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The Universities Council on Water Resources

Irrigator and Springflow Response to a Dry Year Option for the Edwards Aquifer

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Recent events regarding management of the Edwards aquifer have focused attention on ways to reduce pumping in order to augment declining springflows. This interest has occurred within the context of: years of litigation centered around springflows; a severe drought which has plagued the region; several new lawsuits which have recently been filed; a nascent (and cash strapped) Edwards Aquifer Authority; and a federal court order to limit pumping which has been challenged by both the city of San Antonio and the state of Texas.

Despite political and legal wrangling over how the aquifer should be managed, all interests agree that the Edwards aquifer can no longer produce enough water to fully satisfy all demands during dry years. One way to relieve the burden on municipalities, who are most often the entities forced to cut back in times of drought, is by implementing a dry year option. This arrangement would involve private contacts between irrigators and a purchasing entity which would require irrigators not to pump during dry years in exchange for cash payments on a per acre basis.

Dry year options for the Edwards aquifer have also been considered in previous aquifer management plans. A 1992 interim management plan drafted by the Texas Water Commission (TWC) suggests a two stage dry year option to curtail water use: 1) 25% of irrigated land to be withheld from irrigation when the J17 index well is at, or below 649 feet mean sea level (msl) on January 1, and 2) 75% of irrigated land to be withheld from irrigation when J17 is at or below 632 feet msl on January 1 (Texas Water Commission, 1992). The plan proposed compensating farmers with cash payments of about $75 per acre, the approximated average net return per irrigated acre.

PREVIOUS RESEARCH

Despite the prominence the Edwards aquifer debate has assumed in recent years, few studies have preformed detailed analyses of the economic and hydrologic impacts of aquifer management plans. Most of these analyses rely on an economic/hydrologic optimization model of the Edwards aquifer and the six county economic region initially (EDOPT) specified by Dillon (1991).

Dillon's model implemented stochastic programming with risk specification where states of nature were specified as levels of recharge to the aquifer. Three economic sectors were modeled: agriculture, municipal, and industrial. For the agricultural sector, overall crop production mixes were selected over all states of nature, but separate irrigation strategies were allowed for each state of nature and each crop. Weather history, crop prices, input costs, and biological relationships between crop water use, yields, and weather were used to determine irrigation water use. Sectoral demands for municipal and industrial water were also developed from current water use patterns and economic studies defining price-quantity relationships. The Texas Water Development Board's (TWDB's) GWSIM-IV Edwards Aquifer simulation model (Thorkildsen and McElhaney, 1992) was used to develop hydrologic relationships between recharge, pumping, aquifer head level, and springflow. Non-linear programming was employed to maximize total surplus of all sectors in the model subject to the policy constraints imposed. Dillon's model was later refined and employed to assess aquifer management plans by McCarl et al. (1993), New (1994), and Williams (1996).

Very little research effort, to date, has focused specifically on implementing dry year options in the Edwards aquifer region. A study by Rothe (1996) outlines the procedure and contractual elements of a pilot dry year option program in sufficient detail for legal counsel to draft an option contract document which could be executed by the buyer and farmers. Issues and price determination are also explored. A thesis by Phillips (1996) explores barriers to water marketing and opinions of major pumpers on water marketing issues in the Edwards aquifer region. No studies have attempted to quantify the relationship between a dry year offer and the number of acres which will respond to the offer, the reduction in water use this will produce, and the potential effect on springflow which can be achieved. In 1995, TWDB funded a study to evaluate dry year water transfers from agricultural to urban use. This report summarizes results from the study partially funded by this grant.

METHODOLOGY

The methodology used in this analysis falls into three major categories: 1) a hydrologic investigation used to develop relationships describing springflow, ending aquifer elevations, and lifts as functions of recharge, pumping, and beginning aquifer elevations; 2) improvements to the existing EDOPT framework; and 3) a detailed description of the agricultural sector models used in the analysis. Although the complete EDOPT model was not directly employed in this analysis, the agricultural sector models, being subsets of EDOPT, incorporate most of the improvements.

Hydrologic Investigations

Hydrologic improvements to the model were made by employing an updated monthly version of GWSIM-IV (Thorkildsen and McElhaney, 1992) to output hydrologic variables for different combinations of eastern pumping, western pumping, starting head levels, and historical recharge. Ordinary least squares regression was employed ,on simulation output to develop linear relationships where Comal springflow, San Marcos springflow, J17 index well ending elevation, Sabinal index well elevation, eastern lift and western lift were specified as functions of beginning J17 elevation, beginning Sabinal index well elevation, annual recharge, eastern pumping (Medina, Bexar, Comal and Hays counties), and western pumping (Uvalde and Kinney counties). Details of this hydrologic investigation are documented in Keplinger and McCarl (1995).

Table 1 lists regression coefficients and R-square values for annual explanatory models of springflow and ending elevations. Although monthly springflow equations were also used in this analysis, the annual models more clearly show the major hydrologic relationships. Focusing on the pumping coefficients of the Comal springflow equation, the coefficient for eastern pumping was found to be -.28 versus a value of -.04 for western pumping. This implies that for every acre foot of water pumped from Medina and Bexar counties, Comal springflow will be reduced by .28 acre feet during the calendar year which the pumping took place, whereas for every acre foot of water pumped from Uvalde or Kinney counties for the current year, Comal springflow will be reduced by .04 acre feet during the year of pumping, or only about one seventh that of pumping from the eastern pool.

Table 1. Regression Coefficients for Annual Comal and San Marcos Springflow

	Comal Springflow (acre feet)	San Marcos Springflow (acre feet)
J17 Starting Elevation (feet above sea level)	2,651	412
Sabinal Starting Elevation (feet above sea level)	551	0.0
Annual Recharge (acre feet)	0.080	0.024
Western Pumping (acre feet)	-0.04	-0.0005
Eastern Pumping (acre feet)	-0.28	-0.025
Intercept	-1924677	-203976
R-Square	0.93	0.77

The foregoing does not imply that eastern pumping has a greater overall effect on springflow, but only that the pumping-springflow linkage is felt more immediately for eastern pumping. Hydrologic dynamics demonstrate that pumping not only reduces current year springflow, but also lowers aquifer elevations, thereby reducing springflows in future years. If we assume no leakage from the aquifer, other than that of springs, then the hydrologic balance of mass relationship predicates that eastern and western pumping will have the same effect over time on springflow, even though pumping from the eastern pool is manifest much more quickly as reduced springflows.

The annual and monthly coefficients produced in this investigation were used to develop hydrologic responses to cutbacks in agricultural pumping due to implementations of dry year option programs as explained in following sections.

The Edwards Aquifer Optimization Model

The equations developed in the foregoing hydrologic investigation were implemented in the existing EDOPT framework, thereby transforming the existing annual specification to a monthly specification, with regard to springflow. Water use variables and municipal demand parameters were also specified on a monthly basis, rather than annual. In addition, the aquifer was modeled as having two pools (eastern and western).

Other enhancements to EDOPT include dividing each agricultural county into three lift zones to better account for the effects of pumping lifts on irrigators' decisions; replacing many irrigation strategies with new strategies developed from the EPIC crop simulator; and fully integrating sprinkler irrigation and sprinkler irrigation strategies into the model. These improvements produced a larger, but more refined representation of the hydrologic, biological, and economic phenomena affecting water use and springflow from the aquifer, allowing us to investigate more policy questions, especially with regard to eastern versus western pumping, and their effects on monthly springflow.

An Agricultural Sector Optimization Model

Although maximizing overall social welfare from all sectors (agricultural, municipal and industrial) is an important consideration, agricultural practices under current institutions can best be simulated by employing only the agricultural sector of the model. Irrigators make their cropping and pumping decisions based on personal cost and revenue considerations without the (current) ability to market water rights to the highest bidder. This environment is most accurately simulated by an "agricultural sector only" model where the objective function is maximizing expected profits to agriculture.

The agricultural sector model incorporates nine states of nature which are based on aquifer recharge. These states of nature are developed by ordering historical recharge (as estimated by USGS) for the years 1934 to 1989 from low to high, grouping the resulting series into nine groups, and assigning one year from each group to represent each state of nature. Associated with each state of nature is the probability that it will occur.

The objective function of the agricultural model incorporates the following profit maximizing behavior. The first decision for irrigators is to decide what to plant, i.e., the crop mix. After planting, the current year's weather pattern is revealed, whereupon this additional information is used to determine which irrigation strategy to use for each crop throughout the year. Both decisions are made with regard to maximizing profits. For the first decision, the irrigator does not know what weather patterns will develop, and thus makes his decision with regard to maximizing expected profits, based on his knowledge (or perception) of the probability of experiencing various weather conditions. The agricultural model assumes that an irrigator's perceptions for the coming year are based on historical probabilities of receiving various weather conditions.

A key constraint is imposed, however, to prevent the model from assigning all crop acres to the most profitable crop. Since irrigators are generally risk averse, cannot always accurately predict crop prices, and have different perceptions, real world behavior shows a variety of crops being grown, even though only one of the crops is the most profitable.

To reflect this behavior, the agricultural model restricts crop mixes to combinations of crop mixes which have been observed in a sequence of recent years, i.e., from 1975 to 1985.

Another consideration of the irrigator which is incorporated into the model is pumping cost. Pumping cost is a product of both the amount and distance (in vertical feet) of water pumped. Thus, irrigators in higher lift zones incur higher pumping costs than those in lower lift zones, leading to model results which suggest less water intensive crop mixes and irrigation strategies are employed in higher lift zones. The amount of land in each lift zone is determined by the elevation of each irrigation well, the number of acres it irrigates, and the cutoff values used to divide adjacent lift zones, as determined from the GWSIM-IV data set.

Sprinkler irrigation strategies are fully implemented into the current EDOPT and agricultural sector models. Total number of acres irrigated from the Edwards aquifer (79,892), and number of acres irrigated by sprinkler systems (24,553 or 31%) were obtained from the Natural Resource Conservation Service (NRCS).

Annualized fixed costs of maintaining a sprinkler irrigation system were calculated to be $35.43 per acre. Additionally, the fixed costs associated with maintaining pumping facilities are estimated to be $39 per acre for both furrow and sprinkler irrigation systems.

The objective function for the agricultural model maximizes expected profits based on the following relationship:

$$\text{Max } \Pi = R - O - H - I - SI - P$$

where Π is expected profit, R is expected revenue, O is operating cost, H is expected harvest cost, I is the fixed cost of irrigation, SI is the fixed cost of sprinkler irrigation, and P is the expected cost of pumping.

Expected revenues are the probabalistic average of revenue for all states of nature. For each state of nature, revenue is the summation of the revenues from all crops where:

R = price x yield x number of acres (for each crop).

Since yield varies according to weather variables, a different revenue is produced for each state of nature.

Operating costs for each crop include the cost of herbicide, pesticide and fertilizer applications, labor, fuel, repair, and miscellaneous costs as given in Peña (1995). In all but a few cases, these costs are considered fixed on a per acre basis. Operating costs, thus, vary according to the number of acres devoted to each crop in the crop mix.

Harvest costs are a function, not only of the number of acres devoted to each crop, but of the crop yield per acre of each crop. Since yield varies by state of nature, the expected value of harvest cost is considered where, for each state of nature:

H= (harvest cost / unit harvested) x (units harvested / acre)
x number of acres harvested.

Pumping cost depends on the quantity of water pumped (in acre feet) times the cost of pumping each acre foot of water. The quantity of water pumped depends on the amount of water required on irrigate one acre for each irrigation strategy used, multiplied by the number of acres devoted to each irrigation strategy. Thus, it is evident that the particular irrigation strategies chosen by the optimization routine depend largely on the amount of water required by each strategy (and to a lesser extend on differences in yield among strategies). A formula describing pumping costs, provided in Lacewell and McCarl (1995), was adapted for use in the EDOPT formulation.

Dry Year Option Scenarios

Three dry year option scenarios are simulated. All three scenarios assume a payment structure where all irrigators are offered a set per acre payment for agreeing not to irrigate for the remainder of the year.

The first dry year option scenario involves offering a set per acre payment to irrigators not to irrigate for the entire year starting January 1st which would be offered sometime in the fall. The second and third dry year option scenarios offer irrigators a per acre payment to stop irrigating as of June 1st. The second scenario assumes that irrigators do not anticipate a dry year offer, i.e., the irrigator's planting decision is unaffected by a possible dry year offer. By contrast, the third scenario assumes that irrigators are told in January to anticipate a possible dry year offer on June 1st. This information enables them to modify their planting decisions to account for this possibility.

All three dry year option scenarios assume that aquifer irrigators can obtain revenues from three sources: 1) from irrigated crop production, 2) from dryland crop production, and 3) from receiving dry year option payments which require them either not to irrigate for the cropping season or to suspend irrigation after May. Irrigators, however, may convert irrigated production to dryland production and still receive dry year option payments for all scenarios considered.

RESULTS

Selected results of the three dry year option scenarios are presented in Table 2. All figures in Table 2 apply to those dry years where farmers are eligible for dry year payments. Specifically, the figures in the columns under "Irrigation Water," "Springflow Response," "Agricultural Income," and "Cost of Program" represent probabilistic average values for all dry years. We assume that dry year offers will be made to irrigators for 48% of all years based on an analysis of recharge over the 56 year period of record.

Because of the differential impact of pumping on springflow between the eastern and western regions of the aquifer discovered in the hydrologic investigation, separate analyses were performed to simulate dry year option programs for each region. Sections A and B of Table 2 depict the January 1st cutoff scenario for Uvalde and Kinney counties (Section A, western region) and Medina and Bexar counties (Section B, eastern region). Sections C and D portray a June 1st cutoff strategies for the eastern region where the cutoff is unanticipated by irrigators (Section C) and anticipated by irrigators with a 48% probability (Section D). June 1st cutoff strategies for the western region were not investigated because of the very limited impact these strategies would have in producing more water for municipal use or springflow since little irrigation occurs after June 1.

Eastern Agricultural Counties Versus Western Agricultural Counties

Comparing Section A to Section B, we find that the total number of acres irrigated from the Edwards Aquifer is somewhat higher in Uvalde and Kinney counties (the western agricultural counties) than from Medina and Bexar counties (the eastern agricultural counties): 41,560 acre versus 38,332 acres, for a total of 79,892 irrigated acres for the region. The "Dryland" column in Table 2 shows that as the dry year offer price is increased, the number of dryland acres increases, but at a faster rate for the eastern region than for the western region. This is due, in part, to higher average pumping lifts and correspondingly higher pumping costs experienced in the eastern agricultural counties.

Model results suggest that irrigators in Medina and Bexar counties will withdraw 13,885 acres from irrigated production for a dry year offer price of only $10/acre. All of this production is diverted from *furrow* irrigation to dryland agriculture. Not until a dry year offer of $50/acre is reached does the number of *sprinkler* irrigated acres start to decline, suggesting that sprinkler irrigation is substantially more profitable, requiring a higher dry year payment to induce these producers to convert to dryland farming.

When the dry year offer is raised to $90/acre, model results indicate that all irrigated production in Medina and Bexar counties, both sprinkler and furrow, will convert to dryland production. For an offer of $50/acre, 34,801 acres, or about 91% of irrigated acres in Medina and Bexar counties convert to dryland agriculture.

For Uvalde and Kinney counties (Table 2, Section A), irrigated acres do not begin to convert to dryland until an offer price of $60/acre is reached. At $60/acre, model results suggest that 17,618 acres in Uvalde county will accept the dry year offer. At a $120/acre offer, all the irrigated land in Uvalde and Kinney counties converts to dryland. The correlation between the amount of irrigated land converted to dryland ("Dryland") and the reduction in water use ("Amount of Reduction") is direct and averages 2.5 acre feet of water per irrigated acre for dry years for both regions.

Results of the hydrologic investigations referred to earlier were used to determine the effects of reduced eastern and western pumping on springflows. Agricultural sector model results suggest that as a result of 13,885 acres accepting the January 1st dry year offer in Medina and Bexar counties (Section B), irrigation pumping will be reduced by 37,011 acre feet. Our hydrologic findings indicate that this will result in increased springflow at Comal and San Marcos springs of 15,034 acre feet during the calendar year of the dry year option. The remainder of the reduction in irrigation pumping goes into storage, thereby raising aquifer elevation.

The result of the 17,618 acre reduction in Uvalde and Kinney counties converting to dryland is a reduction in water use of 49,621 acre feet, but results in an increase in springflow of only 2,789 acre feet. This disparity in the pumping/springflow relationship between the eastern and western agricultural regions is often explained by the existence of a constriction in the aquifer which slows transfers of water from the western to the eastern regional pools.

Although the primary purpose of implementing a dry year option program is to increase springflows or to allow additional municipal pumping without harming springflows, it should not be overlooked that reductions in agricultural pumping also raise aquifer levels. Higher aquifer levels benefit future springflow, reduce pumping costs, and reduce the probability that pumping from the aquifer will need to be cut back in future years. The amount by which aquifer levels would be raised, holding municipal pumping constant, is shown in Table 2, under the column "Aquifer Response." As expected, cutbacks in western pumping raise levels in the western region of the aquifer, but, since both regions of the aquifer are hydrologically connected, cutbacks in western pumping also help raise aquifer levels in the eastern region. The corollary statement applies to pumping from the eastern pool of the aquifer.

The effects of dry year options on agricultural incomes were also examined. Since irrigated acreage is converted to less profitable dryland agriculture when dry year option programs are implemented, agricultural income from operations, in general, is reduced. Irrigators, on the other hand, receive dry year option payments for each acre converted to dryland. The net effect is that agricultural incomes rise when dryland option programs are implemented. The column headings under "Agricultural Income" and "Cost of Program, Total" bear this out. Here, the total cost of the dry year option program represents transfer payments to irrigators. No overhead or administrative costs are included in "Cost of the Program, Total." Total cost of the program or transfer payments to farmers is found simply by multiplying the amount of the dry year offer times the number of acres converted to dryland agriculture as a result of the offer.

Table 2, Section B, for instance, suggests that 34,801 acres in Medina and Bexar counties will accept a dry year offer of $50, resulting in payments to irrigators of $1,740,050. Income from operations is reduced from $1,374,515 to $1,159,786, a reduction of $214,729 which is more than compensated for by the transfer payment to irrigators. The net result is that agricultural incomes increase from $1,374,515 to $2,899,836, for a gain of $1,525,321.

Summarizing the results in Table 2, Sections A and B: large, and roughly equivalent amounts of water can potentially be obtained from irrigators in the agricultural counties which overlie the aquifer: 94,397 acre feet from the eastern agricultural counties versus 104,516 acre feet from the western agricultural counties. Current year springflow response, however, is seven times greater for eastern agricultural counties than for western agricultural counties. Thus, if irrigation were completely halted, San Antonio could pump only 1/7 or 14,931 of the 104,516 acre feet of the water saved in the western agricultural counties without affecting flows from Comal Springs. If all of the reduced pumping were applied to springflow, the cutback in the eastern agricultural counties would produce 38,132 acre feet of additional springflow, while the western agricultural counties would produce only 5,836 acre feet of additional springflow for the current year.

Maintaining continuous levels of springflow is an important consideration in implementing any dry year option program. Model results indicate that cutting off all irrigation in the eastern region would result in an additional 72 cfs of springflow for Comal Springs in August, whereas springflow is increased by about 12 cfs if all ag pumping in Uvalde and Kinney counties were to cease.

June 1st Cutoff Strategies

Results of simulating the two June 1st cutoff strategies are presented in Table 2, Sections C and D. The results in Section C assume that planting decisions are unaffected by the possibility of a dry year offer, whereas Section D assumes irrigators are told in January to anticipate a dry year offer to be made for the driest 48% of the years. Since the results in Section D assume irrigators can anticipate the possibility of a dry year offer, we would expect at least as many acres to take advantage of the dry year offer as in the unanticipated scenario, Section C. Although small differences in model specifications prevent this from happening for all offer prices, this expected relationship is clearly seen for offer prices of $80/acre and above, where acres converted to dryland ("Dryland") is always higher for the anticipated June 1st cutoff scenario. These higher offer prices encourage irrigators to make planting decisions in a way that enables them to take advantage of a dry year offer, should it occur.

For the unanticipated June 1st cutoff, (Section C) higher offer prices always result in greater reductions in water use, ("Amount of Reduction") and springflow responses, ("Springflow Response"). For the anticipated June 1st cutoff scenario, however, when the offer price is increased from $110 to $120 per acre, water application by irrigators actually increases, while the springflow response decreases. This is because, given sufficient incentive, irrigators are able to shift to crops which don't need to be irrigated after June 1 in order to receive the payment. Even within the fairly substantial constraints imposed on cropping patterns in all agricultural sector models, results suggest that irrigators will move to more water intensive crops which do not require irrigation after June 1st, if a high enough offer price is made. In some cases, this leads to more water being applied to crops when the offer price is increased, not less. This, of course, would be counter-productive, given the intent of implementing a dry year option program is to reduce water use.

June 1st Cutoff versus January 1st Cutoff

For a given offer price, a January 1st cutoff is more effective in reducing agricultural pumping for two reasons: 1) water use is cut for the entire year, rather than for the last seven months of the year, and 2) land is not yet committed to a particular cropping pattern. Conversely, for the June 1st cutoff scenarios, irrigated crops have already been planted, fixed costs have been incurred, and, more importantly, a June 1st cutoff for many crops would substantially reduce, or eliminate, yields and therefore, revenue. Thus, a June 1st cutoff carries with it a substantially higher opportunity cost for irrigators, since revenue from production is at stake and planting costs are sunk. This is particularly the case for the unanticipated June 1st cutoff scenario. One manifestation of the higher opportunity cost of a June 1st cutoff is that a smaller number of acres accept a June 1st dry year offer for any given offer price.

SUMMARY AND CONCLUSIONS

Growing aquifer demands, interest in maintaining springflow, and episodic drought conditions such as the one experienced throughout much of 1996, have produced conditions where all demands made on the Edwards aquifer cannot be met during dry years. One proposal to reduce demand during dry years is through the implementation of a dry year option, an agreement whereby irrigators receive cash payment in exchange for not pumping. Given that the conditions do exist which merit consideration of dry year options, two important considerations are *when* and *where* a dry year option should be implemented.

Results suggest that reduced pumping in the eastern region is much more effective in producing current year springflow or in supplying additional water to San Antonio, than from reduced pumping in the western region. This is because the effect eastern pumping on near-term Comal springflow is approximately seven times greater than the effect of western pumping.

Results suggest that large reductions in agricultural water use can be obtained for a relatively small per acre foot cost. A $50 per acre offer price to irrigators in Medina and Bexar counties for a January 1st dry year option, for instance, results in 34,801 acres in the region (or 91% of total acreage) converting to dryland. This produces a reduction in agricultural water use of 87,660 acre feet, or about 93% of average use during dry years. San Antonio and other communities in the eastern region could increase pumping by roughly this amount without impacting springflow. On the other hand, if municipal pumping were not increased, this reduction in agricultural pumping would result in an increase in springflow of 35,491 acre feet for the current year. Springflow at Comal Springs during the month of August, a month often experiencing low flows, would increase by an estimated 67 cfs.

The total cost for implementing this version of a dry year option would be $1,740,050. This works out to an average cost of additional water saved, which could be applied to municipal use, at about $20 per acre foot, while the corresponding marginal cost would be about $32 per acre foot. If the cutback in agricultural pumping were applied to springflow, the average cost of additional springflow would be approximately $49 per acre foot, while the marginal cost would be about $78 per acre foot.

Many techniques for providing more water to the region's growing population while preserving springflow are currently being considered. Developing a dry year option exhibits several advantages over other potential solutions. First, unlike solutions requiring costly public works, implementing a dry year option requires no physical infrastructure or costly conveyance systems. Conveyance to municipal purveyors or to Comal Springs is provided by the aquifer itself. Second, the type of dry year option considered here does not rely on established and tradable water rights which currently do not exist. Thirdly, a dry year option can be implemented as needed, based on aquifer levels. Fourth, the cost of obtaining additional water by implementing a dry year option is likely to be much less than obtaining water by other methods. Finally, there are no negative environmental consequences associated with implementing a dry year option.

Given that municipal users in San Antonio are willing to pay several times the amount which this study indicates that water can be "purchased" from irrigators, this analysis suggests that significant gains in economic efficiency can be obtained by implementing a dry year option for the Edwards aquifer region when aquifer levels are low.

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Table 2. Response to Offer Price of Implementing a Dry Year Option

Offer Price ($)	Type of Land Use: Irrigated Total (Acres)	Irrigated Furrow (Acres)	Irrigated Sprinkler (Acres)	Dryland (Acres)	Irrigation Water: Applied (AF)	Irrigation Water: Amount of Reduction (AF)	Springflow Response: Total Current Yr. (AF)	Springflow Response: Comal August (CFS)	Aquifer Response: Eastern Region (feet)	Aquifer Response: Western Region (feet)	Agricultural Income: Total ($)	Agricultural Income: From Operation ($)	Cost of Program: Total ($)	Cost of Water: Average ($/AF)	Cost of Water: Marginal ($/AF)	Cost of Springflow: Average ($/AF)	Cost of Springflow: Marginal ($/AF)
Section A. January 1st Cutoff - Uvalde and Kinney Counties																	
0	41,560	28,357	13,203	0	104,516	0	0	0.00	0.00	0.00	2,813,701	2,813,701	0	0	inf.	0	inf.
60	23,941	10,738	13,203	17,618	54,895	49,621	2,789	5.55	1.67	6.14	3,168,235	2,111,155	1,057,080	149	149	379	379
90	3,265	0	3,265	38,294	6,092	98,424	5,507	10.93	3.30	12.12	4,550,983	1,104,523	3,446,460	245	343	626	879
120	0	0	0	41,560	0	104,516	5,836	11.58	3.50	12.84	5,908,681	921,481	4,987,200	334	6,899	855	18,194
Section B. January 1st Cutoff - Medina and Bexar Counties.																	
0	38,332	26,982	11,350	0	94,397	0	0	0.00	0.00	0.00	1,374,515	1,374,515	0	0	inf.	0	inf.
10	24,447	13,097	11,350	13,885	57,385	37,011	15,034	28.25	6.07	2.68	1,602,128	1,463,278	138,850	4	4	9	9
50	3,531	0	3,531	34,801	6,737	87,660	35,491	66.86	14.32	6.34	2,899,836	1,159,786	1,740,050	20	32	49	78
70	950	0	950	37,382	1,858	92,538	37,403	70.45	15.09	6.68	3,736,095	1,119,355	2,616,740	28	180	70	458
90	0	0	0	38,332	0	94,397	38,132	71.81	15.39	6.81	4,530,525	1,080,645	3,449,880	37	448	90	1,143
Section C. June 1st Cutoff, Unanticipated, Medina and Bexar Counties																	
0	38,332	26,982	11,350	0	94,397	0	0	0.00	0.00	0.00	1,374,515	1,374,515	0	0	0	0	0
30	27,743	18,993	8,749	10,589	86,051	8,346	2,665	6.73	1.08	0.48	1,538,065	1,220,385	317,680	38	37	119	117
60	21,126	14,748	6,378	17,206	78,968	15,429	4,939	12.44	1.99	0.88	1,984,319	951,981	1,032,338	67	580	209	1,760
90	19,956	13,687	6,269	18,376	76,810	17,586	5,509	14.18	2.22	0.98	2,509,058	855,261	1,653,797	94	215	300	828
120	18,055	11,786	6,269	20,277	73,211	21,186	6,474	17.08	2.61	1.16	3,082,071	648,817	2,433,253	115	153	376	588
150	17,262	10,993	6,269	21,070	71,863	22,533	6,850	18.16	2.76	1.22	3,709,746	549,246	3,160,500	140	inf.	461	inf.
Section D. June 1st Cutoff, Anticipated with 48% Probability, Medina and Bexar Counties																	
0	38,332	26,982	11,350	0	94,397	0	0	0.00	0.00	0.00	1,374,515	1,374,515	0	0	0	0	0
30	28,738	19,955	8,783	9,594	87,181	7,216	2,337	5.82	0.94	0.42	1,554,415	1,266,589	287,826	40	50	123	153
60	22,365	15,987	6,378	15,967	78,577	15,820	5,196	12.75	2.10	0.93	1,958,205	1,000,187	958,018	61	102	184	321
90	17,280	11,211	6,069	21,052	75,555	18,842	5,092	14.63	2.05	0.91	2,669,370	774,690	1,894,680	101	inf.	372	inf.
120	10,255	6,376	3,879	28,077	73,383	21,014	4,038	15.34	1.63	0.72	3,804,981	435,741	3,369,240	160	inf.	834	inf.
150	10,255	6,376	3,879	28,077	73,383	21,014	4,038	15.34	1.63	0.72	4,647,291	435,741	4,211,550	200	inf.	1,043	inf.