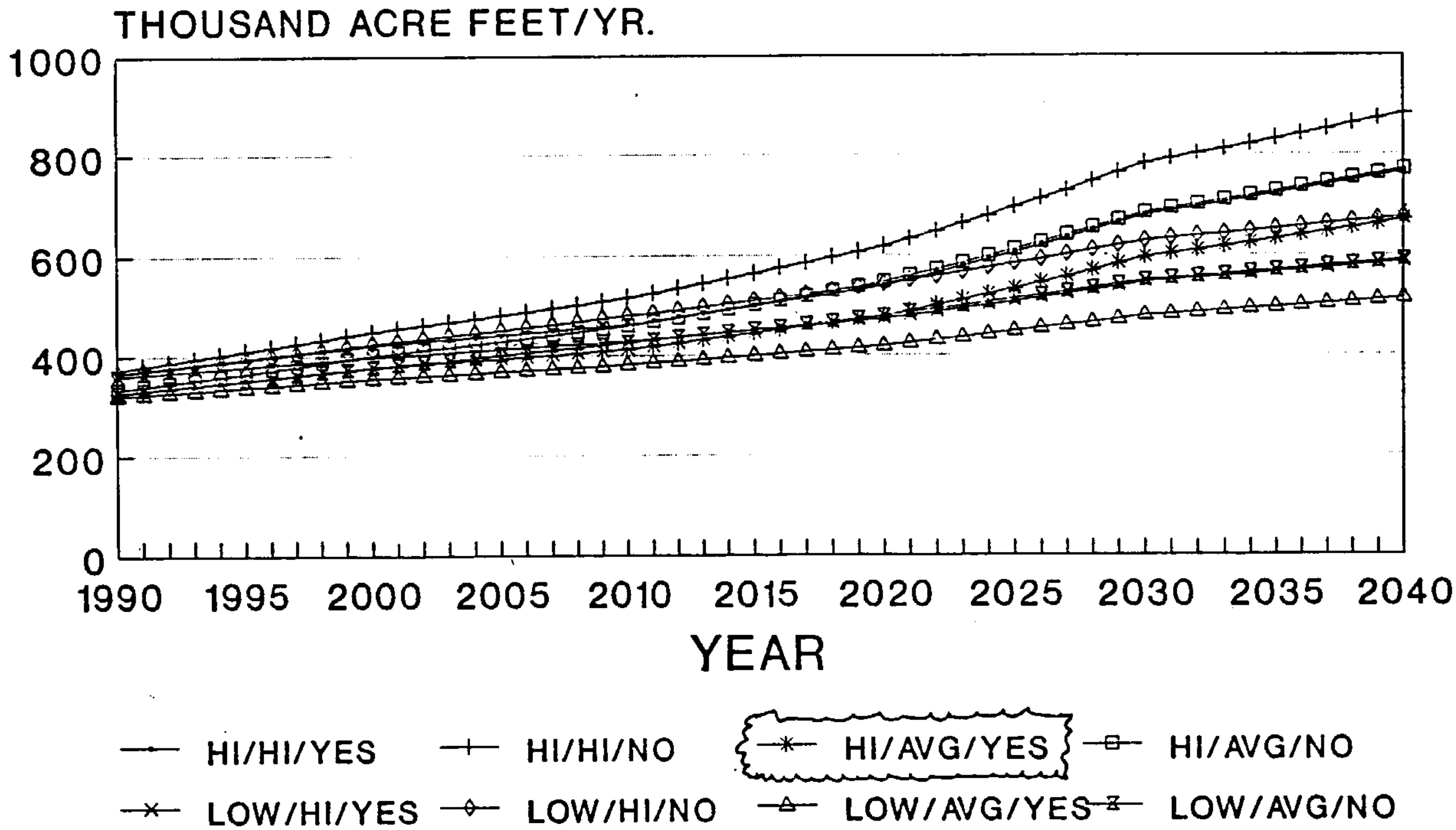
ALTERNATIVE	YIELD (AC-FT/YR)	COST ($/1000 GAL)	COST ($/AC-FT)	VIABILITY
Cibolo Reservoir (Lower)	25,000	$3.78	$1,226.50	2 - B
Cibolo Reservoir (Upper)				2 - B
Cibolo and Goliad Reservoirs Combined (With Diversion at Cibolo and Goliad Used to Meet Downstream Needs)	173,000	$1.80	$584.05	2 - B
Transfer of Water From Lake Travis to Canyon Reservoir, Recapture at Cuero Reservoir	50,000	$1.25	$405.59	2 - B
Transfer from Town Lake to the Blanco River with Recapture at Cuero Reservoir	50,000	$1.08	$350.43	2 - B
Cloptin Crossing Reservoir	43,000	$1.84	$597.02	2 - B
Shaws Bend Reservoir	123,000	$1.82	$590.54	2 - B
Diversion of Surface Water from Cibolo Creek (CIB E-1)	3,000		$200.00	1 - A
Guadalupe River	Recharge			2 - B

VIABILITY KEY

1 - Feasible A - Before the year 2000
2 - Questionable B - After the year 2000


BLANCO RIVER
HAYS CO
BASTROP CO
COLORADO RIVER
FAYETTE CO
CLOPTIN CROSSING
EL. 953
CANYON LAKE EL. 918
DAM 7. EL. 1225
KENDALL CO
COMAL CO
NEW BRAUNFELS
SAN MARCOS
LOCKHART
CALDWELL CO
APPROXIMATE OUTCROP OF CARRIZO SANDS
SAN MARCOS RIVER
LEGEND
WWTP
WTP
PUMP STATION
RESERVOIR
MEDINA LAKE EL. 1065
GUADALUPE CO
GONZALES
GUADALUPE RIVER
GONZALES CO
LAVACA CO
SAN ANTONIO EL. 830
BEXAR CO
BRAUNIG AND CALAVERAS LAKES
CIBOLO CREEK
WASTE WATER REUSE
MEDINA RIVER
MEDINA IRRIGATION WATER
MEDINA CO
APPLEWHITE DAM EL. 525
WILSON CO
YOAKUM
CUERO DAM EL. 235
CUERO
CIBOLO DAM EL. 320
DEWITT CO
GARWOOD/TEXANA
APPROXIMATE OUTCROP OF CARRIZO SANDS
POTEET
SAN ANTONIO RIVER
ECLETO DAM
PLEASANTON
ATASCOSA CO
KARNES
KARNES CO
KENEDY
VICTORIA CO
VICTORIA
GUADALUPE
PEARSALL
FRIO CO
FRIO RIVER
SURFACE WATER POTENTIAL
SAN ANTONIO AREA
SCALE IN MILES
0
5
10
15
20
GOLIAD CO
GOLIAD
LIVE OAK
BEE CO
GOLIAD DAM EL. 200

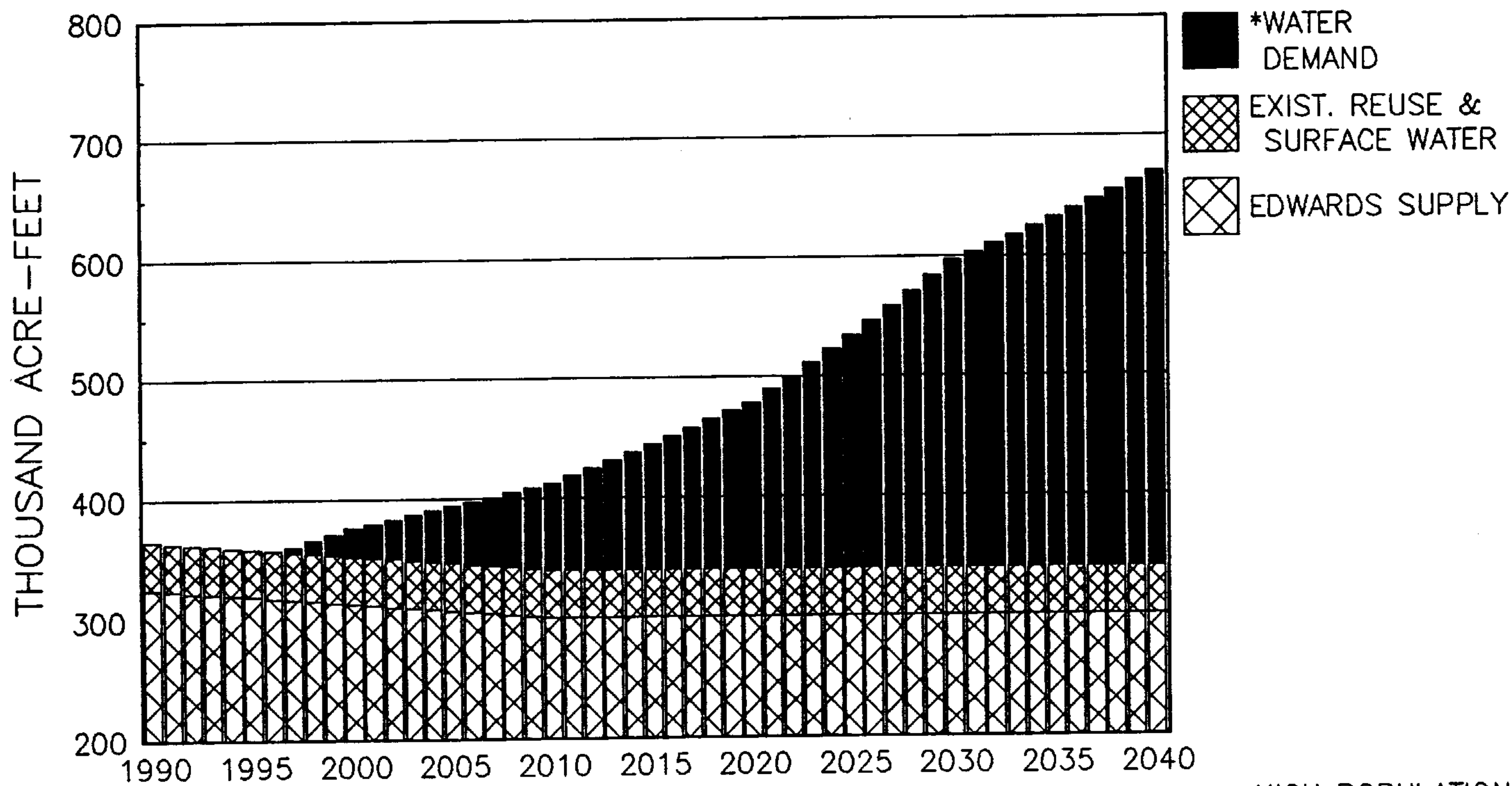
WATER DEMAND PROJECTIONS
BEXAR COUNTY



CPS JUNE 1990

POP/USE/CONSERVATION

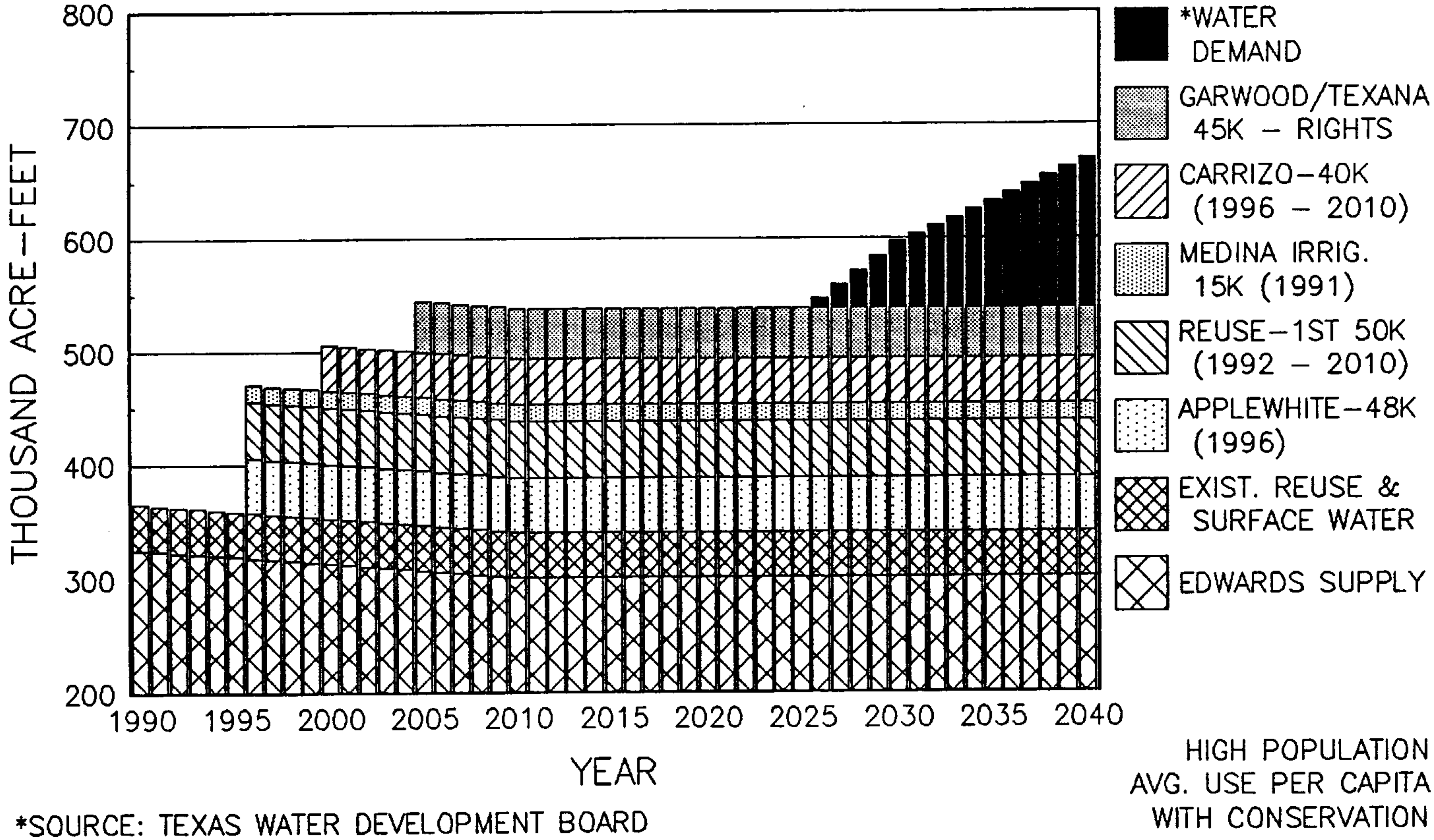
GREATER SAN ANTONIO METROPOLITAN AREA
WATER DEMAND PROJECTIONS
AND SUPPLY SOURCES



HIGH POPULATION
AVG. USE PER CAPITA
WITH CONSERVATION

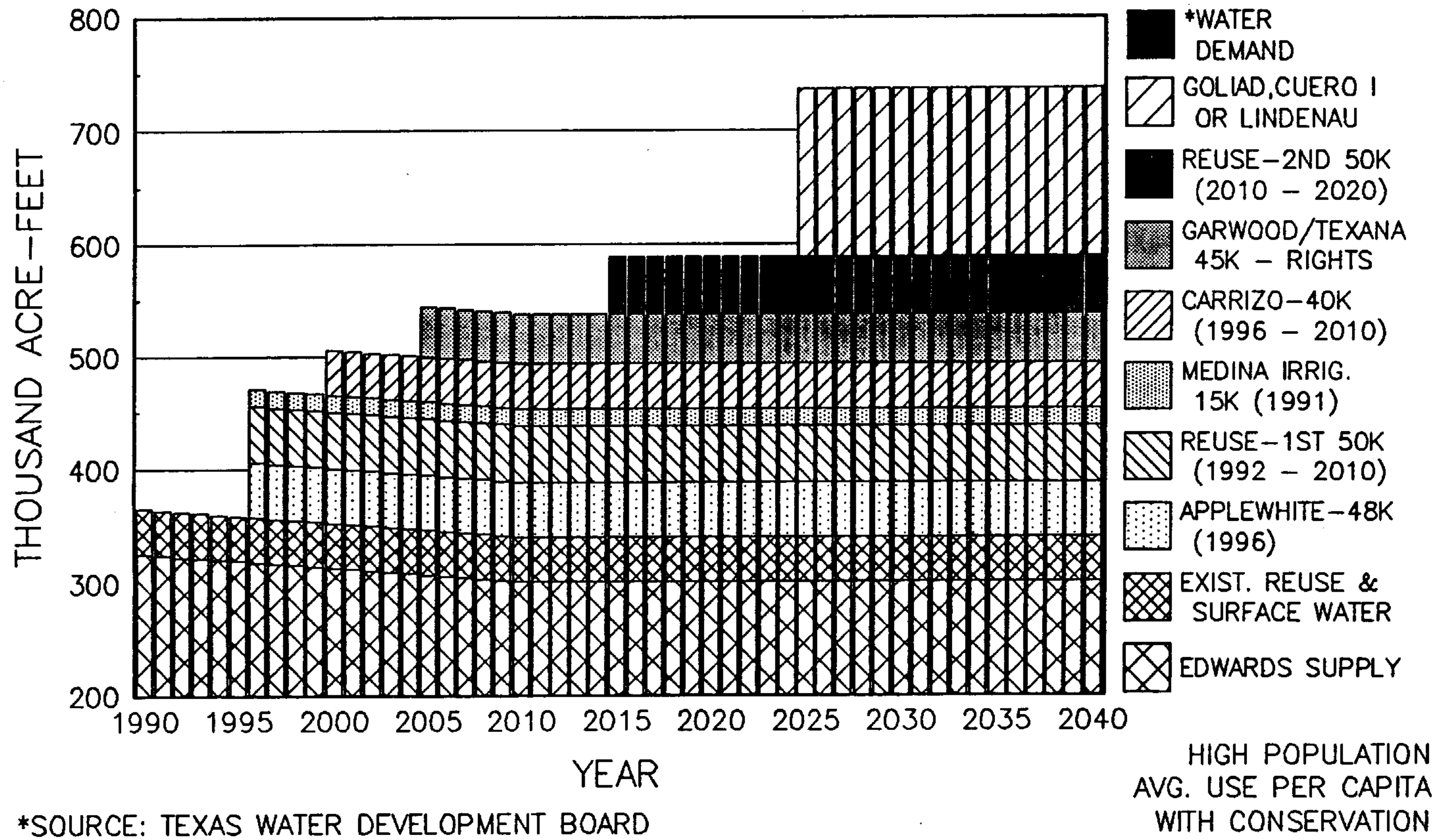
*SOURCE: TEXAS WATER DEVELOPMENT BOARD

GREATER SAN ANTONIO METROPOLITAN AREA
WATER DEMAND PROJECTIONS
AND SUPPLY SOURCES THROUGH THE YEAR 2010



*SOURCE: TEXAS WATER DEVELOPMENT BOARD

GREATER SAN ANTONIO METROPOLITAN AREA
WATER DEMAND PROJECTIONS
AND SUPPLY SOURCES THROUGH THE YEAR 2040



*SOURCE: TEXAS WATER DEVELOPMENT BOARD

TEXAS WATER DEVELOPMENT BOARD

May 17, 1990

Commissioner J. E. Birdwell, II
Texas Water Commission
P. O. Box 12037
Capitol Station
Austin, Texas 78711

Re: Unit Costs for San Antonio Water Supply Alternatives

Dear Commissioner Birdwell:

We have prepared a brief report, which is attached, identifying a number of alternatives for additional water supplies to the Bexar County area, including preliminary relative unit cost figures for each alternative. Also in the report is one of many possible scenarios for meeting water demands and stabilizing Edwards Aquifer pumpage. This is provided as an example only, and should not be considered an Agency recommendation.

As the report states, these are preliminary, relative numbers, and should not be used for engineering planning for specific projects.

I trust this information will be useful to you. If we can be of further assistance, please let me know.

Sincerely,

/s/

G. E. Kretzschmar
Executive Administrator

Attachment

P. O. Box 13231 Capitol Station • 1700 N. Congress Avenue • Austin, Texas 78711-3231
Telephone 512/463-7847 • Telefax 512/475-2053

UNIT COST COMPARISONS FOR ALTERNATIVE WATER SUPPLIES FOR BEXAR COUNTY
Prepared by Texas Water Development Board
Planning Division, Facility Needs Section
May, 1990

I. EXECUTIVE SUMMARY

A preliminary review of the costs and availability of additional water supplies for Bexar County indicates that sufficient supplies can be made available through a balanced program of conservation and wastewater reuse along with the implementation of alternatives that could include additional ground-water sources, new reservoirs and diversions from adjoining basins, which will satisfy area water demand and permit net ground water pumpage from the Edwards Aquifer to be stabilized at approximately 200,000 acre-feet per year. Preliminary cost data indicates that the unit cost of treated water, supplied through a combination of alternatives, will increase dramatically, but will remain in the range of costs which are currently experienced by similar urban areas which must rely on surface water. Cost estimates developed for this report are very preliminary, and, while sufficient for relative comparison with other alternatives, should not be relied upon for estimating costs for specific projects. Instead, they are intended to be used as guidelines to identify the most promising means for additional water supply, so that institutional, financial, and engineering planning for a coordinated solution to the water supply problems in this urban county can be completed.

II. BACKGROUND

Numerous studies and reports on water supply in Bexar County have all concluded that alternative water supplies must be identified and developed as soon as possible, so as to avoid irreversible and serious damage to the environmental features of the San Antonio area, as well as serious economic impacts. The CH2M Hill report, San Antonio Regional Water Resources Study, (1986), is perhaps the latest and most comprehensive of studies in this regard. Much of the data used to develop this summary report came from this study, and from Espey Huston and Associates, report on Water Availability Study for the Guadalupe and San Antonio River Basins, (1986), as well as information found in the United States Bureau of Reclamation's Study of the San Antonio-Guadalupe River Basins, (1978). The purpose of this summary report is: (1) to identify options available to supply additional water to the Bexar County area, regardless of institutional or contractual barriers to their implementation; (2) to use a common methodology for estimating both capital and annual costs to arrive at a relative unit cost for treated water, and; (3) to compare the alternatives, strictly on a cost basis. No attempt has been made to identify or evaluate the numerous environmental, legal and institutional concerns which will need to be worked out before many of these alternatives can be implemented. Resolution of these concerns may increase the costs of the alternatives. Perhaps the most important step in beginning any long-range plan to supply additional water to Bexar County is to develop an institutional arrangement whereby the costs for providing this water can be shared fairly among the numerous entities which currently withdraw water from the Edwards Aquifer. Many other questions remain regarding some of these alternatives, involving inter-basin transfers, contractual arrangements, and water rights, which will require review and approval by the Texas Water Commission, river authorities, and other governmental entities.

III. ASSUMPTIONS

As mentioned above, many volumes have been written on possible solutions to the water supply problem in Bexar County, and because this summary report was, of necessity, prepared in a very short time, certain simplifying assumptions have been made, which require that the unit costs developed herein be seen as only a relative guide to be used in comparing alternatives, and not as rigorous cost estimates for costs of water. Major assumptions made in developing this summary are as follows:

A. All costs are in 1990 dollars. No attempt was made to adjust future costs for inflation, nor to account for differential inflation rates for projects which will be started at different times in the future. In order to partially account for this, the average costs for treated water for the total supply to Bexar County have been developed decade by decade, with costs for new sources added only after construction is scheduled to begin. Costs are for obtaining and treating water only, and should not be construed as water rates which have additional cost components.

B. All of the southern and eastern alternatives are assumed to discharge into Applewhite Reservoir, which would serve as equalization storage, and which is scheduled to be completed as one of the first projects. Northern alternatives are assumed to discharge to a storage facility and water treatment plant located in northeast San Antonio.

C. Pipelines are sized approximately, based on the Hazen Williams formula, C=100, using approximate routing.

D. Pipeline velocities are generally held between 3 and 5 feet per second.

E. Only water which would come from the Colorado River is assumed to be purchased, and is estimated to cost $85 per acre-foot for firm supplies, and $4.50 per acre-foot for interruptible supplies.

F. Only undeveloped water, or developed water which is currently in excess of known water rights and/or contracts was considered.

G. No costs for storage, transmission and distribution of finished water have been included in these cost estimates.

H. Operation and maintenance costs for surface water treatment came from cost curves developed for the City of Austin, for a conventional system with lime softening.

I. Construction costs for pipelines, water treatment plants, intake structures and booster pump stations came from cost curves developed for similar projects in Texas.

J. Debt service costs are estimated based on 25 year bonds at 8.5% interest, except for the Texana purchase, where actual debt service is used.

K. The cost of treating Edwards Aquifer water and pumping to the surface was assumed at $16 per acre-foot, based on 1985 data included in the CH2M Hill study, (1986), adjusted to 1990 dollars using the Consumer Price Index.

L. Estimates for major reservoirs were based upon numerous engineering studies conducted by Espey, Huston and Associates and the Bureau of Reclamation, cost indexed to 1990 dollars using the Bureau of Reclamation composite cost index.

M. No streambed or evaporative losses are included for options using lakes and rivers for conveyance

IV. METHODOLOGY

Water demands over the next 50 year period were obtained from Texas Water Development Board projections, made in October, 1989, using the high series for population projections, and the high series projection for all non-municipal water use categories. Municipal water conservation projections of the Water Development Board were then subtracted from the projected demands, for a net water demand projection, as indicated in Figure 1. It was then assumed that an increasing amount of wastewater would be reused over the planning period, as projected by CH2M Hill (1986), reaching a maximum of 100,000 acre-feet per year, by treating and re-using it.

Cost estimates were prepared for proposed reservoirs, and for conveyance of the water from the reservoirs to either Applewhite Reservoir or to northeast San Antonio. An exception was the Medina Reservoir, from which water was assumed to be recharged directly into the Aquifer near the reservoir. Water from the Carrizo-Wilcox Aquifer in both Bastrop and Wilson/Atascosa Counties was assumed to be developed using wellfields, and pumped directly to the distribution system for San Antonio and/or other utilities in Bexar County, after receiving the same treatment as Edwards Aquifer water. With suitable blending, it is believed that this ground water will be of sufficient quality to meet Safe Drinking Water Act standards, but further analysis and evaluation will need to be performed prior to proceeding with this option, because of the relatively high iron content and the presence of other dissolved chemicals.

Based on the above cost estimates, a spreadsheet model was developed to calculate a total annual cost for debt service to repay the capital costs of reservoirs, conveyance systems, and water treatment plants, along with the estimated annual costs for treating the water, pumping it, and purchasing it, if applicable. Some of the alternatives involve capture of the water at the reservoir or source, and pumping it directly to either Applewhite or a utility distribution system, while others use a combination of pumpovers to rivers, with subsequent recapture and diversion at reservoirs downstream.

From this spreadsheet, unit costs were calculated based on assumed annual yields, which came from one or more of the references mentioned above, and/or from Texas Water Development Board allocations.

From these estimates, a menu of alternatives was developed, as shown in Table 1, which compares the relative costs.

As can be seen from an inspection of Table 1, relative unit costs vary from a low of $0.41 per 1,000 gallons for the Carrizo Aquifer in Wilson County, to a high of $3.78 for Cibolo Reservoir. Most of the costs range from $1.00 to $2.00 per 1,000 gallons. Because of limited supplies, ground water from the Carrizo Aquifer should be seen only as an interim, supplementary source.

V. ANALYSIS

Using the unit costs and yields for the various alternatives listed in Table 1, along with the demands developed by the Texas Water Development Board, Figure 1 was constructed, showing one possible solution to the water supply needs for Bexar County, while retaining net ground-water pumpage at approximately 200,000 acre-feet per year, on the average. CH2M Hill (1986) determined that this floor pumping level would maintain sufficient flow at Comal and San Marcos Springs. It should be emphasized that Figure 1 is only one of a myriad of combinations which could be implemented to supply water to Bexar County. In general, those shown in Figure 1 were the alternatives which had the lowest unit costs, met long-term needs, and were considered relatively high in probability of implementation.

TABLE 1

RELATIVE COSTS PER 1,000 GALLONS OF TREATED WATER DELIVERED TO BEXAR COUNTY UTILITY DISTRIBUTION SYSTEMS

Alternative	Yield in Acre-Feet per year	Estimated Cost per 1000 gallon
Applewhite Reservoir (Firm Yield)	15,000	$2.50
Applewhite Reservoir (Average Yield)	53,000	$1.05
Cuero 1 Reservoir	145,000	$1.49
Lindenau Reservoir	107,000	$1.83
Cuero 1 and Lindenau Reservoirs	219,000	$1.80
Cibolo Reservoir	25,000	$3.78
Cibolo and Goliad Reservoirs Combined (With Diversion at Cibolo and Goliad Used to Meet Downstream Needs)	173,000	$1.80
Goliad without Cibolo Reservoir, Including a Conveyance System from Goliad to Applewhite	148,000	$1.48
Wastewater Reuse	100,000	$0.90
Transfer of Water From Lake Travis to Canyon Reservoir, Recapture at Cuero Reservoir	50,000	$1.25
Purchase of Medina Reservoir, and Construction of Injection Wells to Recharge the Edwards Aquifer	30,000	$0.84
Transfer from Town Lake to the Blanco River, with Recapture at Cuero Reservoir	50,000	$1.08
Transfer of Water by Pipeline to San Antonio from Town Lake	50,000	$1.32
Purchase of Texas Water Development Board share of Texana Reservoir, and Conveyance to Applewhite Reservoir	43,000	$1.89
Texana Purchase, Combined with Purchase of Water from Garwood Irrigation District	88,000	$1.32
Clopton Crossing Reservoir	43,000	$1.84
Pumpover from Lake Travis to Canyon Reservoir, with Recapture at McQueeny Lake	50,000	$1.34
Shaws Bend Reservoir	123,000	$1.82
Carrizo-Wilcox Aquifer Wells in Wilson or Atascosa County, Pumping to the San Antonio Finished Water Distribution System	40,000	$0.41
Carrizo-Wilcox Wells in Bastrop County, Pumping to Northeast San Antonio Distribution System	40,000	$0.95
Substitute interruptible water for firm in LCRA Alternatives	?	deduct $0.25

As mentioned earlier in this report, many of the alternatives have significant environmental and/or institutional problems which must be worked out, and some may, in fact, not be feasible at all, but such a determination was beyond the scope of this report.

If interruptible water is purchased, in lieu of, or in addition to, the firm purchases, costs would decrease by about $0.25 per 1,000 gallons. Use of interruptible water from LCRA could be considered to reduce aquifer pumping in the early years, but because of the probable coincident occurrence of peak need and interruption of supply, it is not considered a viable, long-term option.

Figure 1 also shows the average total costs per 1,000 gallons, for treated water in Bexar County, by decade from 1990 to 2040. Current costs are approximately $0.05 per 1,000 gallons, or about $16.00 per acre/foot, according to CH2M Hill, (1986). As additional purchased water, ground water, wastewater reuse, and surface water reservoir sources are introduced, the costs rise dramatically, reaching a peak of $1.00 per 1,000 gallons in 2010, and declining to $0.61 per 1,000 gallons in 2040, as debt service payments on earlier projects drop off. Even so, an increase from $0.05 per 1,000 gallons to $1.00 per 1,000 gallons represents a monthly increase of approximately $11.00 in real terms over a 20 year period, for a typical residential consumer using 11,400 gallons per month. When added to the current water rate for San Antonio, the total unit cost is still below many urban areas which use surface water as their supply. This analysis also assumes that the total cost would be allocated as a water use charge, as opposed to a wider distribution of costs through user charges, taxes, and connection fees, proposed by CH2M Hill (1986).

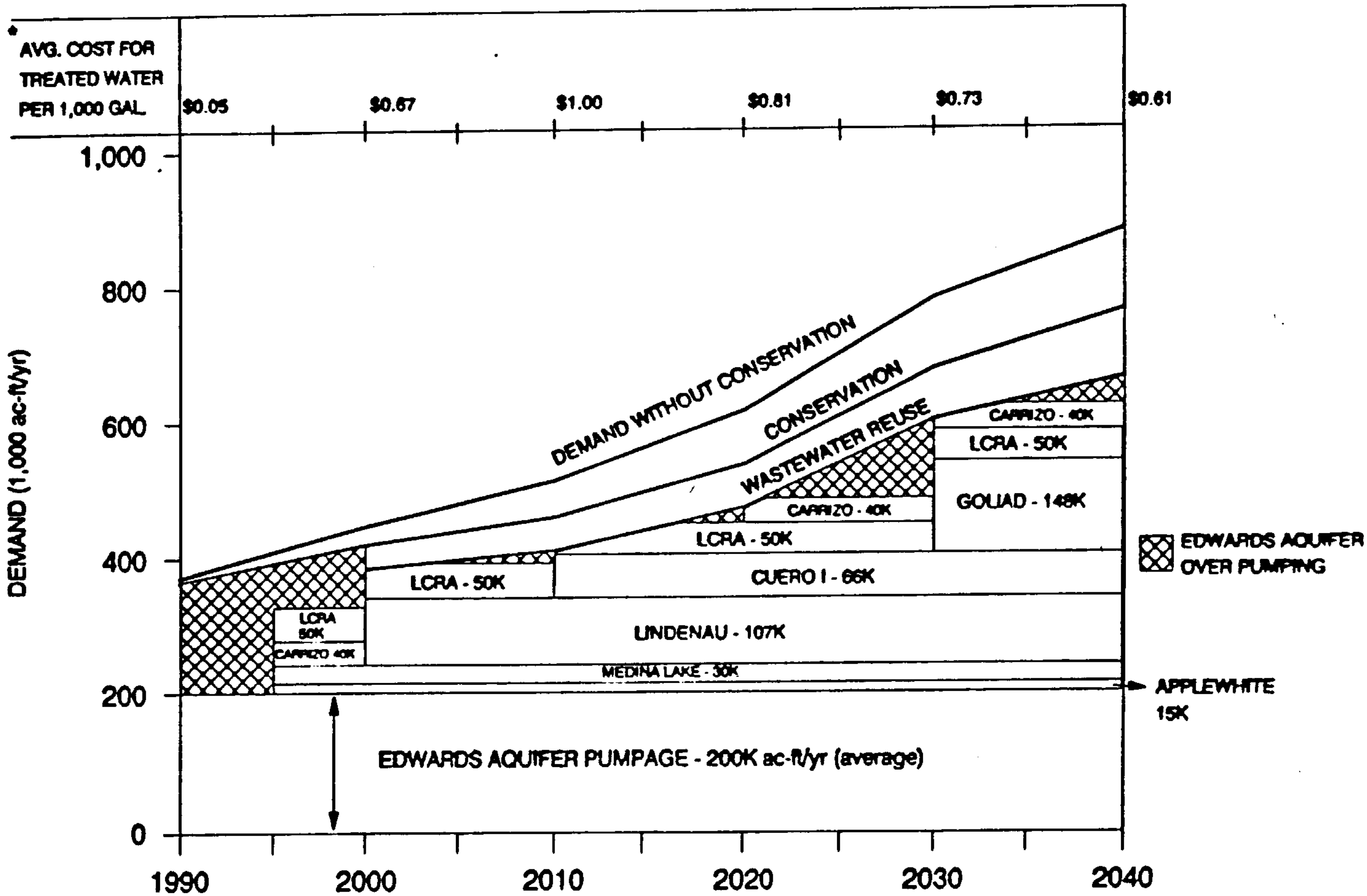
VI. SUMMARY

In summary, this preliminary, relative cost comparison between the water supply alternatives for San Antonio indicates that there are a number of viable, economically feasible alternatives to supplying the needs projected for Bexar County through the year 2040. In order for a water supply plan to be successful, however, it will be necessary for an institutional framework to be put into place which will ensure an integrated approach to supplying the water, as well as equitable distribution of costs and benefits to the users of water in the San Antonio area.

It seems apparent that the most viable plan consists of conservation, wastewater reuse and a system of surface water reservoirs, possibly including Applewhite, Medina, Lindenau, Cuero and Goliad, supplemented by purchases from adjoining basins, and/or additional ground-water sources from the Carrizo-Wilcox Aquifer.

Provided appropriate institutional arrangements can be made, stabilization of Edwards Aquifer pumping can be accomplished, at reasonable cost to water users.

WATER DEMAND/SUPPLY FOR BEXAR COUNTY



*Includes cost of acquisition and treatment only, and is not intended to reflect retail water rates, which include additional cost components

FIGURE 1

410 Larkwood
San Antonio, Tx 78209
April 13, 1992

Mike Personnett, Water Policy Division
Texas Water Commission
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

Dear Mike:

Thanks for our phone conversation this morning. I also appreciated your presence in the meeting last Wednesday.

The promised article is enclosed. It was published in 1977 in the Scientific American, written by Robert Ambroggi, a senior advisor with the Food and Agriculture Organization of the United Nations. It was this article that gave us confirmation that the aquifer storage was a significant factor in regional water planning.

Also enclosed is Dr. David Todd's presentation material that accompanied his talk to the Citizens Committee in October. He is an extraordinarily articulate, as well as capable scientist, and won approval from people from opposing "camps" with a balanced overview of the advantages and disadvantages of groundwater storage. It might be helpful if you explored with him the meaning of "conjunctive use." The coordinated planning effort needed for conjunctive use of ground and surface water should result in optimal yield of an aquifer--not minimal yield. If you adjudicate rights for an aquifer, rather than using a withdrawal fee, you make it almost impossible to manage aquifer storage and you create shortage by law even when water is abundant in the region.

The "augmentation" study is a real opportunity to resolve many questions. If we can ennumerate all the costs and benefits (economic, and environmental) of managing the aquifer as a storage reservoir vs. treating the aquifer as a river and causing us to seek storage facilities elsewhere, it will be easier to make sound and equitable, long range decisions. The fact that Comal Springs is projected to go dry for seven years in a repeat of a '50's drought even with a 350,000 af/y limit on pumping suggests that the species is condemned unless augmentation works, and that adjudicating rights is, in fact, a relatively short term solution.

Thanks for your time. Please keep in touch.

Sincerely,

Carol

Mrs. Kirk Patterson

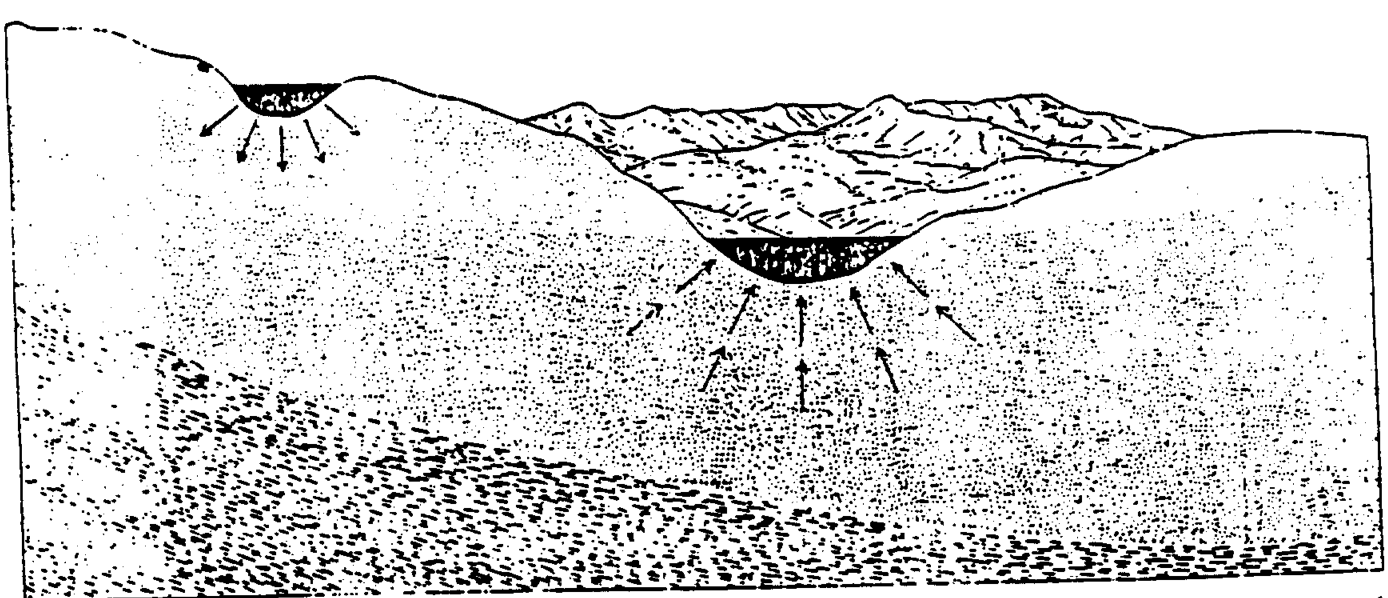
Established 1845 SCIENTIFIC AMERICAN May 1977 Volume 236 Number 5

Underground Reservoirs to Control the Water Cycle

At any one time perhaps two-thirds of the fresh water on the earth is held in underground reservoirs. These reservoirs could be much more intensively drawn on, to be refilled when water is plentiful

by Robert P. Ambroggi

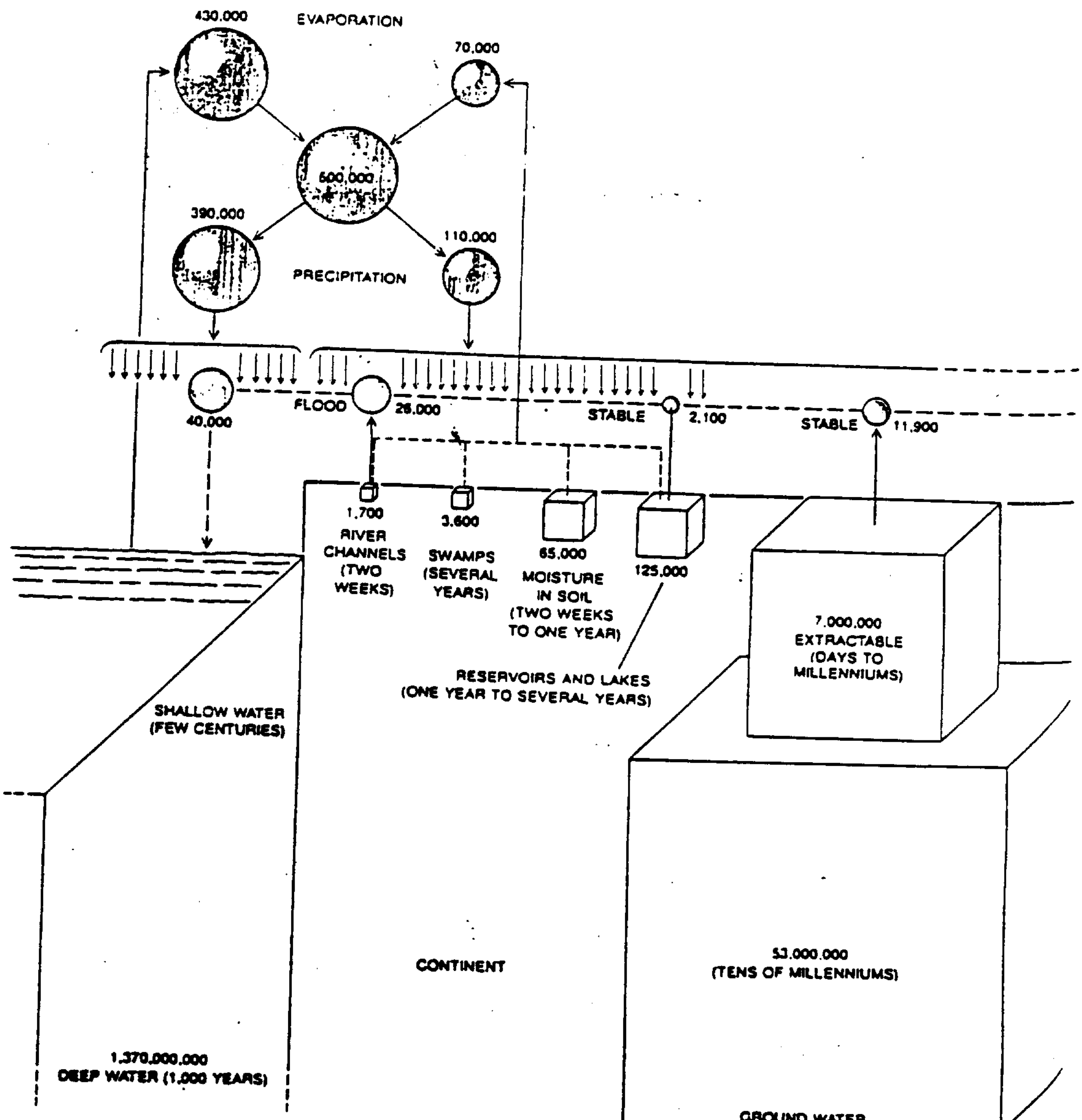
One tends to think of the global water cycle as proceeding in the following way. Water is evaporated from the oceans by solar energy; meteorological processes transport it through the atmosphere, from which it falls to the earth as rain or snow, and eventually it returns to the oceans by way of rivers and streams. This picture overlooks the enormous amounts of water that reside for various periods of time (from weeks to millenniums) in underground reservoirs. Moreover, few of the people involved in planning the distribution of water resources have recognized the opportunity the underground reservoirs provide for dealing with the water shortages that increasingly beset agriculture and other human activities in various parts of the world and for greatly increasing the amount of water that could be put to the service of human endeavor. In this article I contend that mankind should deliberately draw down the underground reservoirs—far more than it already does to some extent—to meet the needs of agriculture, industry and community activities, because sooner or later nature, sometimes abetted by human efforts, will refill the



NATURAL UNDERGROUND RESERVOIR is filled when water percolates into permeable soil or rock formations under a river or stream, as in the example at the left. There it may remain for periods ranging from weeks to millenniums before it finds its way back into the global cycle of evaporation, precipitation and runoff. Ground water also constitutes a significant part of the flow of most streams, as is indicated by the lower river in this illustration. Other natural processes that contribute to underground reservoirs include rain and snow falling on the ground and seepage from lakes and swamps. Reservoirs depleted by intensive use can be refilled artificially by seepage from canals and man-made lakes and by the pumping of water into the ground in periods when the water supply exceeds demand.

reservoirs. The result will be a vastly increased control of the water cycle and an avoidance of the struggles over water that virtually every nation will face within the next few decades if the present wasteful practices in the management of water are continued.

The widespread crop shortages of 1972 provided an indication of the difficulties that lie ahead if water is not managed more efficiently. The shortages were the result of a deficit of some 400 cubic kilometers (400 billion cubic meters) in the continental part of the water cycle. On the global scale of water flow the deficit was small, but it had a heavy impact because most countries use water in such a way that they have little margin for dealing with the consequences of drought. Under present practices the production of food in the world is coming dangerously close to the limit of self-sufficiency. The prevention of food crises will in the future require the



WATER RESOURCES of the world are depicted in a diagram that shows both the annual water cycle, which is represented in the upper part of the diagram, and the water stored in the oceans (*bottom left*) and on the continents (*right*). All numerals represent cubic kilometers of water. The period of time during which water is likely to remain in a particular storage area is also shown. Following the water cycle, one sees that 430,000 cubic kilometers of water is evaporated from the oceans and 70,000 from the continents, whereas precipitation is 390,000 cubic kilometers per year over the oceans and 110,000 over the continents. There is thus a transfer of 40,000 cubic kilometers of manipulation of water on a far larger scale than nations have practiced up to now. One can envision the need for a great increase in irrigation and for the transfer of water between river basins and even between continents.

People involved in the management of water draw a distinction between renewable water resources and nonrenewable ones. The conventional water cycle I have described carries the renewable resources, which amount to about 500,000 cubic kilometers per year. The nonrenewable resources have a volume of 1.5 billion cubic kilometers. They are stored in three reservoirs: the oceans (97.3 percent of the resources), the continents (2.7 percent) and the atmosphere (.0001 percent).

These distinctions overlook the fact that all the water resources of a continent proceed through a cycle. The only difference between renewable and nonrenewable resources is the speed with which the water is cycled. The resources that are called renewable move fairly rapidly, whereas the nonrenewable resources move quite slowly.

The period of time a particular amount of water spends in its cycle is termed its residence time. Water in the atmospheric reservoir may have a residence time of 10 days. Deep in the oceans the residence time of a body of water may be more than 1,000 years. The residence time of continental water resources ranges from a few weeks to many millenniums, depending on the type of reservoir: a river channel, a lake, a swamp, a glacier, polar ice and ground water. The ground-water reservoirs show the largest diversity of residence time: a few days or weeks in karst (limestone) aquifers, a few weeks or months in gravelly riverbeds, a few months or years in alluvial deposits, a few years or decades in other unconfined aquifers and a few decades, centuries or millenniums in confined aquifers.

Let us look more closely at the movement of water in the conventional water cycle. The annual evaporation from the oceans and the continents is about 500,000 cubic kilometers per year: 430,000 from the oceans and 70,000 from the continents. The other part of the equation is precipitation, which averages 110,000 cubic kilometers per year over the continents and 390,000 cubic kilometers over the oceans. To put it another way, the oceans yield 430,000 cubic kilometers by evaporation and receive 390,000 in precipitation, whereas the continents lose 70,000 by evaporation and receive 110,000 in precipitation. Hence every year 40,000 cubic kilometers of fresh water is transferred from the oceans to the continents. In accordance with the principle of the conservation of water within the water cycle, every year 40,000 cubic kilometers returns to the ocean in the form of surface and underground runoff.

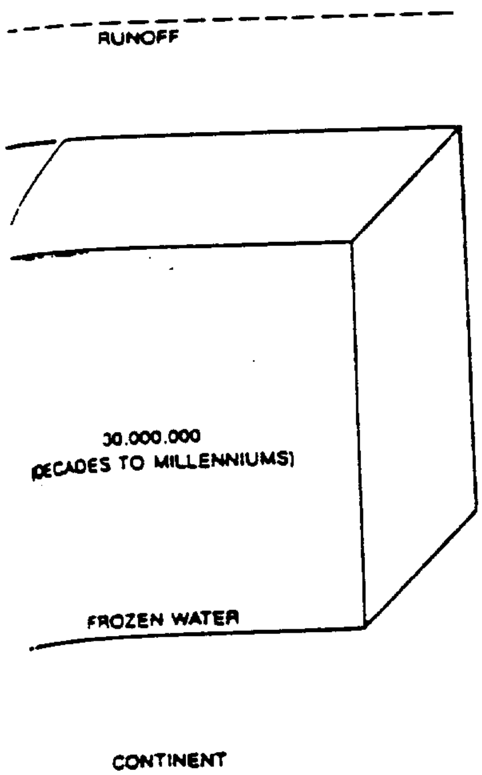
One might therefore suppose 40,000 cubic kilometers of water per year would be available to mankind if water resources were managed with the utmost efficiency. Actually much of that water is inaccessible: it consists of floods, water held in the soil, water running in uninhabited places and so on. The most that mankind might hope to utilize is about 14,000 cubic kilometers which is the base, or stable, flow in rivers and streams. The base flow is regulated mainly by discharges from underground reservoirs (11,000 cubic kilometers), from man-made reservoirs (1,840) and from lakes (260).

Even the total of 14,000 cubic kilometers is not fully within reach unless transfers of water are made on an enormous scale, since a large part of the total is in uninhabitable areas. As of 1972 the amount of water under human control was approximately 3,000 cubic kilometers per year. Taking into account the fact that about 5,000 cubic kilometers of the stable river runoff is in inhospitable regions, there remains some 6,000 cubic kilometers that under conditions of sound management man could employ for his needs in the future.

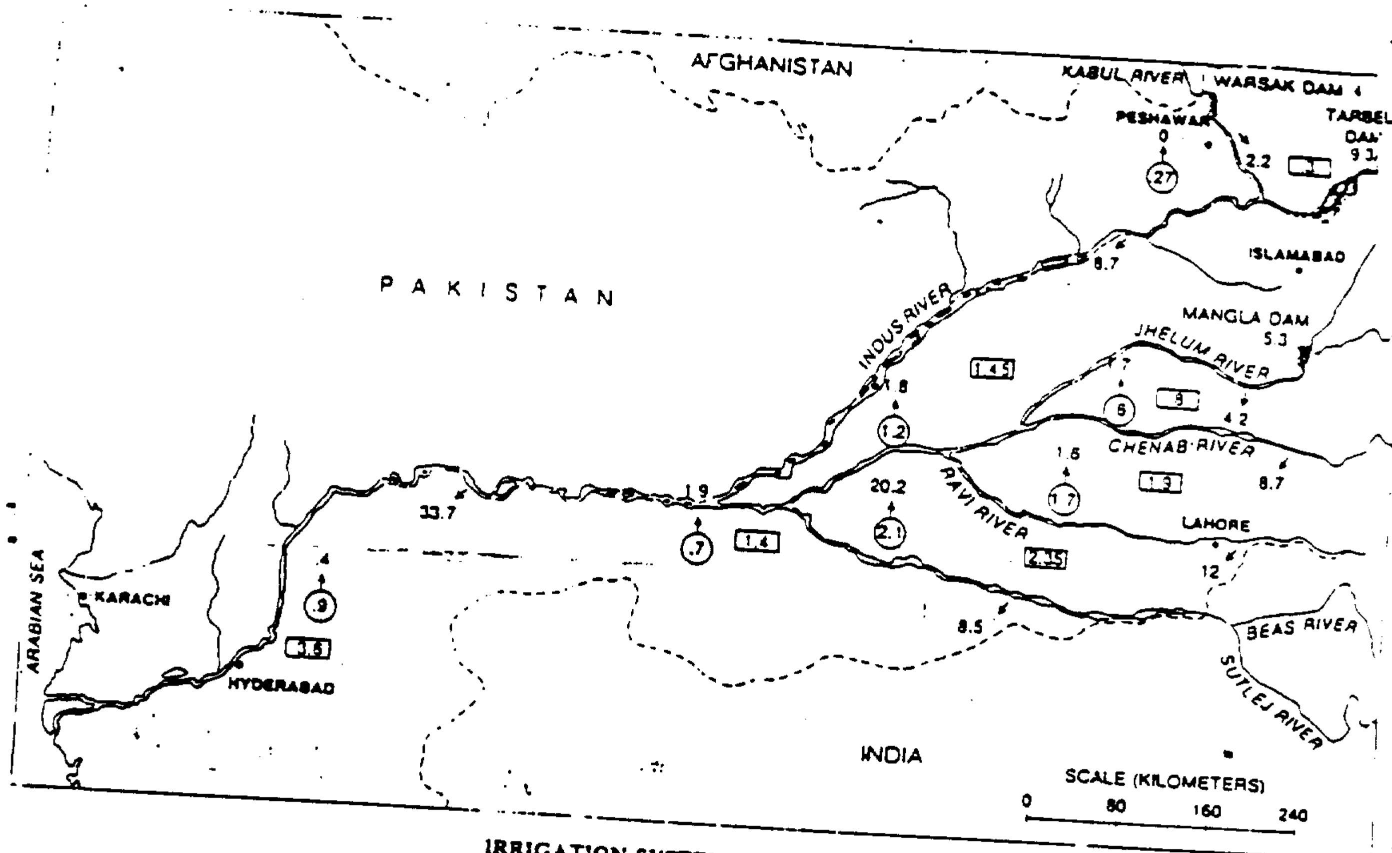
The human species normally inhabits only 60 million of the 150 million square kilometers of the continents, being effectively excluded from such places as deserts, polar regions, high mountains and forests. Within the inhabitable zones about 3,200 million hectares of land are potentially usable for agriculture; in 1970 about 1,400 million hectares were under cultivation. (A hectare is 2.47 acres.) It is unreasonable to suppose the amount of additional land that could be brought under cultivation over the next century would be as much as 1,000 million hectares. A better strategy in meeting the rising requirement for food would be to use land more intensively, with irrigation playing a major role. The amount of land under irrigation in 1970 was 180 million hectares. Irrigation consumed some 2,400 cubic kilometers of water per year. Industry consumed 500 and other human activities 200, so that mankind's worldwide consumption of water was 3,100 cubic kilometers.

The food crisis of 1972 arose from a deficit of 35 million metric tons of cereals (wheat, rice and coarse grains). A further consequence was that the wheat stocks of the exporting countries dropped from 50 million metric tons in 1971 to 30 million in 1974. Another year or two of deficit in rainfall would create a global food crisis with dramatic international implications. Thus it appears that the food situation in the world has reached a point where the effects of water deficiency are much severer and more widely felt than they were in the past.

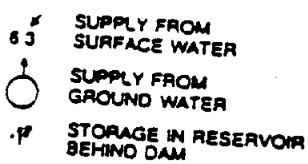
Another disturbing problem for food production is the possibility that the world's weather patterns may be changing. An example is offered by the north-

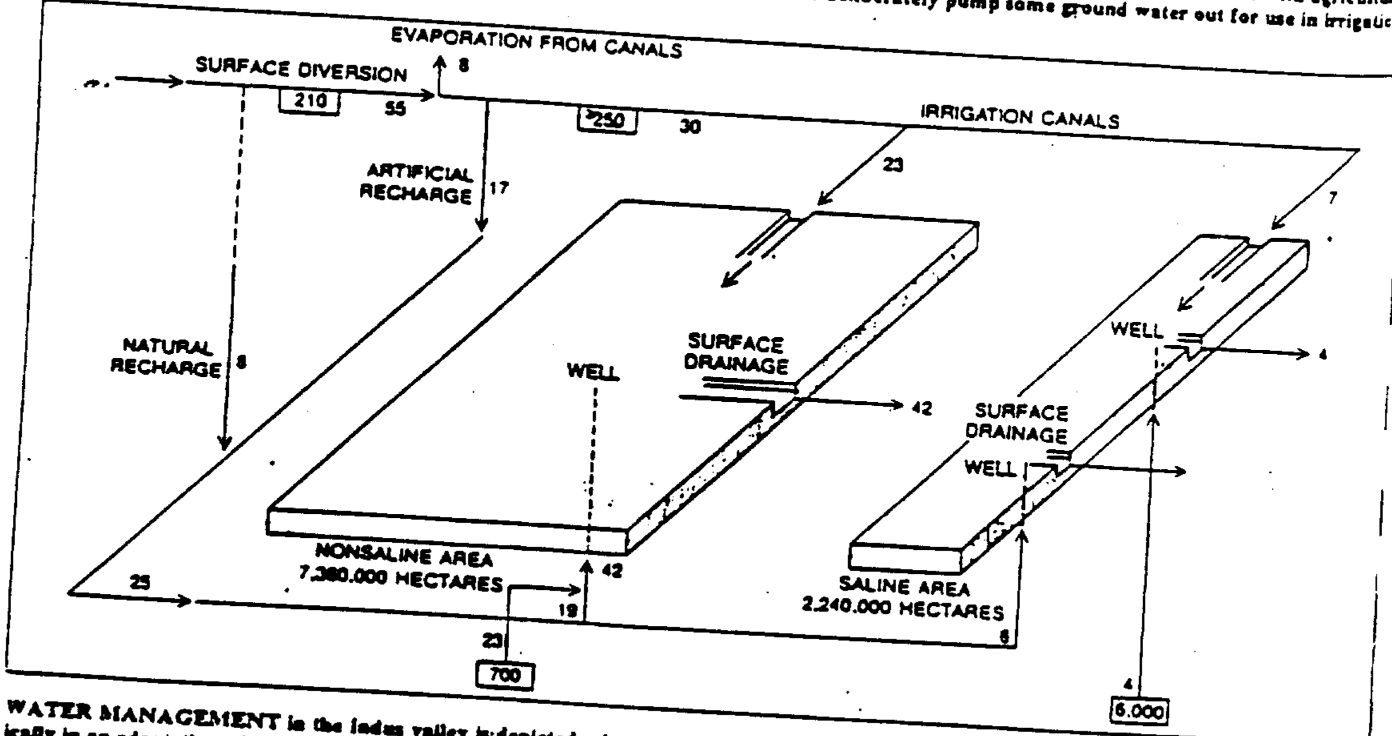


fresh water per year from oceans to continents, which is balanced in the yearly cycle by runoff. All continental storage areas contribute to runoff, as is shown by numerals next to circles. Runoff from polar ice is omitted.



IRRIGATION SYSTEM of the Indus River basin in Pakistan represents an enormous m made contribution to the reservoir of ground water through a system of some 60,000 kilomet of canals, which are in the regions shown in color. The numerals in rectangles in the canal re gions represent in millions of hectares the amount of land affected by the canal system, and the numerals in circles show in millions of hectares the area underlain by ground water of usal quality. All other numerals represent cubic kilometers of water and are explained in the lege at the left. The construction of the system began in 1860. Gradually the seepage of water into the ground from canals raised the water table so high that it began to interfere with agriculture. New system is managed so as to deliberately pump some ground water out for use in irrigatic





WATER MANAGEMENT in the Indus valley is depicted schematically in an adaptation of a conception of Harold A. Thomas, Jr., and Robert P. Burden of Harvard University. The numerals associated with arrows show the flow of water in cubic kilometers per year. The numerals in rectangles represent (in parts per million) the concentration of total dissolved solids in water and therefore indicate salinity. The entire 9.6 million hectares of irrigated land is divided into a saline area and a nonsaline area because the management of the aquifers differs. The top layer of the ground-water reservoir is pumped in excess of the annual recharge, thereby drawing down the high water table built up during the past century. The effect of these actions is a reduction in problems of waterlogging and salinity that had hampered agriculture. In addition the use of ground water in irrigation has made possible a substantial expansion of ...

ern circumpolar vortex, the great cap of high-altitude winds revolving around the pole from west to east. In recent years the lower edge of the northern vortex has been farther south than it was for some years previously. As a result the high-pressure zones have also been farther south, thereby blocking the monsoon rains out of the regions where they are vital to the survival of hundreds of millions of people. The rains therefore have fallen into the oceans or onto land areas that already have more than enough rain.

All these events raise the question of whether man is technologically capable of manipulating the water cycle in such a way as to prevent the calamities that might arise with prolonged shortages of rainfall or changes of climate. Certainly a fair number of technological efforts to deal with such problems have been made or proposed. They include cloud seeding, the long-distance transport of icebergs, the desalination of seawater and the storage of river floodwaters through systems of dams and reservoirs. How effective are these approaches?

The effort to induce precipitation by seeding clouds with silver iodide, frozen carbon dioxide and other substances has not yet been put on a firm scientific basis. It remains a somewhat expensive and haphazard endeavor. Only a few of the many experiments in this field have demonstrated that cloud seeding can increase precipitation in a limited range of favorable conditions. Some experiments have resulted in less precipitation. In sum, weather modification is still in the research stage.

The towing of polar icebergs, mainly from the Antarctic, to arid continental coasts has been proposed. For example, it would be possible to tow a large iceberg (containing six cubic kilometers of fresh water) from Antarctica to the Atacama Desert in Chile in about seven months, with a water loss of 30 percent. The iceberg would be moored at its destination and then melted or quarried for various purposes. Although nothing has actually been done along this line, it would be worthwhile to consider a pilot project for developing countries such as Chile and Peru. The Antarctic runoff amounts to about 2,000 cubic kilometers of icebergs per year, so that the water resource is considerable.

The desalination of seawater has attracted a good deal of attention, particularly because over the past decade the cost has been reduced from about $1.50 per 1,000 gallons to about 50 cents (13 cents per cubic meter). The present trend is to build nuclear plants with the dual purpose of generating electricity and desalinating substantial quantities of seawater. This approach, however, appears feasible only for the domestic water supply of coastal regions in the affluent countries, in view of the capital investment required and the high cost of operating the plants. The present production of fresh water by this means is a mere three cubic kilometers per year.

Up to now the most effective method mankind has employed to manipulate the water cycle has been to build dams and reservoirs that control the flood cycles of rivers. Some 1,840 cubic kilometers of fresh water is stored in this way: 560 in Asia, 490 in North America, 400 in Africa, 200 in Europe, 160 in South America and 30 in Australia. The prospects for a large expansion of the technology appear to be limited, however, particularly in the developing countries, because the cost of regulating one cubic kilometer of water per year by the dam-reservoir method now amounts to about $100 million. Moreover, the residence time of the stored water rarely exceeds a year, so that the system offers inadequate protection against a rainfall deficit that continues for more than a year.

Nevertheless, by building dam-reservoir systems mankind has unwittingly set in motion the long-term control of the water cycle through ground-water reservoirs. For example, the vast irrigation system of the Indus River basin in Pakistan, which was initiated in 1860, gave rise to a dense network of irrigation canals. A large proportion of the surface water diverted from rivers into these canals seeped into the underground reservoirs. The result was that the water table rose steadily for more than a century, creating a huge underground storage. Another example is afforded by the Aswan Dam in Egypt: several cubic kilometers per year is leaking from the reservoir behind the dam into the sandstone aquifer of the Western Desert of Egypt, the largest ground-water reservoir of the Sahara. Ventures of this kind suggest a long-term control of the water cycle through the artificial recharge of underground reservoirs. Is this a sound strategy for the future?

Nature annually cycles about 12,000 cubic kilometers of water through underground reservoirs to form the stable river runoff, or low river flow; this represents 30 percent of the total runoff. Mankind meanwhile is regulating less than 2,000 cubic kilometers by dam-reservoir systems. On the other hand, only 1,200 cubic kilometers of the 3,100 cubic kilometers of water that mankind uses yearly comes from ground-water reservoirs. For more than a century governments have relied on the dam-reservoir approach and have largely ignored the resources available underground. Apparently the reason was that little was known about the condition and behavior of the underground water.

Underground reservoirs have various functions, including the supply, storage, mixing and conveying of water. Until now mankind's main reliance has been on the supply function, that is, on drilling wells that tap the underground supplies. Only in California and more recently in Israel has much attention been given to the storage function. California diverts a good deal of water from the north, where it is abundant, to the south where it is scarce. Ground water has been extensively depleted by pumping in the south, and much of the water transferred from the north serves to replenish those ground-water reservoirs. The depleted reservoirs therefore provide a mechanism of storage.

Similarly, in Israel the National Water Carrier system transfers 300 million cubic meters of water per year from the north to the south. Some 200 million cubic meters of it is stored in winter in the two main ground-water reservoirs of sandstone and limestone. The objectives are to cover the peak demand for water in the summer and the higher demand in years of low rainfall and also to improve the quality of the water through mixing.

Obviously a ground-water reservoir that is full cannot be employed for additional long-term storage. This was the condition of almost all the world's ground-water reservoirs until the 19th century, when the technology of drilling and pumping became widespread. Nevertheless, even now only a few ground-water reservoirs are depleted enough to provide space for trapping water from the water cycle. Part of the problem is that hydrologists are generally conservative and insist that the exploitation of ground-water reservoirs be kept below the "safe yield," which is defined as the amount of yield that can be expected to be replaced by natural recharge during the year.

Any reservoir managed in this way must be considered a saturated reservoir. It has no room for deliberate recharging for long-term storage, which is the best way to control the water cycle. The first condition for long-term storage therefore is to deliberately increase the exploitation of an aquifer beyond the safe yield. If it is possible, the exploitation should also carry the level of the reservoir below its natural outlets. In short, the policy should be to overexploit the reservoir.

Such a policy implies attention to the problem of recharging the reservoir, which can be done either naturally or artificially. The natural recharge of a ground-water reservoir results from the downward percolation of water from streams and also of water that falls as rain or snow on permeable soils. Experience over the past three decades has shown that a single year of unusually heavy rainfall, which can be expected usually at least once in 15 years, will replenish an aquifer that has been drawn down from 10 to 20 meters during previous years. For instance, the floods of 1969 in Tunisia replenished all the reservoirs that up to then had been described as overexploited. Similarly, a shallow aquifer in the Souss Valley of Morocco had supported a flourishing production of citrus fruit since 1946 but by 1957 was a source of great concern because the water table had declined at a rate of a meter per year. The rains of 1957 were well above normal; they recharged the aquifer by about 10 meters, almost restoring the initial situation.

Nature is therefore already operating a long-term storage system with some 10 or 15 years of residence time, which represents the best security against droughts or years of low rainfall. I suspect that further experience with ground-water reservoirs will reveal that in some places it may be possible to deplete a reservoir for as long as 40 years and still have it refilled by natural processes. Indeed, we already know that a much longer storage time (centuries or millenniums) was arrived at by nature in the huge ground-water reservoirs that exist under deserts such as the Sahara. Recent studies have shown that the recoverable water from those reservoirs would make possible the irrigation of several hundred thousand hectares of land for centuries, even if it were assumed that the natural recharge of the reservoirs was insignificant. Mankind's perpetual quest for more water means, however, that close attention should be given to the artificial recharge of underground reservoirs.

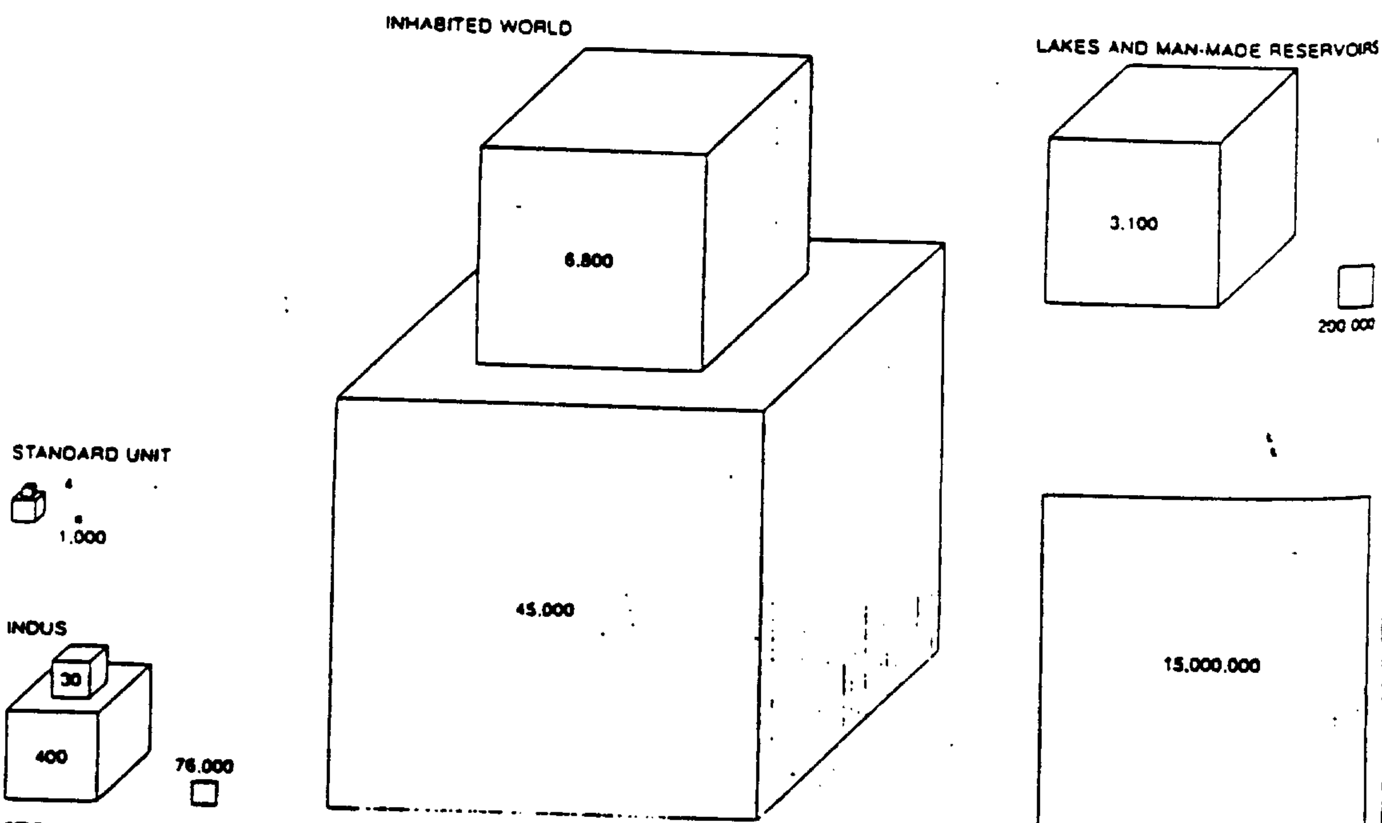
The practice of artificial recharge began in this century. In general it was done on a small scale and with limited objectives: restoring the level of a water table that was declining rapidly or improving the quality of the water. Most of the work was done in California, where some 300 stations recharged a total of about eight cubic kilometers of water between 1900 and 1960. Since 1960 the level of artificial recharge has reached one cubic kilometer per year. A certain amount of artificial recharging has also been done in Europe, mainly to improve water quality.

The later plans of California and Israel that I have mentioned involve artificial recharging on a larger scale and also embrace the concept of long-term storage in ground-water reservoirs. The most striking example of artificial recharge, however, is to be found in the Indus valley, although until about 15 years ago it was an uncontrolled and largely incidental process.

The Indus project is the largest irrigation system in the world, covering more than 10 million hectares. As I have mentioned, it was developed in the Indus River system over the past century. A network of 60,000 kilometers of canals in Pakistan covers the greater part of a vast ground-water reservoir encompassing 16 million hectares and extending 350 meters downward. The reservoir has a bottom layer of relatively saline water (6,000 parts per million, compared with the 35,000 parts per million in typical seawater) and an upper layer with water of higher quality (700 parts per million).

The reservoir is continuously recharged by leakage from the irrigation canals. This artificial recharge was estimated in 1965 at 17 cubic kilometers per year, compared with eight cubic kilometers of natural recharge. As a result of these inputs the water table rose by 30 centimeters per year, bringing about waterlogging in many parts of the Indus valley and causing problems of salinity in the soil.

A group from Harvard University studied this situation as part of a project sponsored by the World Bank. The team proposed making use of the ground water for irrigation and water management. Part of the plan was to mine the ground water for 30 years to lower the water table and alleviate the salinity problem. The water thus pumped must be diluted by canal water in order to keep an acceptable level of salinity near



STORAGE AND RECHARGE OF WATER in the upper 30 meters of ground-water reservoirs are shown for a standard unit, for the Indus region and for the inhabited world. In each diagram the figure by a square represents number of square kilometers of land underlain by ground-water reservoirs; the figure in the upper cube is the amount of annual recharge in cubic kilometers, including the artificial recharge in the Indus, and the figure in the lower cube shows how many additional cubic kilometers of usable and recoverable water are available. For comparison the amount of surface area and the amount of annual recharge in lakes and man-made reservoirs are also shown.

the roots of irrigated plants. In addition the water taken out of the ground-water reservoir must be carried off to the sea through the canals.

The water the Indus system has trapped from the water cycle over the past century and stored in underground reservoirs represents today a volume of about 400 cubic kilometers of usable water stored in the upper 30 meters of the part of the aquifer that is overlain by the irrigated area. The water has been mined by means of a system of tube wells. Most of them were drilled by private enterprise to a depth of about 30 meters; they draw water up at the rate of about 30 liters per second. Tube wells installed by government agencies go to a depth of about 70 meters and discharge at a rate of about 120 liters per second.

The result of these activities is that ground water, heavily supplemented by artificial recharge, is contributing a third of the water supply in the region and has made possible an expansion of four million hectares in the amount of land from which crops can be harvested. Each hectare of irrigated land could also benefit from 40,000 cubic meters of usable water stored underground over the past century. The exploitation of this stored water could allow either an annual expansion of the cropped area or a guarantee of full irrigation in times of severe drought or several years of low rainfall. At present prices one cubic kilometer of usable water per year could be produced from the ground-water reservoir for about $20 million, whereas the same amount of water trapped from the water cycle with a dam and reservoir would cost $100 million.

Such a system is the key to the future of agriculture and of water management if food production is to keep pace with the increase in population and the availability of water is to keep pace with the rising demands being put on water resources. The joint operation of surface and underground reservoirs will alleviate both seasonal and long-term deficiencies of water. The success of such a system requires that the underground reservoirs be fully equipped for an exploitation that could continue for any period of time from a few months per year to a few years per decade. To prepare such a system calls for political decisions that up to now have not even been considered in most jurisdictions.

The application of systematic management to aquifers is only in the exploratory stage. Further experience should improve the techniques employed for management of water resources in general and of ground-water reservoirs in particular.

A case in point is the technology of artificially recharging ground-water reservoirs on a large scale. If that technology were improved, the ground-water reservoirs would serve for both seasonal and prolonged storage. Moreover, the total supply of manageable water would be increased because the system would save water that otherwise would evaporate or escape unused.

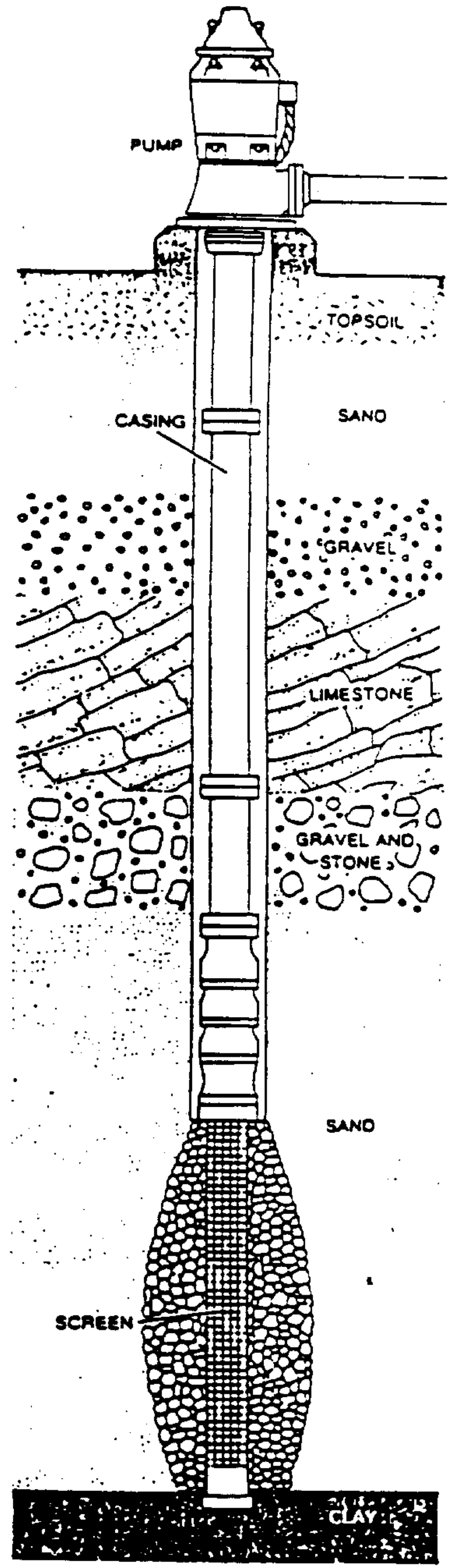
Seepage from irrigation canals is one of the best techniques for artificially recharging ground-water reservoirs on a large scale. Accordingly the lining of canals, which is often done to reduce seepage, is in fact a useless expenditure. It would be better to remodel the canals and enlarge them, provided that the work were closely coordinated with the installation of tube wells to control the rising of the water table.

Another means of artificially recharging ground-water reservoirs in Temperate zones is to spread the high waters from winter thaws over bare irrigable land, that is, to irrigate the land even though no crops are growing. The technique would provide both a temporary storage in the soil that would be useful to the crops when they were planted and a long-term storage in the ground-water reservoir underlying the irrigated area.

A simple and very old technique for recharging ground-water reservoirs is to build lakes and small dams in the upper basins of rivers, so that some of the water that would normally run off will seep into the ground. More expensive techniques are to build infiltration pits (an excavation to catch storm runoff that otherwise would run uselessly out to sea) and recharging wells, by means of which water is pumped into the ground rather than drawn from it. In the U.S. infiltration pits and recharging wells have been installed extensively on Long Island, in Arkansas, on the northern Great Plains and in certain Western states.

On a global scale the problem facing mankind is not a lack of fresh water but a lack of efficient regimes for using the water that is available. The need to produce more food will continue, and it can be met only by an assured supply of water in agricultural areas. The water deficit of 400 cubic kilometers that caused the food crisis of 1972 is insignificant when one considers that about 45,000 cubic kilometers of water is still in storage in the top 30 meters of ground-water reservoirs.

Mankind can solve the water problem if governments and decision makers are prepared to embark on the proper management of their water resources and particularly of their reserves of ground water. Moreover, it is becoming technologically feasible to deal with such adverse developments as water deficiencies resulting from changes in weather patterns by initiating the large-scale and long-term control of the water cycle through ground-water reservoirs.



CASED WELL, which in the Indus region is called a tube well, is portrayed. Such wells are the means whereby ground water is drawn down in the Indus valley as a source of irrigation and also of management of the ground-water resources. The well is made by drilling to a depth of from 30 to 70 meters and putting into the hole a casing ending in a screen that is some distance into the water table. Screen keeps out the large particles of solid matter.

THE AUTHORS

ROBERT P. AMBROGGI ("Underground Reservoirs to Control the Water Cycle") has been senior adviser with the Food and Agriculture Organization of the United Nations since 1961. In addition he serves as a consultant to the United Nations Development Program, the World Bank and the United Nations Environment Program. A French citizen from Corsica, he was graduated from the University of Nancy in 1939 and received his doctorate at the University of Paris (the Sorbonne). Before he joined the Food and Agriculture Organization he was director of the Water Resources Department of Morocco, where in 1942 he began working in the field of ground-water hydrology. Ambroggi's major current interest is the improved management of the scarce resources of water of good quality. He is involved in the Blue Plan for the Mediterranean, a regional undertaking of the 18 Mediterranean countries to assist their governments in the sound development and national management of their natural resources.

ELWYN L. SIMONS ("Ramapithecus") is professor of geology at Yale University and head of the division of vertebrate paleontology at the Yale Peabody Museum. Last year he was on leave doing research at the University of Kassel in Germany, where he held an Alexander von Humboldt Senior Scientist's Prize from the Federal Republic of Germany. During that sabbatical he carried out his new studies of *Ramapithecus* in Europe, Africa and the Near East. Simons has led or has participated in more than 30 fossil-hunting expeditions on three continents, and he has written two books and more than 100 research papers. The most significant achievements of his fieldwork were the discovery of *Aegyptopithecus* and other early apes of the North African Oligocene, and the uncovering of the first specimen of *Gigantopithecus* in northern India.

DAVID ADLER ("Amorphous-Semiconductor Devices") is professor of electrical engineering at the Massachusetts Institute of Technology. After attending the Bronx High School of Science and Rensselaer Polytechnic Institute, he received his Ph.D. from Harvard University in 1964. Before joining the faculty at M.I.T. he spent a year at the Atomic Energy Research Establishment at Harwell in England. He is a member of the Solid State Sciences Committee that advises the U.S. Army Research Office in the National Research Council, as chairman of the Solar Photovoltaic Panel of the M.I.T. Solar Energy Workshop and as president of the Harvard Graduate Student Council. In addition to amorphous semiconductors Adler's research interests include solar cells, transitions between insulators and metals, transition-metal compounds and polymeric semiconductors.

LLOYD J. OLD ("Cancer Immunology") is vice-president of the Sloan-Kettering Institute for Cancer Research. Born in California, he is a graduate of the University of California at Berkeley. He received his M.D. at the University of California School of Medicine in 1958 and that year joined the Sloan-Kettering Institute. He was appointed vice-president and associate director of the institute in 1973, and also associate director of research of the Memorial Sloan-Kettering Cancer Center and Memorial Hospital for Cancer and Allied Diseases. In addition he has been professor of biology in the Sloan-Kettering Division of the Graduate School of Medical Sciences at Cornell University. Old is one of the founders of the discipline of tumor immunology. He was among the first to offer evidence for the ability of microbial derivatives to increase immunological responsiveness in a broad manner and thereby heighten resistance against cancer cells.

JOHN A. EDDY ("The Case of the Missing Sunspots") is a solar astronomer at the Center for Astrophysics of the Harvard College Observatory and the Smithsonian Astrophysical Observatory. He was graduated from the U.S. Naval Academy in 1953 and received his Ph.D. from the University of Colorado in 1962. The next year he was a research fellow in radio astronomy at the National Bureau of Standards. In 1963 he joined the research staff of the High Altitude Observatory in Colorado; concurrently he lectured on astronomy and the history of astronomy at the University of Colorado. Between 1967 and 1970 he was a consultant to the College Science Improvement Program. In addition to his work in solar astronomy Eddy has also done research in infrared astronomy, the history of astronomy, and archaeoastronomy (particularly the astronomical alignment of Indian medicine wheels in the U.S. and Canada).

Citizens Committee on Water
San Antonio, Texas

Optimal Management Planning for a Rechargeable Aquifer

October 16, 1991

David Keith Todd

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and

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ADVANTAGES OF GROUNDWATER RESERVOIRS

- Large natural storage capacity.
- No evaporative loss.
- No land area involved.
- No structural failure problem.
- No limit on reservoir life.
- Uniform water temperature.
- High biological purity.
- Natural water conveyance system.
- Low cost.

DISADVANTAGES OF GROUNDWATER RESERVOIRS

- Water must be pumped.
- Recharge dependent on surplus surface water.
- Potential for land surface subsidence.
- Absence of recreation facilities.
- Possible interference with surface water rights.
- Difficult to manage.

EQUATION OF HYDROLOGIC EQUILIBRIUM

Inflow - Outflow = Change in Storage

$$\begin{bmatrix} \text{Surface Inflow} \\ \text{Subsurface Inflow} \\ \text{Precipitation} \\ \text{Imported Water} \end{bmatrix} - \begin{bmatrix} \text{Surface Outflow} \\ \text{Subsurface Outflow} \\ \text{Consumptive Use} \\ \text{Exported Water} \end{bmatrix} = \begin{bmatrix} \text{Change in Surface} \\ \text{and Groundwater} \\ \text{Storage} \end{bmatrix}$$

PERENNIAL YIELD

Perennial yield is the rate at which water can be withdrawn perennially under specified operating conditions without producing an undesired result.

Undesired results:

- Progressive reduction of the water resource.
- Development of uneconomic pumping conditions.
- Degradation of water quality.
- Interference with prior water rights.
- Land subsidence by lowered water levels.

BASIN MANAGEMENT BY CONJUNCTIVE USE

Conjunctive use is a concept to obtain the optimal benefit of the water resources in a basin.

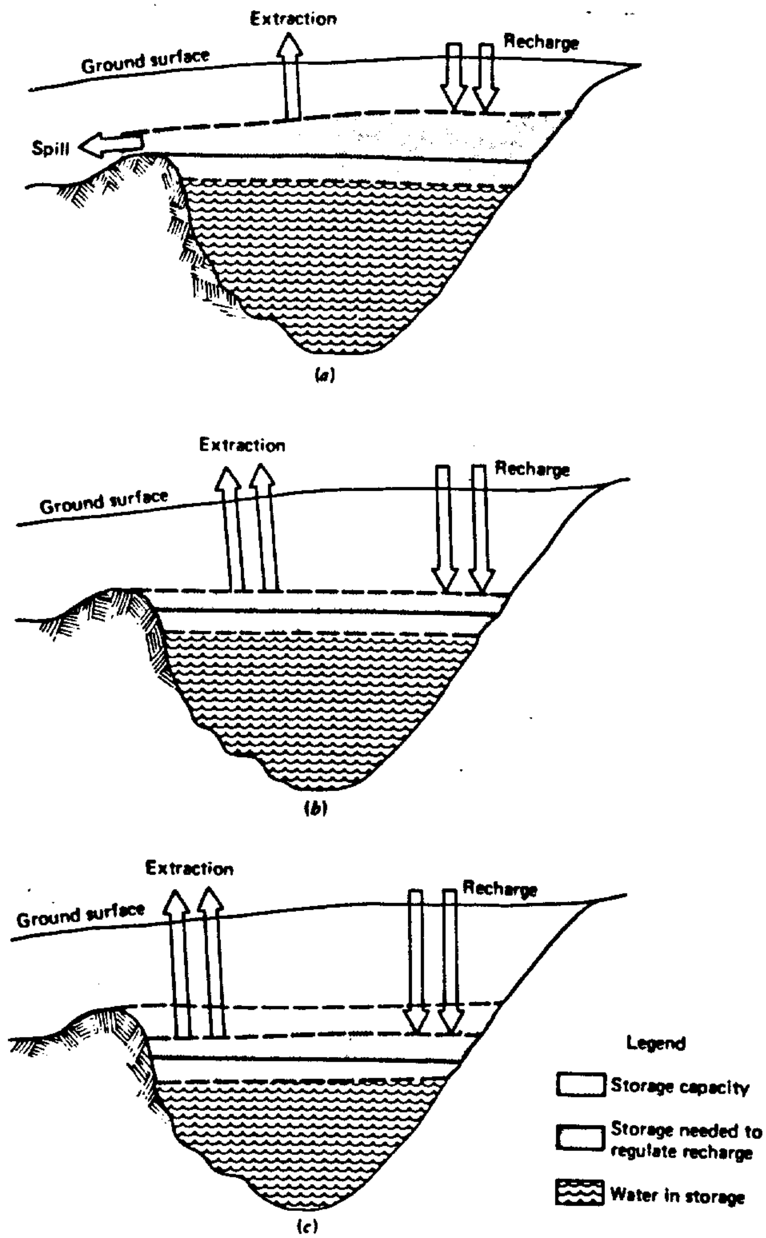
Conjunctive use involves the coordinated and planned operation of both surface water and groundwater resources.

Basic principles include:

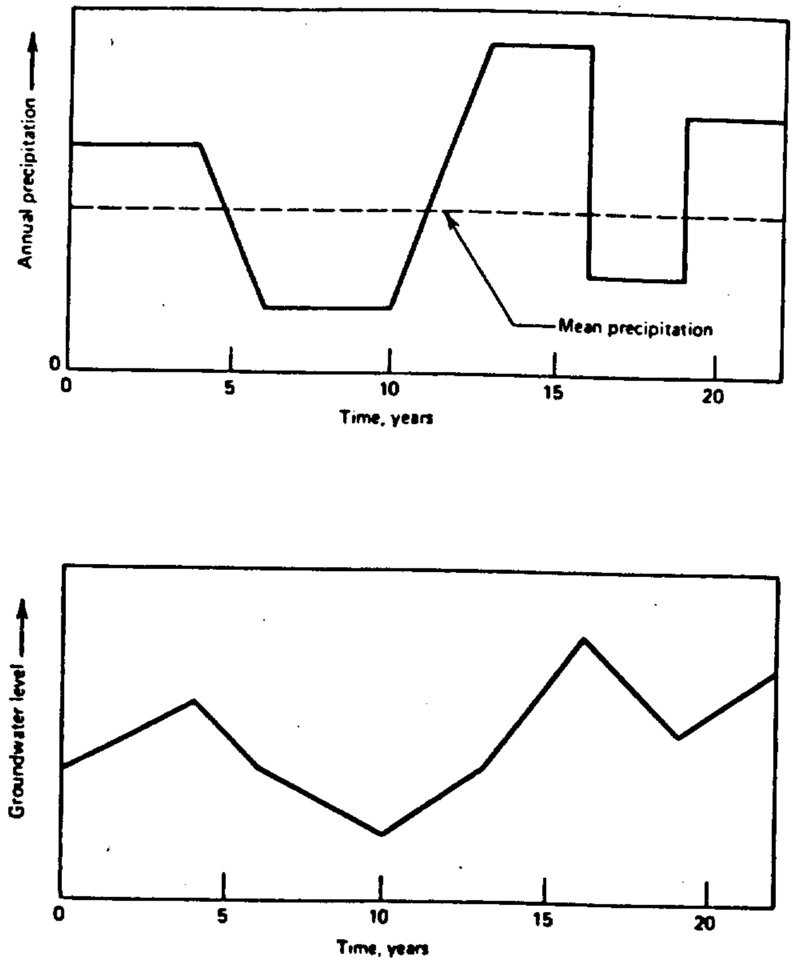
- Surface and underground storage capacities must be integrated to obtain the most economical utilization of the local storage resources and the optimum amount of water conservation.

- Surface distribution system must be integrated with the groundwater basin transmission characteristics to provide the maximum cost distribution system.

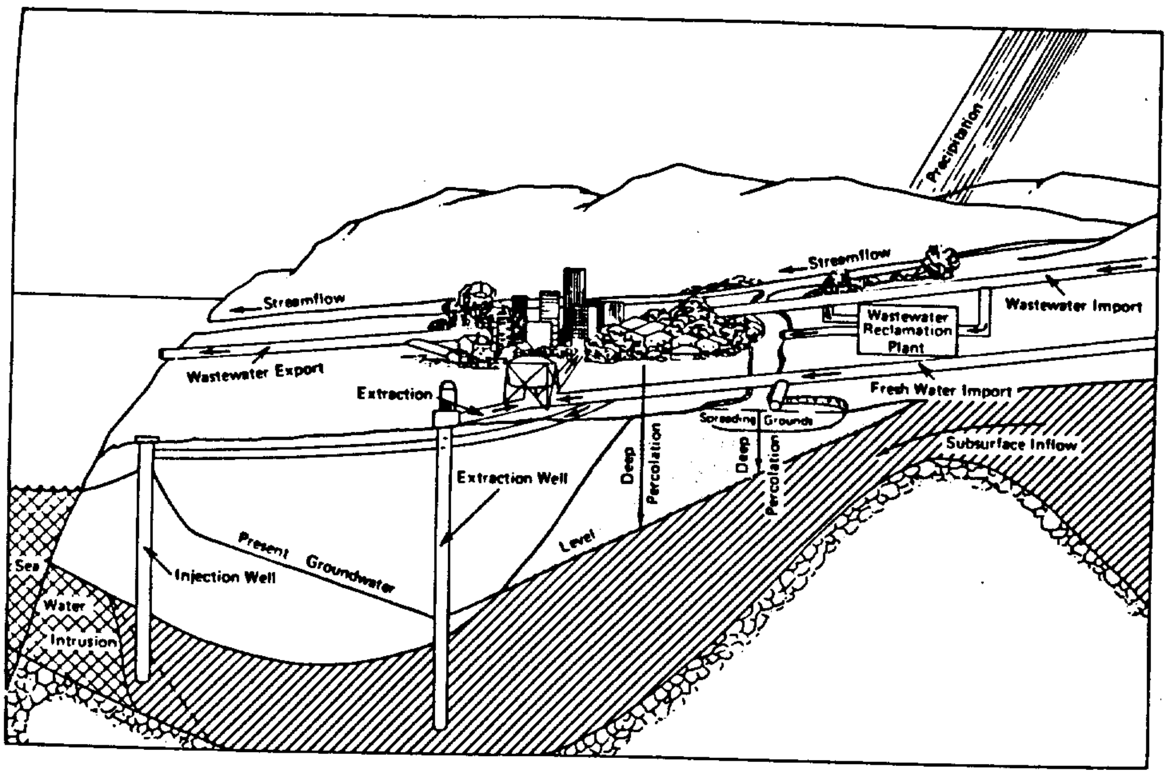
- An operating agency must be available to manage surface water resources, groundwater recharge sites, surface water distribution facilities, and groundwater extractions.



Schematic diagram showing storage relations in a groundwater basin for three stages of development. (a) Less than perennial yield. (b) Minimum perennial yield. (c) Increased perennial yield.



Illustrative example of variation in groundwater levels in relation to annual precipitation under conjunctive use management.



Pictorial representation of conjunctive use of surface water and groundwater resources, Los Angeles Coastal Plain, California.

ARTIFICIAL RECHARGE OF GROUNDWATER

Artificial recharge is the augmenting of the natural movement of surface water into underground formations by some means of construction, by spreading of water, or by artificially changing natural conditions.

Recharge methods:

- **Basins**
- **Stream channels**
- **Ditch and furrows**
- **Flooding**
- **Irrigation**
- **Pits**
- **Wells**

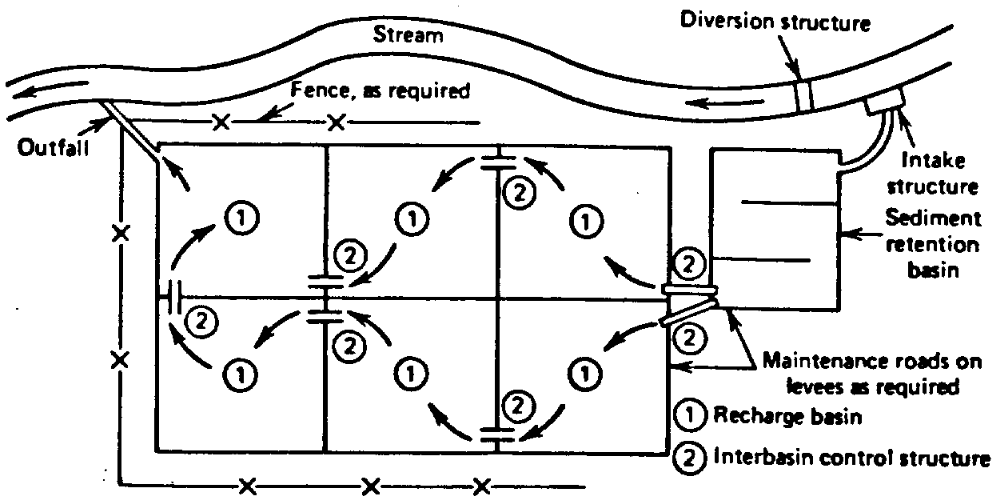
SOURCES OF RECHARGE WATER

Deliberate artificial recharge

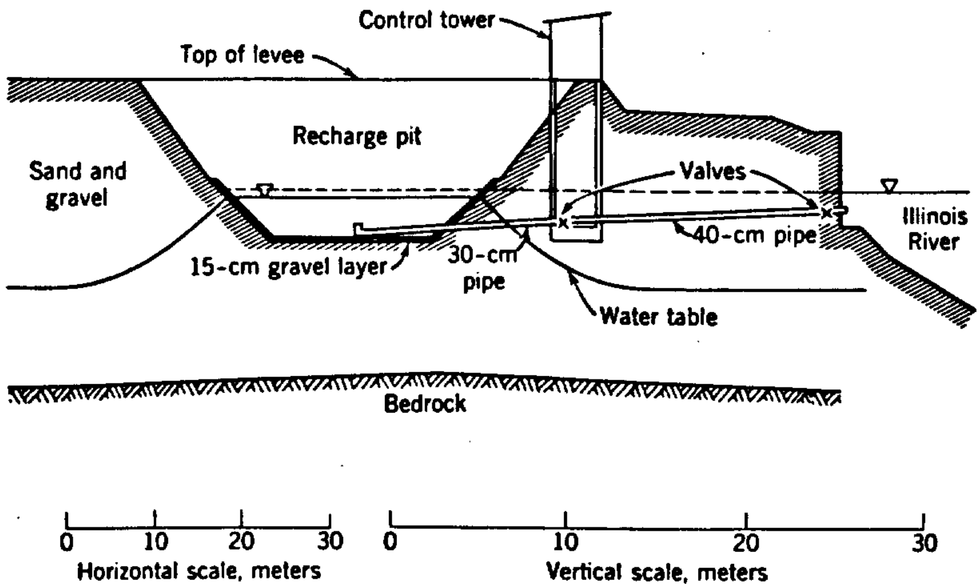
- Local surface water
- Imported surface water
- Wastewater

Incidental artificial recharge

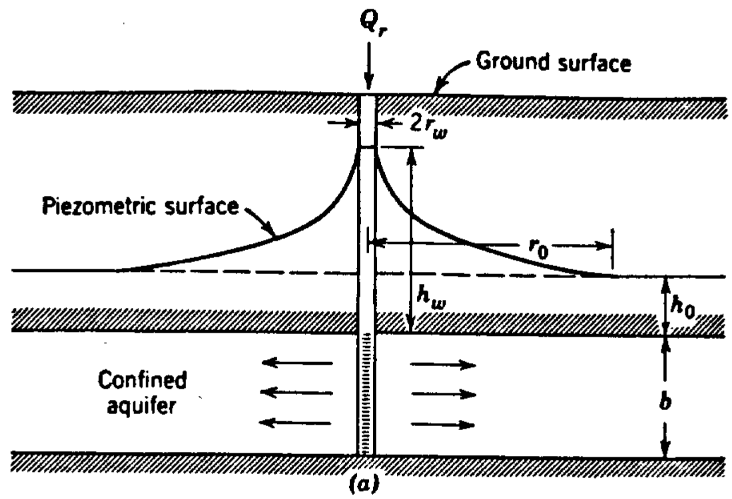
- Irrigation
- Cesspools
- Septic tanks
- Water mains
- Sewers
- Landfills
- Canals
- Reservoirs

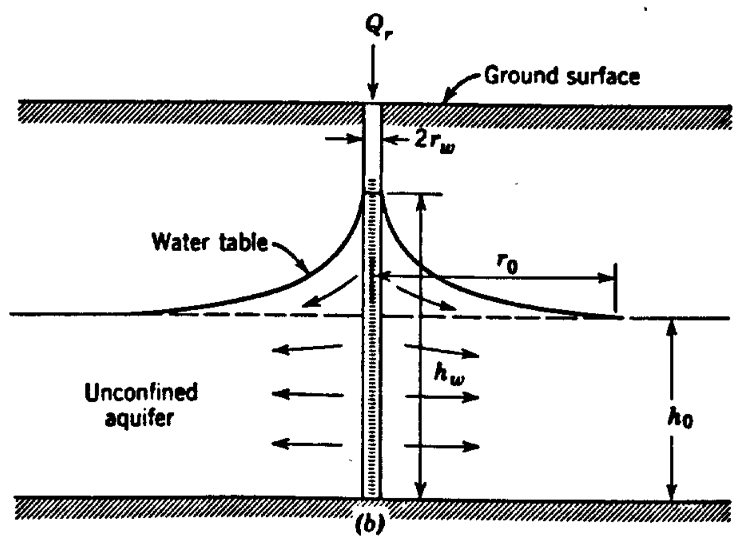


Typical plan of a multi-basin recharge project diverting water from a stream.

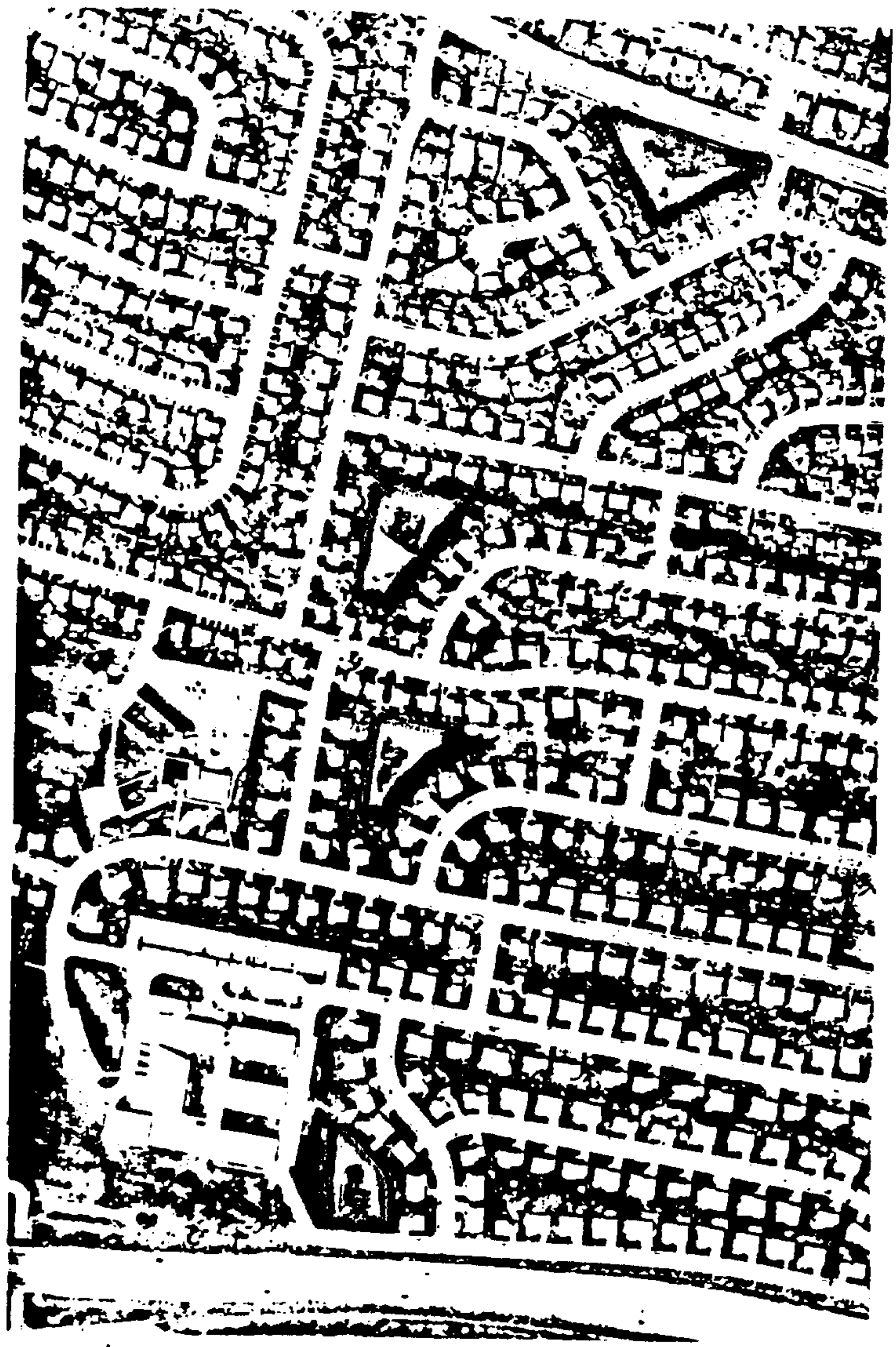


Cross section of a recharge pit a Peoria, Illinois.





Radial flow from recharge wells penetrating (a) confined and (b) unconfined aquifers.



Aerial photograph of a residential portion of Syosset, New York, showing four basins for recharging surface runoff to groundwater.