POTENTIAL CONJUNCTIVE WATER RESOURCES USE PLAN FOR THE GRAND PRAIRIE REGION OF EASTERN ARKANSAS

BY

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OBJECTIVES AND OVERVIEW

The main objective of this study is to develop two conjunctive water use strategies that can satisfy maximum potential irrigation water demand in the Grand Prairie region of Arkansas, for climatically average growing seasons. To accomplish this, the potential irrigation demand in each 3 mile x 3 mile cell of the study area is first determined on a monthly and seasonal basis for average climatic conditions. The potential demand is also calculated for dry climatic conditions, although these latter demand figures are not used in developing the potential conjunctive water use strategies.

It is assumed that the average season potential demand will be satisfied with a combination of groundwater withdrawals and surface water diversions. Therefore, we next present two sustained groundwater withdrawal strategies that will approximately maintain 1983 groundwater levels. The difference between the two strategies is that one of them assures at least a 20 ft saturated thickness in the Quaternary aquifer in all cells (Strategy A) while the other is not constrained in that way (Strategy B). Each strategy presents cell by cell annual groundwater withdrawal volumes. It should be noted that implementation of a particular sustained yield groundwater withdrawal strategy will result in the evolution of a unique steady state potentiometric surface[6].

A potential conjunctive water use strategy is a spatially distributed and temporally varying pattern of groundwater and diverted river water use. To develop such a strategy for a particular sustained yield groundwater withdrawal strategy, one subtracts each cell's annual groundwater withdrawal volumes from its potential annual water needs. The result is the required annual diverted volume of surface water required for each cell. Then, the potentially required annual volumes of groundwater and diverted river water are appropriately divided into the volumes of water needed during each month of the irrigation season. This is accomplished in such a way as to minimize river water requirements during months of low flow. The resulting set of monthly cell-by-cell groundwater and river water use values is a conjuctive water use strategy. This process is performed for both sustained groundwater withdrawal strategies A and B.

Other affiliated information provided is : the elevations of the top and bottom of the water bearing formation of the Quaternary aquifer in the center of each 3 mile x 3 mile cell, recharge and discharge historically observed across the study area boundaries, and the potential crop acreage in each cell. In addition, we present an analysis of the time required for the potentiometric surfaces to evolve from 1983 levels to the stable steady-state levels corresponding to Strategy A.

METHODOLOGY

The Grand Prairie (GP) Study Area

The study area considered in this report is the Grand Prairie (GP) Region, which includes parts of Arkansas, Lonoke, Monroe and Prairie counties. The eastern boundary is the White River; the western boundary is the Bayou Meto from Beacon, Arkansas, to its confluence with the Arkansas River; the southern boundary is the Arkansas Post Canal; the northern boundary is an east-west line located approximately 3 miles south of State Highway 38 between Cabot and Des Arc, Arkansas. The Grand Prairie study region is shown in Figure 1(a). Major tributaries in the region include Lagrue Bayou, Little Lagrue Bayou, Mill Bayou, Bayou Two Prairie, and Bayou Meto. The entire area lies within the Mississipi River Alluvial flood plain.

Literature Review of Hydrogeologic Characteristics

A storage coefficient of 0.3 and a permeability of 1900 gpd (254 ft or 77.4 m per day) per square foot were reported by Engler et al., [3]. They concluded that deep percolation from the ground surface into the aquifer was negligible because of the clay cap overlying the aquifer.

Sniegocki [11] reported a permeablity of 2,000 gpd (267 ft or 81.4 m per day) and a storage coefficient of 0.3.

In a two dimensional groundwater simulation model of the

Quaternary aquifer underlying the GP region, Griffis [4] successfully used a storage coefficient of 0.3 and a hydraulic conductivity of 267 feet per day. He assumed that deep percolation was negligible and that the regional aquifer behaved as an unconfined aquifer.

Broom and Lyford [1] used a two-dimensional flow model in studying a nearby portion of the Quaternary aquifer. Their model produced the best results when a storage coefficient of 0.3 and a hydraulic conductivity of 270 feet or 82.3 meter per day were used. They also assumed a regionally unconfined aquifer.

Peralta et al.[5] successfully validated a two dimensional groundwater simulation model of the Quaternary aquifer. They used an effective porosity of 0.3 and a hydraulic conductivity of 270 ft per day. The same hydraulic conductivity is used in this study.

Division of the Area into 3 Mile x 3 Mile Cells and Cell Coding

The study area is divided into 204 (3 mile x 3 mile) cells. Figure 1(a) shows the counties and the row and column of all cells within the area. Figure 1(b) shows the surface water basins and reaches of all cells. There are 52 constant head cells on the study area periphery. These are cells in which the groundwater levels are assumed to remain constant throughout the year. There are 152 internal cells for which potential water needs are determined in this study. Table 1 identifies cells by I,J and surface water basin and county codes.

Aquifer Properties and Elevations Above Mean Sea Level (MSL) in the Center of Each 3 Mile x 3 Mile Cell

The study area is underlain by a Quaternary (alluvial) aquifer composed of sand and gravel. This aquifer is overlain by a semipermeable layer of silt and clay beds about 25 to 50 feet thick and is underlain by a thick confining bed in the Jackson Group. The average thickness of the aquifer (not the saturated thickness) is about 90 feet. The ground surface elevations in the study region range from 250 feet above MSL in northern Prairie county to 150 feet above MSL in the southern part of Arkansas county. Surface drainage basin divides do not coincide with the ground water divides in the area. Well yields vary from 500 to 3,000 gpm in the area.

Elevations of the top of the water bearing sands in the center of each cell in the spring of 1983 are shown in Figure 2. The value for a particular cell is either the elevation of the spring 1983 potentiometric surface or the elevation of the top of the Quaternary aquifer, whichever is lower. Also shown in Figure 2 is the elevation of the bottom of the aquifer. These values were developed using geostatistical kriging from the U.S. Geological Survey records [2], from records of water well construction and topographic quadrangle maps.

Subtraction of the elevation of the bottom of the Quaternary aquifer from the elevation of the top of the water bearing sand within the aquifer (Figure 2) yields the saturated thickness estimated for the center of each cell in 1983. All such calculated saturated thicknesses exceeded 20 ft, although five of them were less than 25 ft.

Crop Acreage and Water Requirements

The three crops evaluated for the study area are soybeans, rice, and wheat. The maximum potential cell by cell acreage for each crop was estimated on the basis of SCS crop recommendations for predominant soils in a given cell [12]. This had already been accomplished for some parts of the region [8,9,10].

The first step was identifying soil texture. Peralta et al. [9] used the 1977 Arkansas Resource Data Information System (RIDS) to identify the soil texture in the center of each quarter km^2 subcell for parts of Arkansas and Prairie counties. They assumed that the soil in the center of a subcell existed throughout that subcell. Peralta and Dutram [8,10] used county soil surveys to assign a dominant soil texture to each square mile cell in parts of Lonoke and Arkansas counties. In the current study, the procedure described by Peralta et al. [9] was used to assign soil texture to those cells of Arkansas and Prairie counties that had not been previously assigned. For those parts of Lonoke and Monroe counties that had not been previously assigned, the dominant soil texture of each quarter km^2 subcell was identified from county soil surveys [12].

The second step was to assign a crop or land use to each soil texture. Based on the county soil surveys [12], the most water intensive of the three subject crops that was appropriate for a particular soil texture was assigned to that texture. In doing so, land that is only appropriate for or was already assigned to pastures, woodlands, urban use, water (bayou, reservoir, stream, etc.), levees, mines, quarries, and borrow pits was not considered available for production of the subject crops. Nor were non usable lands (intermittent, rocky, cobbly, wildlife or unmapped) considered appropriate for agriculture.

Finally, the potential acreage appropriate for each crop in each cell was computed for those cells for which it had not already been determined [8,9,10] by adding all the quarter km^2 subcells assigned to each crop. Figures 3-5 depict potential soybean, rice, and wheat land in each 3 mile x 3 mile cell in the Grand Prairie Region for the 152 internal cells. The total acres of land judged to be appropriate for three crops are: soybeans (124,652 acres), rice (542,892 acres), and wheat (28,657 acres).

In estimating the potential water needs for each cell, the potential rice land shown in Figure 4 is assumed to be planted 1/2 in rice and 1/2 in soybeans and wheat, the potential soybean land shown in Figure 3 is double cropped with wheat, and the potential wheat land shown in Figure 5 is planted to wheat only, in a given season. This results in assuming actual acreages of 271,446 acres for rice, 396,098 acres for soybeans and 424,755 acres for wheat in the tested cropping pattern.

The potential water requirements for a particular crop were estimated by using an irrigation scheduling simulation computer model developed by Peralta and Dutram [10]. In computing the crop water requirements for each cell the same procedures were followed as are described in references 8,9, and 10. Pertinent data on crop acreage and crop water requirements documented in these references [8,9,10] were also utilized in this study.

Figures 6-11 depict monthly potential irrigation water needs for the months of April through September of an average climatic season for each of the 152 internal cells. Figure 12 shows the cell by cell total annual potential irrigation water needs for an average season . Figures 13-18 show the monthly irrigation water needs for April through September in a droughty season (e.g.1980). Figure 19 shows the annual potential irrigation water needs for each of the 152 internal cells in a droughty season.

Recharge and Discharge Across the Study Area Boundaries

Figure 20 shows the maximum annual recharge or minimum annual discharge rates that occurred across the study area boundaries between 1972 and 1983, based on springtime hydraulic gradients. Negative numbers in the peripheral constant-head cells indicate recharge to the aquifer underlying the study area. Recharge comes either from surface water resources in connection with the aquifer, or from extensions of the aquifer system outside the study area.

Since the hydraulic gradients between the peripheral cells and the internal study area change somewhat during the year, estimates of recharge based on springtime gradients are not completely accurate estimators of the maximum feasible recharge to the study area. In fact, the net total annual recharge to the area shown in Figure 20 is 128,624 ac-ft, while unpublished volume balance studies of the area indicate an annual recharge rate of about 170,000 ac-ft. This 24 percent disparity may be partially due to the change in gradients during the year, which are in turn the result of pumping during the summer. Since water levels have been falling during that period of analysis, 170,000 ac-ft is obviously not a sustainable rate. The true upper limit on sustained groundwater withdrawal is probably between 128,000 and 170,000 ac-ft per year.

Annual Sustained Groundwater Withdrawal Strategies

Two sustained groundwater withdrawal strategies were developed for the study area using the approach reported by Yazdanian and Peralta [13]. The procedure utilizes quadratic goal programming to minimize the sum of the squares of the deviations between the target (1983) water levels and the optimized groundwater levels, while determining the spatially distributed groundwater withdrawal strategy that will maintain the optimized levels. In developing the strategies, the kriged top and bottom elevations of the aquifer, 1983 saturated thicknesses and a hydraulic conductivity of 270 ft/day were assumed. Upper limits were placed on the volume of groundwater that could enter the study area in any constant-head cell. These limits are the recharge values shown in Figure 20 plus 1000 ac-ft. The use of the 1000 ac-ft buffer in each recharge cell prevented mathematical constraints within the model from unrealistically restricting the development of a desirable strategy. In the strategies discussed below, portions of the buffer were used, but only in cells along the White River or Bayou Meto where recharge is most likely available. No limit was placed on the volume of groundwater that could leave the study area.

Strategy A represents the groundwater withdrawal strategy that will approximately maintain the current (1983) groundwater levels, as well as insuring 20 feet of saturated thickness in all cells. The spatially distributed withdrawals of Strategy A are seen in Figure 21. The total of groundwater use is 117,731 ac-ft per year, which equals the total recharge. This lies well within the estimated range of feasible recharge to the region.

Strategy B is the strategy that will approximately maintain the current (1983) groundwater levels, without assuring any particular minimum saturated thickness. The cell by cell groundwater withdrawals of Strategy B are seen in Figure 28. The total pumping in this strategy is 117,209 ac-ft per year.

It should be noted in Figures 21 and 28 that some cells show no groundwater withdrawal even though they may be adjacent to cells pumping significant volumes. As Peralta and Peralta have stated [6] and Yazdanian and Peralta have demonstrated [13], pumping strategies that are spatially more uniformly distributed can be developed. In general however, constraining the solution in this way hurts attainment of the regional objective.

Surface Water Requirements in Each 3 Mile x 3 Mile Cell

The potential annual surface (river) water required for diversion to a given cell was estimated by subtracting the annual withdrawals of that cell either Strategy A or B Figure 21 or 28 respectively) from its crop water needs in a climatically average year (Figure 12). The potential monthly surface (river) water requirements were also estimated. To accomplish this, it was assumed that as much of the annual allotment of groundwater as possible would be used in August. If annual groundwater availability exceeded the August water requirements of a cell, the remaining available groundwater was utilized consecutively in July, June, May, April, and lastly in September. The process was followed backwards in time to minimize the need for surface water during periods of low flow. The same technique was used for both Strategies A and B. Figures 22-27 show monthly surface water needs for an average year based on Strategy A. Figures 29-34 show monthly surface water needs for an average year based on Strategy B.

Estimated Number of Years to Attain the Target Potentiometric Surface for Strategy A, Beginning from 1983

Implementation of any particular sustained yield groundwater withdrawal strategy will result in the evolution of a unique steady state potentiometric surface [6,7]. We will refer to the potentiometric surface that will evolve if Strategy A is implemented as the "optimal" or "target" surface. (Figure 35). Although, the optimal surface is similar to the 1983 potentiometric surface, in some cells the differences between the two exceeded 20 ft. It was appropriate to determine how long it will take for the optimal surface to be attained assuming that groundwater withdrawal Strategy A were implemented in the spring of 1983. To accomplish this, a validated groundwater simulation model of the Grand Prairie Quaternary aquifer was utilized [5]. Dynamic simulation was performed using annual time steps, and the potentiometric surface elevations resulting after 1, 30, and 60 years of simulation were evaluated.

After the first simulated year, 90 percent of the 152 internal cells had a difference between the simulated potentiometric surface elevation and the optimal potentiometric surface elevation less than plus or minus 5 ft. Seven percent of the cells had a difference between 5 and 10 ft, 2 percent of cells had a difference between 10 and 15 ft and 1 percent of the cells had a difference between 15 and 20 ft. After 30 years of simulation, 99 percent had an elevation difference of less than or equal to plus or minus 5 ft and 1 percent had a difference between 5 and 10 ft. No cells had an elevation difference greater than 10 ft. Thus, after 30 years, the estimated potentiometric surface was practically coincident with the optimal surface. After 60 years of simulation, the elevation difference was within plus or minus 5 ft for 99.3 percent of the cells and only 0.7 percent of the cells had a difference beteween 5 and 10 ft.

SUMMARY OF RESULTS

As outlined in the methodology, the top and bottom of the water bearing sand in the Quaternary aquifer were estimated for the center of each cell using geostatistical kriging. The elevations of the top of the water bearing sand varied from 96 to 181 ft above mean sea level (MSL). Aquifer bottom elevations varied from 9 to 121 ft above (MSL). The aquifer saturated thickness varied from 19 to 119 ft with an average thickness of 69 ft for the entire study area. The saturated thickness is always less than or equal to the aquifer thickness. The sum of the maximum recharge rates observed at all peripheral cells based on the springtime hydraulic gradients of 1972-83 is 128,624 ac-ft.

The evaluated cropping pattern assumed potential acreages of 396,098, 271,446, and 424,755 for soybeans, rice and wheat respectively. These acreages, used in double cropping and crop rotation practices, are assumed for a total crop area of 696,201 acres.

For average climatic conditions, total annual potential crop water requirements for the study area were 863,153 ac-ft, with surface water requirements of 745,422 ac-ft and groundwater pumpage of 117,731 ac-ft for Strategy A. Table 2 displays monthly potential crop water requirements and surface and groundwater requirements based on Strategy A. Surface and groundwater requirements are respectively 86.4 % and 13.6 % of the seasonal crop water requirements. Table 2 indicates that 86.2 % of the annual Strategy A pumping is utilized in August alone and 13.8 % is distributed over the other five months of the irrigation season.

The percent of the water needs met by surface water and groundwater in each month are also shown in Table 2. It is assumed that as much groundwater as possible will be used in August, then consecutively in July, June, May, April and September. In this way groundwater use will be concentrated in months during which streamflow is the least. As a result, in August of a climatically average season, 36.3 % of the potential crop water needs will be met by groundwater, the largest monthly contribution by groundwater. The percentage of the monthly needs met by groundwater declines significantly through the rest of the irrigation months and reliance on surface water increases.

Table 3 shows the monthly potential crop water needs and surface and groundwater needs based on Strategy B. Similar results were obtained to those of Strategy A (Table 2). In the case of Strategy B (Table 3), 88.4 % of the total annual pumping is utilized in August alone and only 11.6 % is available for the other 5 irrigation months. As is the case in Strategy A, the percentage of the monthly water needs met by groundwater declines significantly and reliance on surface water increases during the rest of the irrigation season.

There are differences between the 1983 potentiometric surface and the steady state potentiometric surfaces (target surfaces) that will evolve if either Strategy A or Strategy B is adopted. Dynamic simulation of water level response to the pumping of Strategy A was performed in order to evaluate how long it would take to complete the evolution from current levels to the target potentiometric surface of Strategy A. The potentiometric surface elevations resulting after 1, 30, and 60 years of simulation were evaluated.

After the first simulated year 90 percent of the 152 internal cells had a difference between the simulated potentiometric surface elevation and the optimal potentiometric surface elevation less than plus or minus 5 ft. Seven percent of the cells had a difference between 5 and 10 ft, 2 percent of cells had a difference between 10 and 15 ft and 1 percent of the cells had a difference between 15 and 20 ft. After 30 years of simulation, 99 percent had an elevation difference of less than or equal to plus or minus 5 ft and 1 percent had a difference between 5 and 10 ft. No cells had an elevation difference greater than 10 ft. Thus, after 30 years, the estimated potentiometric surface was practically coincident with the optimal surface. After 60 years of simulation, the elevation difference was within plus or minus 5 ft for 99.3 percent of the cells and only 0.7 percent of the cells had a difference beteween 5 and 10 ft.

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Table 1: Cell Identifiers and Their Surface Water Basin and County Codes.

I	J	Surface Water Basin Code	County Code
1	2	LWØ1	LO
1	3	LWØ1	LO
1	4	LWØ1	PR
1	5	LWØ1	PR
1	6	LWØ1	PR
1	7	LWØ1	PR
1	8	LWØ1	PR
2	1	BBØ3	LO
2	2	BBØ3	LO
2	3	LWØ1	LO
2	4	LWØ1	LO
2	5	LWØ1	LO
2	6	LWØ1	PR
2	7	LWØ1	PR
2	8	LWØ1	PR
2	9	LWØ1	PR
3	1	BBØ3	LO
3	2	BBØ3	LO
3	3	BBØ3	LO
3	4	BBØ3	LO
3	5	LWØ1	LO
3	6	LWØ1	PR
3	7	LWØ1	PR

I	J	Surface Water Basin Code	County Code
3	8	LWØ1	PR
3	9	LWØ1	PR
3	1Ø	LWØ1	PR
4	1	BBØ3	LO
4	2	BBØ3	LO
4	3	BBØ3	LO
4	4	BBØ3	LO
4	5	BBØ3	LO
4	6	GPØ1	PR
4	7	GPØ1	PR
4	8	GPØ1	PR
4	9	GPØ1	PR
4	1Ø	GPØ1	PR
5	1	BBØ3	LO
5	2	BBØ3	LO
5	3	BBØ3	LO
5	4	BBØ3	LO
5	5	BBØ3	LO
5	6	GPØ1	PR
5	7	GPØ1	PR
5	8	GPØ1	PR
5	9	GPØ1	PR
5	1Ø	GPØ1	PR
5	11	LWØ1	PR
6	2	BBØ2	LO
6	3	BBØ3	LO

I	J	Surface Water Basin Code	County Code
6	4	BBØ3	LO
6	5	BBØ3	LO
6	6	GPØ1	PR
6	7	GPØ1	PR
6	8	GPØ1	PR
6	9	GPØ1	PR
6	1Ø	GPØ1	PR
6	11	LWØ1	PR
6	12	LWØ1	PR
7	2	LBØ1	LO
7	3	BBØ3	LO
7	4	BBØ3	LO
7	5	BBØ3	LO
7	6	BBØ3	PR
7	7	BBØ3	PR
7	8	GPØ1	PR
7	9	GPØ1	PR
7	1Ø	GPØ1	PR
7	11	GPØ1	PR
7	12	LWØ2	MO
7	13	LWØ2	MO
8	3	BBØ2	LO
8	4	BBØ2	LO
8	5	BBØ3	LO
8	6	BBØ3	LO
8	7	BBØ3	PR

I	J	Surface Water Basin Code	County Code
8	8	GPØ1	PR
8	9	GPØ1	PR
8	1Ø	GPØ1	PR
8	11	GPØ1	MO
8	12	LWØ2	MO
8	13	LWØ2	MO
9	5	BBØ2	LO
9	6	BBØ3	LO
9	7	BBØ3	PR
9	8	BBØ4	PR
9	9	GPØ2	PR
9	1Ø	GPØ2	PR
9	11	GPØ2	PR
9	12	GPØ2	MO
9	13	LWØ2	MO
9	14	LWØ2	MO
1Ø	6	BBØ3	LO
1Ø	7	BBØ3	PR
1Ø	8	BBØ4	AR
1Ø	9	GPØ2	AR
1Ø	1Ø	GPØ2	AR
1Ø	11	GPØ2	AR
1Ø	12	GPØ2	AR
1Ø	13	LWØ2	AR
1Ø	14	LWØ2	AR
11	7	BBØ4	PR

I	J	Surface Water Basin Code	County Code
11	8	BBØ4	AR
11	9	BBØ5	AR
11	1Ø	GPØ2	AR
11	11	GPØ2	AR
11	12	GPØ2	AR
11	13	GPØ2	AR
11	14	LWØ2	AR
11	15	LWØ2	AR
12	7	BBØ4	AR
12	8	BBØ4	AR
12	9	BBØ5	AR
12	1Ø	BBØ5	AR
12	11	GPØ2	AR
12	12	GPØ2	AR
12	13	GPØ2	AR
12	14	GPØ2	AR
12	15	GPØ2	AR
12	16	LWØ2	AR
13	7	BBØ4	AR
13	8	BBØ4	AR
13	9	BBØ5	AR
13	1Ø	BBØ5	AR
13	11	GPØ2	AR
13	12	GPØ2	AR
13	13	GPØ2	AR
13	14	GPØ2	AR

I	J	Surface Water Basin Code	County Code
13	15	GPØ2	AR
13	16	LWØ2	AR
13	17	LWØ2	MO
14	8	BBØ4	AR
14	9	BBØ5	AR
14	1Ø	BBØ5	AR
14	11	GPØ2	AR
14	12	GPØ2	AR
14	13	GPØ2	AR
14	14	GPØ2	AR
14	15	GPØ2	AR
14	16	GPØ2	AR
14	17	LWØ3	AR
14	18	LWØ2	MO
15	8	BBØ4	AR
15	9	BBØ4	AR
15	1Ø	BBØ5	AR
15	11	BBØ5	AR
15	12	GPØ2	AR
15	13	GPØ2	AR
15	14	GPØ2	AR
15	15	GPØ2	AR
15	16	GPØ2	AR
15	17	LWØ3	AR
15	18	LWØ3	AR
16	8	BBØ4	AR

I	J	Surface Water Basin Code	County Code
16	9	BBØ4	AR
16	1Ø	BBØ5	AR
16	11	BBØ5	AR
16	12	GPØ2	AR
16	13	GPØ2	AR
16	14	GPØ2	AR
16	15	GPGØ2	AR
16	16	GPØ2	AR
16	17	LWØ3	AR
16	18	LWØ3	AR
17	9	BBØ5	AR
17	1Ø	BBØ4	AR
17	11	BBØ5	AR
17	12	GPØ2	AR
17	13	GPØ2	AR
17	14	GPØ2	AR
17	15	GPØ2	AR
17	16	GPØ2	AR
17	17	LWØ3	AR
17	18	LWØ3	AR
18	1Ø	BBØ5	AR
18	11	BBØ5	AR
18	12	BBØ5	AR
18	13	GPØ2	AR
18	14	GPØ2	AR
18	15	GPØ2	AR

I	J	Surface Water Basin Code	County Code
18	16	GPØ2	AR
18	17	LWØ3	AR
19	11	BBØ5	AR
19	12	BBØ5	AR
19	13	GPØ2	AR
19	14	GPØ2	AR
19	15	GPØ2	AR
19	16	GPØ2	AR
19	17	LWØ3	AR
2Ø	11	BBØ5	AR
2Ø	12	BBØ5	AR
2Ø	13	APØ1*	AR
2Ø	14	APØ1	AR
2Ø	15	LWØ4	AR
2Ø	16	LWØ4	AR
21	11	APØ1	AR
21	12	APØ1	AR
21	13	APØ1	AR
21	14	APØ1	AR
21	15	APØ1	AR
21	16	LWØ4	DE
22	12	APØ2*	AR
22	13	APØ2	AR
22	14	APØ2	AR
22	15	APØ2	AR

* APØ1 is the basin just north of the Arkansas Post canal and APØ2 is the basin just south of the Arkansas Post canal.

Table 2: Monthly Potential Crop Water Needs and Surface and Groundwater Needs Based on the Strategy that Maintains at least 20 ft Saturated Thickness (Strategy A).

Month	Total Water Needs (ac-ft) (monthly % of the total seasonal water needs)	Surface Water Needs (ac-ft) (monthly % of the annual surface water needs)	Groundwater Needs (ac-ft) (monthly % of the annual groundwater needs)	% of total Monthly Water Needs: Surface	% of total Monthly Water Needs: Ground
August	279709 (32.4)	178200 (23.9)	101509 (86.2)	63.7	36.3
July	213897 (24.8)	204428 (27.4)	9469 (8.0)	95.6	4.4
June	249668 (28.9)	244375 (32.8)	5293 (4.5)	97.9	2.1
May	63528 (7.4)	62761 (8.4)	767 (0.7)	98.8	1.2
April	39003 (4.5)	38534 (5.2)	469 (0.4)	98.8	1.2
September	17348 (2.0)	17124 (2.3)	224 (0.2)	98.7	1.3
Total Annual	863153	745422	117731		

Surface water needs are 86.4 % of the annual crop water needs.

Groundwater needs are 13.6 % of the annual crop water needs.

Table 3: Monthly Potential Crop Water Needs and Surface and Groundwater Needs Based on the Strategy that Maintains at least 0 ft Saturated Thickness (Strategy B).

Month	Total Water Needs (ac-ft) (monthly % of the total seasonal water needs)	Surface Water Needs (ac-ft) (monthly % of the annual surface water needs)	Groundwater Needs (ac-ft) (monthly % of the annual ground-water needs)	% of total Monthly Water Needs Surface	Ground
August	279709 (32.4)	176168 (23.6)	103541 (88.4)	63.0	37.0
July	213897 (24.8)	204527 (27.4)	9370 (8.0)	95.6	4.4
June	249668 (28.9)	246099 (33.0)	3569 (3.0)	98.6	1.4
May	63528 (7.4)	63145 (8.5)	383 (0.3)	99.4	0.6
April	39003 (4.5)	38769 (5.2)	234 (0.2)	99.4	0.6
September	17348 (2.0)	17236 (2.3)	112 (0.1)	99.4	0.6
Total Annual	863153	745944	117209		

Surface water needs are 86.4 % of the annual crop water needs.

Groundwater needs are 13.6 % of the annual crop water needs.

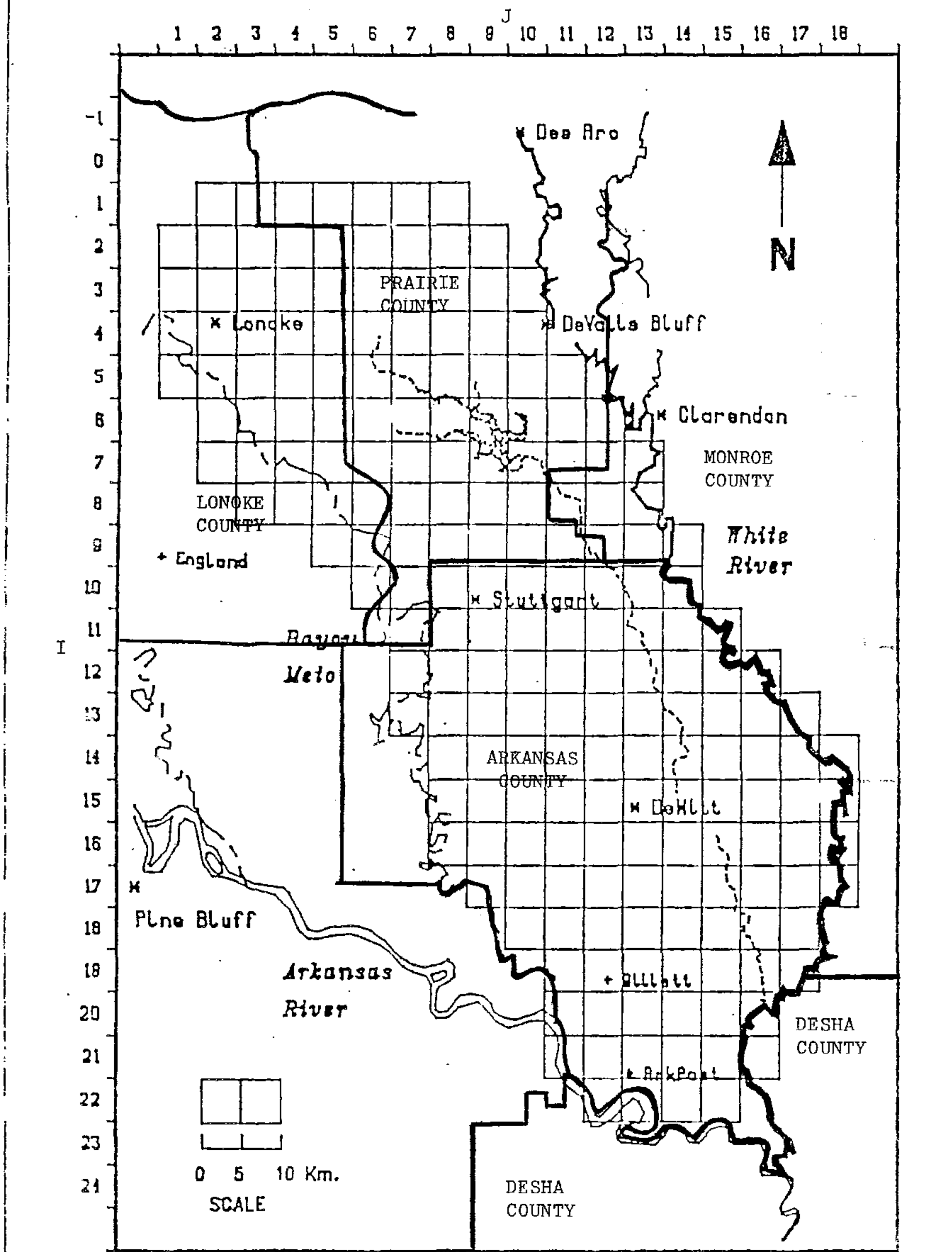

Figure:1(a)General Layout of the Grand Prairie Study Area Showing Cell Locations in Each County.

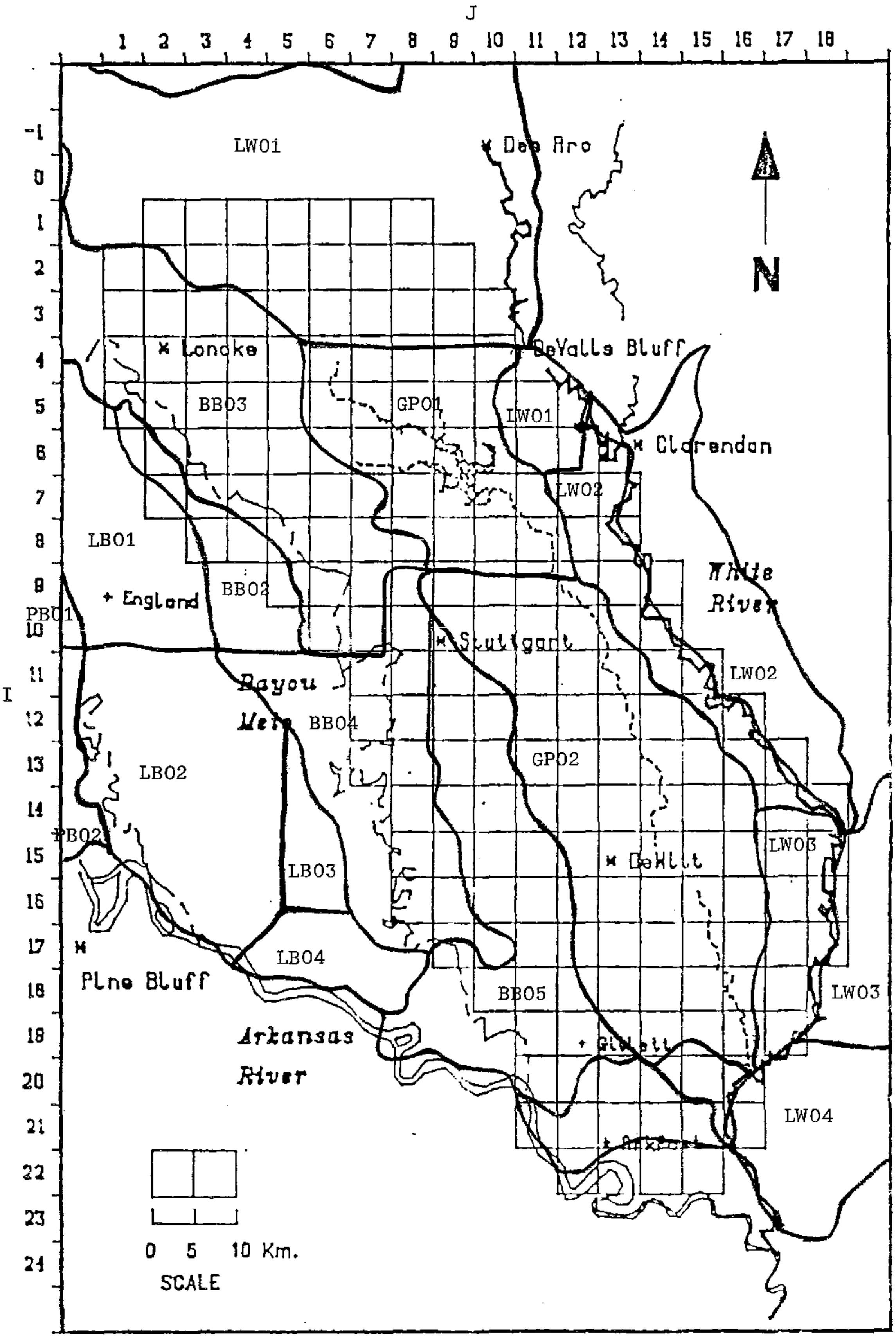

Figure:1(b)General Layout of the Grand Prairie Study Area Showing Cell Locations in Each Surface Water Basin & Reach.

I \ J	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		181 121	171 100	171 91	168 87	158 93	150 86	147 80										
2	177 116	163 99	151 69	156 63	158 76	146 93	142 84	146 71	152 72									
3	168 116	151 100	144 64	141 55	130 71	125 89	130 81	140 59	145 62	128 70								
4	164 73	143 85	135 55	130 65	124 73	118 83	115 96	125 58	136 63	127 76								
5	167 113	143 100	132 67	127 75	123 86	118 86	114 89	115 72	121 63	132 68	114 39							
6		152 109	138 80	129 68	125 86	122 100	116 93	113 82	113 67	125 82	130 62	122 46						
7		162 78	148 75	138 72	133 66	127 74	120 89	114 85	112 64	119 74	130 75	135 59	136 61					
8			158 85	149 82	143 85	136 87	125 86	113 89	108 78	113 75	123 67	122 53	123 42					
9					153 102	144 79	133 67	117 79	105 66	110 59	117 69	129 56	137 53	139 51				
10						151 76	142 74	127 72	114 76	110 77	113 80	123 62	137 51	136 48				
11							145 88	132 87	118 79	111 78	108 69	116 53	128 46	138 48	144 54			
12							149 95	135 97	120 91	108 67	103 68	108 40	118 29	128 36	137 48	145 47		
13							152 94	137 91	121 100	106 80	98 52	99 45	110 30	120 29	129 32	140 39	151 41	
14								143 85	124 87	105 82	97 52	96 29	103 19	113 24	123 28	133 29	143 31	145 32
15								155 84	133 82	112 62	100 33	96 16	100 31	108 23	119 12	130 20	139 23	142 26
16								163 79	147 80	122 78	107 59	99 32	100 43	107 28	117 13	130 14	138 19	140 22
17									157 80	138 75	120 69	107 61	103 50	110 28	119 9	129 12	136 17	139 22
18										153 63	136 57	122 43	114 47	115 32	116 20	120 13	128 17	
19											145 45	137 44	114 39	117 27	122 24	117 16	120 16	
20											143 33	135 25	125 24	121 22	116 15	116 14		
21											135 32	122 15	128 24	127 28	113 13	113 11		
22												141 40	142 39	134 38	123 27			

Figure 2: Kriged 1983 Top and Bottom Elevations of the Water Bearing Sands of the Quaternary Aquifer Underlying the Grand Prairie Region (in ft. above MSL).

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	5638	5638	4326	80	2379	4592	4098									
3	64	64	0	0	1359	3182	2837	3496								
4	0	0	480	320	480	0	352	574								
5	2720	1280	1440	2240	960	476	636	309	2162							
6		3840	1120	3520	2251	247	636	618	1853	1662						
7		1600	2080	1600	2380	3714	454	476	1538	12	1281					
8				2240	2560	3692	1429	6	105	266	2563					
9					2880	4960	2080	320	105	389	161	2403				
10						4640	1120	320	0	0	43	0				
11							480	0	0	0	62	185	62			
12							0	0	0	0	62	62	0	309		
13							160	0	0	0	0	185	0	0	0	
14								0	0	0	124	185	0	0	0	0
15								160	160	0	0	204	371	206	276	0
16								800	160	0	0	0	105	0	129	67
17									0	0	0	62	0	0	541	324
18										0	0	0	0	185	0	
19											0	0	62	247	0	
20											800	0	0	0		
21											1568	352	587	62		
22																

Figure:3 Potential Soybean Land in each 3 x 3 mile cell in the Grand Prairie Region in acres.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0	0	0	0	803	845	927									
3	0	1441	2883	721	2456	3222	2626	1833								
4	960	1920	1440	320	1621	2088	1674	1575								
5	2080	4480	4320	2880	4049	4949	5029	5270	2255							
6		1920	4640	2240	2876	4961	4881	4288	2823	2275						
7		4160	3680	4160	3379	1903	5384	4158	3472	56	641					
8				3520	3200	2208	4292	5566	5418	3476	2403					
9					2880	800	3674	5071	5233	5276	1582	0				
10						1120	4640	4035	4528	5023	5190	445				
11							4960	3207	5516	4942	5251	1650	3393			
12							5760	5760	5760	5237	5579	3645	4664	3635		
13							5600	5760	5600	5297	5270	4912	1056	5468	4242	
14								5760	5760	5664	5208	4016	2199	5190	5169	2528
15								5600	5600	5760	4035	3404	1433	4860	4541	3413
16								4320	5600	5760	5760	5517	4423	877	3635	2785
17									5760	5280	5183	5455	5165	3688	1483	124
18										4640	5600	5467	4102	3435	618	
19											5120	5144	3423	3972	2471	
20											4960	3136	5164	4664		
21											2400	2144	3738	3429		
22																

Figure: 4 Potential Rice Land in each 3 x 3 mile cell in the Grand Prairie Region in acres.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0	0	0	0	0	0	0									
3	0	0	0	0	0	0	0	0								
4	0	0	0	0	0	0	0	0								
5	0	0	0	0	0	0	0	0	0							
6		0	0	0	0	0	0	0	0	0						
7		0	0	0	0	0	0	0	0	0	0					
8				0	0	0	0	0	0	0	0					
9					0	0	0	0	0	0	173	0				
10						0	0	0	0	0	235	93				
11							0	0	0	0	185	402	1132			
12							0	0	0	0	0	815	967	690		
13							0	0	0	0	185	612	136	20	741	
14								0	0	0	247	1501	519	432	618	1050
15								0	0	0	185	1192	834	783	649	1637
16								0	0	0	0	105	1131	1100	1462	618
17									0	0	0	185	599	636	649	0
18										0	0	179	1155	1470	494	
19											0	204	741	259	62	
20											0	0	556	432		
21											0	0	247	340		
22																

Figure:5 Potential Wheat Land in each 3 x 3 mile cell in the Grand Prairie Region in acres.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	517	517	397	7	255	460	418									
3	6	72	132	33	237	398	381	405								
4	44	88	110	44	118	96	109	125								
5	345	323	330	338	274	271	289	270	302							
6		440	316	426	338	250	282	253	299	257						
7		338	360	338	373	428	289	234	300	4	147					
8				367	382	440	327	256	258	184	345					
9					396	492	359	262	250	278	103	220				
10						477	316	214	208	230	263	29				
11							271	147	253	227	263	129	265			
12							264	264	264	240	261	248	303	258		
13							271	264	257	243	259	298	61	438	263	
14								264	264	259	273	339	148	278	294	110
15								271	271	265	203	284	176	314	293	307
16								271	271	264	268	263	316	141	313	190
17									264	242	237	273	292	227	177	35
18										213	257	267	294	309	74	
19											235	254	231	229	119	
20											301	144	288	254		
21											254	131	248	194		
22																

Figure:6 Potential Irrigation Water needs in April for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	846	846	649	12	417	752	684									
3	10	118	216	54	388	651	622	662								
4	72	144	180	72	193	157	178	204								
5	564	528	540	552	448	442	473	442	493							
6		720	516	696	554	409	461	414	490	420						
7		552	588	552	610	699	472	383	491	6	240					
8				600	624	719	536	418	422	301	565					
9					648	804	588	428	408	454	169	360				
10						780	516	351	340	377	431	47				
11							444	241	414	371	431	212	434			
12							432	432	432	393	428	405	495	422		
13							444	432	420	397	423	488	100	716	429	
14								432	432	425	446	554	243	454	480	180
15								444	444	433	332	465	288	513	480	502
16								444	444	432	438	429	517	231	511	312
17									432	396	388	446	477	372	290	58
18										348	420	437	481	506	120	
19											235	304	377	374	195	
20											492	235	471	415		
21											415	214	405	317		
22																

Figure:7 Potential Irrigation Water needs in May for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0	0	0	0	375	394	432									
3	0	673	1346	336	1146	1084	1225	855								
4	448	896	672	149	756	975	781	735								
5	971	2091	2016	1344	1890	2309	2347	2459	1052							
6		896	2166	1045	1342	2315	2278	2001	1318	1062						
7		1942	1718	1942	1577	888	2513	1940	1620	26	299					
8				1643	1493	1033	2003	2598	2529	1623	1121					
9					1344	373	1715	2366	2442	2462	738	0				
10						523	2166	1883	2113	2344	2422	208				
11							1419	1318	1335	2307	2451	770	1583			
12							2688	2688	2688	2444	2604	1701	2177	1696		
13							2614	2688	2614	2472	2459	2292	493	2552	1980	
14								2688	2688	2643	2431	1874	1026	2422	2412	142
15								2614	2614	2690	1891	1589	669	2268	2119	1593
16								2016	2614	2688	2728	2575	2064	409	1696	1300
17									2688	2464	2418	2546	2410	1721	692	58
18										2166	2614	2551	1941	1603	288	
19											2390	2400	1597	1854	1153	
20											2315	1464	2410	2177		
21											1120	1001	1744	1600		
22																

Figure: 8 Potential Irrigation Water needs in June for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	1033	1033	793	15	719	1139	1072									
3	12	520	1016	254	1115	1401	1445	1287								
4	338	677	596	171	660	736	655	661								
5	1232	1814	1787	1426	1603	1831	1889	1914	1191							
6		1381	1841	1435	1426	1794	1837	1624	1335	1107						
7		1760	1678	1760	1627	1352	1981	1553	1506	22	461					
8				1651	1597	1455	1775	1963	1929	1275	1317					
9					1543	1191	1676	1846	1864	1931	587	440				
10						1245	1841	1480	1596	1770	1837	157				
11							1836	1131	1944	1742	1862	615	1207			
12							2030	2030	2030	1846	1978	1296	1644	1338		
13							2003	2030	1974	1867	1858	1765	372	1927	1495	
14								2030	2030	1997	1858	1449	775	1829	1822	107
15								2003	2003	2032	1429	1237	573	1751	1651	1203
16								1669	2003	2030	2060	1945	1578	309	1305	994
17									2030	1861	1827	1934	1820	1300	622	103
18										2030	1805	2469	1446	1245	218	
19											1805	1813	1218	1445	871	
20											1895	1105	1820	1644		
21											1133	820	1425	1220		
22																

Figure: 9 Potential Irrigation Water needs in July for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	2020	2020	1549	29	1208	2020	1879									
3	23	662	1278	320	1575	2169	2180	2065								
4	426	851	810	256	890	926	868	904								
5	1897	2444	2431	2079	2138	2364	2457	2447	1774							
6		2227	2458	2254	2082	2287	2391	2122	1915	1604						
7		2417	2338	1525	147	649	2415	2013	2090	29	743					
8				2363	2336	2302	2414	2470	2439	1637	1983					
9					2308	2132	2374	2362	2357	2478	759	861				
10						2159	2458	1903	2007	2226	2316	197				
11							2371	1422	2445	2191	2350	798	2068			
12							2553	2553	2553	2321	2495	1638	2068	1722		
13							2540	2553	2482	2348	2336	2243	468	2424	1880	
14								2553	2553	2510	2353	1846	975	2300	2291	135
15								2540	2540	2555	1796	1582	768	2228	2112	1513
16								2202	2540	2553	2591	2445	1998	389	1657	1258
17									2553	2341	2298	2440	2289	1635	851	171
18										2057	2482	2423	1818	1589	274	
19											2270	2280	1539	1849	1095	
20											2485	1390	2289	2068		
21											1626	1077	1867	1542		
22																

Figure:10 Potential Irrigation Water needs in August for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	235	235	180	3	117	211	192									
3	3	35	65	16	112	185	177	187								
4	22	43	52	21	56	47	52	59								
5	160	154	157	158	131	131	140	131	141							
6		203	151	197	159	122	136	122	141	121						
7		160	170	160	175	198	140	113	142	2	68					
8				173	179	203	156	125	126	89	161					
9					185	225	169	128	122	135	42	100				
10						219	151	105	102	113	119	10				
11							132	72	124	111	121	45	79			
12							130	130	130	118	128	85	105	95		
13							133	130	126	119	119	118	24	123	95	
14								130	130	127	122	98	49	117	116	7
15								133	133	130	91	85	48	118	114	77
16								131	133	130	132	124	104	20	87	65
17									130	119	117	125	116	83	56	16
18										104	126	123	92	85	14	
19											115	115	80	100	56	
20											145	71	116	105		
21											119	63	109	80		
22																

Figure:11 Potential Irrigation Water needs in September for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	4669	4669	3582	67	3099	4990	4697									
3	53	2079	4053	1013	4578	5899	6041	5472								
4	1350	2699	2422	715	2675	2935	2645	2690								
5	5177	7358	7266	5904	6487	7350	7596	7664	4961							
6		5880	7450	6065	5907	7178	7388	6539	5504	4575						
7		7173	6896	7173	6721	5751	7945	6239	6155	88	1962					
8				6804	6619	6162	7218	7830	7703	5109	5500					
9					6434	5233	6888	7393	7443	7739	2398	1990				
10						5418	7450	5937	6366	7060	7387	648				
11							7370	4508	7755	6948	7478	2569	5094			
12							8097	8097	8097	7362	7893	5372	6791	5532		
13							8005	8097	7872	7446	7453	7205	1518	8178	6142	
14								8097	8097	7961	7483	6161	3217	7399	7415	681
15								8005	8005	8104	5742	5242	2523	7192	6770	5194
16								6736	8005	8097	8217	7781	6578	1499	5569	4120
17									8097	7423	7286	7764	7405	5338	2689	442
18										6523	7872	7729	6046	5337	988	
19											7198	7280	5042	5851	3489	
20											7635	4409	7393	6661		
21											4673	3306	5800	4953		
22																

Figure: 12 Annual Potential Irrigation Water needs for an average season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	846	846	649	12	417	752	684									
3	10	118	216	54	388	651	622	662								
4	72	144	180	72	193	157	178	204								
5	564	528	540	552	448	442	473	442	493							
6		720	516	696	554	409	461	414	490	420						
7		552	588	552	610	699	472	383	491	6	240					
8				600	624	719	536	418	422	301	565					
9					648	804	588	428	408	454	169	360				
10						780	516	351	340	377	431	47				
11							444	241	414	371	431	212	434			
12							432	432	432	393	428	405	495	422		
13							444	432	420	397	423	488	100	716	429	
14								432	432	425	446	554	243	454	480	180
15								444	444	433	332	465	288	513	480	502
16								444	444	432	438	429	517	231	511	312
17									432	396	388	446	477	372	290	58
18										348	420	437	481	506	120	
19											235	304	377	374	195	
20											492	235	471	415		
21											415	214	405	317		
22																

Figure:13 Potential Irrigation Water needs in April for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	2583	2583	1982	37	1274	2298	2090									
3	29	359	661	165	1186	1190	1902	2022								
4	220	440	550	220	591	478	545	624								
5	1723	1613	1650	1686	1368	1352	1444	1349	1508							
6		2090	2200	1576	2541	2526	1410	1265	1496	1283						
7		1686	1796	1686	1865	2138	1441	1171	1500	18	734					
8				1833	1906	2202	1639	1278	1290	919	1725					
9					1980	2456	1795	1309	1247	1387	515	1101				
10						2383	1576	1071	1038	1151	1316	144				
11							1357	735	1264	1132	1316	647	1325			
12							1320	1320	1320	1200	1307	1237	1512	1291		
13							1357	1320	1283	1213	1292	1419	304	2187	1312	
14								1320	1320	1298	1363	1693	742	1387	1467	551
15								1357	1357	1321	1014	1420	880	1567	1465	1532
16								1357	1357	1320	1340	1312	1580	705	1562	952
17									1320	1210	1187	1363	1458	1137	885	177
18										1063	1283	1335	1469	1546	368	
19											1173	1272	1152	1142	595	
20											1503	719	1438	1267		
21											1269	653	1239	970		
22																

Figure: 14 Potential Irrigation Water needs in May for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0	0	0	0	412	433	475									
3	0	739	1478	369	1258	1190	1346	939								
4	492	984	738	164	830	1070	858	807								
5	1066	2296	2214	1476	2075	2536	2577	2701	1156							
6		984	2378	1148	1473	2542	2501	2197	1447	1166						
7		2132	1886	2132	1731	976	2759	2131	1779	28	328					
8				1804	1640	1131	2200	2853	2777	1782	1231					
9					1476	410	1883	2617	2682	2704	811	0				
10						574	2378	2068	2321	2574	2659	228				
11							2542	1643	2827	2533	2691	845	1739			
12							2952	2952	2952	2684	2859	1868	2390	1863		
13							2870	2952	2870	2714	2701	2517	541	2802	2174	
14								2952	2952	2903	2669	2058	1127	2659	2649	156
15								2870	2870	2955	2077	1744	735	2491	2372	1749
16								2214	2870	2952	2996	2827	2267	450	1863	1427
17									2952	2706	2656	2796	2647	1890	760	63
18										2378	2870	2802	2102	1760	317	
19											2624	2636	1754	2036	1266	
20											2542	1607	2646	2390		
21											1230	1099	1915	1757		
22																

Figure: 15 Potential Irrigation Water needs in June for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	3805	3805	2919	54	2249	3776	3508									
3	43	1197	2309	577	2884	4007	4017	3827								
4	769	1538	1477	472	1622	1672	1578	1469								
5	3502	4452	4431	3818	3890	4284	4456	4428	3265							
6		4130	4472	4170	3822	4139	4338	3850	3512	2944						
7		4411	4351	4411	4312	4031	4618	3650	3818	53	1378					
8				4331	4291	4260	4401	4461	4409	2964	3654					
9					4250	3989	4347	4276	4261	4487	1375	1622				
10						4029	4472	3447	3626	4022	4185	356				
11							4296	2568	4417	3958	4247	1446	2759			
12							4613	4613	4613	4194	4509	2960	3735	3119		
13							4592	4613	4484	4241	4220	4058	846	4378	3397	
14								4613	4613	4536	4254	3341	1761	4155	4139	243
15								4592	4592	4617	3245	2863	1398	4031	3824	2733
16								3999	4592	4613	4681	4418	3613	702	2997	2275
17									4613	4228	4150	4410	4136	2953	1552	318
18										3716	4484	4378	3285	2876	495	
19											4100	4119	2782	3348	1979	
20											4512	2511	4135	3735		
21											2980	1954	3389	2787		
22																

Figure:16 Potential Irrigation Water needs in July for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	4792	4792	3676	68	2713	4630	4280									
3	54	1294	2481	620	3268	4702	4670	4548								
4	826	1652	1647	547	1803	1797	1740	1844								
5	4102	4943	4941	4382	4300	4662	4868	4797	3778							
6		4916	4945	4919	4388	4479	4740	4214	4005	3371						
7		4940	4935	4940	4930	4794	5018	3982	4295	58	1640					
8				4933	4929	5038	4908	4795	4751	3219	4245					
9					4926	4904	4930	4635	4592	4870	1497	2042				
10						4908	4945	3743	3896	4322	4502	383				
11							4676	2760	4746	4253	4571	1577	2972			
12							4956	4956	4956	4506	4853	3189	4013	3390		
13							4955	4956	4819	4558	4534	4383	909	4704	3650	
14								4956	4956	4874	4586	3613	1892	4465	4447	262
15								4965	4955	4961	3487	3102	1548	4357	4143	2937
16								4397	4955	4956	5030	4747	3895	755	3236	2453
17									4956	4543	4459	4746	4444	3173	1735	382
18										3993	4819	4705	3530	3113	532	
19											4406	4426	2997	3628	2126	
20											4948	2698	4443	4013		
21											3398	2144	3715	3003		
22																

Figure:17 Potential Irrigation Water needs in August for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	940	940	721	13	464	837	761									
3	11	132	244	61	434	727	695	738								
4	81	162	202	80	217	177	200	229								
5	629	592	605	617	502	498	531	497	179							
6		802	579	776	618	461	519	465	548	469						
7		618	658	618	683	781	531	431	550	7	268					
8				671	697	802	601	472	475	338	630					
9					724	895	657	482	460	511	160	401				
10						868	579	394	383	425	446	38				
11							499	271	467	418	454	170	297			
12							487	487	487	443	482	318	394	359		
13							500	487	473	448	445	446	89	462	359	
14								487	487	479	461	370	186	439	437	26
15								500	500	487	343	322	183	445	430	289
16								499	500	487	494	466	391	74	329	247
17									487	446	438	471	437	312	215	65
18										392	473	462	347	321	52	
19											433	435	300	377	209	
20											553	265	436	394		
21											464	240	414	300		
22																

Figure 18 Potential Irrigation Water needs in September for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

I \ J	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	12965	12965	9946	185	7528	12725	11799									
3	146	3840	7388	1847	9418	13288	13252	12738								
4	2460	4920	4794	1556	5257	5351	5100	5358								
5	11588	14424	14382	12532	12583	13774	14349	14214	10751							
6		13752	14468	13836	12546	13280	13868	12407	11497	9854						
7		14340	14214	14340	14132	13418	14840	11748	12434	171	4588					
8				14172	14088	14151	14265	14277	14125	9523	12050					
9					14004	13458	14200	13728	13850	14414	4527	5528				
10						13542	14468	11074	11604	12870	13540	1198				
11							13814	8217	14135	12884	13710	4897	9525			
12							12780	14760	14760	13420	14437	9978	12540	10443		
13							14718	14760	14350	13573	13818	13383	2790	15250	11320	
14								14760	14760	14513	13779	11829	5951	13560	13818	1418
15								14718	14718	14773	10497	9917	5032	13403	12889	9742
16								12910	14718	14760	14978	14200	12284	2817	10498	7665
17									14760	13530	13281	14233	13589	9838	5437	1063
18										11890	14350	14118	11214	10122	1884	
19											13120	13304	9363	10905	6370	
20											14550	8038	13589	12215		
21											9758	6304	11077	9135		
22																

Figure:19 Annual Potential Irrigation Water needs for a dry season in each 3 x 3 mile cell in the Grand Prairie Region in ac-ft.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
-1																		
0																		
1		-3306	-3880	-3455	-2399	-1186	-546	-86										
2	-3287	0	0	0	0	0	0	0	-2268									
3	-1308	0	0	0	0	0	0	0	0	-2327								
4	-4769	0	0	0	0	0	0	0	0	-3550								
5	-3896	0	0	0	0	0	0	0	0	0	-3776							
6		-1764	0	0	0	0	0	0	0	0	0	-2985						
7		-3844	0	0	0	0	0	0	0	0	0	0	-3079					
8			-3757	-1377	0	0	0	0	0	0	0	0	-1968					
9					-2785	0	0	0	0	0	0	0	0	-3104				
10						-2865	0	0	0	0	0	0	0	-2001				
11							-1497	0	0	0	0	0	0	0	-3163			
12							-2022	0	0	0	0	0	0	0	0	-3690		
13							-2360	0	0	0	0	0	0	0	0	0	-6711	
14								-1254	0	0	0	0	0	0	0	0	0	-2359
15								-3092	0	0	0	0	0	0	0	0	0	-793
16								-4285	0	0	0	0	0	0	0	0	0	-648
17									-5060	0	0	0	0	0	0	0	0	-1823
18										-7122	0	0	0	0	0	0	-1287	
19											-2700	0	0	0	0	0	-1776	
20											-2101	0	0	0	0	-594		
21											-1445	0	0	0	0	-626		
22												-611	-539	-1079	-423			
23																		
24																		

Figure:20 The maximum annual recharge values estimated from 1972-83 in each constant head cell in the Grand Prairie Region in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	657	0	0	13	0	0	660									
3	53	299	0	0	0	0	849	126								
4	1350	387	1024	0	0	2936	372	379								
5	731	7358	1025	832	1867	1031	2816	1074	697							
6		830	1050	854	0	0	1035	1988	771	643						
7		1009	970	1007	942	0	345	870	860	12	277					
8				0	0	340	464	1092	1074	713	771					
9					896	725	957	1878	1034	1078	334	281				
10						749	0	822	0	983	1030	91				
11							0	0	0	0	0	359	715			
12							0	1372	1128	1026	1101	751	953	0		
13							1118	0	1099	1040	1043	0	217	1149	862	
14								1134	1135	1117	1053	870	459	1044	1043	97
15								0	1127	1144	816	2935	368	1019	956	0
16								561	1130	5313	1166	1105	939	227	661	0
17									1144	1052	1036	5307	1278	767	0	0
18										658	1121	1102	867	0	0	
19											0	1038	725	834	495	
20											0	634	1051	0		
21											665	475	823	0		
22																

Figure: 21 Annual withdrawals based on the Strategy that maintains ≥20 ft. Saturated Thickness and Groundwater Levels similar to those of 1983 in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	1363	2020	1549	16	1208	2020	1219									
3	0	363	1278	320	1575	2169	1331	1939								
4	0	464	0	256	890	0	496	525								
5	1166	0	1406	1247	271	1333	0	1373	1077							
6		1397	1408	1400	2082	2287	1356	134	1144	961						
7		1408	1368	518	0	649	2070	1143	1230	17	466					
8				2363	2336	1962	1950	1378	1365	924	1212					
9					1412	1407	1417	484	1323	1400	425	580				
10						1410	2458	1081	2007	1243	1286	106				
11							2371	1422	2445	2191	2350	439	1353			
12							2553	1181	1425	1295	1394	887	1115	1722		
13							1422	2553	1383	1308	1293	2243	251	1275	1018	
14								1419	1418	1393	1300	976	516	1256	1248	38
15								2540	1413	1411	980	0	400	1209	1156	1513
16								1641	1410	0	1425	1340	1059	162	996	1258
17									1409	1289	1262	0	1011	868	851	171
18										1399	1361	1321	951	1589	274	
19											2270	1242	814	1015	600	
20											2485	756	1238	2068		
21											961	602	1044	1542		
22																

Figure: 22 Surface Water Requirements for August of an Average year based on the Strategy that maintains ≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	1033	1033	793	15	719	1139	1072									
3	0	520	1016	254	1115	1401	1445	1287								
4	0	677	382	171	660	0	655	661								
5	1232	0	1787	1426	1603	1831	1530	1914	1191							
6		1381	1841	1435	1426	1794	1837	1624	1335	1107						
7		1760	1678	1760	832	1352	1981	1553	1506	22	461					
8				1651	1597	1455	1775	1963	1929	1275	1317					
9					1543	1191	1676	1846	1864	1931	587	440				
10						1245	1841	1480	1596	1770	1837	157				
11							1836	1131	1944	1742	1862	615	1207			
12							2030	2030	2030	1846	1978	1296	1644	1338		
13							2003	2030	1974	1867	1858	1765	372	1927	1495	
14								2030	2030	1997	1858	1449	775	1829	1822	107
15								2003	2003	2032	1429	0	573	1751	1651	1203
16								1669	2003	0	2060	1945	1578	309	1305	994
17									2030	1861	1827	0	1820	1300	622	103
18										2030	1805	2469	1446	1245	218	
19											1805	1813	1218	1445	871	
20											1895	1105	1820	1644		
21											1133	820	1425	1220		
22																

Figure:23 Surface Water Requirements for July of an Average year based on the Strategy that maintains ≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0	0	0	0	375	394	432									
3	0	673	1346	336	1146	1084	1225	855								
4	0	896	672	149	756	0	781	735								
5	971	0	2016	1344	1890	2309	2347	2459	1052							
6		896	2166	1045	1342	2315	2278	2001	1318	1062						
7		1942	1718	1942	1577	888	2513	1940	1620	26	299					
8				1643	1493	1033	2003	2598	2529	1623	1121					
9					1344	373	1715	2366	2442	2462	738	0				
10						523	2166	1883	2113	2344	2422	208				
11							1419	1318	1335	2307	2451	770	1583			
12							2688	2688	2688	2444	2604	1701	2177	1696		
13							2614	2688	2614	2472	2459	2292	493	2552	1980	
14								2688	2688	2643	2431	1874	1026	2422	2412	142
15								2614	2614	2690	1891	1473	669	2268	2119	1593
16								2016	2614	1958	2728	2575	2064	409	1696	1300
17									2688	2464	2418	1613	2410	1721	692	58
18										2166	2614	2551	1941	1603	288	
19											2390	2400	1597	1854	1153	
20											2315	1464	2410	2177		
21											1120	1001	1744	1600		
22																

Figure:24 Surface Water Requirements for June of an Average year based on the Strategy that maintains ≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	846	846	649	12	417	752	684									
3	0	118	216	54	388	651	622	662								
4	0	144	180	72	193	0	178	204								
5	564	0	540	552	448	442	473	442	493							
6		720	516	696	554	409	461	414	490	420						
7		552	588	552	610	699	472	383	491	6	240					
8				600	624	719	536	418	422	301	565					
9					648	804	588	428	408	454	169	360				
10						780	516	351	340	377	431	47				
11							444	241	414	371	431	212	434			
12							432	432	432	393	428	405	495	422		
13							444	432	420	397	423	488	100	716	429	
14								432	432	425	446	554	243	454	480	180
15								444	444	433	332	465	288	513	480	502
16								444	444	432	438	429	517	231	511	312
17									432	396	388	446	477	372	290	58
18										348	420	437	481	506	120	
19											235	304	377	374	195	
20											492	235	471	415		
21											415	214	405	317		
22																

Figure:25 Surface Water Requirements for May of an Average year based on the Strategy that maintains≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	517	517	397	7	255	460	418									
3	0	72	132	33	237	398	381	405								
4	0	88	110	44	118	0	109	125								
5	345	0	330	338	274	271	289	270	302							
6		440	316	426	338	250	282	253	299	257						
7		338	360	338	373	428	289	234	300	4	147					
8				367	382	440	327	256	258	184	345					
9					396	492	359	262	250	278	103	220				
10						477	316	214	208	230	263	29				
11							271	147	253	227	263	129	265			
12							264	264	264	240	261	248	303	258		
13							271	264	257	243	259	298	61	438	263	
14								264	264	259	273	339	148	278	294	110
15								271	271	265	203	284	176	314	293	307
16								271	271	264	268	263	316	141	313	190
17									264	242	237	273	292	227	177	35
18										213	257	267	294	309	74	
19											235	254	231	229	119	
20											301	144	288	254		
21											254	131	248	194		
22																

Figure:26 Surface Water Requirements for April of an Average year based on the Strategy that maintains≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	235	235	180	3	117	211	192									
3	1	35	65	16	112	185	177	187								
4	0	43	52	21	56	1	52	59								
5	160	0	157	158	131	131	140	131	141							
6		203	151	197	159	122	136	122	141	121						
7		160	170	160	175	198	140	113	142	2	68					
8				173	179	203	156	125	126	89	161					
9					185	225	169	128	122	135	42	100				
10						219	151	105	102	113	119	10				
11							132	72	124	111	121	45	79			
12							130	130	130	118	128	85	105	95		
13							133	130	126	119	119	118	24	123	95	
14								130	130	127	122	98	49	117	116	7
15								133	133	130	91	85	48	118	114	77
16								131	133	130	132	124	104	20	87	65
17									130	119	117	125	116	83	56	16
18										104	126	123	92	85	14	
19											115	115	80	100	56	
20											145	71	116	105		
21											119	63	109	80		
22																

Figure:27 Surface Water Requirements for September of an Average year based on the Strategy that maintains≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	657	0	0	13	0	0	0									
3	53	297	0	0	0	0	848	0								
4	1350	2699	0	0	378	2935	373	379								
5	3583	4341	1023	831	1682	1031	2625	1625	697							
6		829	1048	1233	60	212	772	1967	772	643						
7		1008	969	1007	942	0	0	872	862	13	277					
8				0	0	322	886	1094	1077	715	771					
9					899	18	961	1535	1038	1081	335	281				
10						0	0	826	888	986	1033	0				
11							1027	0	0	0	1045	360	0			
12							1131	0	0	1029	1104	0	0	0		
13							1120	360	787	1042	1673	1011	216	1148	862	
14								1463	1135	1117	1622	869	457	1042	1042	97
15								1124	1126	1142	3805	744	363	1016	954	0
16								0	2498	1142	1162	1101	934	221	203	0
17									1140	1048	2533	4507	2255	761	0	0
18										923	1115	1095	860	0	0	
19											0	1032	719	829	494	
20											0	0	0	0		
21											662	471	819	0		
22																

Figure: 28 Annual Withdrawals based on the Strategy that maintains ≥ 0 ft. Saturated thickness and Groundwater Levels similar to those of 1983 in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	1363	2020	1549	16	1208	2020	1879									
3	0	365	1278	320	1575	2169	1332	2065								
4	0	0	810	256	512	0	495	525								
5	0	0	1408	1248	456	1333	0	822	1077							
6		1398	1410	1021	2022	2075	1619	155	1143	961						
7		1409	1369	518	0	649	2415	1141	1228	16	466					
8				2363	2336	1980	1528	1376	1362	922	1212					
9					1409	2114	1413	827	1319	1397	424	580				
10						2159	2458	1077	1119	1240	1283	197				
11							1344	1422	2445	2191	1305	438	2068			
12							1422	2553	2553	1292	1391	1638	2068	1722		
13							1420	2193	1695	1306	663	1232	252	1276	1018	
14								1090	1418	1393	731	977	518	1258	1249	38
15								1416	1414	1413	0	838	405	1212	1158	1513
16								2202	42	1411	1429	1344	1064	168	1454	1256
17									1413	1293	0	0	34	874	851	171
18										1134	1367	1328	958	1589	274	
19											2270	1248	820	1020	601	
20											2485	1390	2289	2068		
21											964	606	1048	1542		
22																

Figure: 29 Surface Water Requirements for August of an average year based on the Strategy that maintains≥0 ft. Saturated thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	1033	1033	793	15	719	1139	1072									
3	0	520	1016	254	1115	1401	1445	1287								
4	0	0	596	171	660	0	655	661								
5	0	0	1787	1426	1603	1831	1721	1914	1191							
6		1381	1841	1435	1426	1794	1837	1624	1335	1107						
7		1760	1678	1760	832	1352	1981	1553	1506	22	461					
8				1651	1597	1455	1775	1963	1929	1275	1317					
9					1543	1191	1676	1846	1864	1931	587	440				
10						1245	1841	1480	1596	1770	1837	157				
11							1836	1131	1944	1742	1862	615	1207			
12							2030	2030	2030	1846	1978	1296	1644	1338		
13							2003	2030	1974	1867	1858	1765	372	1927	1495	
14								2030	2030	1997	1858	1449	775	1829	1822	107
15								2003	2003	2032	0	1237	573	1751	1651	1203
16								1669	2003	2030	2060	1945	1578	309	1305	994
17									2030	1861	1592	0	1820	1300	622	103
18										2030	1805	2469	1446	1245	218	
19											1805	1813	1218	1445	871	
20											1895	1105	1820	1644		
21											1133	820	1425	1220		
22																

Figure:30 Surface Water Requirements for July of an Average year based on the Strategy that maintains≥0 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	0	0	0	0	375	394	432									
3	0	673	1346	336	1146	1084	1225	855								
4	0	0	672	149	756	0	781	735								
5	517	2008	2016	1344	1890	2309	2347	2459	1052							
6		896	2166	1045	1342	2315	2278	2001	1318	1062						
7		1942	1718	1942	1577	888	2513	1940	1620	26	299					
8				1643	1493	1033	2003	2598	2529	1623	1121					
9					1344	373	1715	2366	2442	2462	738	0				
10						523	2166	1883	2113	2344	2422	208				
11							1419	1318	1335	2307	2451	770	1583			
12							2688	2688	2688	2444	2604	1701	2177	1696		
13							2614	2688	2614	2472	2459	2292	493	2552	1980	
14								2688	2688	2643	2431	1874	1026	2422	2412	142
15								2614	2614	2690	1311	1589	669	2268	2119	1593
16								2016	2614	2688	2728	2575	2064	409	1696	1300
17									2688	2464	2418	2413	2410	1721	692	58
18										2166	2614	2551	1941	1603	288	
19											2390	2400	1597	1854	1153	
20											2315	1464	2410	2177		
21											1120	1001	1744	1600		
22																

Figure:31 Surface Water Requirements for June of an Average year based on the Strategy that maintains≥20 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	846	846	649	12	417	752	684									
3	0	118	216	54	388	651	622	662								
4	0	0	180	72	193	0	178	204								
5	564	528	540	552	448	442	473	442	493							
6		720	516	696	554	409	461	414	490	420						
7		552	588	552	610	699	472	383	491	6	240					
8				600	624	719	536	418	422	301	565					
9					648	804	588	428	408	454	169	360				
10						780	516	351	340	377	431	47				
11							444	241	414	371	431	212	434			
12							432	432	432	393	428	405	495	422		
13							444	432	420	397	423	488	100	716	429	
14								432	432	425	446	554	243	454	480	180
15								444	444	433	332	465	288	513	480	502
16								444	444	432	438	429	517	231	511	312
17									432	396	388	446	477	372	290	58
18										348	420	437	481	506	120	
19											235	304	377	374	195	
20											492	235	471	415		
21											415	214	405	317		
22																

Figure:32 Surface Water Requirements for May of an Average year based on the Strategy that maintains≥0 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	517	517	397	7	255	460	418									
3	0	72	132	33	237	398	381	405								
4	0	0	110	44	118	0	109	125								
5	345	323	330	338	274	271	289	270	302							
6		440	316	426	338	250	282	253	299	257						
7		338	360	338	373	428	289	234	300	4	147					
8				367	382	440	327	256	258	184	345					
9					396	492	359	262	250	278	103	220				
10						477	316	214	208	230	263	29				
11							271	147	253	227	263	129	265			
12							264	264	264	240	261	248	303	258		
13							271	264	257	243	259	298	61	438	263	
14								264	264	259	273	339	148	278	294	110
15								271	271	265	203	284	176	314	293	307
16								271	271	264	268	263	316	141	313	190
17									264	242	237	273	292	227	177	35
18										213	257	267	294	309	74	
19											235	254	231	229	119	
20											301	144	288	254		
21											254	131	248	194		
22																

Figure:33 Surface Water Requirements for April of an Average year based on the Strategy that maintains≥0 ft. Saturated Thickness in ac-ft.

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1																
2	235	235	180	3	117	211	192									
3	1	35	65	16	112	185	177	187								
4	0	0	52	21	56	2	52	59								
5	160	154	157	158	131	131	140	131	141							
6		203	151	197	159	122	136	122	141	121						
7		160	170	160	175	198	140	113	142	2	68					
8				173	179	203	156	125	126	89	161					
9					185	225	169	128	122	135	42	100				
10						219	151	105	102	113	119	10				
11							132	72	124	111	121	45	79			
12							130	130	130	118	128	85	105	95		
13							133	130	126	119	119	118	24	123	95	
14								130	130	127	122	98	49	117	116	7
15								133	133	130	91	85	48	118	114	77
16								131	133	130	132	124	104	20	87	65
17									130	119	117	125	116	83	56	16
18										104	126	123	92	85	14	
19											115	115	80	100	56	
20											145	71	116	105		
21											119	63	109	80		
22																

Figure: 34 Surface Water Requirements for September of an Average year based on the Strategy that maintains ≥20 ft. Saturated Thickness in ac-ft.

I \ J	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		181/121	176/100	172/91	168/87	158/93	150/86	147/80										
2	177/116	169/99	165/69	161/63	157/76	151/93	146/84	145/71	152/72									
3	168/116	160/100	154/64	151/55	147/71	142/89	138/81	138/59	146/62	158/70								
4	164/73	151/85	142/55	139/65	137/73	131/83	119/96	128/58	137/63	152/76								
5	167/113	147/100	125/67	129/75	126/86	117/86	112/89	113/72	124/63	137/68	150/39							
6		152/109	137/80	131/68	126/86	122/100	116/93	110/82	114/67	126/82	139/62	148/46						
7		162/78	148/75	138/72	132/66	126/74	120/89	112/85	111/64	119/74	131/75	141/59	151/61					
8			158/85	149/82	142/85	134/87	124/86	114/89	107/78	112/75	123/67	134/53	146/42					
9					153/102	140/79	129/67	117/79	107/66	110/59	117/69	129/56	140/53	151/51				
10						151/76	137/74	126/72	114/76	112/77	114/80	123/62	134/51	145/48				
11							145/88	131/87	118/79	112/78	112/69	118/53	126/46	134/48	144/54			
12							149/95	135/97	113/91	103/67	104/68	110/40	117/29	125/36	135/48	145/47		
13							152/94	137/91	122/100	102/80	99/52	104/45	112/30	119/29	127/32	138/39	151/41	
14								143/85	126/87	106/82	98/52	100/29	105/19	114/24	121/28	131/29	141/31	145/32
15								155/84	137/82	114/62	100/33	98/16	99/31	110/23	118/12	127/20	136/23	142/26
16								163/79	146/80	123/78	99/59	99/32	100/43	110/28	119/13	126/14	134/19	140/22
17									157/80	138/75	120/69	109/61	99/50	111/28	120/9	128/12	134/17	139/22
18										153/63	136/57	124/43	117/47	119/32	125/20	130/13	136/17	
19											145/45	136/44	129/39	127/27	129/24	133/16	137/16	
20											150/33	144/25	139/24	134/22	135/15	137/14		
21											151/32	151/15	148/24	141/28	139/13	139/11		
22												150/40	149/39	145/36	141/27			

Figure 35: Optimal or Target Steady-state Potentiometric Surface Resulting from Implementation of Strategy A, and Aquifer Bottom Elevations (in ft. above MSL).