

4.0 Water Supply

As described in Section 2.0, the LCRA-SAWS Water project is designed to make water available to support various economies and environments over a large area of south central Texas. Water is made available by diverting Colorado River water when it is available, storing river water in off-channel storage facilities to provide supplemental supplies during low-flow periods, reducing agricultural water demands through conservation, and pumping groundwater in limited amounts when conservation and river water do not meet agricultural needs. Groundwater will not be transferred to San Antonio as part of the project.

4.1 Surface Water

Overview

Surface water availability studies address how the various sources of water available to LCRA can be used most effectively as a system to meet future water needs within the lower Colorado River basin and to deliver up to 150,000 acre-feet per year to SAWS in accordance with the terms of the agreement between LCRA and SAWS. This includes satisfying all the conditions and stipulations in the LCRA-SAWS agreement, as well as other legal and regulatory requirements.

For evaluating the surface water availability aspects of the project, a computer model is used to simulate the operation and behavior of all components of the LCRA water supply system under varying long-term hydrologic conditions, different levels of system demands (including water for environmental flows), and alternative water supply and delivery procedures. For example, the model can simulate time-varying reservoir storage, river flows, and the amount of water available for off-channel storage and delivery to SAWS. The simulations include projected future demand conditions within the Colorado River basin and use the long-term historical climatic and hydrologic conditions that occurred between 1940 and 1998. This allows the project to be tested over a simulation period that includes both wet and dry conditions, including the drought of the 1950s that is considered the most extreme drought of record for the Colorado River's Highland Lakes.

The study team has used modified versions of the Texas Commission on Environmental Quality (TCEQ) water availability model (WAM) for the Colorado River basin to simulate future flows in the river and its tributaries and storage in the Highland Lakes under projected water demand conditions both with and without the project in operation. The WAM performs calculations on a monthly basis using hydrologic inputs based on the 1940-1998 historical period. A companion spreadsheet program is used to perform daily analyses of the project operations using the simulated monthly outputs from the WAM as basic input data. RiverWare, another model under development, is expected to perform simulations on a daily basis pending its full-scale application to the project. Results from RiverWare will be especially useful for assisting with the design of the project's river diversion facilities to assure they are appropriately sized and as efficient as possible. The study team's modeling work now involves primarily the testing and evaluation of project alternatives and

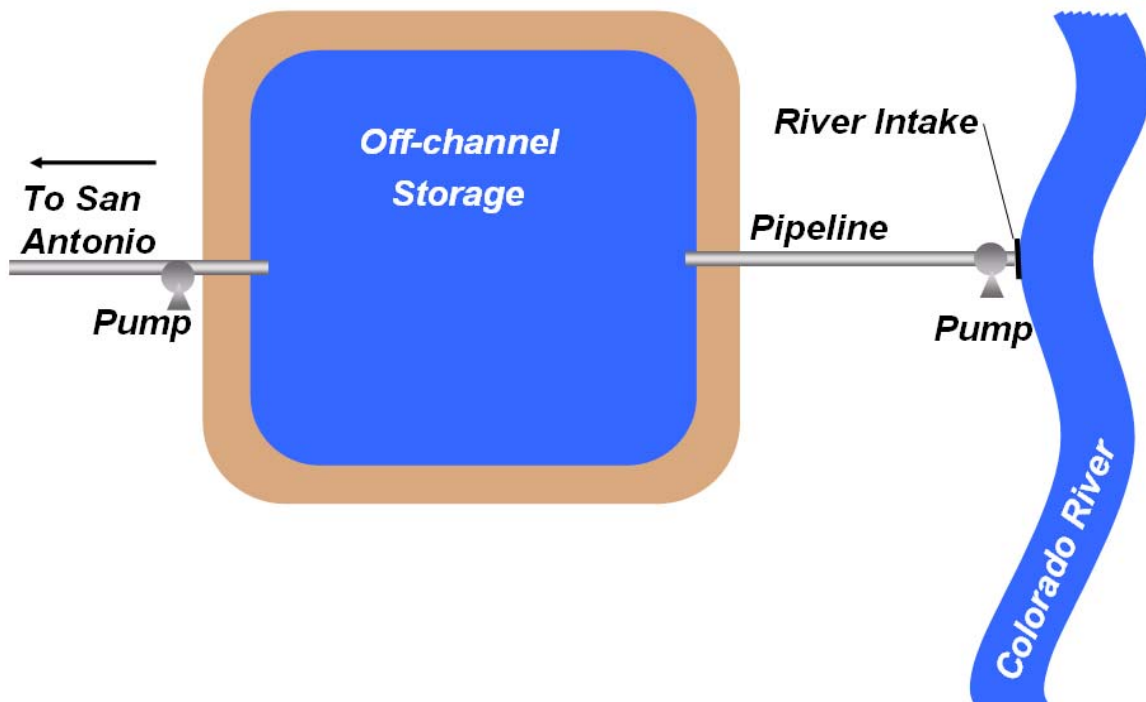
assumptions as part of the overall process to develop a final project design concept that satisfies all project requirements.

How the System Would Operate

The project as analyzed to date uses water from both the LCRA run-of-river water rights and the Highland Lakes, which LCRA owns and operates. For these analyses (to be refined as additional site-specific information is available), diversions from the Colorado River for the project are assumed to be made at the existing low-head dam where LCRA currently diverts water for the Pierce Ranch irrigation operation. (The intake structure is proposed to be located at Lane City; however, for surface water modeling purposes, the diversion was located at the existing Pierce Ranch diversion model control point. These two locations are close enough in proximity and have no intervening diversions or discharges that the results of the surface water availability modeling are the same at the two locations.) Diversions of water are made only after satisfying all demands by senior water rights and assumed minimum instream flow restrictions, as well as specific bay and estuary freshwater inflow requirements.

Diversions for the project are subject to existing water rights administrative and legal constraints under Texas water law. For analyses purposes, the project diversions are made at the most junior priority date in the basin due to legal requirements associated with interbasin transfers of water. In other words, the water demands of all other existing water rights are satisfied before diversions are made for the project. Water diverted from the river for the project is pumped into an off-channel storage facility (see Figure 4-1).

FIGURE 4-1
 Off-Channel Storage Facility Operation Schematic
 LCRA-SAWS Water Project



The purpose of the off-channel storage facility is to provide a supply of stored water for the project during times when river flows are too low to allow diversions. Flows in the river are pumped and stored in the off-channel storage facility primarily during higher flow periods. All deliveries of project water from the lower Colorado River basin to San Antonio will be made from the off-channel storage facility. For planning purposes, it is assumed that these deliveries would be made at a constant rate throughout a year, which is considered the most efficient means for delivering the water, given the pipeline length and the flow magnitudes involved. It has been assumed that monthly or daily fluctuations in local demands in San Antonio would be accommodated with terminal water storage facilities in San Antonio.

Water is made available to the project by managing all LCRA's available water supply sources as a system. This system approach includes the following components:

1. The use of LCRA's existing run-of-river rights on the lower Colorado River to supply water for agriculture, to supply water to the project, and to meet the needs of some of LCRA's future municipal and industrial water customers.
2. The use of LCRA's pending excess flows permit for making project diversions from the river¹.
3. The occasional use of water stored in the Highland Lakes to supplement river diversions for the project during periods of low river flows.
4. The implementation of agricultural water conservation measures in Colorado, Wharton, and Matagorda counties to reduce demands for irrigation water from the river.
5. The limited use of groundwater supplies (through new and/or existing wells) only to supplement irrigation water supplies in LCRA's three irrigation operations in Colorado, Wharton, and Matagorda Counties and Pierce Ranch (no groundwater will be transferred to San Antonio per legislative requirements).

The use of groundwater for satisfying agricultural water demands is similar to, but will not replace, the current practice of using stored interruptible water from the Highland Lakes to supplement agricultural water needs when river flows are low. The new groundwater supplies to be developed in the lower basin as part of the project will provide an additional reliable water source for meeting these agricultural demands. Portions of LCRA's existing run-of-river water rights will also be made available (through amendment) for a variety of in-basin and interbasin uses, subject to permitting and other legal requirements. All these components of LCRA's future water management program have been considered and included in the water availability analyses for the project.

Surface Water Availability Assumptions

Analyses of the LCRA water supply system under assumed future conditions, with and without the project in operation, were performed using various modified versions of the WAM. The modifications made to the TCEQ model specifically address anticipated basin-wide water supply conditions and LCRA system operating procedures both with and without the project implemented. Results from simulations with these models have been used to evaluate the potential impacts of the project on other water users in the basin,

¹ LCRA's application for the excess flows permit has been declared administratively complete by TCEQ and is currently pending at the State Office of Administrative Hearings. The permit would require further amendment as part of the project.

environmental flows, and the Highland Lakes, as well as to determine the available supply of project water that could be made available to SAWS. To address changing demands and water needs over the assumed 80-year life of the project, analyses have been performed with the WAM assuming projected conditions as they are expected to occur in the year 2010 (without the project in operation) and in the years 2030, 2060, and 2080 both with and without the project implemented. Specific assumptions included in the models for purposes of these water availability analyses are summarized below:

- No “calls” (a water rights term for requesting water) for water during dry periods were made by any downstream water rights on any water rights upstream of or from Lake O. H. Ivie on the Colorado River and Lake Brownwood on Pecan Bayou, a tributary of the Colorado River, even though many downstream water rights are senior in priority. These senior water rights include significant water rights held by LCRA, and the cities of Austin and Corpus Christi. This manner of water rights administration approximates the current operation of the basin and represents a conservative approach to modeling existing agreements between LCRA and the Colorado River Municipal Water District and Brown County Water Improvement District No. 1. Moreover, this approach is generally consistent with the way available water supplies were calculated by both the Region K and Region F water planning groups in the most recent state water planning process.
- It is assumed that return flows discharged from the City of Austin’s wastewater treatment plants into the Colorado River will be available for downstream users in a manner generally consistent with assumptions adopted by the Region K Water Planning Group in its 2006 plan and with provisions included in the recent settlement agreement (2007) between the City of Austin and LCRA. Under these conditions, the city directly reuses a portion of its treatment plant effluent to meet some of its future demands within the city, but the vast majority of the city’s effluent is discharged as return flows to the river below Austin. The return flows discharged to the river are dedicated first to satisfy any shortages that may occur with respect to specific environmental flow requirements for instream uses and for freshwater inflows to Matagorda Bay. The balance of the city’s return flows then is assumed to be available for diversion from the river by the city either at a point downstream near the mouth of Gilleland Creek for a proposed future reuse project (up to 75,000 acre-feet per year) or at the Fayette Power Plant to satisfy part of the city’s steam electric water demand (3,500 acre-feet per year). Any of the city’s return flows remaining in the river after these diversions are available for use by other water users or uses in accordance with the prior appropriation doctrine (primarily to serve LCRA irrigation customers).
- In general, demands for municipal and industrial users in the Colorado River basin that are not supplied by LCRA’s water delivery system and that rely on surface water have been conservatively assumed equal to the full annual diversion amounts authorized by individual water rights. Assumptions regarding future municipal and industrial water demands associated with LCRA’s water delivery system are generally consistent with the 2006 Region K plan, including the demands of those users who rely on water supply contracts with LCRA for some or all of their water supply. The difference is how these demands are to be met in the future under conditions with and without the project implemented. Without the project in operation, it is assumed that all of these demands will continue to be satisfied directly or backed up with stored water from the Highland Lakes. However, with the project implemented, a significant portion of these demands are to be

met with water diverted under LCRA’s existing run-of-river rights (following amendment by TCEQ), backed up with stored water from the Highland Lakes.

- In general, demands for non-LCRA irrigation in the Colorado River basin that rely on surface water have been conservatively assumed to be equal to the full annual diversion amounts authorized by individual water rights under conditions both with and without the project in operation.
- Without the project implemented, future water demands associated with LCRA’s irrigation operations (Lakeside, Garwood, and Gulf Coast divisions as well as Pierce Ranch) are based on preliminary projections derived by the project’s agricultural conservation study team through refinements of demand estimates in the Region K plan. The study team correlated historical monthly irrigation water use over the last 10 to 15 years within each of the LCRA irrigation operations with corresponding monthly rainfall and evaporation data. These correlations were then used together with the projected Region K annual drought demands for each decade through 2060, to develop corresponding monthly irrigation demands for each of LCRA’s irrigation operations over the 1940-1998 WAM simulation period. This process resulted in variations in the total annual irrigation demands without the project in operation as shown in Table 4-1. As shown, projected irrigation demands are expected to decrease in the future, with the 2080 demands expected to be about 80 percent of the 2010 demands.

TABLE 4-1
 Projected Irrigation Water Demands in the LCRA Irrigation Divisions without the Project (in acre-feet per year)
LCRA-SAWS Water Project

	2010	2030	2060	2080
Minimum	233,393	225,705	205,371	191,814
Average	332,398	321,247	290,686	270,342
Maximum	407,672	393,929	355,913	330,608

- Irrigation demand reductions associated with implementation of the project’s agricultural conservation program also have been estimated by the project’s agricultural conservation team for the water needs for LCRA’s irrigation operations. The overall annual conservation reductions in LCRA’s projected future irrigation water demands that are incorporated into the project’s surface water availability analyses average about 106,000 acre-feet per year. (As noted in the “Summary of Agricultural Conservation Savings” discussion in Section 4.3 of this PVA, the average water use reduction is estimated at 106,000 acre-feet per year with savings during peak periods estimated at 123,000 acre-feet per year.) Again, using the correlations between monthly irrigation water use and rainfall-evaporation conditions, the agricultural conservation study team developed projected monthly irrigation demands for each of LCRA’s irrigation operations over the 1940-1998 WAM simulation period. This process resulted in estimates of the total annual irrigation demands with the project in operation as shown in Table 4.2. As shown, projected irrigation demands are expected to decrease in the future, with the 2080 demands expected to be about 80 percent of the 2030 demands.

TABLE 4-2
 Projected Irrigation Water Demands in the LCRA Irrigation Divisions with the Project (in acre-feet per year)
 LCRA-SAWS Water Project

	2030	2060	2080
Minimum	162,377	140,436	127,037
Average	221,591	190,145	170,912
Maximum	271,582	230,989	206,588

Note: 2010 demands are not presented because the project will not be in operation in 2010.

- Existing run-of-river water rights owned by LCRA in the lower basin authorize a total diversion from the Colorado River of 636,750 acre-feet per year. These rights historically have been used primarily to supply water for LCRA’s irrigation operations. Without the project in operation, it has been assumed that these rights will continue to be used primarily for irrigation purposes through 2090. However, with the project in operation, it has been assumed that, following amendment of these water rights by TCEQ, the balance of the annual diversions authorized under these water rights not needed by LCRA for supplying future irrigation needs will be available to meet a portion of LCRA’s future in-basin municipal and industrial customer firm water demands and to deliver water to SAWS. By the year 2080, it is assumed that about 115,000 acre-feet per year of LCRA’s existing run-of-river rights will be used to supply LCRA’s steam electric power demands, the City of Austin when its demands exceed its own water rights, and manufacturing and mining demands in the lower basin. Additionally, approximately 110,000 acre-feet per year will be used as the primary supply (backed up with Highland Lakes water) for LCRA’s other contractual municipal and industrial customers.
- Water diverted as an interbasin transfer from the Colorado River for the project under LCRA run-of-river water rights, following their amendment, would be assigned a priority date that is junior to all other water rights in existence at the time the amendments are accepted for filing by TCEQ. Similarly, releases from storage in the Buchanan-Travis reservoir system to supplement or backup the interbasin deliveries for the project are refilled with inflows to the reservoirs at a similar junior priority date, thus assuring that none of the originally authorized storage in the reservoir system is used for the project. Note that, although this modeling process applied a junior priority date to the water that will be transferred from the Colorado basin, the yield of the project with respect to the deliveries to SAWS is a firm supply (that is, reliable through a repeat of the drought of record).
- As part of the project, groundwater will be developed and produced in the lower basin to partially satisfy LCRA’s projected irrigation water demands. **No groundwater** from the Colorado River basin will be provided to San Antonio; groundwater is strictly limited to use in the LCRA service area for agriculture. Limitations on the amount of groundwater usage have been assumed consistent with the contract between LCRA and SAWS:
 - 95,000 acre-feet maximum in any one year
 - A rolling 10-year average less than or equal to 62,000 acre-feet per year
 - An annual average of 36,000 acre-feet over the life of the project (50 years with a possible extension of 30 thirty years)

- With the project implemented, interruptible water will continue to be supplied from the Highland Lakes to help meet agricultural water demands in LCRA's lower basin irrigation operations. Highland Lakes water, together with diversions of river water under LCRA's existing run-of-river rights and the available supply of groundwater to be developed in the lower three counties of the basin, will be used for meeting the irrigation water demands (following implementation of conservation measures) over the life of the project.
- Without the project in operation, agricultural water supplies for LCRA's irrigation operations in the lower basin will continue to be subject to curtailment depending on the available supply of stored water in Lakes Buchanan and Travis and the need to use the Highland Lakes to provide firm water supplies for LCRA's municipal and industrial customers. The curtailment of the water supply for the Garwood irrigation operation is limited to be no more severe than the curtailment procedures stipulated in the pending 2003 Water Management Plan.
- Over the life of the project, the conservation storage capacities of Lakes Buchanan and Travis are projected to continue to decrease due to sedimentation. Between 2010 and 2080, the capacity of Lake Buchanan is expected to decrease from approximately 860,000 acre-feet down to approximately 730,000 acre-feet. Conservation storage in Lake Travis is projected to decrease from approximately 1,130,000 acre-feet down to approximately 1,100,000 acre-feet. Hence, the total system conservation storage capacity is projected to be approximately 1,830,000 acre-feet in 2080, a reduction of about 8 percent from 2010 conditions. These changes in the future capacity of the reservoirs are generally consistent with assumptions contained in the 2006 Region K plan.
- The environmental instream flow criteria developed by the project's aquatic habitat study team for the lower Colorado River have been assumed to be in effect as a replacement for the criteria stipulated in the pending 2003 Water Management Plan for all analyses with and without the project in operation. In applying these criteria, the *subsistence* flow criteria are engaged all the time, the *base-dry* criteria are engaged when the combined storage in the Buchanan-Travis reservoir system is greater than certain trigger levels on January 1 of any given year (>1,100,000 acre-feet for 2010, 2030, and 2060; and >1,400,000 acre-feet for 2080), and the *base-average* flow criteria are engaged when the combined storage in the Buchanan-Travis reservoir system is greater than certain trigger levels on January 1 of any given year (>1,400,000 acre-feet for 2010; >1,500,000 acre-feet for 2030; >1,700,000 acre-feet for 2060, and >1,750,000 acre-feet for 2080). These *base-average* trigger levels are the same as those used to initiate curtailment of interruptible irrigation supplies from the Highland Lakes for LCRA's irrigation operations under conditions without the project in operation.
- In applying the project's proposed instream environmental flow criteria under conditions both with and without the project in operation, releases of stored water from Lakes Buchanan and Travis are made to assure that the *subsistence* flow criteria are satisfied all the time. The *base-dry* and *base-average* instream flow criteria are satisfied only to the extent that inflows to the Highland Lakes are available for passage downstream to meet these criteria. However, as a conservative assumption that results in exceeding the commitments for environmental flows in the pending 2003 Water Management Plan, the quantities of water contributed from the Highland Lakes to satisfying these instream flow requirements are not limited by the multiyear caps stipulated in that pending Water Management Plan.

- To provide a starting point prior to the completion of the project's Matagorda Bay health evaluation study team freshwater inflow studies for Matagorda Bay, the bay and estuary freshwater inflow criteria as contained in the 2006 Freshwater Inflow Needs Study (commonly referred to as "the FINS study") are assumed to be in effect for all analyses with and without the project in operation. In applying these criteria, the *critical* inflow criteria are engaged all the time, the *intermediate* criteria are engaged when the combined storage in the Buchanan-Travis reservoir system is greater than certain trigger levels on January 1 of any given year (>1,100,000 acre-feet for 2010, 2030, and 2060 and >1,400,000 acre-feet for 2080), and the *target* flow criteria are engaged when the combined storage in the Buchanan-Travis reservoir system is greater than certain trigger levels on January 1 of any given year (>1,700,000 acre-feet for 2010, 2030, and 2060 and >1,750,000 acre-feet for 2080).
- For analyses both with and without the project in operation, the 2006 Freshwater Inflow Needs Study criteria are satisfied only to the extent that inflows to the Highland Lakes are available for passage downstream to meet these criteria. Again, as a conservative assumption that results in exceeding the commitments for environmental flows in the pending 2003 Water Management Plan, the quantities of water contributed from the Highland Lakes to satisfying the bay and estuary freshwater inflow requirements are not limited by prescribed multiyear caps.
- Diversions from the river for the project under the amended LCRA run-of-river rights are subject to the more restrictive of the aquatic habitat study team's proposed instream flow criteria at Wharton or the 2006 Freshwater Inflow Needs Study bays and estuary freshwater inflow requirement applied at the mouth of the Colorado River. Currently and prior to amendment, the LCRA run-of-river rights used to serve the irrigation divisions in the lower basin are not subject to any environmental flow requirements.
- Diversions from the river for the project under LCRA's pending excess flows permit are simulated as subject to the more restrictive of the *target* instream flow requirement at Wharton as stipulated in the pending 2003 Water Management Plan or the 2006 Freshwater Instream Needs Study *target* bay and estuary freshwater inflow requirement applied at the mouth of the Colorado River. This analysis did not verify compliance with the scouring flow requirement included in the draft permit.
- With the project, diversions under the amended LCRA run-of-river rights assigned as the primary supply for portions of LCRA's projected municipal and industrial water demands below Smithville have been assumed to be subject to the more restrictive of the project's proposed instream flow criteria at the next downstream location or the 2006 Freshwater Inflow Needs Study bay and estuary freshwater inflow requirements applied at the mouth of the Colorado River. Currently and prior to amendment, the LCRA run-of-river rights used to serve the irrigation divisions in the lower basin are not subject to any environmental flow requirements.
- With the project, diversions under the amended LCRA run-of-river rights assigned as the primary supply for portions of LCRA's projected municipal and industrial water demands above Smithville have been assumed to be subject to only the project's proposed instream flow criteria at the next downstream location. Currently and prior to amendment, the LCRA run-of-river rights used to serve the irrigation divisions in the lower basin are not subject to any environmental flow requirements.

- For purposes of this PVA, the river diversion point for the project has been assumed to be located at the existing low-head dam where water is currently diverted for the Pierce Ranch irrigation operation, with the associated off-channel storage facility located on Pierce Ranch property.
- To supply water to the project's off-channel storage facility, a combination of: (1) LCRA's excess flows permit now pending at TCEQ, (2) LCRA's amended lower basin run-of-river water rights, and (3) LCRA's stored water from the Highland Lakes are assumed to be available, in this order, depending on availability. The required river diversion rate for the project varies depending on the available flows in the river and the capacity, configuration, and operation of available off-channel storage.
- For all analyses with the project in operation, the maximum storage capacity of the project's off-channel storage facility has been assumed to be 212,000 acre-feet, with a maximum surface area of 2,938 acres and a maximum average depth of 72 feet.
- For all analyses with the project in operation, the annual seepage loss from the project's off-channel storage facility is assumed to be 2 percent of the maximum storage capacity, or approximately 4,200 acre-feet per year.
- All water deliveries to SAWS from the project's off-channel storage facility are made with a uniform temporal pattern, i.e., same amount delivered every month.

Surface Water Availability Preliminary Results

As described above, modified versions of the state's WAM were used to evaluate the operation of the project and its impacts on other water users or uses in the basin under conditions corresponding to 2030, 2060, and 2080. An assumed "base case" reflecting projected future conditions without the project for each of these decadal points was used for comparing results and evaluating potential impacts. Year-2010 conditions without the project also were analyzed to reflect a current-conditions case.

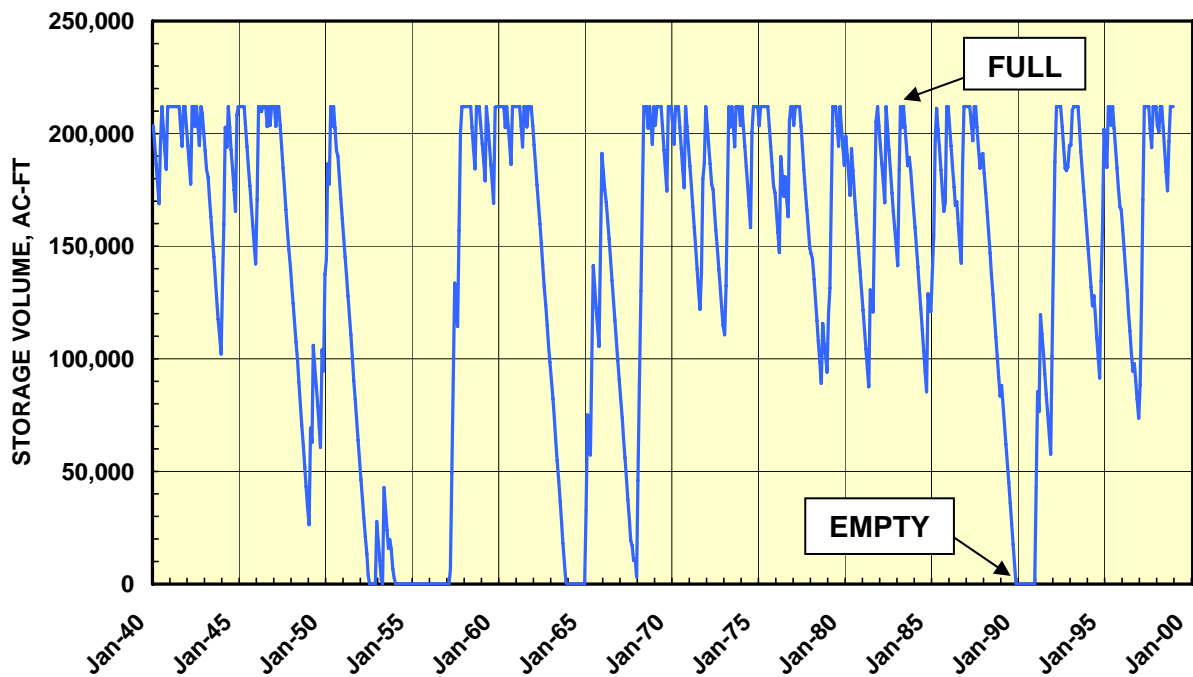
For purposes of this PVA, specific results regarding the operation of the project were developed for the 2030, 2060, and 2080 decadal conditions with the delivery of surface water to SAWS set equal to the minimum amount of firm supply that the project is capable of providing for any of the three decadal conditions. This amount turns out to be 95,000 acre-feet per year (based on the 2060 and 2080 conditions) under the assumptions listed above and assuming that the LCRA irrigation demands with the project in operation would be fully satisfied. A second simulation for 2080 conditions was performed with 120,000 acre-feet per year of firm supply of surface water delivered to SAWS. For this case, the available supplies for the LCRA irrigation operations with the project implemented were curtailed by an average of 7.5 percent over the entire period of record (1940-1998) and 20.3 percent during the drought-of-record period (1947-1957) compared to 23.7 percent over the period of record and 54.6 percent during the drought-of-record without the project.

Results from these different decadal simulations including conditions with and without the project in operation are summarized in Table 4-3 (beginning on page 4-17). Values of selected parameters are organized in groups corresponding to the project operations (rows 1-20), Highland Lakes system conditions (rows 21-42), LCRA agricultural irrigation operations (rows 43-58), instream environmental flows (rows 59-74), and bay and estuary freshwater inflows (rows 75-87). There is considerable additional information that could be

presented from these simulations, but the parameters in the table provide a general indication of the changes and variations among the different simulated conditions. Following are several key points or conclusions regarding the results from the model simulations focusing on the simulation results with 95,000 acre-feet per year annual delivery to SAWS. Additional model simulations are expected to be made in 2008 with different input conditions and assumptions that could lead to different results.

- Storage in the project off-channel storage facility is expected to vary considerably in response to pumpage of available river flows, with the facility projected to be full about 20 percent of the time (row 17) and empty about 7 to 10 percent of the time (row 18). (Note that when the storage facility is “empty,” water sent to San Antonio will be just the water pumped into the facility from the river either as river flow or stored water released from the Highland Lakes and does not include water previously diverted and stored). The monthly variation of storage in the project off-channel storage facility is illustrated on the graph in Figure 4-2 for 2060 conditions.

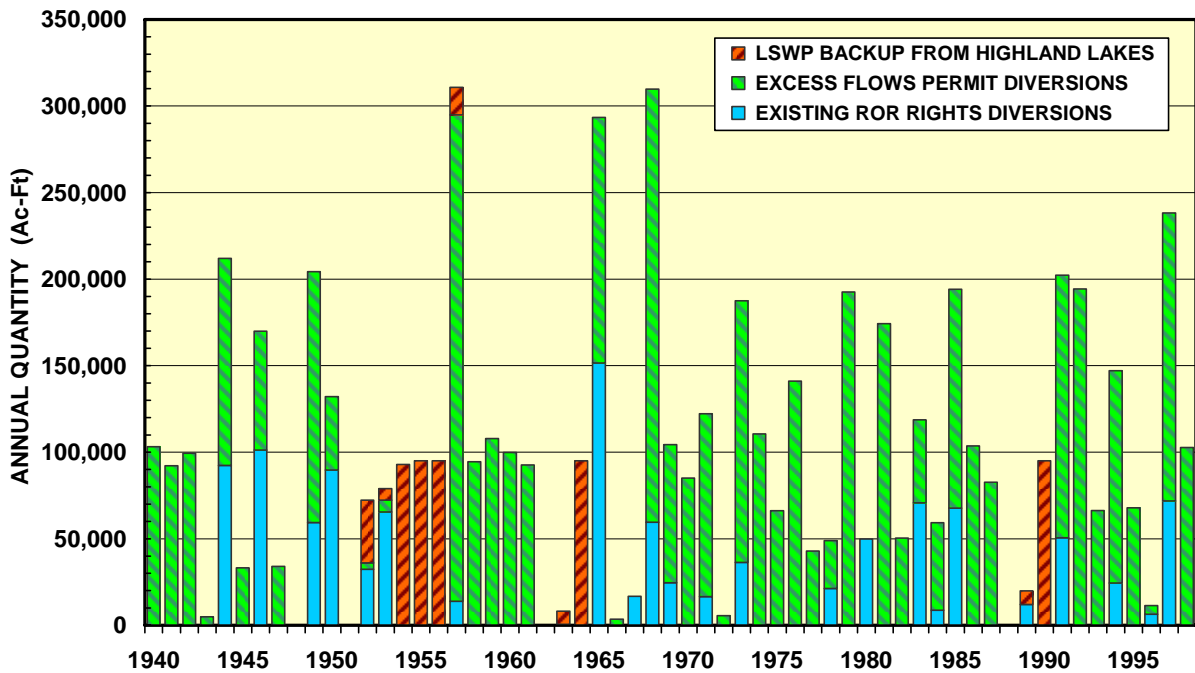
FIGURE 4-2
 Simulated Storage in Project Off-Channel Storage Facility under 2060 Conditions
 LCRA-SAWS Water Project



- The maximum required river pumping rate for the project appears to be around 2,500 cubic feet per second (cfs) under 2030 conditions and reduces to 1,425 cfs under 2080 conditions, as more water is available in the lower segment of the river in 2080, primarily due to reduced irrigation demands compared to 2030. The river pumps for the project are operated only about half of the time (all decades, row 8), with the maximum pumping rate required only about 5 percent of the time under 2060 and 2080 conditions and about 4 percent of the time under 2030 conditions (row 9). Pumping characteristics are subject to change with future changes in bay and estuary freshwater inflow requirements.

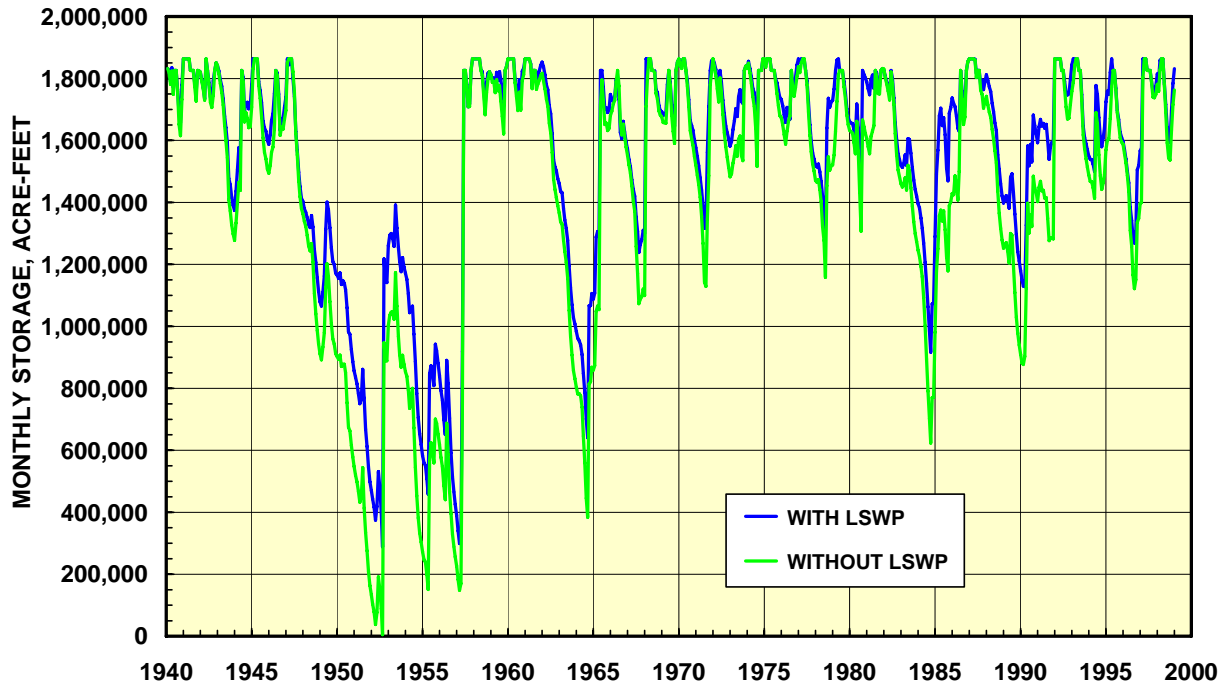
- For the 95,000 acre-foot per year scenario, average backup from the Highland Lakes for the project is projected to be approximately 7,000 to 9,000 acre-feet per year (row 13), with an average of 24,000 to 33,000 acre-feet per year required during critical drought conditions similar to those that occurred during the 1947-1957 historical critical drought period (row 14). The maximum amount of Highland Lakes backup required for the project in any one year is projected to approximately equal the annual delivery to SAWS (~95,000 acre-feet per year, row 12). The quantities of water supplied from river flows to the off-channel storage facility for the project under 2060 conditions for each year of the 1940-1998 simulation period are indicated by the bar chart in Figure 4-3. These flows would be diverted under LCRA’s new excess flow permit now pending at TCEQ, but further amended for this project, and LCRA’s assumed amended lower basin run-of-river water rights and from the Highland Lakes.
- The minimum storage amounts in the Buchanan-Travis reservoir system under 2060 and 2080 critical drought-of-record conditions are projected to increase from near zero without the project to more than 300,000 acre-feet with the project (row 28). Without the project, demands for Highland Lakes water fully use the stored water supply during critical drought conditions in these decades, but with the project, minimum storage amounts and overall lake levels are higher. The higher lake levels result from reduced irrigation demands due to the project’s conservation measures and groundwater produced to meet agricultural needs. Further, some of the municipal and irrigation demands were shifted from the Highland Lakes to LCRA run-of-river rights.

FIGURE 4-3
 Water Supplied to Off-Channel Storage Facility for the Project under 2060 Conditions
 LCRA-SAWS Water Project



- In accordance with one of the legislatively mandated requirements of the project², over the life of the project, the average storage amounts in Lakes Buchanan and Travis (rows 25-27) and the average lake levels (rows 21-24) are projected to be higher compared to corresponding future conditions without the project. Figure 4-4 illustrates the higher combined storage in Lakes Buchanan and Travis under 2060 conditions with and without the project in operation.

FIGURE 4-4
 Monthly Combined Storage Variations in Lakes Buchanan and Travis under 2060 Conditions with and without the Project
 LCRA-SAWS Water Project



- Under 2010 and 2030 conditions without the project in operation, storage reserves in Lakes Buchanan and Travis are maintained during the critical drought period generally consistent with those provided for in the current 1999 and pending 2003 Water Management Plans. Such reserves are possible because demands for Highland Lakes water do not fully require all the stored water in the reservoirs during the critical drought period.
- Overall demands on the LCRA system in the early decades (for example, in 2030) would not likely result in significant reductions in lake levels without the project. In other words, lake levels under 2030 conditions are expected to be relatively high even without the project.³ As water demands on the LCRA system increase over time, more significant lake level benefits in the later years (for example, in 2060 and 2080) are expected. Further

² Texas Special District Local Code, §8503.030, Provision of Water to Municipality Outside Colorado River Basin.

³ Note in Table 4-3, row 27, that the average storage in the Buchanan-Travis reservoir system under 2030 conditions without the project in operation is greater than the average storage in the system under 2060 conditions without the project.

evaluation of this issue will continue, and an implementation plan consistent with the legislative requirements will be developed.

- Evaporation losses from Lakes Buchanan and Travis (rows 29-30) will increase with the project because of the higher lake levels associated with the project.
- With the project in 2060 and 2080, substantial amounts of LCRA's projected municipal and industrial customer demands are projected to be satisfied with LCRA's existing run-of-river water rights backed up with stored water from the Highland Lakes (row 32). Consequently, the backup requirements for Highland Lakes municipal and industrial water users (row 35), excluding those for the project, are projected to increase substantially in 2060 and 2080 compared to conditions without the project. This shift in the use of the Highland Lakes as the primary source of supply for these users is apparent from the projected significant decreases in the fixed demands on the system in 2030, 2060, and 2080 (row 31).
- The need for interruptible stored water for agriculture from the Buchanan-Travis reservoir system (rows 56-57) is projected to decrease substantially with the project due to the implementation of advanced conservation measures that will significantly lower demands for irrigation water as well as the use of additional groundwater for meeting irrigation water needs during some years.
- Without the project implemented, the percent of the time on an annual basis that LCRA's future demands for irrigation water in the lower basin are projected to be fully satisfied are projected to decrease from about 76 percent under 2010 conditions to below 32 percent under 2080 conditions. Figure 4-5 shows projected agriculture irrigation shortages without the project. With the project in operation and delivering 95,000 acre-feet of water per year to SAWS, irrigation demands are projected to be fully satisfied 100 percent of the time (row 46). The combination of annual supplies of water from the river, from groundwater, and from the Highland Lakes for meeting projected irrigation water demands with the project under 2060 conditions are indicated on the bar chart in Figure 4-6.
- With the project in operation and delivering 120,000 acre-feet of water per year to SAWS in 2080; however, the overall average annual reliability of the irrigation supply is 92 percent compared to 100 percent with the 95,000 acre-foot per year project and 76 percent without the project.

FIGURE 4-5
 Projected Shortages for Irrigation Water Demand under 2060 Conditions without the Project.
 LCRA-SAWS Water Project

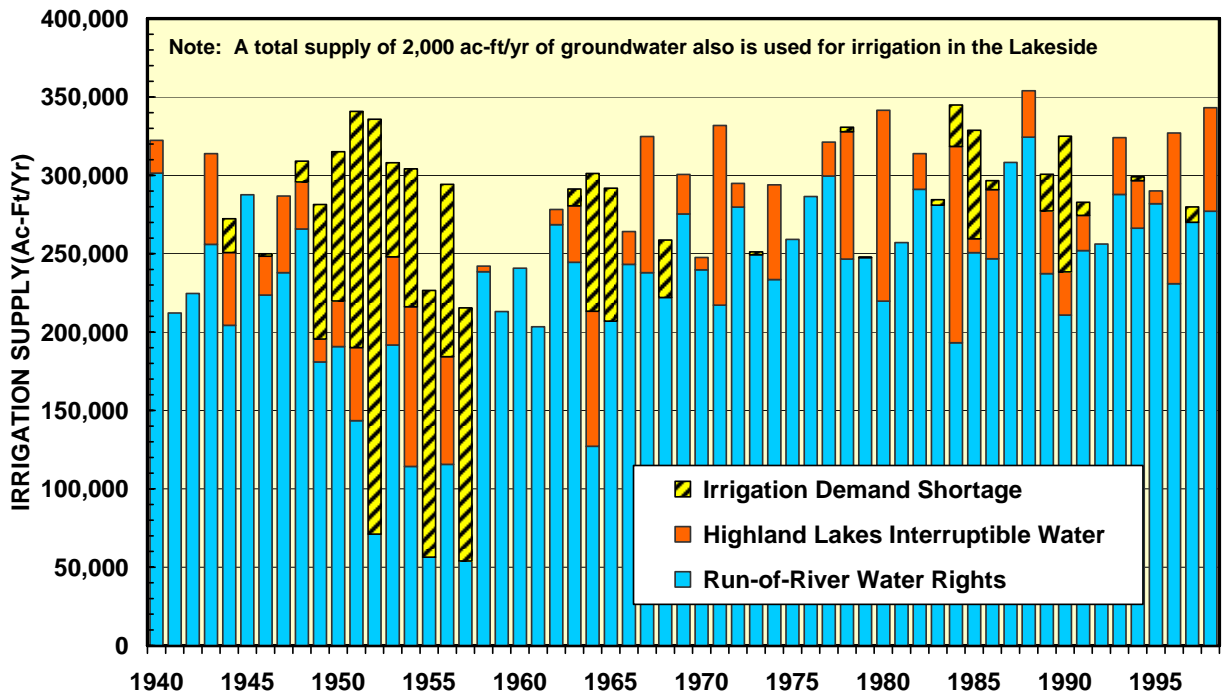
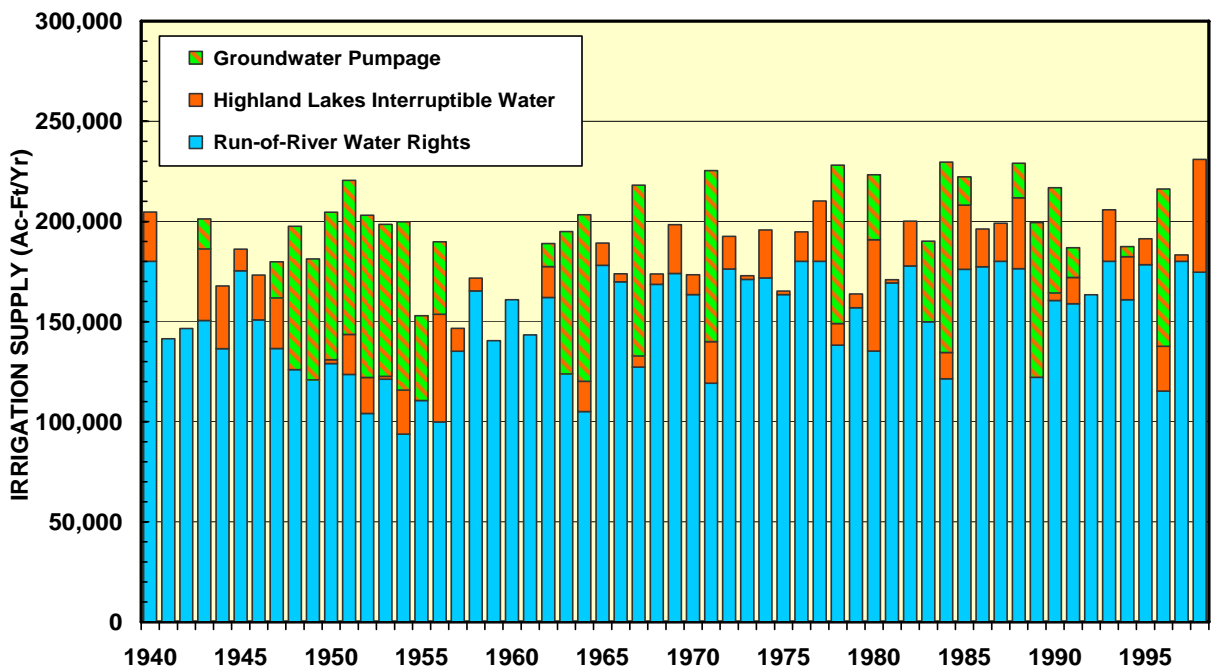
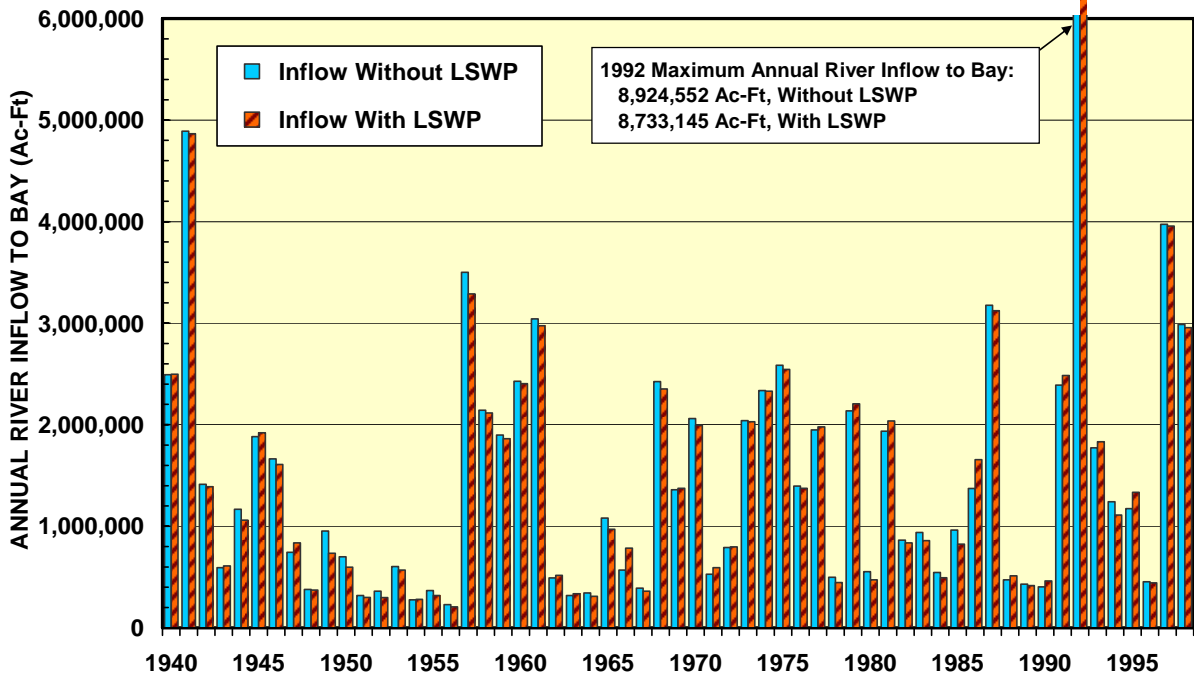


FIGURE 4-6
 Annual Supplies of River Water, Groundwater, and Highland Lakes Stored Water used to meet LCRA's Projected Irrigation Demands with the Project in Operation under 2060 Conditions and with 95,000 Acre-Feet per Year Delivered to SAWS
 LCRA-SAWS Water Project



- With the project, the quantities of groundwater used for irrigation in the lower basin are not projected to exceed any of the pumping limits established in the LCRA-SAWS agreement (rows 53-55).
- *Subsistence* instream environmental flow criteria along the lower Colorado River in accordance with the project's recommendations are engaged all the time and are expected to be satisfied practically all the time under conditions with or without the project (rows 63-66).
- *Base-dry* instream environmental flow criteria are satisfied at least 80 percent of the time (excluding at Wharton in 2080 with the project), which is the compliance goal recommended by the river habitat study team.
- *Base-normal* instream environmental flow criteria are generally satisfied at least 60 percent of the time (excluding Wharton in most decades with or without the project and Columbus in 2080 with the project), which is the compliance goal recommended by the river habitat study team.
- On the average, freshwater inflows to Matagorda Bay from the Colorado River, under 2006 Freshwater Inflow Needs Study *critical* criteria (row 80) are projected to satisfy the corresponding flow needs approximately 69 to 70 percent of the time with the project and without the project in 2030 and 2060. In 2080, the *critical* criteria are projected to be met approximately 69 percent of the time with the project and 73 percent of the time without the project. During the drought of record, freshwater inflows to Matagorda Bay are projected to satisfy the corresponding flows needs generally less (2, 4 and 10 percent less on average during 2030, 2060 and 2080, respectively) with the project than without it (row 81).
- On the average, freshwater inflows to Matagorda Bay from the Colorado River under 2006 Freshwater Inflow Needs Study *intermediate* criteria (row 83) and *target* criteria (row 86) are projected to satisfy the corresponding flow needs substantially more often with the project than without. During the drought of record, freshwater inflows to Matagorda Bay are projected to satisfy the corresponding flows needs somewhat more often with the project than without it (row 84 and row 87).
- Generally, freshwater inflows into Matagorda Bay from the Colorado River are projected to be slightly less with the project than without the project (row 75). A comparison of annual river flows at the mouth of the Colorado River under 2060 conditions with and without the project (with 95,000 acre-feet per year delivered to SAWS) is presented on the bar chart in Figure 4-7.

FIGURE 4-7
 Annual River Flows at Mouth of Colorado River under 2060 Conditions with and without the Project (95,000 Acre-Feet per Year Delivered to SAWS)
 LCRA-SAWS Water Project



Increasing the project's firm delivery to SAWS from 95,000 to 120,000 acre-feet per year under 2080 conditions results in only small reductions in the quantities of river flows reaching Matagorda Bay. Specifically, the average annual flow at the mouth of the Colorado River (row 75) is reduced from 1,490,882 acre-feet per year down to 1,477,846 acre-feet per year.

TABLE 4-3
 Results from Water Availability Analyses
 LCRA-SAWS Water Project

ROW	PARAMETER	UNITS	201	203		206		208		
			BASE W/ LOW	BASE W/ LOW	FUTURE WITH LSW	BASE W/ LOW	FUTURE WITH LSW	BASE W/ LOW	FUTURE WITH LSW P95	FUTURE WITH LSW P20
LSWP OPERATIONS (Based on Daily Spreadsheet Model)										
1	Annual Water Delivery to SAWS	ac-ft/yr	n/	n/a	95,000	n/	95,00	n/	95,00	120,00
2	Maximum Off-Channel Storage Capacity	ac-ft	n/	n/a	212,00	n/	212,00	n/	212,00	212,00
3	Maximum Off-Channel Storage Surface Area	acre	n/	n/a	2,938	n/	2,938	n/	2,93	2,93
4	Maximum Depth of Off-Channel Storage	fee	n/	n/a	72.	n/	72.	n/	72.	72.
5	Maximum Daily River Pumping Rate	cfs	n/	n/a	2,500	n/	2,150	n/	1,42	6,00
6	Average Daily River Pumping Rate When Pumping	cfs	n/	n/a	34	n/	33	n/	33	38
7	Minimum Daily River Pumping Rate	cfs	n/	n/a	0	n/	0	n/	0	0
8	Percent of Time River Pumps in Operation	%	n/	n/a	37.	n/	38.	n/	39.	40.
9	Percent of Time River Pumps at Maximum Pumping Rate	%	n/	n/a	3.	n/	4.	n/	6.	1.
1	Maximum Annual River Diversion Amount	ac-ft/yr	n/	n/a	310,87	n/	313,05	n/	313,17	337,35
1	Average Annual River Diversion Amount	ac-ft/yr	n/	n/a	93,042	n/	92,73	n/	95,41	115,36
1	Maximum Annual Highland Lakes Backup	ac-ft/yr	n/	n/a	95,000	n/	95,26	n/	95,26	120,32
1	Average Annual Highland Lakes Backup	ac-ft/yr	n/	n/a	9,075	n/	9,349	n/	6,98	11,77
1	1948-1956 Drought-Averaged Highland Lakes Backup	ac-ft/yr	n/	n/a	32,411	n/	33,77	n/	23,39	38,90
1	Average Volume of Off-Channel Storage	ac-ft	n/	n/a	146,49	n/	148,00	n/	150,43	146,01
1	Minimum Volume of Off-Channel Storage	ac-ft	n/	n/a	0	n/	0	n/	0	0
1	Percent of Time Off-Channel Storage Full	%	n/	n/a	19.	n/	19.	n/	20.	22.
1	Percent of Time Off-Channel Storage Empty	%	n/	n/a	9.	n/	9.	n/	7.	9.
1	Average Off-Channel Storage Evaporation Loss	ac-ft/yr	n/	n/a	3,206	n/	3,190	n/	3,38	3,21
2	Average Off-Channel Storage Seepage Loss	ac-ft/yr	n/	n/a	3,843	n/	3,831	n/	3,93	3,83
HIGHLAND LAKES SYSTEM CONDITIONS (Based on WAM simulations)										
2	Adjusted Average Lake Buchanan Level Increase for <90% Full (6' Target)	fee	n/	n/a	6.	n/	6.	n/	6.	6.
2	Adjusted Average Lake Travis Level Increase for <90% Full (18' Target)	fee	n/	n/a	18.	n/	18.	n/	18.	18.
2	Adjusted Average Lake Buchanan Level Increase for Drought (10' Target)	fee	n/	n/a	10.	n/	10.	n/	10.	10.
2	Adjusted Average Lake Travis Level Increase for Drought (20' Target)	fee	n/	n/a	20.	n/	20.	n/	20.	20.
2	Average Storage in Lake Buchanan	ac-ft	744,07	691,07	718,83	631,80	660,94	614,038	639,44	638,81
2	Average Storage in Lake Travis	ac-ft	907,82	856,59	934,84	807,97	881,58	798,216	875,09	876,79
2	Average Storage in Buchanan-Travis System	ac-ft	1,651,898	1,547,666	1,653,677	1,439,774	1,542,531	1,412,254	1,514,534	1,515,608
2	Minimum Storage in Buchanan-Travis System	ac-ft	309,94	199,81	532,68	5,205	288,05	1,84	268,11	288,22
2	Average Annual System Evaporation Loss	ac-ft/yr	82,39	80,02	84,866	77,51	82,47	77,94	82,86	82,97
3	Drought-Averaged System Evaporation Loss	ac-ft/yr	100,27	93,00	112,44	83,97	102,37	87,08	105,57	106,10

TABLE 4-3 (CONTINUED)
Results from Water Availability Analyses
LCRA-SAWS Water Project

ROW	PARAMETER	UNITS	2010	2030		2060		2080		
			BASE W/O LSWP	BASE W/O LSWP	FUTURE WITH LSWP	BASE W/O LSWP	FUTURE WITH LSWP	BASE W/O LSWP	FUTURE WITH LSWP 95K	FUTURE WITH LSWP 120K
HIGHLAND LAKES SYSTEM CONDITIONS (Based on WAM simulations), cont'd.										
31	Annual Fixed M&I Demands on Highland Lakes	ac-ft/yr	165,611	209,740	59,066	256,552	62,937	308,684	64,563	64,563
32	Annual M&I Demands on LCRA Run-of-River Rights	ac-ft/yr	0	0	150,674	0	193,615	0	244,121	244,121
33	Annual Austin M&I Water Rights and Reuse Demands	ac-ft/yr	181,172	234,659	234,658	291,704	291,704	291,704	291,704	291,704
34	Annual Other Power Water Rights Demands	ac-ft/yr	63,156	96,281	96,281	96,281	96,281	96,281	96,281	96,281
35	Average Annual M&I/Power Backup Supply from Highland Lakes	ac-ft/yr	24,023	39,646	85,859	57,845	117,715	52,867	128,354	126,550
36	Drought-Averaged M&I/Power Backup Supply from Highland Lakes	ac-ft/yr	58,099	85,299	154,322	111,169	205,027	104,640	220,387	219,772
37	Average Annual Interruptible Irrigation Supply from Highland Lakes	ac-ft/yr	48,280	43,054	20,584	30,232	14,574	17,200	10,826	9,103
38	Drought-Averaged Interruptible Irrigation Supply from Highland Lakes	ac-ft/yr	96,109	67,333	25,299	39,072	14,014	13,825	8,416	7,586
39	Average Annual H. L. Supply for Instream Environmental Flows	ac-ft/yr	90,152	77,106	88,573	49,935	64,175	45,033	49,801	52,114
40	Drought-Averaged H. L. Supply for Instream Environmental Flows	ac-ft/yr	56,742	30,462	66,868	22,650	36,754	16,733	16,301	27,967
41	Average Annual H. L. Supply for B&E Freshwater Inflows	ac-ft/yr	114,714	98,364	97,811	91,106	87,822	87,436	71,080	68,958
42	Drought-Averaged H. L. Supply for B&E Freshwater Inflows	ac-ft/yr	57,246	64,138	35,322	49,030	40,820	47,716	39,416	27,756
LCRA AGRICULTURAL IRRIGATION DEMANDS (Based on WAM simulations)										
43	Projected Maximum Total Irrigation Demands	ac-ft/yr	407,672	393,929	271,582	355,913	230,989	330,608	206,588	210,229
44	Projected Average Total Irrigation Demands	ac-ft/yr	332,398	321,247	221,591	290,686	190,145	270,342	170,912	170,912
45	Projected Minimum Total Irrigation Demands	ac-ft/yr	233,393	225,705	162,377	205,371	140,436	191,814	127,037	115,948
46	Percent of Time Annual Demand Fully Satisfied	%	76.3	69.5	100.0	35.6	100.0	32.2	100.0	39.0
47	Percent of Time >95% of Annual Demand Fully Satisfied	%	91.5	76.3	100.0	62.7	100.0	32.2	100.0	57.6
48	Percent of Time >90% of Annual Demand Fully Satisfied	%	98.3	83.1	100.0	74.6	100.0	35.6	100.0	67.8
49	Percent of Total Demand Met for Period of Record	%	99.1	95.0	100.0	89.7	100.0	76.3	100.0	92.5
50	Percent of Total Demand Met during Critical Drought Period	%	96.1%	79.8%	100.0%	65.7%	100.0%	45.4%	100.0%	79.7%
51	Average Annual Supply from Colorado River Rights	ac-ft/yr	279,136	260,184	176,432	228,534	150,522	187,035	133,851	121,300
52	Drought-Averaged Supply from Colorado River Rights	ac-ft/yr	233,062	196,467	138,501	156,624	117,795	111,469	103,829	69,562
53	Average Annual Supply from Groundwater (<36,000 ac-ft/yr Required)	ac-ft/yr	2,000	1,992	24,575	1,992	25,049	1,968	26,235	27,607
54	Drought-Averaged Supply from Groundwater (<62,000 ac-ft/yr Required)	ac-ft/yr	2,000	1,992	62,000	1,992	62,000	1,968	62,000	62,000
55	Maximum Amount Supplied by Groundwater (<95,000 ac-ft/yr Required)	ac-ft/yr	2,000	2,000	95,000	2,000	95,000	2,000	95,001	95,001
56	Average Annual Supply from Highland Lakes Interruptible Water	ac-ft/yr	48,280	43,054	20,584	30,232	14,574	17,200	10,826	9,103
57	Drought-Averaged Supply from Highland Lakes Interruptible Water	ac-ft/yr	96,109	67,333	25,299	39,072	14,014	13,825	8,416	7,586
58	Average Annual Total Irrigation Supply from All Sources	ac-ft/yr	329,416	305,230	221,591	260,757	190,145	206,202	170,912	158,010

TABLE 4-3 (CONTINUED)
Results from Water Availability Analyses
LCRA-SAWS Water Project

ROW	PARAMETER	UNITS	201	203		206		208		
			BASE W/ LOW	BASE W/ LOW	FUTURE WITH LSW	BASE W/ LOW	FUTURE WITH LSW	BASE W/ LOW	FUTURE WITH LSW P95	FUTURE WITH LSW P20
INSTREAM ENVIRONMENTAL FLOWS (Based on WAM)										
5	Average Annual Contribution from Highland Lakes Inflows	ac-ft/yr	87,91	74,87	86,57	48,40	62,12	43,74	48,10	50,37
6	Drought-Average Contribution from Highland Lakes Inflows	ac-ft/yr	48,63	23,72	59,84	19,21	33,02	13,61	12,66	24,45
6	Average Annual Contribution from Highland Lakes Storage	ac-ft/yr	2,23	2,232	2,00	1,53	2,05	1,28	1,69	1,74
6	Drought-Average Contribution from Highland Lakes Storage	ac-ft/yr	8,10	6,736	5,40	3,44	3,73	3,11	3,63	3,51
6	% of Time Only Subsistence Instream Flow Criteria Engaged	%	9	1	7	2	1	3	3	3
6	Percent of Time Subsistence Criteria Met at Bastrop	%	100	10	10	10	10	100	10	10
6	Percent of Time Subsistence Criteria Met at Columbus	%	100	10	10	10	10	100	10	10
6	Percent of Time Subsistence Criteria Met at Wharton	%	100	10	10	10	10	100	10	10
6	% of Time Only Base-Dry Instream Flow Criteria Engaged	%	1	1	1	4	3	3	3	3
6	Percent of Time Base-Dry Criteria Met at Bastrop	%	100	9	9	9	9	9	9	9
6	Percent of Time Base-Dry Criteria Met at Columbus	%	9	9	9	9	9	9	8	8
7	Percent of Time Base-Dry Criteria Met at Wharton	%	8	8	8	8	8	8	7	7
7	% of Time Only Base-Normal Instream Flow Criteria Engaged	%	7	7	7	3	4	3	3	3
7	Percent of Time Base-Normal Criteria Met at Bastrop	%	9	9	8	9	8	9	8	8
7	Percent of Time Base-Normal Criteria Met at Columbus	%	7	7	6	6	6	6	5	5
7	Percent of Time Base-Normal Criteria Met at Wharton	%	6	6	5	5	5	5	5	5
BAY & ESTUARY ENVIRONMENTAL INFLOWS (Based on WAM)										
7	Average Annual Colorado River Matagorda Bay Inflow	ac-ft/yr	1,641,512	1,557,823	1,550,696	1,523,818	1,507,377	1,539,420	1,490,822	1,477,846
7	Minimum Annual Colorado River Matagorda Bay Inflow	ac-ft/yr	211,41	212,37	209,945	227,565	205,310	239,69	215,46	220,90
7	Average Annual Contribution from Highland Lakes Inflows	ac-ft/yr	114,71	98,36	97,81	91,10	87,82	87,43	71,08	68,95
7	Drought-Ave. Contribution from Highland Lakes Inflows	ac-ft/yr	57,24	64,13	35,32	49,03	40,82	47,71	39,41	27,75
7	% of Time Only Critical B&E Inflow Criteria Engaged	%	8	1	7	2	1	3	3	3
8	% of Time Critical Criteria Met at Mouth, POR	%	6	6	7	6	6	7	6	7
8	% of Time Critical Criteria Met at Mouth, Drought	%	4	4	4	4	4	4	3	4
8	% of Time Only Intermediate B&E Inflow Criteria Engaged	%	3	3	3	4	3	3	3	3
8	% of Time Intermediate Criteria Met at Mouth, POR	%	5	5	8	5	8	5	8	8
8	% of Time Intermediate Criteria Met at Mouth, Drought	%	5	5	5	5	6	5	6	6
8	% of Time Only Target B&E Inflow Criteria Engaged	%	5	4	5	3	4	3	3	3
8	% of Time Target Criteria Met at Mouth, POR	%	3	3	4	3	4	3	4	4
8	% of Time Target Criteria Met at Mouth, Drought	%	7	7	1	7	1	7	6	8

Potential Risks Associated with Water Supply

As noted previously, the analysis of water availability relative to the project incorporates numerous assumptions, many of which have a direct influence on the water supply capabilities of the project and the ability to implement the project in a manner that satisfies existing legal, institutional, and regulatory requirements. The assumptions were developed to reflect reasonably foreseeable conditions in the system and, where practical, to conservatively address input variables that are subject to change or uncertainty. Certainly, there are risks associated with these assumptions, and the degree to which reality reflects these assumptions as time passes could influence the ability of the project to function as planned. For this reason, it is important to understand the risks relative to water supply during the project development process.

The assumed hydrology represents a risk. This hydrology, particularly the drought of record, has been used to evaluate the water supply capabilities of the project that has largely dictated the conceptual design of the project components and the projected firm supply of water available to SAWS. The use of drought-of-record hydrology as the basis for determining firm water supplies is consistent with the assumptions used for state water rights permitting and regional water planning in Texas. While the drought of the 1950s certainly is considered an extremely severe drought by all accounts, there is no guarantee that a worse drought may not be experienced some time during the life of the project. Should this happen, the available firm supply of water from the project will be less. This is not unique to this project, as all water development projects face the same possibility, and contingency plans often are implemented to minimize the impacts of reduced supplies. According to state law, in these situations, suppliers are generally required to curtail supply to customers on a pro rata basis according to the terms of their contracts. This is the procedure that will be used by LCRA under such circumstances, consistent with the agreement with SAWS.

If future conditions within the basin turn out to be contrary to any of the assumptions that have been made with respect to the future available water supply in the lower Colorado River, the projected supply for SAWS could be either adversely or positively affected. For example, if the projected demands of LCRA's municipal, industrial, and irrigation water users are different from those assumed for evaluating water availability for the project, then there could be more or less water available for all users in the lower basin. The projected municipal, industrial, and irrigation demands of LCRA's customers over the life of the project as used in the surface water availability assessment are based on the best available information at this time and are consistent with those demands being used by other water planners in this region, including Region K's most recently approved plan (2006). The projected demands for LCRA water could change in the next round of regional water planning, which could result in more or less water available for the project after those in-basin water demands are satisfied.

One area of particular uncertainty pertains to future requirements for environmental flows to support both instream uses and bay and estuary resources. The water availability analyses of the project have incorporated the proposed instream environmental flow criteria developed by the project's aquatic habitat study team, which are subject to approval by state agencies. For providing freshwater inflows to Matagorda Bay, the project has used the 2006 Freshwater Inflow Needs Study criteria, which are the most recent criteria developed by

state agencies in collaboration with LCRA. The project's Matagorda Bay health evaluation study team recently has presented preliminary inflow criteria for establishing appropriate freshwater inflows to Matagorda Bay; how these criteria will affect overall water availability in the lower basin has yet to be determined. While the various environmental flow criteria provide considerable protection for both instream and bay and estuary uses, refinements are continually being considered as new data and studies produce new information. This is the nature of the environmental flow issue, and it is something that is likely to continue to result in some degree of uncertainty with regard to water supply planning and development.

It is important to note that Senate Bill 3 passed by the 80th Texas Legislature establishes a process for reexamining and refining environmental flow requirements for river basins across Texas to provide more meaningful and defensible information for managing and protecting the state's aquatic resources. Recommendations from this process regarding environmental flow criteria for protecting both instream uses and bay and estuary resources in the Colorado River basin may be implemented before the permits for this project are issued. These new programs and procedures could affect the way environmental flow requirements are established and subsequently imposed on water supply projects, including this project through the water rights permitting process.

As with any conjunctive use project, the total yield for the project is a function of groundwater availability and permitting. Groundwater is discussed in more detail in the following section of this PVA.

As far as the project facilities are concerned, no significant risks that affect yield have been identified. The exact location of the project diversion point on the river below the city of Wharton does not appear to be particularly important from a river water availability standpoint, so the location of the river pump station is not critical to this particular analysis. Assumptions regarding pump station size are likely to change through the design process, as these facilities are made more efficient; however, these changes will not affect the achievable yield of the project. Guidance from other studies, including the facility siting study, is already anticipated as part of the design process.

Further Water Availability Studies

Future water availability analyses will be performed to refine the optimal operation of the project relative to other water supply activities undertaken by LCRA and new information developed by other ongoing studies. Water availability modeling with and without the project implemented under 2020 and 2050 conditions along with 2030, 2060 and 2080 will be performed, as well as analyses of conditions after the termination of the project. The structure and operation of the project will be examined also to assure compliance with all legal, regulatory, and contractual requirements, to improve the efficiency of the project, and to evaluate alternative means for potentially mitigating identified adverse project impacts.

In most cases, the timing of the amount of water flowing down the river is as important to overall ecological health of the system as the amount of water provided on a yearly basis. For example, certain species of fish require low river flows in the spring with higher flows needed in the fall. On the other hand, because many of the bay organisms retreat to the Gulf of Mexico during winter, large volumes of winter river flows may not be as important to the bay. To predict flows available to both meet environmental needs (the river flow relationships to habitat and bay health studies are summarized elsewhere in this PVA) and

determine the water supply available for agricultural as well as for storage and transfer to the San Antonio area, modeling of surface water availability under different scenarios is necessary.

4.2 Groundwater for Agriculture

One objective of the project is to use groundwater and surface water conjunctively to meet the agricultural water supply needs of within the LCRA irrigation divisions its lower basin counties. LCRA will determine the need for groundwater on a real-time basis and pump groundwater when surface water supplies are insufficient to meet its irrigation divisions' needs in Colorado, Wharton, and Matagorda counties.

LCRA anticipates that the project's well systems will be developed by leasing existing underutilized wells and, where necessary, installing new wells for the most efficient delivery of groundwater to irrigation customers. If new wells are needed within a particular irrigation division, the preference will be to work with a landowner regarding permitting and use of the groundwater. When groundwater is pumped from project wells, it will be piped into existing irrigation canals. To help minimize construction costs and environmental impacts, the well system will consist of wells located near the irrigation canals. Since the wells are for irrigation, they will only operate during the irrigation season, which is primarily between April and October.

This section highlights the results of the groundwater for agriculture study during 2007. This is followed by a more detailed discussion of the project's groundwater modeling efforts, the preliminary well network design, and the development and results of the latest predictive model simulations.

Study Status

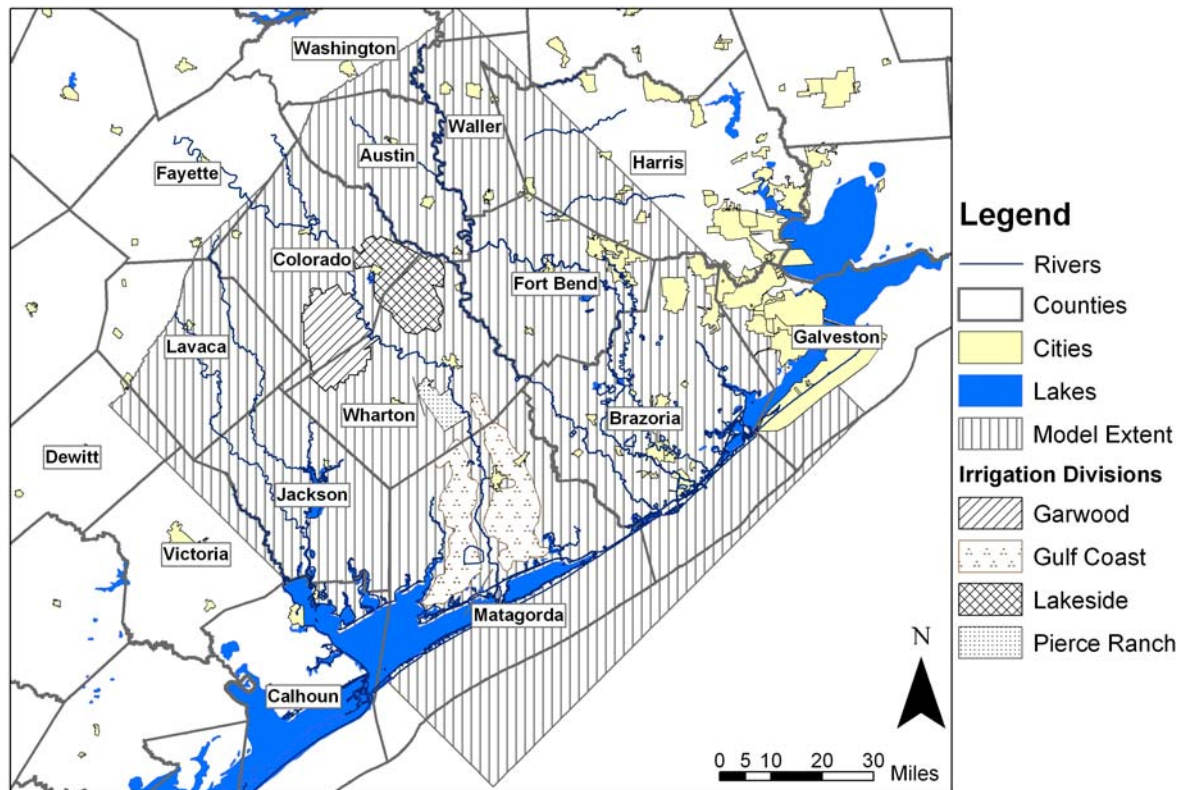
In 2007, the team continued development and refinement of the groundwater model for the project. Model calibration was performed on data from years 1900 through 1997; model verification used data from years 1998 through 2006. The area covered by the LSWP groundwater model is an eight-county region including and surrounding the irrigation divisions operated by LCRA and Pierce Ranch (in Wharton County). Figure 4-8 shows the area covered by the model, along with the locations of the irrigation divisions.

In addition to model refinements, progress was made on several other activities related to use of groundwater. The team:

- Performed a literature search of land subsidence in the study area and incorporated a land subsidence capability into the historical and predictive groundwater models. Subsidence was calibrated in the historical model using historical data derived from the literature search.
- Developed an analytic model and two numerical SEAWAT models (computer programs that simulate three-dimensional groundwater flow) to simulate variable-density flow and water quality impacts. These models were used to improve the flow model calibration and to help evaluate the potential movement of brackish water near proposed project production wells in Matagorda County. This is discussed in more detail in the subsection, "Description of the LSWP Groundwater Models."

- Updated a preliminary well system for the project based upon the groundwater needs determined by modeling of water availability and the irrigation canal delivery systems provided by other project teams, as well as upon other logistical, physical, and environmental design constraints. This is described in more detail in the “Description of the LSWP Well Network” section of this PVA. The well locations are preliminary in nature and subject to change as further project information comes available.

FIGURE 4-8
 LSWP Groundwater Model Geographic Domain
 LCRA-SAWS Water Project



- Continued monitoring four shallow monitoring wells. The data continues to demonstrate the gaining nature of the Colorado River (that is, water flow increases at downstream points) and the significant contribution of irrigation to the recharge of the regional groundwater system.
- Evaluated the existing network of groundwater monitoring wells system for assessing future potential drawdown near the irrigation divisions.

Study Findings in 2007

The study findings in 2007 can be grouped into three categories: 1) those related to field studies and monitoring; 2) those related to improved understanding of the regional hydrogeology through conceptualization, development, and calibration of the groundwater model; and 3) those related to well field design and performance. Study highlights are provided for these three categories below:

Analyses of Field Data

- Measurements from shallow wells installed near the Colorado River show that water flows from groundwater to the river except for relatively brief periods of high rainfalls that may last several days. These data are consistent with the previous LCRA river studies that indicate that the Colorado River is a gaining stream in these reaches.
- A review of monitoring data in the region indicates that the shallow water table is largely unaffected by the deep pumping historically associated with irrigation in the region.
- Analysis of data from wells monitored by the Texas Water Development Board and the Coastal Bend and Coastal Plains groundwater conservation districts indicate that, across most of the study region, the hydraulic head values are rising or relatively stable because of decreased pumping since the late 1970s and early 1980s.

Regional Hydrogeology and Groundwater Modeling

- The project's model estimates recharge to the shallow aquifer of about 2.5 inches per year. This estimate is significantly greater than the deep recharge estimated by the Central Gulf Coast groundwater availability model (GAM). The difference results from the refined model effectively simulating the shallow groundwater system, which is dominated by local hydrology. Only about 13 percent (0.27 inch per year) of total recharge reaches the confined portions of the aquifers. The remainder is discharged through stream baseflow and evapotranspiration. In Colorado, Wharton, and Matagorda counties, agricultural irrigation is estimated to contribute about 0.8 inch per year to recharge to the shallow aquifer.
- Since 1900, the land-surface subsidence caused by groundwater pumping in Colorado, Wharton, and Matagorda counties is estimated to be less than 1 foot. This estimate is consistent with an analysis of field measurements and simulated results using the project's groundwater model.
- Regional heads (elevations of measured water level in a well) in the heavily pumped Lissie and Willis formations vary significantly (in the range of 20 to 60 feet) between the growing season and the winter when pumping volumes and rates are reduced. Not only are seasonal variations observed, but also water levels tend to vary in the "downdip" or confined portions of these formations, depending on the level of confinement and the depth of the well screens. Drawdown (pressure decline) measured within a pumping irrigation well may exceed 100 feet during the growing season; however, the shallow unconfined aquifer water levels (heads) are largely unaffected by larger head declines in the deeper pumped formations. The moderated effect is due to low vertical conductivities (vertical movement between and among formations) and large storativity values (measurements of the volume of water stored) in the unconfined system.

Project Well System

- Groundwater production wells should be installed within and near the canals associated with the LCRA irrigation divisions. In general, a short distance between the irrigation well location and the irrigation canal is desired to minimize the conveyance system costs and to reduce the potential for the conveyance system to interfere with farming practices.
- In designing its well network, LCRA has a preference to lease existing wells instead of installing new wells where it is beneficial for the project. However, LCRA has not yet begun to identify the best leasing locations or to develop leasing documents.
- Construction of the project's well system is expected to take several years and be a dynamic process based on continual updates consisting of model results, field data, regulatory conditions, and stakeholder feedback. Because of this and other unresolved factors, a proposed system design has not been developed for the project.
- Based on the results of the surface water availability model's predictive simulations of future project operation, there may be several months (over the 1940-1998 simulation period) during which groundwater comprises over 80 percent of the total canal flow. To deliver sufficient volumes of irrigation water during these months, a majority of the groundwater wells will need to be located near the major canals.

Description of Project's Groundwater Models

Groundwater models developed for the project fall into three categories: historical model, predictive model, and water quality models. Much of the modeling efforts to date have focused on developing, calibrating, and analyzing the historical model. This model was used to provide insight into the hydrogeologic system, and to evaluate the conceptualization of the flow system. This model incorporates a level of detail regarding aquifer properties, aquifer structure, and aquifer lithology that enhances previous models in the region. Model layering and gridding is more refined than the previously existing groundwater models to allow for improved representation of groundwater recharge, groundwater pumping, and groundwater-surface water interactions. The model has been calibrated using historical hydrographs from approximately 800 wells in the region. Calibration errors meet accepted criteria and are improved over any previous model developed in the central study area.

The LSWP groundwater model was enhanced in 2007 to include land-surface subsidence, the contribution of agriculture irrigation on recharge, pumping from domestic and livestock wells in the shallow aquifer, and the addition of a model verification period that extends through 2006. For the 2005 and 2006 pumping years, the project is using the pumping information collected by the Coastal Bend and the Coastal Plains groundwater conservation districts for Wharton and Matagorda counties, respectively.

The predictive model shares the same structure and physical properties with the calibrated historical model, but uses estimated future conditions and management scenarios as input to assess potential effect from the project. All predictive simulations use the same annual stress periods, running from year 2000 to 2090, with identical physical properties and lateral boundary conditions, and non-project pumping rates. The non-project pumping rates are based on numbers provided by the Texas Water Development Board in the 2007 State Water

Plan. The various predictive simulations are discussed in more detail in a subsequent section in this assessment, "Description of Future Pumping Scenarios."

Groundwater quality modeling received increased focus this year. One of the considerations with operating the project's wells is the possibility of changes to groundwater quality over time. Two potential water quality concerns are the upward movement of brackish water from beneath well screens and the lateral movement of the fresh/saline interface due to pumping from the project. The team developed both numerical and analytical models to help evaluate the potential for these changes. Given the nature of the modeling effort, the results should be considered approximate. The numerical models include a two-dimensional, cross-sectional model and a three-dimensional "box" model that use the variable density flow and transport code SEAWAT to simulate the migration of total dissolved solids.

The analytical models suggest that, for typical project pumping rates, upward movement of brackish groundwater is not expected in Wharton County, but potentially could be observed in Matagorda County. These results suggest that to prevent potential brackish groundwater upward movement in Matagorda County, the bottom of the well screens should be kept approximately 300 feet above brackish groundwater having total dissolved solids values greater than 3,000 parts per million (ppm). Results of the numerical model indicate that the predictions from the analytical model are conservative, and that the 300-foot buffer zone would be more than adequate to prevent the upward movement of brackish groundwater.

Evaluation of the lateral migration of the fresh/saline groundwater interface near Matagorda County was performed using a two-dimensional, cross-sectional model. Model results indicate that for pumping rates of about 40,000 acre-feet per year in Matagorda County (a historical high), no significant changes occur to groundwater quality.

Description of the Preliminary LSWP Well Network

The agreement between LCRA and SAWS defines limits for the use of groundwater to supplement irrigation needs:

- 95,000 acre-feet maximum in any one year
- A rolling 10-year average of 62,000 acre-feet per year
- An average of 36,000 acre-feet per year during the entire term of the implementation period for the project

To meet projected irrigation needs, it is expected that the project will use a combination of new and existing (leased) wells to provide the groundwater portion of the needed water. At this time, the project has not identified potential wells for lease.

The conceptual project well network has been slightly revised from the previous year, both in number of wells and their approximate locations. The estimated number of project wells is based primarily on the maximum groundwater demand predicted by month and by irrigation division using the surface water availability model. Groundwater is used to supplement surface water only if, and as, needed based on the simulation of surface water availability to meet demands. In other words, groundwater is used to supplement surface water, but is not the primary source projected to meet irrigation needs. The predicted overall groundwater demand has not changed substantially from 2006. However, canal

modeling by the agricultural conservation team in January 2007 refined estimates of the location and timing of demands. Based on the agricultural conservation team’s recommendations, and an analysis of maximum monthly and weekly demands, the current range of potential wells for the project varies from 105 to 133. The required number of wells will be revised as project conditions change or additional information becomes available. Table 4-4 summarizes the assumed percentage of the wells located in each irrigation division based on irrigation demand projections.

TABLE 4-4
 Preliminary Estimate of Total Wells by Irrigation Division (as a Percentage by Division)
 LCRA-SAWS Water Project

Irrigation Division	Percent of Total Wells Assumed for PVA Analysis
Garwood	15%
Lakeside ⁽¹⁾	36%
Pierce	4%
Gulf Coast East	26%
Gulf Coast West	19%
Total	100%

⁽¹⁾Lakeside has five existing LCRA wells that are considered in this percentage

In addition to satisfying demand predictions, proposed well locations were constrained by a desired proximity to irrigation division canals, groundwater conservation districts’ spacing requirements, avoidance of surveyed wetlands as shown on the National Wetlands Inventory, and the minimization of drawdown affects (based on spacing and aquifer transmissivity). The conceptual well locations were used in the predictive modeling runs described in a following subsection.

Description of Future Pumping Scenarios

The predictive groundwater model described previously integrates the conceptual project well network. Several pumping scenarios are simulated with this model to estimate potential effects of the project on groundwater levels under different drought conditions and management scenarios.

Project demands were estimated based on water availability simulations performed by the project’s surface water availability team. The results of the surface water model runs provide estimates for demands under 2030, 2060, and 2080 management conditions, over the period of record from 1940-1998, which includes the drought of record for the Colorado River basin from 1947-1956. The simulations were conducted both with and without the project. Both groundwater and surface water demands were estimated for each of the irrigation divisions operated by LCRA and the Pierce Ranch. Surface water demands are important in the groundwater modeling because canal losses and field percolation can recharge the groundwater system. Table 4-5 is a summary of projected groundwater demands for each of

the decades as estimated by using the surface water model as described previously. The demands for management conditions not modeled by the project’s surface water availability team (2040, 2050, and 2070) were linearly interpolated.

TABLE 4-5
 Estimated Future Project Groundwater Demands
 LCRA-SAWS Water Project

Year	Period of Record: 1940-1998 Annual Demand (in acre-feet)					Drought of Record: 1947-1956 Annual Demand (in acre-feet)				
	Garwood	Gulf Coast	Lake-side	Pierce Ranch	Total	Garwood	Gulf Coast	Lake-side	Pierce Ranch	Total
2010	0	0	2,000	0	2,000	0	0	2,000	0	2,000
2020*	5,492	7,976	9,706	1,400	24,575	13,861	19,335	25,307	3,497	62,000
2030	5,492	7,976	9,706	1,400	24,575	13,861	19,335	25,307	3,497	62,000
2040*	5,587	7,927	9,773	1,446	24,733	13,875	19,380	25,167	3,577	62,000
2050*	5,681	7,877	9,840	1,493	24,891	13,890	19,425	25,028	3,656	62,000
2060	5,775	7,828	9,906	1,540	25,049	13,905	19,470	24,889	3,736	62,000
2070*	5,964	8,108	9,983	1,586	25,642	14,433	19,224	24,579	3,764	62,000
2080	6,154	8,388	10,061	1,632	26,235	14,960	18,978	24,270	3,792	62,000

*2020, 2040, 2050 and 2070 demands were estimated by linear interpolation

The recharge based on precipitation was estimated for both the average annual precipitation during the entire period and the average annual precipitation during the drought of record. The irrigation recharge from canal losses and field percolation was based on the varying surface water and groundwater demands. The occurrence of the drought of record was systematically varied by decade among the simulations, creating a suite of predictive runs. Table 4-6 summarizes the conditions for each of the with-project runs. Note that each with-project simulation required a corresponding without-project simulation, so the difference (impact of the project) could be analyzed, making 14 predictive simulations.

TABLE 4-6
 Years during which the Drought of Record (DOR) occurred in Groundwater Modeling Predictive Simulations
 LCRA-SAWS Water Project

Simulation	DOR years
1	no DOR
2	2026-2035
3	2036-2045
4	2046-2055
5	2056-2065
6	2066-2075
7	2076-2085

Estimated Impacts to Groundwater Resources from the Project

The primary test used for quantifying the potential effects of the project on groundwater resources is net (or incremental) drawdown. Net drawdown is defined as the difference between the drawdown predicted for a “without project” simulation and the drawdown predicted by a “with project” simulation, for a given simulation pair. Because a given pair of simulations with and without the project will begin with identical water levels, the calculation of net drawdown can be achieved by taking the difference in predicted water levels at any given time during the simulations.

To provide a broad summary of simulated net drawdowns, the average net drawdowns for each decade, at existing well locations in the project area, were recorded. For Wharton and Matagorda counties, we used the locations of registered and permitted wells provided by the Coastal Bend and Coastal Plains groundwater conservation districts. In Colorado County, we used the well locations from the current project well database, which was compiled from sources such as the Texas Water Development Board well database. The wells were divided into two categories by location based on whether they fell inside or outside irrigation division boundaries. The total number of wells located within and outside of the irrigation divisions are 913 and 5106, respectively.

Table 4-7 shows the net drawdown statistics averaged by decade for the simulation where the drought of record occurs from 2056-2065 (Simulation 5 in Table 4-7). The decade average is centered on the reported year, e.g., “2030” indicates the years from 2026-2035. This simulation predicted the largest net drawdown, although all of the simulations showed similar period of record and drought of record results. These statistics were calculated using the end-of-year water levels (previous studies have shown this to be the approximate annual average.)

TABLE 4-7

Predicted Net Drawdown Statistics (in feet) by Decade for End of Year Water Levels in Simulation where Drought of Record Occurs from 2056-2065

LCRA-SAWS Water Project

Decade	Inside Irrigation Divisions				Outside Irrigation Divisions			
	Mean	Median	Min	Max	Mean	Median	Min	Max
2030	1.95	1.75	0.13	5.84	0.81	0.64	0.00	5.64
2040	2.24	2.03	0.17	6.31	0.95	0.78	0.00	6.10
2050	2.48	2.27	0.18	6.69	1.06	0.89	0.00	6.47
2060	4.49	4.08	0.17	13.88	1.95	1.58	0.00	13.39
2070	3.34	3.02	0.18	8.59	1.57	1.38	0.00	8.38
2080	3.10	2.73	0.16	7.90	1.45	1.27	0.00	15.69

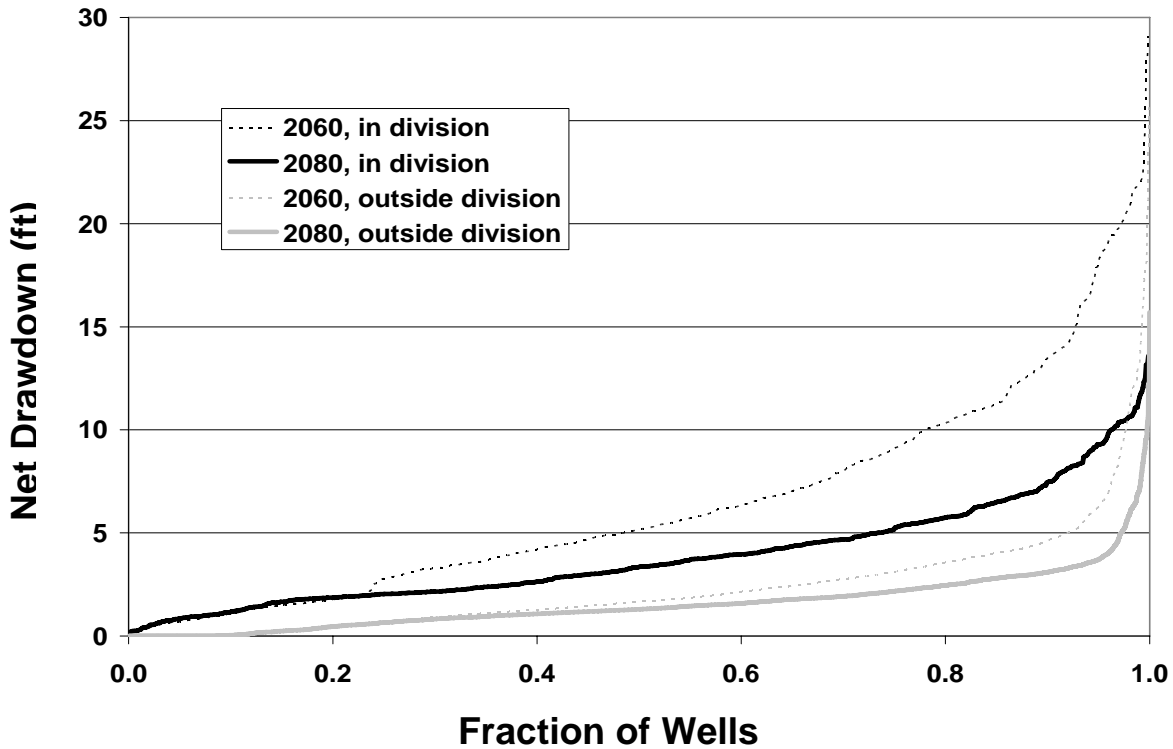
Table 4-8 shows the same net drawdown statistics where the calculations were made using the water levels at the end of the growing season. The trends are similar to the end-of-year case, although the average drawdowns increase by about 20 to 30 percent.

TABLE 4-8
 Predicted Net Drawdown Statistics (in feet) by Decade for End of Growing Season Water Levels in Simulation where Drought of Record Occurs from 2056-2065
LCRA-SAWS Water Project

Decade	Inside Divisions				Outside Divisions			
	Mean	Median	Min	Max	Mean	Median	Min	Max
2030	2.67	2.16	0.13	11.60	0.92	0.66	0.00	10.29
2040	2.98	2.44	0.17	12.11	1.06	0.79	0.00	10.77
2050	3.22	2.66	0.18	12.52	1.18	0.91	0.00	11.17
2060	6.47	5.16	0.17	29.09	2.29	1.67	0.00	25.87
2070	3.92	3.45	0.18	13.79	1.62	1.34	0.00	12.45
2080	3.89	3.35	0.16	13.58	1.58	1.29	0.00	15.70

Figure 4-9 shows the cumulative distribution of net drawdown from the same simulation for two different decades: 2060, which occurs during the simulated drought of record, and 2080, which occurs near the end of the overall simulation. These results are for water levels at the end of the growing season. As with the previous tables, the distributions are shown for wells inside and outside the irrigation divisions. The figure shows that for 95 percent of the wells outside the irrigation divisions, the drawdown at the end of the growing season is less than 5 feet during the drought of record. Inside the irrigation divisions, the drawdown is relatively uniformly distributed from zero to 10 feet for about 80 percent of the wells, with the other 20 percent of wells having a net drawdown ranging from 10 to 30 feet. Under 2080 conditions, the trends are similar but the net drawdowns are generally less than those under drought of record conditions.

FIGURE 4-9
 Cumulative Distribution of Predicted Net Drawdown in Decades 2060 and 2080 for End of Growing Season Water Levels in Simulation where Drought of Record Occurs from 2056-2065
 LCRA-SAWS Water Project



Regulatory Aspects and Permitting

In Wharton and Matagorda counties, permits, to be issued by the Coastal Bend and the Coastal Plains groundwater conservation districts, respectively, will be needed for constructing and operating the groundwater production wells. The districts have no production limits on wells at this time; permit approval criteria are primarily based on beneficial use and well spacing. Colorado County recently formed a district and has not established a management plan or rules within the district. It is expected that the permitting process will be similar to those currently being used in the Coastal Bend and Coastal Plains districts.

Potentially, because of the process required in House Bill 1763 (79th Texas Legislature) whereby districts are required to establish “desired future conditions,” it is possible that production limits for the districts will be established. LCRA is committed to meeting regulatory requirements in the project area and in attaining applicable permits, as necessary. With no production limits currently specified for the project area, other quantifiable requirements currently being regulated such as spacing are being used to guide the analysis.

In developing the preliminary project well system, there does not appear to be a problem with achieving the requirement of spacing the LSWP wells 1,500 feet apart and 2,500 feet away from registered or permitted wells in Wharton County and Matagorda County, respectively. At this time, we assume that similar offsets will be included in the rules for

Colorado County Groundwater Conservation District. As has been demonstrated in the previous section, on average, drawdown impacts of the project will be minimal for most groundwater users both within and especially outside the irrigation divisions. The project team will perform a detailed study looking at the mitigation potential for the project, which will isolate any production wells within the project area that may be adversely affected by the project.

A principal concern regarding permitting of the wells is that currently both groundwater districts issue pumping permits for only three-year to five-year time periods. In addition, the districts require that construction of a well begin within six months of permit issuance. Both of these time spans are too short for a project such as the LSWP. LCRA is in discussions with the groundwater conservation districts about the appropriate approach and process for a project of this magnitude and duration.

Potential Risks Associated with Groundwater

The current assessment of risks associated with the project includes risks in characterization of aquifer groundwater availability, risks related to regulatory issues, and risks associated with public opinion. These will be summarized with each risk being characterized by its nature, potential impact, and management method.

- Related to assessment of groundwater availability, a risk to the project and the stakeholders in the region lies in the accuracy of groundwater availability predictions and, therefore, under or over estimating project impacts. This risk is partially managed by the development of a detailed groundwater model. The project will use the best modeling tools as well as the best information available to attempt to bracket potential uncertainty in model predictions.
- The ability to obtain groundwater permits is a regulatory risk for the project. Further, the existing groundwater conservation districts' rules that establish three to five year terms for pumping permits could be a risk for the project due to its long-term duration.
- Current estimates are that the project requires in the approximate range of 105 to 133 wells. However, for approximately 70 percent of the time during the actual growing season, the project needs to pump from 75 or fewer wells to meet the irrigation needs. To ease the need for new wells in the region, the project will seek to lease existing wells. This approach will benefit those in the study region and reduce the number of wells requiring new permits. A second means of addressing permitting issues is through mitigation. The LCRA is currently developing a mitigation policy that will reflect LCRA's commitment to preserving the Gulf Coast aquifer system as a continuing source of water in the region.
- In 2007, the voters for Colorado County approved a groundwater conservation district. Due to projected irrigation water needs, the layout of the Garwood and Lakeside irrigation divisions, and the project's groundwater production requirements, 35 to 40 percent of the proposed wells could be in Colorado County. With the formation of the Colorado County district, there are some risks that regulations could limit the capability of the project to obtain permits. LCRA is committed to working with the newly formed district to develop and manage groundwater in a manner that is beneficial to the community, results in minimal impacts, and meets water supply needs for irrigation.
- House Bill 1763 (79th Texas Legislature) has the potential to limit production within the region, depending on the determination of "desired future conditions" defined by the

districts. December 2007 was the legislative target date for providing a definition of “desired future conditions.” Groundwater Management Area 15 (the counties in which the project area lies) did not define the desired future conditions by the end of 2007 and it is not clear when this will be determined. Therefore, the associated risk to the project cannot be quantified.

- Through the project stakeholder process, members of the public have raised the increased use of groundwater to meet local irrigation needs as a concern. Thus, negative public opinion could be a risk to the project. The project is using good science, public education and outreach, well leasing, and mitigation to address this risk. Further, the project team will continue to work closely with the local districts.
- Although new wells would be placed in compliance with districts’ well spacing requirements and production managed to minimize drawdown, the potential for some affect on existing wells is possible. Policies to address such impacts and minimize or mitigate them are under development.
- To deliver sufficient volumes of irrigation water during these months, a majority of the groundwater wells will need to be located near the major canals. Existing contractual limitations related to delivery of water in the Garwood division could limit groundwater use or increase cost to the project for groundwater use within that system.

4.3 Agricultural Conservation

The agricultural conservation studies identify potential water saving measures on individual farms and within the irrigation canal delivery system served by the LCRA irrigation system. The LCRA system is composed of three divisions (Lakeside, Garwood, and Gulf Coast), as well as Pierce Ranch, a wholesale water purchaser. To achieve this water use goal, conservation targets have been established for the project. The targets for estimated potential reductions in demand are the same as those anticipated in previous years:

- | | |
|--------------------------------------|----------------------------------|
| • On-farm best management practices: | 40,000 acre-feet per year |
| • Rice Varieties: | 30,000 acre-feet per year |
| • Delivery System: | <u>48,000 acre-feet per year</u> |
| • Total: | 118,000 acre-feet per year |

Study Status

Most of the agricultural conservation study efforts are completing the third full year of development with the exception of some limited irrigation delivery system evaluations performed in late 2004 and the rice variety development work that began in 2002. All field efforts, data collection activities and model development were completed in 2007 with additional model analyses scheduled for completion in 2008. The results of this study are scheduled to be completed during 2008, with the exception of the high yield rice variety research that will continue until at least 2010. Permitting activities may require additional conservation study beyond 2008.

Initially, the various components of the agricultural conservation activities were conducted in parallel, and as somewhat independent processes; however, beginning in 2007, the

studies were extensively integrated as described in this assessment. Through this integrated approach, preliminary results were developed during 2007 to increase the confidence in the estimates of future demand reductions by irrigators.

For example, the on-farm conservation analysis depended upon the results of the socioeconomic studies that predicted the rate of adoption of various conservation measures based on economic principles. The Rice Water Conservation Analyzer (RiceWCA) model, a tool to rapidly evaluate the costs and water savings associated with a wide range of on-farm conservation measures, incorporated the rates at which farmers would be expected to adopt the various conservation measures. Then RiceWCA was used to assess on-farm water demands based on historic weather conditions. This information supported the evaluation of canal delivery system improvements and development of overall estimates of irrigation water demand. Projections using Rice WCA will be refined during 2008.

On-farm Conservation

During 2005, the Texas Agricultural Experiment Station team developed RiceWCA, a water use model for rice irrigation that estimates water demands under various weather conditions considering on-farm water conservation practices. The model was initially applied to develop estimates for demand for the Lakeside irrigation division, and potential reductions in demand that would result from precision grading, multiple field inlets, or other on-farm practices to conserve water. In parallel with the development of RiceWCA, the team evaluated fields using photo interpretation techniques to catalog the extent of existing on-farm practices in the Lakeside division.

In 2006, the RiceWCA model was refined, economic analysis components were more fully developed, and the analysis was expanded to include the Garwood and Gulf Coast divisions. The evaluation of existing conservation practices was also completed in these divisions. Before the end of 2006, the model was applied to all three irrigation divisions to develop initial estimates of reduced irrigation demand resulting from adoption of on-farm practices.

During 2007, RiceWCA was initially applied to develop data needed by the socioeconomic team to perform the farm income maximization modeling (FIMM) effort. The farm income analysis developed estimates of farmers' adoption rates for specific on-farm practices and returned this information to the RiceWCA modelers, who in turn evaluated water demand for the hydrologic period of record. Modeling results predicting adoption rates and the resulting irrigation water demand will be refined during 2008.

Rice Varieties

The rice variety development research began in 2002 with the initial crossing of the first hybrid rice varieties. The specific purpose of developing the hybrid is to create an ultra-high yield and low water demand variety that produces approximately 40 percent more rice than the current varieties. Since 2002, the research has continued with two generations of hybrid varieties cultivated each year. The Texas Agricultural Experiment Station researchers completed the cultivation of one generation of hybrids at the Beaumont and/or Eagle Lake centers and then worked with a research center in Puerto Rico to cultivate a second generation each year.

The reduced water demand for rice is expected to result from the development of varieties that produce significantly higher yield, eliminating the need for a ratoon (second) crop. However, a plant that is able to support and develop this higher yield may require an additional 10 to 14 days of growing season. The longer growing season will reduce the potential for a successful ratoon crop. Current estimates indicate that irrigation water demand without the ratoon crop will decline by about 24 percent.

The 2007 yield trials of the varieties developed to date indicate that the target of 40 percent increase in yield, compared to the commonly grown Cocodrie variety of rice, may be within reach. The best hybrid varieties developed to date have yields that are 20 to 25 percent better than Cocodrie. These trials also confirm that the initial commercial seed releases are expected to be in 2011. Use of new varieties has historically occurred rapidly once new varieties are available; thus, water savings could occur within a few years of the variety becoming available to farmers.

Delivery System

Initial evaluation of the irrigation delivery system was begun in late 2004 with completion of ponding tests to evaluate the potential for leakage from the irrigation canals. In 2005, the team collected most of the raw data for the delivery systems and began developing the system models using a tool called MODSIM. In 2006, additional field data was collected for calibration of the MODSIM model, and the team began evaluating the costs for implementing specific delivery system improvements and analyzing how these improvements would reduce irrigation water demand.

During 2007, the delivery system analyses were integrated with the reduced on-farm demand to further evaluate the combined effect of on-farm conservation strategies, new rice varieties, and delivery system conservation strategies. The initial integrated assessments indicate that the combined targets for irrigation demand reduction can be achieved.

Preliminary Results

On-farm Conservation

Efforts in 2007 were focused on calibrating the web-based RiceWCA model and adapting the program to produce results in various output formats that could be used by other study teams. The program was used to determine which water conservation best management practices should be implemented to achieve the target on-farm conservation savings. This assessment was conducted in two phases. The project team performed an initial assessment of maximum conservation practice adoption rates based on discussions with producers and LCRA personnel managing the irrigation divisions. These adoption rates were then incrementally increased, based on a series of RiceWCA runs, to determine the adoption rates required to reduce on-farm demand for irrigation water by 70,000 acre-feet per year (40,000 acre-feet per year in on-farm best management practices, plus 30,000 acre-feet per year in reductions due to switching to high-yield rice varieties).

The agricultural conservation and socioeconomic teams coordinated their studies during 2007 to ensure that RiceWCA model output was presented and used properly in the farm income maximization model (FIMM) analysis (described in more detail in Section 8). The RiceWCA model was run to produce output needed to run the FIMM. This consisted of estimated water demand for each field based on those conservation practices currently

implemented and estimated water demand for each additional water management practice alternative or viable combination of conservation measures that would likely be implemented for the field. Corresponding information on implementation cost and benefits in terms of increased yield or reduced labor were also estimated for every field. FIMM was initially applied to evaluate practice adoption rates based on the potential to increase farmer income when the best management practices were subsidized at 100 percent of the cost (“with project” case), compared to adoption rates with no subsidies (“without project” case).

FIMM provided “optimistic” and “pessimistic” adoption rates corresponding to changes in the cost of water, prices, labor costs and other variables. These predicted adoption rates were used to bracket likely behavior. As a conservative method for predicting water savings resulting from on-farm conservation measures, maximum values for adoption rates (caps) for each best management practice were imposed as shown in Table 4-9. These caps were based on an assessment of physical characteristics that may limit implementation of various conservation measures. For example, land most well suited to precision-grading based on factors such as slope, field shape, or topsoil thickness would be graded before land less well suited for such a practice. The cost to grade the less-suited fields would be greater than the cost for grading the more-suited fields. Therefore, as more fields are precision-graded, the unit price would likely increase. By setting caps on the maximum implementation rate for a conservation measure, a unit cost representing a reasonable average implementation cost for the measure was calculated.

TABLE 4-9
 Caps Placed on the Adoption of Best Management Practices
 LCRA-SAWS Water Project

Best Management Practice	Maximum Acres Projected for Adoption of Best Management Practice (Maximum Acres Projected for Adoption of Best Management Practice as a Percent of Acres Currently in Production (Caps)			
	Lakeside	Garwood	Gulf Coast	Pierce Ranch	Lakeside	Garwood	Gulf Coast	Pierce Ranch
Acres in Production	25,241	14,902	18,402	4,594	100	100	100	100
Bench Grade	15,140	8,940	9,200	1,840	60	60	50	40
Multiple Inlets	20,190	11,920	9,200	2,300	80	80	50	50
Constant Grade	23,980	14,160	17,480	4,360	95	95	95	95
Conservation Tillage	12,620	7,450	9,200	2,300	50	50	50	50
Tailwater Recovery	10,100	5,960	7,360	1,840	40	40	40	40
High Yield Rice	18,930	11,180	13,800	3,450	75	75	75	75
Ratoon (second) Crop	21,450	12,670	15,640	3,900	85	85	85	85

Note: Acres “currently in production” equals the annual average of acres in production 2001-2005.

Prior to completion of the farm income modeling results, the RiceWCA model was applied to evaluate water demand resulting from the agricultural conservation team’s best estimate of adoption rates, based on the historic conservation measure adoption trends and knowledge of farmer actions. Four adoption scenarios for each of the three LCRA irrigation

divisions (Garwood, Gulf Coast and Lakeside) were developed. The results of these model simulations are summarized in Table 4-10.

- **Scenario One:** A “base” case that estimated current on-farm demand using 2005 data.
- **Scenario Two:** Adoption of various conservation practices at the percentage rates shown in Table 4-9. This scenario is termed “Implementation to Caps” and provides the estimate of water demand with all practices implemented to the maximum reasonable extent.
- **Scenario Three:** Implementation to Caps without high yield rice varieties or increased conservation tillage. This scenario includes adoption of conservation practices at the percentages shown in Table 4-9, except for conservation tillage and high yield rice, which are assumed to have no additional adoption. The restriction on high yield rice adoption results in the ratoon (second) crop remaining at the same percentage as the first crop. This scenario was selected because water savings resulting from adoption of high yield rice and increased conservation tillage are not associated with capital investment subsidies by the project. Therefore, including them in a simple evaluation of total capital costs could result in a misleading (low) cost per acre-foot of water demand reduction.
- **Scenario Four:** Implementation to Caps with tailwater recovery limited to 10 percent adoption. This scenario represents the most likely scenario for adoption of the tailwater recovery practice, based on current analyses. It is highly likely that high yield rice will be adopted and that conservation tillage practices will increase. It is also likely that, given the incrementally greater cost-per-acre-foot of demand reduction resulting from tailwater recovery relative to precision grading and multiple inlets, the adoption of this practice will be limited.
- **Scenario Five:** Region K Modified. RiceWCA results were adjusted to include the effects of Pierce Ranch demand reductions because these were not included in the original Region K projections for irrigation demand reduction used as a basis for the project.

TABLE 4-10
Summary of RiceWCA Projections (Average Values)
LCRA-SAWS Water Project

Scenario	On-farm demand ² (acre-feet/year)	Demand reduction (acre-feet/year)	Capital cost (\$1,000s)	O&M cost (\$1,000s/year)	Unit Cost ¹		
					Amortized capital cost ³ (\$/ac-ft)	O&M Cost (\$/ac-ft)	Total Cost (\$/ac-ft)
One	242,000	0					
Two	124,000	118,000	\$99,700	\$2,100	\$64	\$18	\$82
Three	161,000	81,000	\$99,700	\$2,000	\$115	\$25	\$140
Four	146,000	96,000	\$65,200	\$1,600	\$56	\$61	\$117
Five	144,000	98,000					

1. Based on demand reduction from best management practices only

2. Average irrigation volume for one year

3. Amortized capital at an annual interest rate of 4 7/8 percent over the estimated useful life of each best management practice

The key value in the table is the \$140 per acre-foot of water conserved, shown in the last column for Scenario Three. This value represents a unit cost of the demand reductions to the project sponsors. The volume of water savings that is expected to occur without the project (i.e., the adoption of high yield rice or increases in the number of acres subjected to conservation tillage) is not factored into this estimate of cost per acre-foot of water saved. These additional practices are expected to be adopted by producers without requiring capital subsidies from the project sponsors. It is also expected that that acreage used for rice production will decline somewhat over time resulting in further on-farm demand reductions.

High Yield Rice Variety Development in 2007

High yield rice variety development work continued during 2007 with crossing or hybridization of the hybrids developed to date, crossing of new first generation hybrids, developmental evaluation of varieties, and monitoring of target varieties in nursery plots and multiple yield trials.

A total of 296 hybrids were developed during 2007 including initial crosses and advanced generations of previous crosses. Many of these varieties were subsequently planted in pots in the greenhouse and cultivated to maturity with measurements of plant growth and specific characteristics monitored during the growing season.

Later generation varieties following previous hybridization efforts were planted in field nurseries. The observational and pedigree nurseries consisted of 5,752 rows. Of these rows, 688 rows were selected, based on plant growth characteristics, and harvested for further evaluation in subsequent field nursery studies.

Forty-two lines (or rows) were selected for evaluation in the 2007 preliminary yield trial at Beaumont. Twelve of the 42 rows harvested produced yields greater than Cocodrie, with the highest yielding lines having a 25 percent yield advantage.

DNA analyses were performed on all of the selected nursery rows to evaluate whether the varieties contained three critical characteristic genes:

- Semi-dwarf stature
- Blast resistance
- Cooking quality

Thirty-seven of the lines selected for the preliminary yield trial were evaluated for additional trait parameters such as tillers per plant, leaf area, and biomass that have positive contributions to grain yield at heading and at harvest.

A variety of yield trials was conducted during 2007 with plantings at Beaumont, Eagle Lake and other locations. The best varieties yielded almost 30 percent more than Cocodrie while the worst trials yielded only about 8 percent more than Cocodrie. The maturity period of the new varieties ranged from the same as Cocodrie to requiring 10 to 14 days longer. The plan for release of a variety for commercial growers is on track for 2011. The initial variety releases are projected (RiceWCA analysis) to result in reducing the irrigation water demand by 0.75 acre-feet per acre to 1.4 acre-feet per acre, depending upon the irrigation division, soils, and on-farm practices, compared to a two crop system.

Delivery System Conservation Strategies

Various conservation strategies (individually and in combination) throughout the delivery system were evaluated considering the amount of water that could be potentially saved and the cost of those savings (dollars per acre-foot). These include both structural (e.g., physical improvements to the delivery system) and non-structural (e.g., management practices). The results are reported in the "Conservation Strategies in the LCRA Irrigation Divisions Report" (Parsons, December 15, 2006). A conservation savings report finalized in December 2007 reflects changes that have occurred in the design of various system improvements since the original report was issued. The 2007 report also incorporates the results of the nonstructural conservation measures analysis conducted in the fall of 2007. Nonstructural measures are those measures that predominantly require the adoption or modification of programs and administrative practices.

Structural Delivery System Conservation Strategies

A more detailed review of estimated structural conservation measures and associated costs was conducted during 2007. The scenarios were evaluated in terms of capital as well as operations and maintenance costs, along with the potential savings resulting from the implementation of the measures.

Conservation ponds are proposed to regulate the flow in the delivery system. The ponds are used to catch excess flows from the canal system. The ponds may also be used during dry periods to store canal water for later release to meet peak demands. Potential locations and sizes were reviewed and analyzed in the latter part of 2006. Field visits were made to observe the proposed locations with the intent of identifying potential obstructions, such as gas wells, that could not be observed from aerial photo inspection. A revision of the initial report (October 2006) was issued in November 2007 that refined initial results, addressed science review panel comments, and modified the locations of some ponds in response to

input from irrigation division staff. LCRA will be working with landowners within the irrigation divisions to confirm locations for the conservation ponds.

In addition to the use of conservation ponds, other structural improvements were studied, including:

- lining of those canals with high leakage rates;
- temporary use of the off-channel storage facility to store agricultural flows that have been released from the Highland Lakes for agricultural use; and
- vegetation control in the canals to reduce water losses.

Non-Structural Delivery System Conservation Strategies

The non-structural, or management, strategies include changes to the management and operation of the delivery system. These include:

- employment of a full time conservation engineer;
- increased inspection of canal levees and identification of those with high leakage levels;
- increased monitoring of canal flows and levels; and
- implementation of a conservation savings verification program.

Recommended Delivery System Conservation Strategies

The following actions are recommended for delivery system improvements. Some strategies employ both structural and non-structural elements to optimize water savings:

1. Employ a water conservation engineer familiar with practices in the south central Texas area specifically dedicated to the project to implement, monitor and evaluate the effectiveness of the various conservation measures.
2. Implement a program to identify high-loss canal segments:
 - Install flow-metering stations within the system to identify areas where delivery system losses are the greatest.
 - Conduct repeated instantaneous measurements at locations suspected of high-losses.
 - Based on information collected by the first two activities, conduct ponding tests to further focus in on high-loss segments.
 - Along segments where losses are indicated, conduct intense on-ground inspection of the canal banks and levees.
3. Where vegetation is heavy in suspected high-loss areas, remove the vegetation to an extent that is environmentally sound.
4. Line the River-to-Lake Canal and the River-to-Prairie Relift Canal after conducting preliminary testing to confirm the extent to which each canal is losing water.
5. Construct conservation ponds.

6. Remove unused turnouts.
7. Rehabilitate turnouts and add flow meters, along with automated gate control and SCADA (Supervisory Control and Data Acquisition).
8. Replace check structures on major canals.
9. Install a composite geomembrane-concrete liner in high-loss canals to the extent necessary to achieve the savings goal.

Delivery System Savings and Cost

An annual cost of \$8,500,000 (\$130 per acre-foot conserved per year) is estimated to be needed to reach the target savings volume for the delivery system of 48,000 acre-feet per year. The capital facilities have different life cycles ranging from 10 to 80 years. The cost estimate is based on the sum of the annualized capital costs for each measure, amortized over the life cycle associated with that measure. The value of \$130 per acre-foot includes 35 percent for engineering, administration, and contingencies on capital items and 20 percent contingency for operation and maintenance activities. Costs for the project are addressed in more detail in Section 10. The combination of conservation measures described herein has the potential for saving up to 65,000 acre-feet of water per year. Table 4-11 summarizes the potential savings.

TABLE 4-11
 Potential Maximum Savings from the Delivery System Conservation Measures
 LCRA-SAWS Water Project

Delivery System Conservation Measure	Water Conserved (acre-foot/year)
Line River to Lake and River to Prairie Canals	10,700
Top 10 percent high-loss canals excluding River to Lake and River to Prairie	12,600
Conservation Ponds	11,500
Improved Check Gates	10,500
Vegetation control -- Initial Clearing	3,000
Vegetation control -- On-going	2,000
Remove unused turnouts	800
New Turnout w/ Remote Control	14,000
Measures with non-quantifiable benefits	
Flow Metering Stations (w/ SCADA)	
Instrument Shop	
Dedicated Engineer	
High-Loss Segment Identification	
On-ground Inspection	
Total Potential Maximum Savings	65,100

Summary of Agricultural Conservation Savings

Currently projected implementation of the conservation measures would start in 2015, and approximately two thirds of the conservation measures would be installed by 2023, with the remaining one-third implemented by 2045. Table 4-12 shows the various categories of average demand reductions for 2045, the last year of the conservation implementation schedule. The values in Table 4-12 include average savings resulting from the project of approximately 106,000 acre-feet. Application of a “peaking factor” of 1.16 (calculates peak water use as compared to average use) results in the projected peak savings of approximately 123,000 acre-feet per year which exceeds the targeted savings goal of 118,000 acre-feet per year by a small margin.

TABLE 4-12
 Projected Distribution of Demand Reductions
 LCRA-SAWS Water Project

Agricultural Conservation	Average Savings (acre-feet/year)	Approximate Peak Savings (acre-feet/year)
On-Farm Best Management Practices	34,000	39,000
High-yield rice	31,000	36,000
Total Projected On-Farm Savings	65,000	75,000
Delivery System Savings	41,000	48,000
Total Annual Average Savings	106,000	123,000

Note: As indicated in Table 4-10 (Scenario Three), Rice WCA predicts an additional average savings of 31,000 acre-feet per year from on-farm improvements and reduced acreage in production without the project. An additional 7,000 acre-feet per year of savings in the delivery system are also predicted without the project. Combined savings would then total approximately 144,000 acre-feet and 167,000 acre-feet per year of average and peak savings, respectively.

Figure 4-10 shows the projected demands over time with and without the project based on the anticipated implementation schedule described previously in this section. This is a very aggressive schedule and is subject to the availability of workforce and materials. There are also restrictions on when work can be conducted in the canal system imposed by crop watering requirements. These restrictions could extend the length of the first implementation phase.

FIGURE 4-10
 Irrigation Demand Reductions with and without the Project
 LCRA-SAWS Water Project

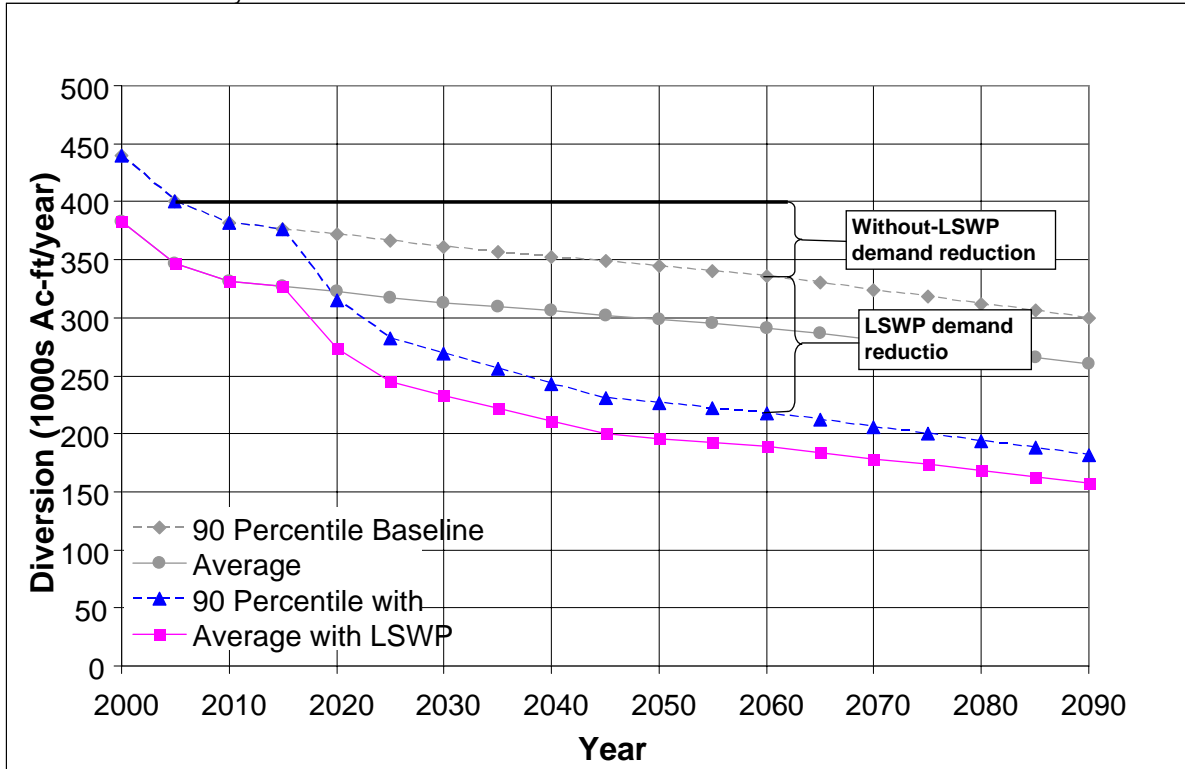
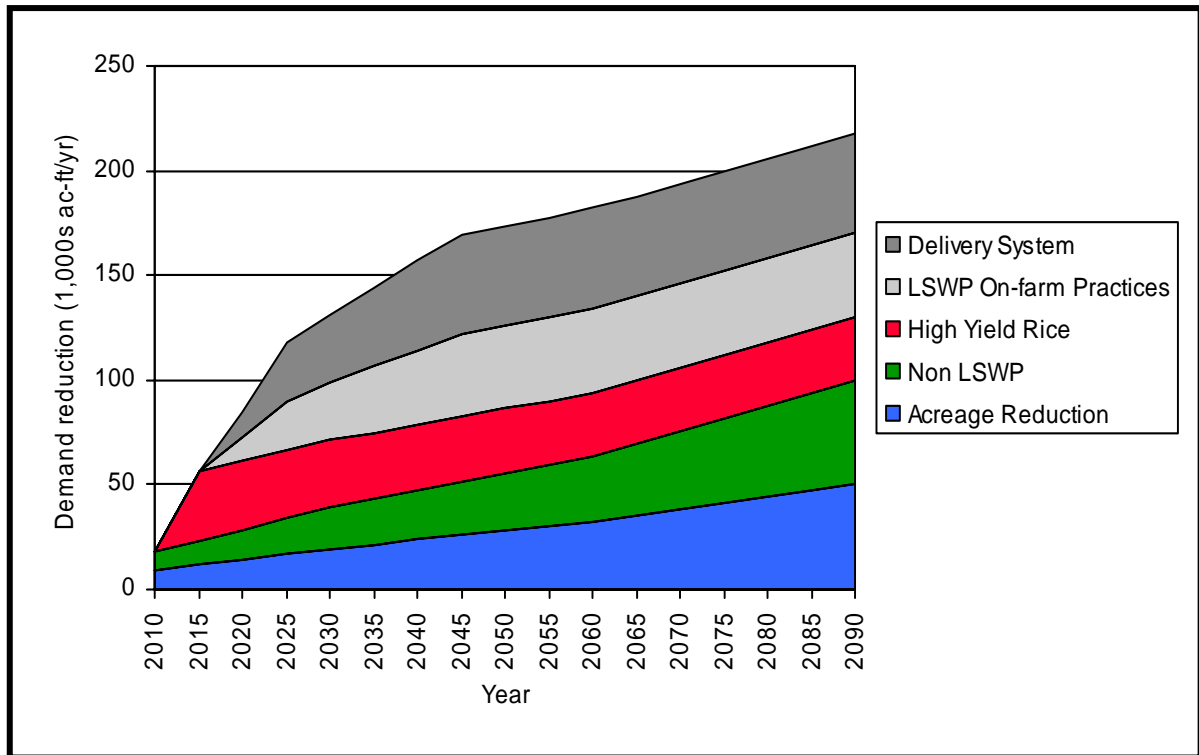


Figure 4-11 shows the increase in projected demand reductions over time estimated to be achieved from the various conservation measures.

FIGURE 4-11
 Projected Increase in Irrigation Water Savings, 2010 -2090
 LCRA-SAWS Water Project



The measures implemented first will be those that have the highest benefit to cost ratio in terms of water savings.

Potential Risks Associated with Agricultural Conservation

In both on-farm and delivery system scenarios, the risks associated with projecting conservation savings are a factor to be considered in all phases of the project.

- In general, implementing conservation measures in the delivery system may provide fewer risks than implementing measures on-farm, because LCRA has direct control over the delivery system; whereas, on-farm savings will vary among hundreds of farmers with their individual practices, availability of time, or acceptance.
- **Savings Estimates.** Projected savings resulting from recommended practices may not be completely achieved due to differences between the LCRA irrigation systems and other systems upon which design criteria were based. For example, data projecting water savings from practices such as installing meters at all turnouts was derived from other irrigation systems and actual savings in LCRA’s system could vary either higher or lower than the projections. Pilot studies to confirm projected savings resulting from the implementation of a particular conservation strategy would be a method of quantifying the expected savings.

- System operation differs from that modeled. Conservation savings are calculated using efficiency figures that can be achieved using SCADA in a manner that helps to control water loss from the delivery system. If actual operation differs, then the savings may not equal the calculated savings. System monitoring, personnel training and implementation of best manage practices will help assure system operations achieve desired efficiency.
- Increased system efficiency may reduce return flows to parts of Matagorda Bay. The Matagorda Bay health evaluation study team to identify and quantify potential effects of such system changes is studying this. Current analysis suggests that the percent of flow into the marshes from irrigation return flows is significantly less than that supplied by precipitation. It is likely not be a significant source of freshwater inflows except, perhaps, during significant drought periods. Further, with the anticipated reductions in acreage, such flows are expected to decline over time even without the project.
- Farmers may not implement conservation practices for a number of reasons including:
 - They are tenant farmers who choose not to invest in improvements on land they do not own
 - They are satisfied with their current operations and may not be willing to implement the new practices
- Global economic forces could change the value of rice crops resulting in more fields being brought into production.