LAKES BUCHANAN AND TRAVIS
WATER MANAGEMENT PLAN

EXECUTIVE SUMMARY

A. Background ES-1
B. Changes from the 2010 Water Management Plan ES-2
C. Demands ES-3
D. Water Availability Modeling ES-5
E. Allocation of Interruptible Supplies ES-5
F. River Operations ES-8
G. Glossary ES-8

A. BACKGROUND

The LCRA Water Management Plan is a plan for operating lakes Buchanan and Travis to help meet water needs up and down the Colorado River Basin. The plan is mandated by the 1988 Final Judgment and Decree that adjudicated (determined the extent of) the Highland Lakes water rights. Consistent with this court order, the plan was developed by LCRA and approved by the state. It is periodically updated to account for changing conditions, and each update is approved by the LCRA Board of Directors and the state, currently the Texas Commission on Environmental Quality (TCEQ).

Under the Final Judgment and Decree, LCRA was granted the right to use up to 1.5 million acre-feet of water annually from lakes Buchanan and Travis. As part of this decree, LCRA was required to determine the combined firm yield of lakes Buchanan and Travis. The combined firm yield is the amount of water the lakes can reliably provide on an annual basis even in conditions equal to the worst drought in recorded history. This water is called "firm" water. The worst drought in recorded history, for purposes of the WMP, is the drought of the 1940s to 50s known as the Drought of Record.

Water from lakes Buchanan and Travis may be available on an interruptible basis any time the actual demand for stored water under firm commitments is less than the Combined Firm Yield. Interruptible supply may be sold on an annual basis under conditions and ~~rules~~ procedures set forth in this WMP, and LCRA's contract rules. This water is called "interruptible" because this supply can be interrupted (cut back or cut off) before the availability of firm water is reduced.

The WMP is not a static document, and is periodically revised to reflect changes in firm water demands. The first WMP was approved by the state in 1989. Previous revisions were approved in 1991, 1992 and 1999. The last revision was approved by the ~~Texas Commission on Environmental Quality (~~TCEQ~~)~~ on Jan. 27, 2010.

The firm demands of LCRA's municipal, industrial and other firm water customers are projected to grow significantly through 2020, which increases the likelihood of ~~significant shortages of~~ interruptible stored water curtailment or cutoff during dry periods. Because of these factors, this WMP contains significant changes to the interruptible stored water curtailment policies.

As in previous revisions, an advisory committee consisting of members representing the diverse interests that depend on lakes Buchanan and Travis provided input to LCRA related to key areas in the plan. Committee members represented municipal and industrial customers, lake area businesses and residents, farmers and the environment. The advisory committee began its work in July 2010 and worked for more than a year to reach a qualified consensus or near consensus on many of the recommended changes to the WMP. LCRA's Board of Directors considered the committee's input when it approved this WMP revision before it was sent to the TCEQ for final approval.

Out of concern for the future needs of the many areas in LCRA's 35-county water service area, including areas now using ground water supplies that are becoming depleted or are of poor water quality, the LCRA Board has reserved 50,000 acre-feet of the Combined Firm Yield.

B. CHANGES FROM THE 2010 WATER MANAGEMENT PLAN

This WMP contains a number of policy changes from the 2010 WMP. These changes are discussed in this executive summary and in more detail in the rest of the Water Management Plan. The following is a list of some of the key changes:

- LCRA used the most recent scientific studies to develop environmental flow criteria;
- LCRA will determine applicable environmental flow criteria on two dates for different periods of the year;
- LCRA will determine the availability of interruptible stored water for the downstream irrigation operations separately for first and second crop;
- LCRA will increase the amount of interruptible stored water available for the downstream irrigation operations if combined storage in lakes Buchanan and Travis increases between Jan. 1 and March 1 for first crop or, between June 1 and Aug. 1 for second crop;
- There will be an annual cap on the total amount of interruptible stored water available for contracting in any given calendar year. LCRA will adjust the amount of interruptible stored water available for second crop to stay within the annual cap;
- LCRA will use a two-phased approach with two sets of curtailment procedures. The first set is designed for interim demands (between 2010 and 2020), and the second is designed for 2020 demands;
- In the initial years in which this WMP is in effect, LCRA will use less restrictive (interim) curtailment procedures for determining available interruptible stored water, and will shift to more restrictive curtailment procedures designed for year 2020 firm demands when specific triggers are reached (based on actual demands, water supply conditions, or a time certain);
- LCRA will stop releasing interruptible stored water for the Lakeside, Pierce Ranch and Gulf Coast irrigation operations when combined storage drops below 600,000 acre-feet whether or not the LCRA Board has declared a Drought Worse than Drought of Record; and
- The LCRA Board will have increased discretion to determine the amount of interruptible stored water available under certain severe dry weather conditions, and to determine a

potential additional amount of assumed run-of-river available to the Gulf Coast irrigation operation under certain wet forecast conditions.

Additionally, the combined firm yield of lakes Buchanan and Travis has reduced from 445,266 acre-feet per year to 434,549 acre-feet per year.

C. DEMANDS

Demands on lakes Buchanan and Travis and the lower Colorado River system are many, varied and often competing. Cities, communities, industrial facilities and farmers throughout the lower Colorado River basin depend on water from lakes Buchanan and Travis and Colorado River. In addition, hydroelectric facilities, lake area businesses, commercial fisheries along the coast, recreation-related businesses along the river and Matagorda Bay, recreation interests along the river and lakes, and the environment rely on the water. These demands are dynamic and continue to evolve as the region's population grows and other factors change. This could include changes in agricultural programs, new water supply strategies, and improvements in conservation, water efficiency and science that enhance our understanding of the environment's water needs.

As LCRA's primary water supply reservoirs, lakes Buchanan and Travis were designed to store water from rainfall runoff and make that water available for the various purposes described above, as well for flood control. Customers divert water directly from the reservoirs, reservoir releases –or from the river downstream of the reservoirs. The reservoir levels decline when inflows are insufficient to replenish water released, diverted or lost to evaporation and they increase when inflows exceed releases, diversions and evaporative losses. The reservoirs thus enable LCRA to serve its customers and the environment through wet and dry periods.

LCRA supplies two general categories of water from lakes Buchanan and Travis: firm and interruptible.

- **Firm water** is available through a repeat of the conditions experienced in the Drought of Record. Cities and industry, including plants that generate electricity, are the primary users of firm water, but other customers also use firm water. These include some agricultural customers, golf courses, domestic and recreation customers and others. Firm water is also used to help meet the environmental needs of the Colorado River and Matagorda Bay. The firm demands used in this WMP revision are based on the LCRA Water Supply Resource Plan (WSRP) approved by the LCRA Board of Directors in October 2010 and are described in detail in Section 2.2 (Firm Water). That plan includes demand projections through year 2100. This WMP revision, however, is designed to meet projected demands to the year 2020.

- **Interruptible water** may be curtailed (cut back) or cut off in drought. Currently, interruptible water from lakes Buchanan and Travis ("interruptible stored water") is used almost entirely for agricultural purposes in four downstream irrigation operations (LCRA's Garwood, Gulf Coast and Lakeside irrigation divisions and Pierce Ranch), and to help meet environmental flow needs below the Highland Lakes. A small amount is made available for other purposes as described in Section 4.6 (Curtailment Procedures for

Interruptible Stored Water Demands Other than the Downstream Irrigation Operations).

The following table shows the demand for firm water in 2010, the projected demand in 2020 and 2030 and an interim demand level between 2010 and 2020. The projected 2030 demands are provided to show future potential growth in firm water demands. However, procedures to cut back interruptible stored water as the combined storage of lakes Travis and Buchanan decreases, known as curtailment procedures, have only been developed for demands though the year 2020 as part of this WMP revision.

WMP Annual Firm Demand Projections

	WMP	WMP Future Projections[1]		
	2010	Interim	2020	2030
Firm Demands (in acre-feet per year)				
City of Austin Municipal[2]	182,788	193,334	203,880	232,923
LCRA Power Plants	25,866	25,866	25,866	25,866
City of Austin Power Plants[2]	13,500	20,851	28,202	31,502
Other Municipal & Industrial[3]	46,452	92,252	138,052	183,843
Other (conveyance and emergency release)	20,000	20,000	20,000	20,000
Total Firm Demand	288,606	352,303	416,000	494,134
STPNOC[4] Firm Back-up	20,000	20,000	40,000	40,000
Other Major Run-of-River Diverters				
Garwood - Corpus Christi	-	-	35,000	35,000
STPNOC/LCRA[4]	102,000	102,000	102,000	102,000

Notes:
1. Future projections of water demands based on LCRA Water Supply Resource Plan & Region K.
2. By contract, ~~T~~these customers ~~contractually~~ depend on independent run-of-river water rights with back-up (firm) water supplies from LCRA. The projected numbers reflect the total of the run-of-river water rights and the amount of contracted back-up water supplies needed from LCRA.
3. Municipal and industrial includes other firm demands such as recreation and irrigation Also included is domestic use around the Highland Lakes.
4. STPNOC total diversions under run-of-river and firm back-up are limited to 102,000 acre-feet through year 2030.

Agricultural water represents the largest demand of any user category on the LCRA system and accounted for, on average, about 70 percent of the total annual water use from 2000 to 2010. The demand for agricultural water varies from year to year based on the number of acres irrigated and weather conditions.

Currently the majority of LCRA's interruptible stored water is used for agricultural purposes downstream of the Highland Lakes in the four irrigation operations: Garwood, Gulf Coast, Lakeside and Pierce Ranch. The water is primarily used for rice farming, although turf grass, row crops, hay, pasture, aquaculture and wildlife management also use interruptible stored water.

The supply used to meet agricultural demand at the four irrigation operations is made up of interruptible stored water from lakes Buchanan and Travis and water from LCRA's run-of-river water rights. To the extent that water is available under these run-of-river rights, LCRA does not have to release stored water from lakes Buchanan and Travis. However, the timing and availability of run-of-river water (whether originating above or below the lakes) is often ~~unreliable or~~ insufficient to meet all~~the~~ agricultural needs.

Forecasts by the Texas Water Development Board show that agricultural diversions by the downstream irrigation operations will decrease over time. The following table shows agricultural water diversions in 2010, the interim phase (which are the same as 2010) and projected diversions in 2020 and 2030.

Projected Annual Diversions by Irrigation Operation

Year	Irrigation Operation				
	Garwood (a-f/yr)	Lakeside (a-f/yr)	Gulf Coast (a-f/yr)	Pierce Ranch (a-f/yr)	Total (a-f/yr)
2010	92,400	139,700	178,700	27,700	438,500
Interim	92,400	139,700	178,700	27,700	438,500
2020	89,700	135,500	147,400	27,000	399,600
2030	87,100	131,300	116,100	26,200	360,700

D. WATER AVAILABILITY MODELING

LCRA developed three Water Availability Models for this WMP revision. A Water Availability Model, or WAM, is a computer model that simulates how much water is available under different or alternative management scenarios through a repeated period of hydrology~~and different management alternatives~~. The models use historic streamflow and evaporation data~~, hydrology and climatic conditions~~ to calculate the supply of available surface water.

During the last WMP revision process, LCRA used a model that simulated the operations of lakes Buchanan and Travis and major water rights downstream of the lakes using hydrologic data from 1941-1965. That model used inflows to the lakes derived from some of the first WAMs developed by the predecessor agencies of the TCEQ in the 1970s and 1980s.

For this WMP revision process, LCRA modified the most current version of TCEQ's WAM to include the most recent historic hydrologic data, including the recent intense droughts experienced in 1999-2009 period. The hydrologic period of record in the WAM used for this WMP is 1940-2009.

E. ALLOCATION OF INTERRUPTIBLE SUPPLIES

One of the fundamental aspects of the WMP is to determine when and how to cut back the available supply of interruptible stored water as needed to protect firm water demands through a

repeat of the Drought of Record. The WMP uses trigger levels that correspond with the combined storage of lakes Travis and Buchanan. The WMP uses those triggers to determine how much supply LCRA will make available to help meet:

- Agricultural (irrigation) demands in the four downstream irrigation operations;
- A range of freshwater inflow levels for Matagorda Bay;
- A range of instream flow levels for the Colorado River downstream of the Highland Lakes;
- Demands for a small category of interruptible users, other than the downstream irrigation operations.

The needs of downstream agricultural customers (mainly rice farmers) are supplied with a combination of the available run-of-river water and interruptible stored water from lakes Buchanan and Travis. The demand for such water can be particularly high during drier conditions.

The firm demands of LCRA's municipal and industrial customers are projected to grow significantly through 2020, which increases the likelihood of significant shortages of interruptible stored water. When determining available interruptible stored water supplies, it is essential that firm water demands be protected through a repeat of the Drought of Record. The curtailment procedures in this WMP are designed to ensure supply is available to meet projected firm demands through the year 2020 under a repeat of the hydrologic period of record (1940-2009) which includes a repeat of the Drought of Record and the short-term intense droughts the region has recently experienced.

This WMP revision includes a number of significant changes in procedures used to allocate interruptible stored water for agricultural use in the four downstream irrigation operations and to other customers, and in the criteria used to allocate water for the environmental needs of the Colorado River and Matagorda Bay. These changes allow LCRA to be more responsive to changes in water supply conditions. A list of key changes can be found in Section B of this executive summary and discussion of some of the key changes that deal with interruptible water follows. As with recent WMPs, evaluation of demands and the curtailment of interruptible stored water for Garwood and Pierce Ranch under this WMP revision will also be accomplished pursuant to the terms of specific agreements related to the supply of interruptible water to those operations.

Separate curtailment procedures

This WMP revision is designed to protect projected increases in firm demands through 2020 through a repeat of the Drought of Record. However, to make the WMP more adaptive to actual firm demands and demand growth, LCRA has developed two separate sets of curtailment procedures for interruptible stored water and environmental flow criteria. The first "interim" set applies immediately, and the second set will apply when certain conditions are met. By creating two sets of curtailment procedures and a mechanism for shifting between the two, this WMP allows LCRA to better align the interruptible stored water curtailment procedures with the level of firm demand~~be more adaptive~~. More interruptible stored water would be provided in the initial

years when firm demands are lower and more restrictive curtailment procedures could be implemented over time as firm demands increase.

Upon the effective date of this WMP revision, t~~T~~he interim demand phase curtailment procedures will be~~are~~ in effect for the next upcoming crop season~~immediately upon the effective date of this WMP revision~~. The LCRA Board will determine whether to shift to the second set of curtailment procedures, the 2020 curtailment procedures, after opportunity for public comment and in accordance with specific criteria. The shift to 2020 curtailment procedures would be effective for the next calendar year if the LCRA Board finds that certain defined criteria ~~(based on a combination of actual and projected demands or other factors)~~ are met. These criteria are more fully described in Section 4.2 (Process for Determining Applicable Curtailment Procedures).

Separate determination for first and second crop

Previous versions of the WMP based the decision of how much interruptible stored water was available for the four downstream irrigation operations on the Jan. 1 combined storage level of lakes Buchanan and Travis. This WMP has a separate process for determining availability of water for first and second crop. First crop availability will be based on Jan. 1 combined storage, with the possibility of increasing the supply of interruptible stored water if combined storage is higher on March 1. Second crop availability will be based on June 1 combined storage, with the possibility of increasing the supply of interruptible stored water if combined storage is higher on Aug. 1.

Annual limit on interruptible stored water

Under this WMP, the amount of interruptible stored water made available for diversions in any given year to the four downstream irrigation operations will be limited even when storage levels in lakes Buchanan and Travis are relatively high or near full. On an annual basis, no more than 273,500 acre-feet per year of interruptible stored water will be available for diversion for first and second crop during the interim demand phase, and no more than 249,000 acre-feet per year of interruptible stored water would be available for diversion during the 2020 demand phase. Water available for contracting for second crop water will be limited as necessary to stay within the annual cap.

Helping meet environmental flow needs

Under this WMP, as in past WMPs, a combination of firm and interruptible stored water is provided to help meet environmental flow needs. For this WMP, LCRA continues to commit 33,440 acre-feet per year of its firm supply from lakes Buchanan and Travis for environmental flow purposes.

This WMP has been updated to reflect the most recent studies on the environmental flow needs of the Colorado River and Matagorda Bay. The criteria include additional levels of flow targets, and changes to the seasonality. The triggers LCRA follows for providing water for

environmental flows are based on the combined storage of lakes Travis and Buchanan. In prior WMPs, the criteria were based on the Jan. 1 combined storage. In this WMP, the environmental flow criteria in place from March through June are based on the combined storage on Jan. 1, and the environmental flow criteria in place from July through the following February are based on the combined storage on June 1.

F. RIVER OPERATIONS

LCRA operates the Colorado River and the Highland Lakes as a system to efficiently manage water supply and mitigate flood damage. To accomplish this goal, LCRA uses a number of tools and practices that it regularly updates.

LCRA maintains and operates a Hydro-meteorological Data Acquisition System (Hydromet) of about 265 gauges located throughout the lower Colorado River basin. The Hydromet gauges send water levels, rainfall and other weather data to LCRA computers every 15 minutes. LCRA also receives data from 12 gauges that the USGS operates cooperatively with other agencies and shares Hydromet data with the National Weather Service West Gulf Coast River Forecast Center in Fort Worth, Texas (RFC).

LCRA develops and maintains computer systems and protocols to collect data from its reservoirs and pump stations and to communicate with major water users that operate reservoirs, pump stations and wastewater treatment plants that contribute significant amounts of return flows to the Colorado River below Mansfield Dam. Data on expected and actual storage, diversions and return flows is used to plan daily water supply operations, to coordinate pumping operations and to report on water use.

LCRA has also developed a suite of computer models to perform the following functions:

- Estimate the amount of flows entering the Colorado River;
- Evaluate the routing or timing and attenuation of flows released from the Highland Lakes to the lower Colorado River;
- Determine the necessary releases of stored water and pass-through of run-of-river flows to meet downstream demands;
- Schedule daily releases from dams; and
- Allocate releases and diversions for users to the appropriate source of supply (run-of-river or stored water) based on water rights priority.

G. GLOSSARY

To understand the Water Management Plan, it is important to know the definitions of the key legal and hydrologic terms used in this plan. The major terms are defined below and should be considered specific to LCRA's WMP.

adjudication - a court proceeding to determine all rights to the use of water on a particular stream system.

agricultural - any of the following uses or activities involving agriculture, including irrigation:

- cultivating the soil to produce crops for human food, animal feed, or planting seed or for the production of fibers;
- the practice of floriculture, viticulture, silviculture, and horticulture, including the cultivation of plants in containers or nonsoil media by a nursery grower;
- raising, feeding, or keeping animals for breeding purposes or for the production of food or fiber, leather, pelts, or other tangible products having a commercial value;
- raising or keeping equine animals;
- wildlife management;
- planting cover crops, including cover crops cultivated for transplantation, or leaving land idle for the purpose of participating in any governmental program or normal crop or livestock rotation procedure; and
- aquaculture.

attenuation - the reduction in the peak of a hydrograph, as it moves downstream, resulting in a more broad, flat hydrograph**.**

beneficial use of water - use of the amount of water that is economically necessary for a purpose authorized by law, when reasonable intelligence and reasonable diligence are used in applying the water to that purpose.

combined firm yield - the calculated firm yield of lakes Buchanan and Travis when operated as a system. See "firm yield" definition below.

curtail or cutback (water) - to reduce the amount of water supply ~~of water~~ being provided.

cutoff (water) - to discontinue, or to terminate completely, the supply of water that would otherwise be provided.

domestic water use –use of water by an individual or a household to support domestic activity. Such use may include water for drinking, washing, or culinary purposes; for irrigation of lawns, or of a family garden and/or orchard; for watering of domestic animals; and for water recreation including aquatic and wildlife enjoyment, but does not include water used to support activities for which consideration is given or received or for which the product of the activity is sold.

drawdown - the lowering of the water level in a water body by diversion, pumping, release, evaporation, or other losses.

drought - a period of below average rainfall and/or runoff that impacts streamflow and has the potential to impact water supplies.

drought contingency plan (DCP) – a plan required by the Texas Commission on Environmental Quality that outlines drought response measures to be taken in response to specific drought conditions.

Drought of Record (DOR) - the worst hydrologic drought for which streamflow records are available and is considered to be t~~T~~he period of time during recorded history when natural hydrological conditions provided the least amount of water supply.

firm water - a supply of water that is to be made available without shortage through a repeat of the Drought of Record.

firm yield - that amount of water, that the reservoir could have produced annually if it had been in place during the worst drought of record. In performing this simulation, naturalized streamflows will be modified as appropriate to account for the full exercise of upstream senior water rights is assumed as well as the passage of sufficient water to satisfy all downstream senior water rights valued at their full authorized amounts and conditions as well as the passage of flows needed to meet all applicable permit conditions relating to instream and freshwater inflow requirements.

first or main crop – refers to the first part of the irrigation season when LCRA may be providing water to the downstream irrigation operations for agricultural purposes; this part of the irrigation season normally runs from March through about July and is coincident with growing of the first or main crop of rice. During the first or main crop season, rice, row crop, turf, hay, pasture and wildlife management are types of agricultural uses that may be supplied with water.

freshwater inflow - the flows from a stream into a bay and estuary system that help support the health and productivity of that ecosystem.

gauging station - a particular site on a stream, canal or lake where systematic observations of hydrological data are obtained.

hydrograph - A graphical representation of stage, flow, velocity, or other characteristics of water at a given point with respect to time.

instream flow - an amount of streamflow in a stream or river to support aquatic life, minimize pollution, or for recreational use.

interim demands (firm) - a level of demand about half-way between year 2010 and year 2020 projected demands. These demands are not an exact average of year 2010 and 2020 demands; rather they take into account the timing in which certain demands are anticipated to occur.

interruptible stored water - a supply of stored water that is subject to interruption, including a partial curtailment or complete cutoff.

irrigation - The use of water for the irrigation of crops, trees, and pasture land, including, but not limited to, golf courses and parks, which do not receive water through a municipal distribution system.

LCRA General Manager (or General Manager) - the General Manager of the Lower Colorado River Authority or his or her designee.

pass-through - the amount of inflows into the Highland Lakes that is being passed through the lakes to meet demands of senior water right holders downstream.

ratoon crop (rice) - also known as second crop of rice. The ratoon crop is the crop of rice that re-grows from the rice plant's root system following harvest of the main or first crop of rice. The ratoon crop matures more quickly than the main crop since it is supported by an established root system.

run-of-river flows - the flow in the river that is available under law at a given point on the river at a given point in time to honor a water right with a given priority date. Rights to use run-of-river flows for beneficial uses, rights to store inflows in reservoirs, and pass-through of inflows and releases from reservoirs, are regulated by the TCEQ.

second or ratoon crop - refers to the second part of the irrigation season when LCRA may be providing water to the downstream irrigation operations for agricultural purposes; this part of the irrigation season normally runs from about August through about mid-October and is coincident with growing of the ratoon crop of rice. During this second or ratoon crop season, rice, turf, row crop, hay, pasture and wildlife management are types of agricultural uses that may be supplied with water.

storable inflows - the daily inflows to the reservoir system minus the daily pass-throughs from the reservoir system required to meet downstream senior water rights demands.

storage capacity - the quantity of water that can be contained in a reservoir.

streamflow - rate of flow of water that occurs in a natural channel.

water conservation - those practices, techniques and technologies that will: (1) reduce the consumption, loss or waste of water; (2) improve the efficiency in the use of water; or (3) increase the recycling and reuse of water, so that a water supply is made available for future or alternative uses.

water right - a legally protected right, granted by law, to impound, divert, convey, or store state water and put it to one or more beneficial uses.

Acronyms:

AF	acre-feet
B&E	bay and estuary
CFS	cubic feet per second
DCP	Drought Contingency Plan
FEMA	Federal Emergency Management Agency

GIS	Geographic Information System
LCRA	Lower Colorado River Authority
MAF	million acre-feet
MBHE	Matagorda Bay Health Evaluation
msl	mean sea level (or above mean sea level)
STPNOC	~~South Texas Project~~STP Nuclear Operating Company
TCEQ	Texas Commission on Environmental Quality
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
WAM	Water Availability Model
WMP	Water Management Plan
WTP	Water Treatment Plant

CHAPTER 1
INTRODUCTION TO THE WATER MANAGEMENT PLAN

1.1 Background 1-1
1.2 Basic Goals and Guidelines for Managing Lakes Buchanan and Travis 1-3
1.3 Texas Commission on Environmental Quality January 2010 Order 1-4
1.4 Interest Groups and Advisory Committee Process 1-4
1.4.1 Firm customers 1-5
1.4.2 Agricultural customers 1-6
1.4.3 Environmental interests 1-6
1.4.4 Lake interests 1-6

1.1 BACKGROUND

The 1988 Final Judgment and Decree[1] adjudicating the Lower Colorado River Authority's (LCRA's) Highland Lakes water rights required LCRA to submit a reservoir operations plan for lakes Buchanan and Travis. The plan must describe how LCRA will determine the amount of firm and interruptible stored water available for use from lakes Buchanan and Travis and how LCRA will manage the waters in lakes Buchanan and Travis and the Colorado River.

- Firm water is water that can be supplied from lakes Buchanan and Travis during a repeat of the worst drought in recorded history for the lower Colorado River basin, which is the drought of the 1940s and 50s. This drought is known as the Drought of Record.
- Interruptible stored water is water from lakes Buchanan and Travis that must be cut back or cut off during drought or times of shortage to ensure that LCRA can meet firm customer demands.

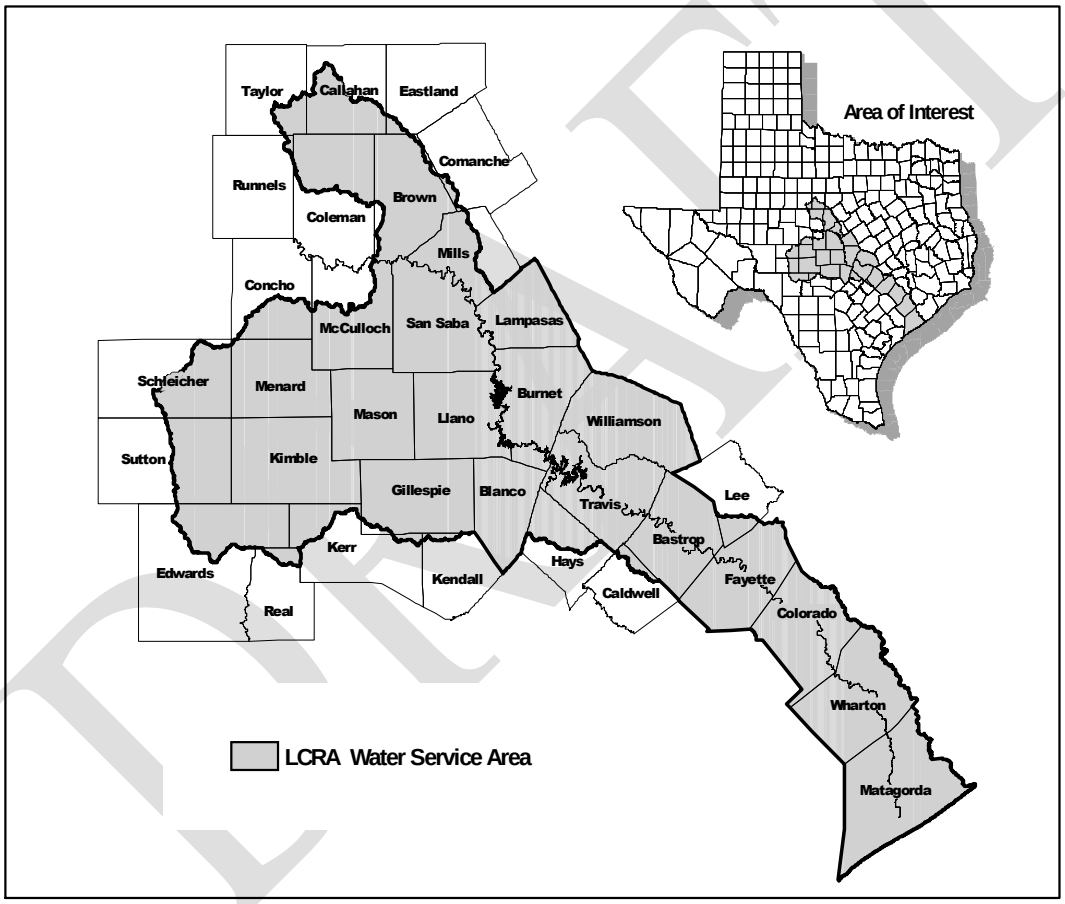
The original reservoir operations plan, referred to as the Water Management Plan (WMP), was developed by LCRA, approved by its Board of Directors, and approved by the Texas Water Commission, predecessor to the Texas Commission on Environmental Quality (TCEQ), in 1989. Since then, the WMP has been revised by LCRA and approved by the TCEQ (or its predecessors) periodically (in 1991, 1992, 1999 and 2010).

The WMP prescribes how LCRA will operate lakes Buchanan and Travis in ~~to~~ supplying water ~~to the diverse interests in~~ to LCRA's service area (*See* Figure 1-1). Specifically, it identifies the actions LCRA will take to allocate available water supplies from the two reservoirs for its firm water customers, interruptible stored water customers, and the environment during drought and nondrought periods. Potential actions outlined in the plan include adjusting stored water available for interruptible agricultural customers and for environmental flow needs. In addition, LCRA's Drought Contingency Plan for firm customers addresses how those customers, primarily municipalities and industries, must respond to drought conditions by implementing provisions of their drought contingency plans.

Lakes Buchanan and Travis are operated as a single water supply system and are designed to supply water and address needs of varied interests within LCRA's service area, including:

- LCRA's firm water customers (primarily municipal, industrial, and electric generation facilities);
- LCRA's interruptible stored water customers (four downstream irrigation operations and other small users);
- Environmental needs to help meet instream flows in the Colorado River downstream of Austin and freshwater inflows into Matagorda Bay; and
- Recreation and economic interests on the Highland Lakes.

Figure 1-1. LCRA Water Service Area as of January 1, 2012.



To that end, the WMP includes procedures for making interruptible stored water available for downstream irrigation operations and other users, procedures for releasing water to help support environmental flow needs and criteria for declaring a Drought Worse than Drought of Record. The WMP also includes a calculation of the combined firm yield, which is the amount of water that can be supplied annually from lakes Buchanan and Travis through a repeat of the Drought of Record.

Revisions to the WMP are necessary to address changing conditions, including, among others, increased demands from firm customers and updated science related to environmental flows. As the actual water demands from lakes Buchanan and Travis for municipal, industrial and other firm water users continue to increase, the amount of interruptible stored water available from the lakes for agricultural use in the downstream irrigation operations and to help meet downstream environmental flows is expected to continue to decrease. (For this revision of the WMP, the amount of firm water to help meet environmental flows is unchanged.)

1.2 BASIC GOALS AND GUIDELINES FOR MANAGING LAKES BUCHANAN AND TRAVIS

The initial WMP and various revisions have been developed using the following major goals as provided in the 1988 Final Judgment and Decree:

- Lakes Buchanan and Travis and the Colorado River will be managed together as a single system for water supply purposes;
- LCRA will manage the system to maximize the beneficial use of water derived from inflows below the Highland Lakes; and
- LCRA will manage the system to stretch and conserve the water stored in lakes Buchanan and Travis.[2]

To achieve the goals stated above, LCRA will manage the system according to the following guidelines:

1. All demands for water from the Colorado River downstream of lakes Buchanan and Travis should be satisfied to the extent possible by run-of-river flows of the Colorado River;
2. Inflows should be passed through lakes Buchanan and Travis to honor downstream senior water rights only when those rights cannot be satisfied by the flow in the Colorado River below the Highland Lakes;
3. Water should be released from storage in lakes Buchanan and Travis to satisfy downstream demands only to the extent that such demands cannot be satisfied pursuant to run-of-river water rights;
4. Firm commitments from lakes Buchanan and Travis shall not exceed the combined firm yield of lakes Buchanan and Travis;
5. Water from lakes Buchanan and Travis may be available on an interruptible basis at any time that the actual demand for stored water under firm commitments is less than the firm yield. To the extent that a demand for water may exist on an interruptible basis, such stored water should be made available;
6. The water from lakes Buchanan and Travis available on an interruptible basis should be interrupted or curtailed to the extent necessary to allow LCRA to satisfy all existing and projected demands pursuant to firm commitments; and
7. Water shall not be released through any dam solely for hydroelectric generation, except during emergency shortages of electricity and during other times that such releases will not impair LCRA's ability to satisfy all existing and projected demands

for stored water for firm and nonfirm, interruptible commitments.[3]

1.3 TEXAS COMMISSION ON ENVIRONMENTAL QUALITY JANUARY 2010 ORDER

On Jan. 27, 2010, TCEQ approved the 2010 WMP. Consistent with the order approving the revised WMP (found in Appendix C-6), LCRA began the WMP revision process in the summer of 2010. The order requires LCRA to address, at a minimum, the following issues:

1. Interruptible curtailment procedures needed to ensure that LCRA can satisfy projected firm customer demand should intense drought conditions such as those experienced over the past several decades recur;
2. An evaluation of the adequacy of the criteria for declaring a drought worse than the Drought of Record;
3. An evaluation of the minimum combined storage in lakes Buchanan and Travis necessary or appropriate to protect firm customers through a repeat of the Drought of Record or under conditions worse than the Drought of Record;
4. Incorporation of appropriate changes to reflect LCRA's agreements and obligations to ~~South Texas Project~~STP Nuclear Operating Company (STPNOC) under the Settlement Agreement and Amended and Restated Contract, including the Water Delivery Plan;
5. LCRA's agreement with the City of Austin regarding return flows, consistent with Section VIII(C)(1) of the Settlement Agreement by and between the City of Austin and the LCRA regarding Joint Water Resource Management and the Resolution of Certain Regulatory Matters Pending at the TCEQ, dated June 18, 2007; and
6. Revisions to provisions governing the manner in which LCRA provides water from lakes Buchanan and Travis to address environmental flow needs using the best available scientific information, and shall provide water for such needs to the maximum extent reasonable and practicable when considering all public interests. Such revisions shall include:
   i. A mechanism for adjusting the manner in which LCRA provides water for environmental flow needs that addresses significant improvements in storage conditions during the course of a year;
   ii. A mechanism for limiting harmful intra-daily fluctuations of instream flows to prevent significant adverse impacts from periods of low flows; and
   iii. Specification, to the maximum extent reasonable, of an overall instream flow regime.[4]

1.4 INTEREST GROUPS AND ADVISORY COMMITTEE PROCESS

LCRA has used input from an advisory committee to develop every WMP. The TCEQ 2010 WMP Order required LCRA to use a revision process designed to allow meaningful participation by interested basin stakeholder groups and achieve regional consensus, where possible. For this WMP revision, LCRA again established an advisory committee to provide input to LCRA on the WMP update. The LCRA Board provided input on the composition of the 16-member advisory committee. LCRA endeavored to create a committee to represent interests within the basin; however, no committee can fully represent all interests within the basin. The committee included

members from each of the major interests that depend on the Highland Lakes: firm customers (cities, industries, etc.), agriculture, environmental interests and lake area businesses and residents. Each advisory committee member also had an alternate to attend meetings and participate in the process in the event of the member's absence.

Over more than 12 months, LCRA hosted 20 formal advisory group meetings, (which were often all-day meetings) as well as several more informal meetings with smaller contingents of the advisory committee. Attendance was greater than 90 percent throughout the advisory committee process. There was extensive dialogue among the interests to educate one another about how and why water is important to each interest. Committee members and their alternates spent a great amount of time, energy and effort learning about and discussing key issues. Most important, the advisory committee provided LCRA staff with input on key areas. Meeting summaries were distributed to the committee, and updates were regularly provided to the LCRA Board and members of the public. Throughout the process, LCRA staff worked hard to provide the committee with the best available information on the issues as members worked toward consensus. From the beginning of the process, consensus was defined ~~by the committee~~ as:

> "All agree that their major interests have been considered and factored in a manner that they can generally support even if all their interests have not been fully satisfied."

The committee spent several months ~~towards the end of the 12-month process~~ addressing key issues such as the availability of interruptible water for irrigated agriculture and associated curtailment triggers and procedures. Much time was spent evaluating many computer simulations to get an understanding of how various changes in curtailment triggers and procedures would change key results or affect their interests.

The advisory committee was able to reach full consensus from all members on all items for which the staff sought consensus except for one. For that one item, the curtailment triggers and procedures for meeting the 2020 level of demands, the representative from the Gulf Coast Irrigation Operation was not able to agree with the rest of the group. Additionally, the lake interests requested that their position on consensus be registered as "qualified."

Following the initial 12-month process, LCRA staff continued to work with the advisory committee on two potential exceptions to the standard curtailment procedures identified in the plan, one for extremely dry conditions, and one for wetter than normal conditions. The committee was able to reach a qualified consensus on these two items.

Throughout the process, the advisory committee thus provided key input as LCRA developed the recommended changes reflected in this WMP revision. LCRA wishes to thank the committee members for their input and for their many hours spent working together to help shape many of the provisions in this update to the WMP.

1.4.1 Firm customers

Firm customers were represented by the following entities:

(Committee members are listed first, followed by their alternates)

- City of Austin: Greg Meszaros and Teresa Lutes;
- City of Burnet: David Vaughn and Crista Bromley;
- Lakeway Municipal Utility District: Earl Foster and George Russell (City of Marble Falls);
- Horseshoe Bay Resort: Ken Gorzycki and Roger Goettsch (Barton Creek Resort and Club);
- ~~South Texas Project~~STP Nuclear Operating Company: Rick Gangluff and Sandra Dannhardt.

1.4.2 Agricultural customers

Agricultural customers were represented by the following irrigation entities:

- Garwood Irrigation Division: Ralph Savino and Jeff Dugie;
- Gulf Coast Irrigation Division: Haskell Simon and GW Franzen;
- Lakeside Irrigation Division: Robby Cook and Ronald Gertson;
- Pierce Ranch: Laurance Armour and Joe Mike Crain.

1.4.3 Environmental interests

Environmental interests were represented by the following entities:

- National Wildlife Federation: Myron Hess and Steve Box (Environmental Stewardship);
- Sierra Club: Jennifer Walker and Ken Kramer;
- Texas Parks and Wildlife Department: Cindy Loeffler and David Bradsby.

1.4.4 Lake interests

Lake interests were represented by the following businesses and communities:

- Lake Buchanan residential: Jo Karr Tedder and Rick Albers;
- Lake Buchanan business: Rusty Brandon and John Williams;
- Lake Travis residential: Kerry Spradley and Dorothy Taylor;
- Lake Travis business: Janet Caylor and Tom Harrison.

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1. Cause No. 115,414 A-1, 264th Judicial District In Re: The Exceptions of the Lower Colorado River Authority and the City of Austin to the Adjudication of Water Rights in the Lower Colorado River Segment of the Colorado River Basin
2. Cause No. 115,414-A-1. Finding 26.
3. Id.
4. Agreed Order Approving Amendments to Lower Colorado River Authority's Water Management Plan, Texas Commission on Environmental Quality, Ordering Provision 1.f.,

Issued Jan. 27, 2010.

CHAPTER 2
DEMANDS

2.1 Background 2-1
2.2 Firm Water Demands 2-2
2.3 Agricultural Demands in the Downstream Irrigation Operations 2-4
2.4 Environmental Needs for Instream Flows and Bay and Estuary Inflows 2-8
2.4.1 Instream Flows 2-8
2.4.2 Bay and Estuary 2-10
2.5. Hydroelectric Power Generation 2-11
2.6. Lake/River Recreation and Economic Interests 2-12
2.7 Water Quality 2-13
2.8 Flood Control 2-13

2.1 BACKGROUND

Demands on the Highland Lakes and the lower Colorado River system are many, varied and often competing. Cities, communities, industrial facilities and farmers throughout the lower Colorado River basin depend on water from the Highland Lakes and Colorado River. In addition, hydroelectric facilities, lake area businesses, commercial fisheries along the coast, recreation-related businesses along the river and Matagorda Bay, recreation interests for the upper river area and lakes all the way to the coast, and the environment rely on the water. These demands are dynamic and will continue to evolve as the region's population grows and other factors change. This could include changes in agricultural programs, implementation of new water supply strategies, improvements in conservation, and new scientific studies that enhance our understanding of the environment's water needs.

LCRA's reservoir system (lakes Buchanan and Travis) is designed to store water from rainfall runoff and make that water available for various purposes. Water is released from the reservoirs for a number of reasons, including customer use, flood control, hydroelectric power generation and environmental needs. Customers divert water directly from the reservoirs or from the river downstream of the reservoirs. The reservoir levels decline when inflows are insufficient to replenish water released, diverted or lost to evaporation, and increase when inflows exceed releases, diversions and evaporative losses. This system enables LCRA to serve its customers and the environment through wet and dry periods.

LCRA supplies two general categories of water from lakes Buchanan and Travis: firm and interruptible.

- Firm water is available through a repeat of the conditions experienced in the Drought of Record. Cities and industry, including power plants, are the primary users of firm water, but other customers also use firm water. These include some agricultural customers, golf courses, domestic, recreation and other users. Firm water may also be used to provide supplemental water for the environmental needs of the Colorado River and Matagorda Bay. The firm demands used in the WMP are based on the LCRA Water Supply

Resource Plan[1] (WSRP) approved by the LCRA Board of Directors in October 2010 and are described in detail in Section 2.2.1. That plan includes demand projections through year 2100. The WMP however is only designed to meet demands up to year 2020 projections.

- Interruptible water may be curtailed (cut back) or cut off in drought. Currently, interruptible water from lakes Buchanan and Travis (interruptible stored water) is used almost entirely for agricultural purposes in the downstream irrigation operations (LCRA's Garwood, Gulf Coast and Lakeside irrigation divisions, and Pierce Ranch), and to help meet environmental flow needs below the Highland Lakes. A small amount is made available for other purposes as described in Chapter 4.

2.2 FIRM WATER

2.2.1 Demands

Firm water demands primarily consist of municipal and industrial demands that are to be met without shortage through a repeat of the Drought of Record. A small portion of firm water is also used for irrigation, mining, domestic and recreational purposes, and LCRA has set aside a portion of its firm supply to help meet environmental flow needs.

Municipal use includes water used by cities, municipalities, water districts, commercial establishments, industries and institutions to the extent that such uses are included in the definition of municipal use in the rules of the Texas Commission on Environmental Quality (TCEQ).

For the purposes of the WMP, the demands of individual households that pump water directly from the lakes (domestic use) were included with municipal demands. As of January 2012, LCRA has issued a significant number of firm water contracts for domestic use. However, many of these diverters still do not have contracts with LCRA. Absent a contract, most if not all of these diverters have no legal claim to the water they are diverting. At some point, LCRA may pursue enforcement of its water rights to curtail these unauthorized diversions. Although contracts do not exist for all of the domestic water use, LCRA has included existing and projected domestic water use in the demands for this WMP revision as it did in the 2010 WMP.

Industrial demands include water for manufacturing, construction and cooling for electric generation by means other than hydrogeneration. Most of the lower Colorado's industrial users today are located downstream of the Highland Lakes.

The WSRP demand projections were based on work by the Texas Water Development Board and the Lower Colorado Regional Water Planning Group (Region K). Where appropriate, the demands were updated based on more recent growth trends and discussions with local municipal and industrial entities. Specific assumptions related to firm water demand projections were:

1. Demands for municipal, industrial, electric power production and other needs were calculated based on the amount of water that would be needed during the Drought of Record to ensure that ample supplies would be available during a similar drought;
2. Communities and utilities that rely on groundwater, and areas where Region K projections indicate sufficient groundwater will be available through the planning period, would not require water from LCRA;
3. Water availability analyses included conservation and reuse for the City of Austin, consistent with Region K and the provisions of the 2007 Settlement Agreement between LCRA and the City of Austin;
4. Demands include the water to be provided by contract (up to 25,000 acre-feet per year) to Williamson County under the provisions of House Bill 1437;
5. Municipal demands were developed using substantiated, revised population estimates based on recent growth patterns to estimate future growth;
6. Municipal demands for each decade were calculated based on population projections using the same per capita water use approach used in the 2006 Region K plan;
7. New and pending contracts for municipal demand were included;
8. Projected demands for domestic use on the Highland Lakes was added;
9. Region K industrial demand, and new and pending contracts for industrial use were included;
10. Conveyance losses from the point of release of water from the Highland Lakes to the point of delivery for existing contracts were added; and
11. Other demands such as emergency hydro-generation were included.

The projected 2020 firm demands used in the WMP are summarized in Table 2-1. The projected 2030 demands are also provided to show future potential growth in firm water demands. However, procedures to cut back interruptible stored water as the combined storage of lakes Travis and Buchanan decreases, known as curtailment procedures, have not been developed for the 2030 demands as part of this WMP revision.

Interim firm demands representing an intermediate scenario roughly halfway between year 2010 and 2020 were developed for the WMP to make the plan more adaptive. Using an interim step, rather than shifting from a year 2010 to a year 2020 demand scenario in a single step, allows additional interruptible stored water to be made available in the near term before the year 2020 firm demands begin to materialize. The interim and year 2020 demands were used to develop the interim and year 2020 curtailment procedures for interruptible stored water presented in Chapter 4. A mechanism to shift from the interim to year 2020 curtailment procedures is also presented in Chapter 4.

2.2.2 Board reservation

Out of concern for the future needs of the many areas in LCRA's 35-county water service area, including areas now using ground water supplies that are becoming depleted or are of poor water quality, the LCRA Board has reserved 50,000 acre-feet of the combined firm yield.

Table 2-1. – WMP Firm Demand Projections

	WMP	WMP Future Projections[1]		
	2010	Interim	2020	2030
Firm Demands (in acre-feet per year)				
City of Austin Municipal[2]	182,788	193,334	203,880	232,923
LCRA Power Plants	25,866	25,866	25,866	25,866
City of Austin Power Plants[2]	13,500	20,851	28,202	31,502
Other Municipal & Industrial[3]	46,452	92,252	138,052	183,843
Other (conveyance and emergency release)	20,000	20,000	20,000	20,000
Total Firm Demand	288,606	352,303	416,000	494,134
STPNOC[4] Firm Back-up	20,000	20,000	40,000	40,000
Other Major Run-of-River Diverters				
Garwood - Corpus Christi	-	-	35,000	35,000
STPNOC/LCRA[4]	102,000	102,000	102,000	102,000

Notes:
1. Future projections of water demands based on LCRA Water Supply Resource Plan & Region K.
2. By contract, ~~T~~these customers ~~contractually~~ depend on independent run-of-river water rights with back-up (firm) water supplies from LCRA. The projected numbers reflect the total of the run-of-river water rights and the amount of contracted back-up water supplies needed from LCRA.
3. Municipal includes other firm demands such as recreation and irrigation. Also included is domestic use around the Highland Lakes.
4. STPNOC total diversions under run of river and firm back-up are limited to 102,000 acre-feet through year 2030.

2.3 AGRICULTURAL DEMANDS IN THE DOWNSTREAM IRRIGATION OPERATIONS

The waters of the Colorado River have served the agricultural and rice farming industry of the Texas Gulf Coast counties of Colorado, Wharton and Matagorda since 1885 when the first rice crops were planted near Eagle Lake, Texas. When legislation creating LCRA was first proposed in the Texas Legislature in 1933, promises were given to the rice producers and other farmers that the waters stored behind the dams proposed for the LCRA system would be available to help serve their needs when the natural flow of the river diminished in dry years. In the late 1930's, LCRA entered into contracts with some of these downstream irrigation operations to provide a limited amount of supplemental water based upon the water rights owned by the then-private irrigation operations. Since that time, LCRA has acquired the water rights associated with the downstream irrigation operations, as well as the operations themselves at Garwood, Gulf Coast and Lakeside. When LCRA purchased these operations, LCRA made certain commitments to the farmers to provide water from lakes Buchanan and Travis as back-up to the run-of-river rights. LCRA continues to make interruptible stored water available for downstream agricultural interests from lakes Buchanan and Travis. The producers understand the interruptible concept

because, in essence, the water supply was always interruptible. The Water Management Plan is the mechanism whereby this water is made available, but is also subject to curtailment or complete cutoff.

Rice is the major crop irrigated in the most downstream three counties in the LCRA Service Area. While some rice producers in the region irrigate their crops with groundwater, the major source of water for irrigation is from the waters of the Colorado River, either under run-of-river water rights, or from releases of interruptible stored water from lakes Buchanan and Travis.

Currently the majority of LCRA's interruptible stored water is used for agricultural purposes downstream of the Highland Lakes in four irrigation operations: Garwood, Gulf Coast, Lakeside and Pierce Ranch. The water is primarily used for rice farming, although turf grass, row crops, hay, pasture, aquaculture and wildlife management also use interruptible stored water within these operations.[2]

Agricultural use represents the largest demand of any user category on the lower Colorado River system and accounted for, on average, about 70 percent of LCRA's total annual water use from 2000 to 2010. The demand for agricultural water varies from year to year based on the number of acres irrigated and weather conditions. From 2000 to 2010, agricultural diversions at the four irrigation operations ranged from a maximum of about 442,000 acre-feet in 2009 to a minimum of 199,000 acre-feet in 2007.

The supply used to meet agricultural demands at the four irrigation operations is made up of interruptible stored water from lakes Buchanan and Travis and LCRA's run-of-river water rights.[3] To the extent that water is available under these run-of-river rights, LCRA does not have to release water from storage. However, the timing and availability of r~~R~~un-of-river water (whether originating above or below the Highland Lakes) is often ~~unreliable or~~ insufficient to meet ~~the~~ all agricultural needs.[4] ~~However~~On the other hand, in some wet years, little to no stored water is needed to meet agricultural demands. On average, from 2000 to 2010, run-of-river rights provided about 64% of the water for agricultural use and stored water provided about 36% of the supply. Over this same period, the amount of stored water diverted for use in the four irrigation operations ranged from about 301,000 acre-feet in 2009 to zero acre-feet in 2007.

The Texas Water Development Board (TWDB) forecasts that agricultural diversions by the downstream irrigation operations will decrease over time. ~~(TWDB 2001[5], and 2006[6]).~~ The 2010 Water Management Plan similarly forecast future reductions in demand. For this WMP revision, the projected agricultural demands were based on the Lower Colorado Regional Planning Group's (Region K) 2006 Regional Water Plan ~~(TWDB, 2006)~~. However, recent water use exceeded the Regional Water Plan's projection ~~in~~ for 2010, particularly in the Gulf Coast operation. The agricultural demands shown in Table 2-2 reflect the Regional Water Plan's forecasted irrigation demands with adjustments for the Gulf Coast operation based on recent water use. The adjusted projected year 2010 diversions were used to develop the interim curtailment procedures and the projected year 2020 diversions were used to develop the 2020 curtailment procedures.

Table 2-2 represents demands that are expected to be exceeded only 10 percent of the time for

the period of historic record and therefore represent irrigation demands during drought conditions. The period of historic record used for development of this WMP was 1940-2009. There was significant weather variability during this period, which resulted in variability in agricultural demands. For example, see Figure 2-1 which illustrates the irrigation water demand variability since 1989 based upon the annual LCRA Water Use Reports. Thus, as has been done in previous revisions to the WMP, weather-varied water demands have been used for model simulations. See Appendix A, Technical Paper A-2 for a more detailed description of how these weather-varied water demands for agriculture were determined.

A unique aspect of agricultural water use in the lower Colorado River basin is that agricultural demands are not necessarily the same as the amount of water needed to be released from the lakes. Water from the lakes is ordered five to seven days before it is needed downstream because of travel time. Thus, if there is significant rainfall below the Highland Lakes between the time the water is released from the lakes and the time it arrives at the irrigation operations' diversion points, some or all of the water would no longer be needed by the irrigation operations. Historically, the amount of interruptible stored water released has generally exceeded the amount diverted by the irrigation operations. To more accurately simulate releases to meet the downstream diversions, factors were developed based on actual orders and diversions for the irrigation seasons of 2001 through 2010. The monthly factors representing the amount of water ordered divided by the amount of water diverted by irrigation operation are shown in Table 2-3.

In some instances, undiverted orders become a potential source of water for downstream users such as the ~~South Texas Project~~STP Nuclear Operating Company, instream flows and freshwater flows to Matagorda Bay. As seen in Table 2-3, the Gulf Coast operation has historically been the most efficient at diverting its orders, which is likely due to the presence of the Lane City and Bay City dams. Similarly, Garwood also has a small pumping pool and is nearly as efficient. Neither Lakeside nor Pierce Ranch have pumping pools on the river, which likely influences their higher proportion of orders not being diverted.

Table 2-2. Projected Diversions by Irrigation Operation

Year	Irrigation Operation				
	Garwood (a-f/yr)	Lakeside (a-f/yr)	Gulf Coast (a-f/yr)	Pierce Ranch (a-f/yr)	Total (a-f/yr)
2010	92,400	139,700	178,700*	27,700	438,500
Interim	92,400	139,700	178,700*	27,700	438,500
2020	89,700	135,500	147,400*	27,000	399,600
2030	87,100	131,300	116,100	26,200	360,700
Notes: *Adjusted upward from WSRP and TWDB projections to the 2008 and 2009 average use					

Figure 2-1. ~~–~~Historic Water ~~Use~~ Diversions by the~~in~~ Four Downstream Irrigation Operations

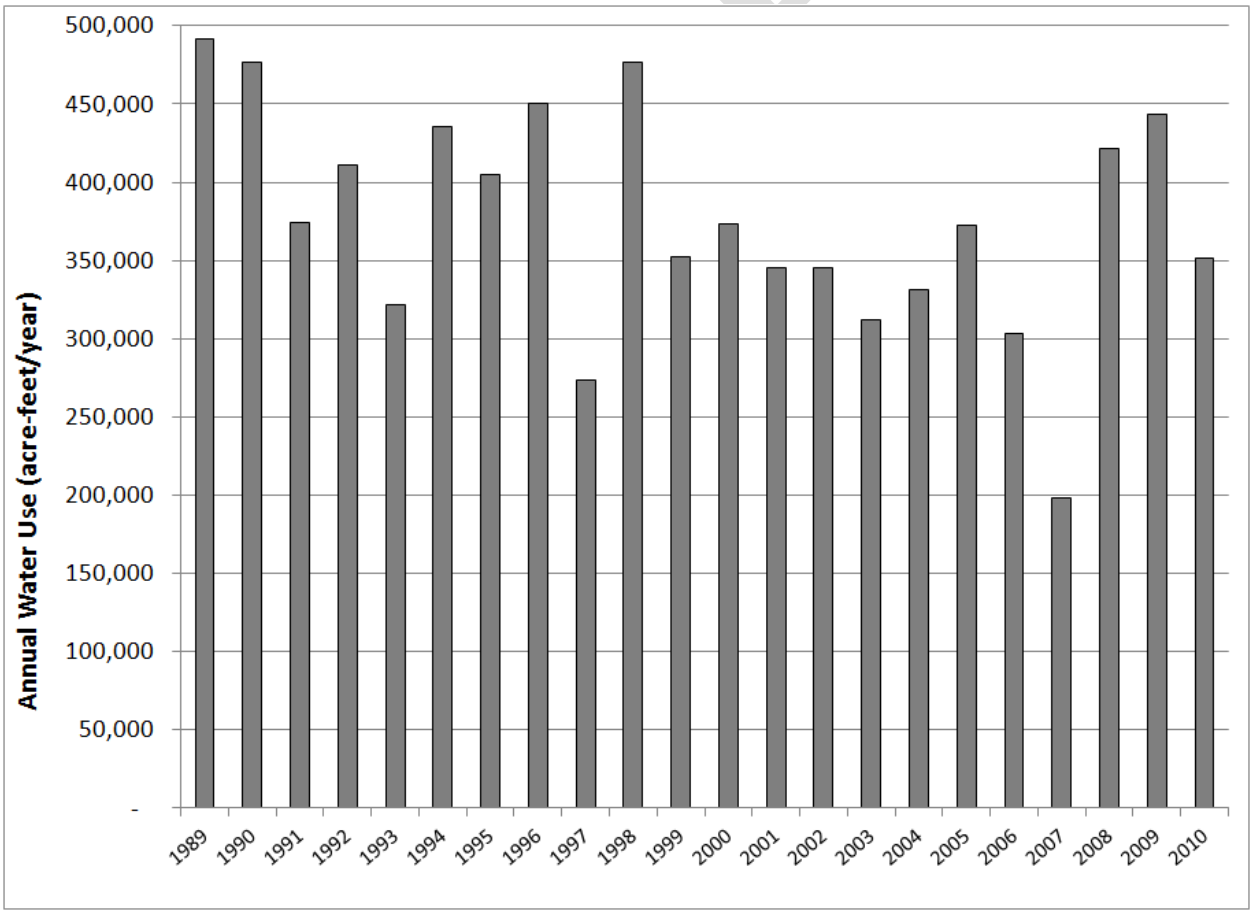


Table 2-3. Orders over Diversion Factors used in Water Availability Models

Month	Average Factor by Irrigation Operation			
	Garwood	Lakeside	Pierce	Gulf Coast
March	1.20	3.63	1.38	1.17
April	2.06	3.42	1.91	1.53
May	1.28	1.23	1.32	1.06
June	1.26	1.38	1.38	1.11
July	1.75	1.93	2.60	1.39
Aug	1.24	1.46	1.32	1.10
Sept	1.43	1.88	1.71	1.33
October	1.62	1.78	2.39	1.18
Annual	1.35	1.46	1.75	1.23

2.4 ENVIRONMENTAL NEEDS FOR INSTREAM FLOWS AND BAY AND ESTUARY INFLOWS

The waters of the lower Colorado River basin help support a diverse and healthy aquatic habitat along the Colorado River downstream of Austin and in Matagorda Bay. Under the WMP, water is made available to help meet varying environmental flow levels based upon the combined storage in lakes Buchanan and Travis consistent with the 2010 TCEQ Order. The environmental flow needs are described in the following subsections.

2.4.1 Instream flows

The aquatic environment of the lower Colorado River downstream of Austin can be affected by the quality, quantity and timing of water flowing through the ecosystem. Streamflow is a key variable that influences riverine habitat, biology, geomorphology and water quality. A range of flow conditions is necessary to maintain healthy ecosystems.

A comprehensive instream flow study was completed in 2008 that investigated the flow relationships to aquatic habitat and the state-threatened blue sucker fish.[7] The study approach was consistent with the Texas Instream Flow Program methodology designed to support "a sound ecological environment," which is described as "…a functioning ecosystem characterized by intact, natural processes, resilience, and a balanced, integrated, and adaptive community of organisms comparable to that of the natural habitat of the region." The study collected extensive biological and physical data to develop hydraulic, habitat, water quality and sediment transport models. These models were used to support the development of the subsistence and base flow recommendations.[8]

- The subsistence flow recommendations represent minimum conditions at which water quality is maintained at acceptable levels and aquatic habitats are expected to be consistent with those found in natural settings during drought conditions. The study

recommendations provide a goal of maintaining flows at or above subsistence levels all the time. Dissolved oxygen is expected to be maintained at 5.0 mg/L, or above, at all sites. This level of dissolved oxygen supports a healthy aquatic community. Special consideration for the state-threatened blue sucker is reflected in the February and March recommendations for instream flows at the Bastrop and Columbus guages. Subsistence recommendations for these months and these sites were adjusted to help ensure that 90 percent of the spawning habitat is maintained during these key spawning times.

- The base flow recommendations provide habitat conditions and year-to-year variability sufficient to maintain a sound ecological environment. Although the study recommendations acknowledge that the frequency of achievement may need to be adjusted to reflect various considerations, those study recommendations call for achieving compliance, on a long-term basis, with Base-Dry recommendations about 80% of the time and with Base-Average recommendations about 60% of the time. A comprehensive evaluation of the habitat model results, duration curves, exceedance tables, and water quality and sediment transport modeling led to the development of two base flow recommendations called Base-Dry and Base-Average. These recommendations are designed to provide the variability in habitat type, amount and distribution needed to support a sound ecological environment.

Subsistence and base flow recommendations for each month are presented in Table 2-4.

Table 2-4. Subsistence and Base Flow Recommendations by Gauge (cubic feet per second)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Austin												
Subsistence	50	50	50	50	50	50	50	50	50	50	50	50
Bastrop												
Subsistence	208	274	274	184	275	202	137	123	123	127	180	186
Base-Dry	313	317	274	287	579	418	347	194	236	245	283	311
Base-Average	433	497	497	635	824	733	610	381	423	433	424	450
Columbus												
Subsistence	340	375	375	299	425	534	342	190	279	190	202	301
Base-Dry	487	590	525	554	966	967	570	310	405	356	480	464
Base-Average	828	895	1,020	977	1,316	1,440	895	516	610	741	755	737
Wharton												
Subsistence	315	303	204	270	304	371	212	107	188	147	173	202
Base-Dry	492	597	531	561	985	984	577	314	410	360	486	470
Base-Average	838	906	1,036	1,011	1,397	1,512	906	522	617	749	764	746

2.4.2 Bay and estuary

The Colorado River along with other area rivers and streams provide freshwater inflows into the Matagorda Bay system. In the early 1990s, the Colorado River was re-routed to increase the freshwater inflows into West Matagorda Bay and now contributes approximately 40 percent of the total inflow on an average annual basis. The Matagorda Bay system is the second largest estuary on the Texas Gulf Coast. The abundant production of finfish and shellfish make this environmentally sensitive area an important ecological resource and a source of economically significant commercial and sport fisheries. Many factors, including freshwater inflows, contribute to this high natural productivity. The seasonality of these flows is also important to the health and productivity of the bay.

The Matagorda Bay Health Evaluation (MBHE) used the latest data and science to assess the relationship between various factors and bay conditions.[9] Several measures of bay health were investigated, including salinity, habitat condition, species abundance, nutrient supply and benthic condition. The computer models and data analysis in the study were used to develop inflow criteria for the Colorado River. Salinity, habitat and benthic modeling were used to develop criteria for most levels, but additional measures of bay health were used wherever possible.

The recommended Colorado River inflows ~~criteria~~ from the MBHE study were designed to cover the full range of inflow conditions into Matagorda Bay, with a regime that incorporates five levels of inflow, each with an associated desired achievement guideline. The lowest level, "Threshold," is a fixed monthly value to provide refuge conditions that would ideally be achieved 100% of the time. The remaining levels, MBHE-1 through MBHE-4, represent different inflow targets that were recommended to be achieved with the following frequencies: MBHE- 1, 90%; MBHE- 2, 75%; MBHE- 3, 60%; and MBHE- 4, 35%. ~~Under this WMP revision, that LCRA would seek to meet the various levels, depending on the combined storage of lakes Travis and Buchanan.~~ The levels all include seasonal variability and incorporate influxes of fresh water into the Bay in the spring and fall that reflect the natural pattern of inflows into the bay. The MBHE freshwater inflow categories and descriptions are summarized in Table 2-5. The inflow values associated with these inflow ~~criteria~~ levels are presented in Table 2-6.

Table 2-5. Summary of Matagorda Bay Health Evaluation Inflow ~~Criteria~~Levels

Inflow ~~Criteria~~ Level	Descriptions
Threshold	Refuge conditions for all species and habitat
MBHE 1	Maintain tolerable oyster reef health, benthic character, and habitat conditions
MBHE 2	Provide inflow variability and sustain oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat
MBHE 3	Provide inflow variability and support quality oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat
MBHE 4	Provide inflow variability and support high levels of primary productivity, and high quality oyster reef health, benthic condition, low estuarine marsh, and shellfish and forage fish habitat

Table 2-6. Matagorda Bay Health Inflow ~~Criteria~~ Values (acre-feet)

Inflow Category	Spring (3 month total)	Fall (3 month total)	Intervening (6 month total)	Monthly
Threshold	-	-	-	15,000
MBHE 1	114,000	81,000	105,000	-
MBHE 2	168,700	119,900	155,400	-
MBHE 3	246,200	175,000	226,800	-
MBHE 4	433,200	307,800	399,000	-

For purposes of this WMP revision, "Operational Criteria" have been developed to help meet the range of freshwater inflow needs associated with the MBHE levels 1 through 4. To help meet MBHE ~~criteria~~inflow levels, the MBHE three-month "spring" and "fall" and six-month "intervening" flow totals for a given inflow category are converted into equivalent two-month Operational Criteria as shown in Table 2-7. These running two-month values are applied in seasonal periods representing spring, fall and intervening. For example, the MBHE-1 spring three-month total of 114,000 acre-feet is converted into a two-month Operational Criteria of 76,000 acre-feet that would apply for the two-month periods ending in March, April, May and June. The MBHE fall three-month inflow value is used to define a two-month Operational Criteria that applies in the two-month periods ending in the months of July through October. Similarly, the MBHE intervening six-month inflow total is converted to a two-month Operational Criteria that applies in the two-month periods ending in November through February. The monthly Threshold bay inflow need applies in every month, regardless of the season or inflow level sought to be achieved.

Table 2-7. Operational Criteria for Matagorda Bay Inflows

Inflow Category	Two-Month Operational Criteria applicable in the individual months (acre-feet)		
	Spring March-June	Fall July-Oct	Intervening Nov-Feb
OP-1	76,000	54,000	35,000
OP-2	112,000	80,000	52,000
OP-3	164,000	117,000	76,000
OP-4	289,000	205,000	133,000

2.5. HYDROELECTRIC POWER GENERATION

Hydroelectric power plants are located at each of the dams owned and operated by LCRA and total approximately 291 megawatts of capacity. Until the 1960s, the hydroelectric plants represented LCRA's total capability for generating electric energy. The Final Judgment and Decree of LCRA's water rights recognized the competing needs for the stored water in the reservoirs. As a result, hydropower has been subordinated, except in emergencies, to be a by-product of the release of water for other purposes or when hydropower generation will not impair

LCRA's ability to satisfy all stored water demands. To the maximum extent possible, releases of water are made in a manner to take maximum advantage of the energy produced by those releases. LCRA retains the right to make releases solely for hydropower production in times of emergencies as part of the WMP operating policies. Such emergencies may include, among other things: a) LCRA receives direction from the Electric Reliability Council of Texas (ERCOT), Independent System Operator, or other regulatory authority to generate, and no exception to the order exists under ERCOT protocols; b) there is the existence of a threat to LCRA's generation and/or transmission systems that may result in the potential need to cutoff firm electric customers; c) when LCRA is not curtailing availability of interruptible supply to the four downstream irrigation operations and LCRA cannot internally meet its own power requirements with available generation or by starting up another LCRA unit; and d) LCRA providing responsive reserve service and nonspinning reserve service, which, if called upon by ERCOT or other regulatory authority, may result in releases of water.

2.6. LAKE/RIVER RECREATION AND ECONOMIC INTERESTS

In many areas, recreational uses of the river and lakes are steadily increasing. The entire lower Colorado River basin, from Lake Buchanan to Lady Bird Lake, and the river downstream to Matagorda Bay and the Gulf of Mexico, receives a great deal of recreational use from fishermen, boaters, park visitors and swimmers from all over Texas. Furthermore, significant economies have developed around these areas, particularly around the Highland Lakes.

Because the reservoirs were built for flood management and water supply and not constructed to maximize recreational use, the demands for higher lake levels can be difficult to accommodate. Similarly, providing a river recreation flow below Austin would also impact the available water supply.

Low lake levels can have an adverse impact on the regional economy surrounding lakes Buchanan and Travis. Economic hardship on the owners of the many marinas, small recreation businesses (bait stores, fishing camps, restaurants, campgrounds), and larger businesses, such as motels, could last much longer than the drought conditions. Many of the marinas on Lake Travis have the ability to move boat docks further out into deeper water and are willing to bear the added operational costs of such moves to stay in business. On Lake Buchanan, the shallow nature of the shoreline allows little flexibility in moving docks and other facilities. Lake area Chambers of Commerce, residents, and representatives of the tourism industry are also concerned about the elevation of the lakes area during low water periods even when a true drought is not in affect.

In prior WMPs, in recognition of the economy around the Highland Lakes, LCRA limited the sales of interruptible stored water other than for the four irrigation operations. Under this WMP, the supply of interruptible water outside of the four downstream irrigation operations will be further limited as discussed in Chapter 4. This limitation is in addition to the changes to the curtailment procedures for the downstream irrigation operations and environmental flows.

2.7 WATER QUALITY

Protecting water quality in the Highland Lakes and the Colorado River is an important part of LCRA's mission. The primary threats to water quality are discharges from industry and wastewater treatment plants (point source pollution), stormwater runoff that carries pollutants and contaminants (nonpoint source pollution), soil erosion, reservoir sedimentation and dissolved oxygen problems.

While the WMP is designed to manage lakes Buchanan and Travis to provide firm and interruptible water supply and help meet environmental needs, the instream flow recommendations also provide for water quality protection as discussed in Section 2.4.1 of this Chapter. Currently, there are a several LCRA programs in place to protect and enhance river and lake water quality. These programs include:

- *On-site Sewage Facilities Program*: LCRA is authorized by the state of Texas to inspect and license septic tanks near the Highland Lakes. http://www.lcra.org/water/quality/oss/index.html

- *Watershed Ordinance*: LCRA manages stormwater runoff from existing and new development around the Highland Lakes by applying and enforcing the Highland Lakes Watershed Ordinance. http://www.lcra.org/water/quality/watershed/index.html

- *Colorado River Watch Network*: Program that supports citizens who volunteer to monitor water quality throughout the lower Colorado River basin. http://www.lcra.org/water/quality/crwn/index.html

- *Texas Clean Rivers Program*: State funded partnership of river authorities and other agencies that monitor and assess water quality issues. http://www.lcra.org/water/quality/crp/index.html

- *Application Review and Response Program*: LCRA reviews and can respond to permits issued by other agencies that may affect water quality in the lower river basin. http://www.lcra.org/water/quality/protectingwaterqualitypage.html

- *Water Quality Models*: To help manage the basin more effectively, LCRA has developed water quality models for the Highland Lakes. http://www.lcra.org/water/quality/models.html

2.8 FLOOD CONTROL

In addition to managing the Highland Lakes for water supply, LCRA also operates the lakes for flood control purposes. Lake Travis has dedicated flood control storage above elevation 681 feet mean sea level (msl). When water is in the flood storage pool, LCRA operates Mansfield Dam in accordance with U.S. Army Corps of Engineers criteria as discussed further in Chapter 5.

1. LCRA, Water Supply Resource Plan, and supporting spreadsheets, October 2010.
2. Parsons, Future Irrigation Water Diversions, 2010-2090, Final Report Prepared for LCRA and SAWS, Sept. 1, 2006.
3. LCRA, An Update to Irrigation Water Use Predictions For the Four Agricultural Water Operations in the Lower Colorado River Service Area, June 14, 2010.
4. LCRA, Water Supply Strategies For Agriculture, June 2011.
5. Texas Water Development Board and Lower Colorado Regional Planning Group, 2001 Adopted Regional Water Plan, December, 2000.
6. Texas Water Development Board and Lower Colorado Regional Planning Group, 2006 Adopted Regional Water Plan, January 2006.
7. Colorado River Flow Relationships to Aquatic Habitat and State Threatened Species: Blue Sucker, BIO-WEST, Inc., 2008.
8. Texas Instream Flow Program Studies, Technical Overview Report 369.
9. Matagorda Bay Health Evaluation Study, Final Report Prepared for LCRA and SAWS, 2008.

CHAPTER 3
WATER AVAILABILITY MODELING

3.1 Background 3-1
3.2 WAM Versions Used in the Water Management Plan 3-1
3.3 Interim and 2020 WMP Models 3-4
3.4 Firm Yield Computation 3-4
3.5 Calibration Summary 3-5

3.1 BACKGROUND

During the last Water Management Plan (WMP) revision process, LCRA's RESPONSE Model for the lower Colorado River basin was used to evaluate different alternatives for managing lakes Buchanan and Travis. The RESPONSE model simulated the operations of lakes Buchanan and Travis and major water rights downstream of the Highland Lakes for the period 1941-1965. The model used inflows to the Highland Lakes derived from some of the first water availability models developed by the predecessor agencies of the Texas Commission on Environmental Quality (TCEQ) in the 1970s and 1980s.

Texas Senate Bill 1 (75th Legislature in 1997) brought about the creation of new water availability models (WAMs) for all river basins in Texas. As part of this process, the WAM for the Colorado River Basin (Colorado WAM) was completed in 2001 and included inflows for the historical hydrologic period of record from 1940-1998, over twice as many years as the RESPONSE model.

Since the Colorado WAM was completed, it has been consistently updated and improved by TCEQ and others and is used on a ~~day-to-day~~regular basis by the TCEQ to evaluate water rights permit applications. It is also used by the Texas Water Development Board (TWDB) for regional water planning purposes. For this WMP revision process, LCRA modified the most current version of TCEQ's WAM to include the recent intense droughts experienced in the 1999-2009 period. Thus, the hydrologic period of record in the WAM used for the WMP (WMP WAM) is 1940-2009.

3.2 WAM VERSIONS USED IN THE WATER MANAGEMENT PLAN

As part of the WMP update process, LCRA developed three variations of the WMP WAM to compute the combined firm yield of lakes Buchanan and Travis and to assess how changes in firm water demands and curtailment procedures for interruptible stored water would impact LCRA's firm and interruptible water supply customers, environmental flows (instream and freshwater inflows to Matagorda Bay) and lake levels. The three variations of the Colorado WAM are:

- Baseline Models (2010 WMP) with 2010, 2020 and 2030 demands;
- Interim WMP WAM and the 2020 WMP WAM; and
- Firm Yield Model.

The model assumptions used in each of the above models are described in detail in the following technical papers included under Appendix A:

- Technical Paper A-3, Assumptions Underlying LCRA 2010 Water Management Plan Baseline Water Availability Models;
- Technical Paper A-4, Assumptions Underlying Water Availability Models Used to Support Development of the LCRA Water Management Plan Revisions; and
- Technical Paper A-5, Development of Combined Firm Yield of Lakes Buchanan and Travis.

Generally, the Baseline Models were created to summarize the current 2010 WMP. In addition, these models served as a starting point against which LCRA and the Water Management Plan Revision Advisory Committee could compare and assess the impacts of various curtailment procedures.

The Interim and 2020 WMP WAMs incorporate the curtailment procedures developed for this WMP revision. These models were developed over many months by LCRA, with input from the committee.

The third variation of the WMP WAM, the Firm Yield Model, was developed to compute the combined firm yield of lakes Buchanan and Travis. This model's parameters and assumptions relate to the legal representation of all water rights in the basin and assume all other rights in the Colorado Basin exercise the full legal amounts authorized by their associated water rights, regardless of what these water rights' demands actually are or are anticipated to be. This model also incorporates the settlement agreement between LCRA and the City of Austin regarding treatment of return flows discharged by the City of Austin as it ~~impacts~~ relates to the firm yield of lakes Buchanan and Travis.

The Baseline, Interim and 2020 WMP WAMs include parameters and assumptions that relate to actual and anticipated conditions and thus are referred to as "operational models." Because these models are constructed to assess significantly different aspects of water availability than the Firm Yield Model, there are numerous differences in assumptions between models, the most notable of which are summarized in Table 3-1.

Table 3-1
Differences Between Operational and Firm Yield Models

Model Parameter	Baseline Models	Interim & 2020 Models	Firm Yield Model
Period of record	1940-2009	1940-2009	1940-2009
Reservoir sedimentation conditions	Year Specific	Year Specific	Year Specific
Priority "cutoff" assumption[1]	Buchanan & Travis	Buchanan & Travis	Ivie and Brownwood
Municipal and industrial demands	Year Specific	Year Specific	Authorized Amount
Irrigation demands	Year Specific	Year Specific	Authorized Amount
Irrigation demand curtailment	2010 WMP	As Proposed	No
Climate variable irrigation demands	Yes	Yes	No
Irrigation return flows represented	Yes	Yes	No
Stored water provided for irrigation	Yes	Yes	No
Run-of-river diversions for lower basin senior rights limited to estimates of reliable water	Yes	Yes	No
Pass-through and stored water releases from Highland Lakes to lower basin users increased to represent daily inefficiencies in actual operations	Yes	Yes	No
City of Austin return flows included	Yes	Yes	Yes
Environmental flows represented	2010 WMP	As Proposed	No

Note: 1. All water rights upstream of the reservoirs noted are represented as being able to divert and store water with priority over all water rights downstream of these upstream reservoirs regardless of the actual priority date stated in their water rights. For Baseline, Interim and 2020 models, this assumption is appropriate because water rights at and below the Highland Lakes do not have a current process in place to monitor upstream junior water rights to ensure inflows are passed downstream to senior water rights holders. For the Firm Yield model, this assumption is appropriate because several of the large water rights at the Highland Lakes and downstream have “no call” agreements in place with numerous entities upstream of these reservoirs.

3.3 INTERIM AND 2020 WMP MODELS

The Interim and 2020 WMP WAMs were created to represent operating provisions of this WMP revision. The Interim WMP WAM uses interim demands (about half way between the projected 2010 and 2020 water demands) and the 2020 WMP WAM uses projected year 2020 water demands. These WMP WAMs include the proposed operating procedures and irrigation curtailment details developed for this WMP revision process~~with input from the Water Management Plan Revision Advisory Committee~~.

The purpose of these operations-based models was to assess how changes in firm water demands and curtailment procedures for interruptible stored water would impact various parameters associated with LCRA's firm and interruptible water supply customers, environmental flows (instream and freshwater inflows to Matagorda Bay) and lake levels through a repeat of the historical hydrology for the period 1940-2009. These operational models are designed to simulate the impact of LCRA's customers' demands and environmental flow criteria on the Highland Lakes and the Colorado River downstream based on a repeat of the historical hydrology. Numerous parameters in these models were set to represent actual operational characteristics and to also recognize several practical limitations associated with the Highland Lakes and lower basin water users' ability to use Colorado River water. Modeling assumptions underlying the Interim and 2020 WMP WAMs are described in more detail in Appendix A, Technical Paper A-4.

3.4 FIRM YIELD COMPUTATION

The 1988 Final Judgment and Decree (1988 Decree) adjudicating LCRA's Highland Lakes water rights requires that LCRA calculate the combined firm yield of lakes Travis and Buchanan. For purposes of the WMP, the combined firm yield of lakes Buchanan and Travis is defined as:

> That amount of water, that the reservoir [system] could have produced annually if it had been in place during the worst drought of record. In performing this simulation, naturalized streamflows will be modified as appropriate to account for the full exercise of upstream senior water rights is assumed as well as the passage of sufficient water to satisfy all downstream senior water rights valued at their full authorized amounts and conditions as well as the passage of flows needed to meet all applicable permit conditions relating to instream and freshwater inflow requirements.[1]

Further, consistent with the 1988 Decree, the combined firm yield represents the maximum amount of water that LCRA can commit from lakes Buchanan and Travis for firm water supply.

The concept of firm yield of a reservoir or system of reservoirs is fundamental to water supply planning. It defines a reliable level of supply that can be reasonably expected to be available in the future should a drought occur that is as severe as the Drought of Record. It is also possible for a drought more severe than the Drought of Record to occur in the future, in which case the full firm yield amount would not be available.

A water availability model (WAM) was used to calculate the combined firm yield of lakes Buchanan and Travis. The computer model accounts for all surface water rights in the Colorado River basin and uses historical streamflow data, hydrology and climatic conditions to simulate the supply of surface water available on a monthly basis. This model also incorporates the settlement agreement between the LCRA and the City of Austin[2] regarding treatment of return flows discharged by the City of Austin as it impacts the combined firm yield of lakes Buchanan and Travis. The combined firm yield of lakes Buchanan and Travis (separate from O.H. Ivie) as calculated in this WMP revision is 434,549 acre-feet per year as compared to the value of 445,266 acre-feet per year calculated in the original WMP,[3] approximately a two percent reduction. A more technical explanation of the firm yield calculation and the assumptions that were used in the calculation can be found in Appendix A -Technical Paper A-5.

3.5 CALIBRATION SUMMARY

At the beginning of the WMP update process, a modified Baseline WAM was created to evaluate the effectiveness of the WAM models at simulating the interactions between upstream and downstream river flows, releases and diversions, and reservoir storage. The modified Baseline WAM used the curtailment procedures from the 1999 WMP (which was in effect through 2009). The results of the modified Baseline WAM were compared with actual observed hydrologic data for the period from 2002-2009, which includes a variety of low and high flow conditions. Specific comparisons were made of:

- Lake levels for lakes Buchanan and Travis;
- Combined LCRA system storage;
- River flows at gauges downstream of the Highland Lakes; and
- Total amount of Colorado River flow reaching Matagorda Bay.

These comparisons demonstrated the Baseline WAM's ability to accurately simulate lakes Buchanan and Travis, releases from these reservoirs and the river flows in the lower Colorado River. Figures 3-1 and 3-2 illustrate the comparisons for combined storage of lakes Buchanan and Travis and for the total inflows to Matagorda Bay. As can be seen in the figures, the Baseline WAM simulated values generally track closely with the observed data with a few exceptions, most of which are expected due to the following inherent differences between the Baseline WAM model logic and historical operations:

- The WAM model simulation was run for the full period beginning in 1940, therefore at the beginning of the comparison in 2002, the ~~quanity~~ quantity in storage in the WAM model did not exactly match the historical data;
- The WAM does not store water in reservoirs above the conservation pool (the elevation associated with maximum water supply storage); and,
- Firm demands in the Baseline WAM are assumed to be the same each year of the simulation and set to 2010 levels, while the historical data reflects the year-to-year variations in actual water use.

Figure 3-1
Comparison of Combined Storage in Lakes Buchanan and Travis

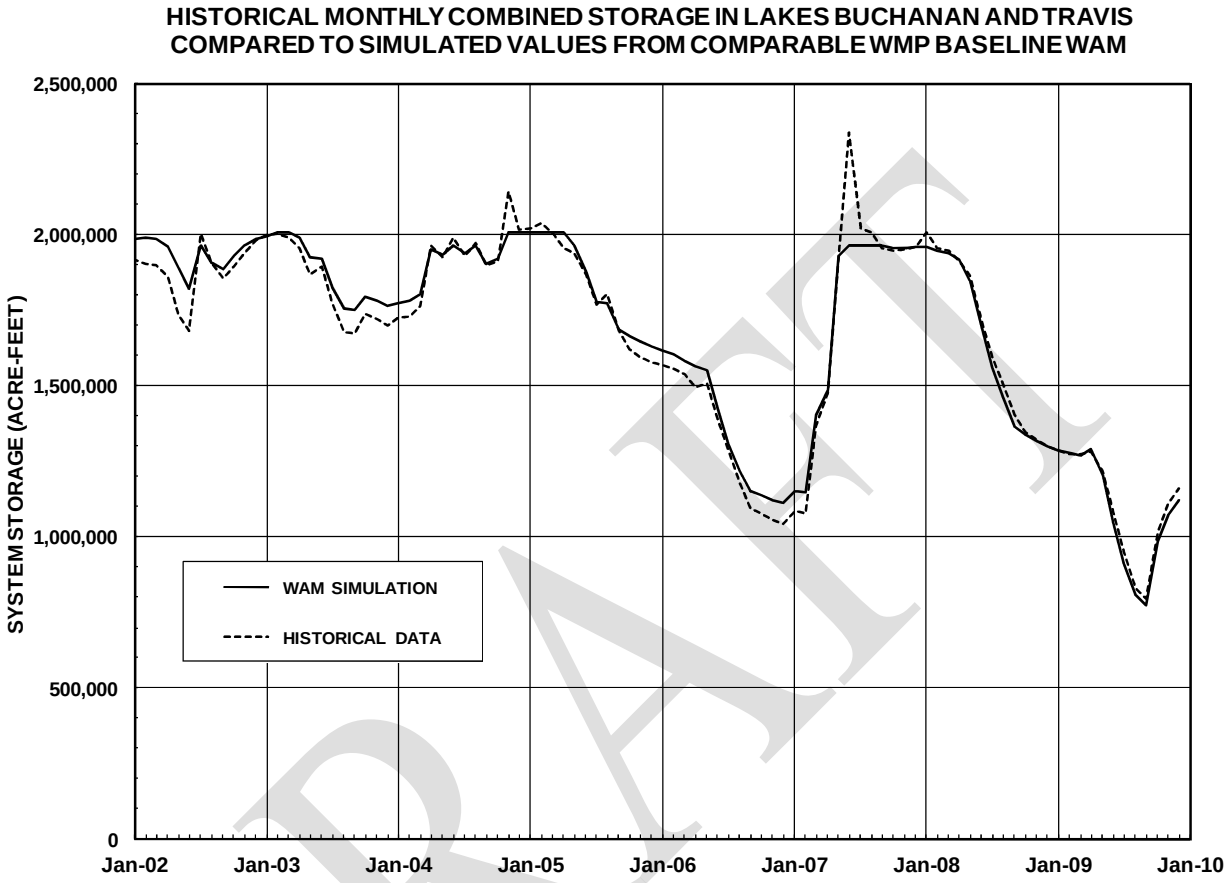
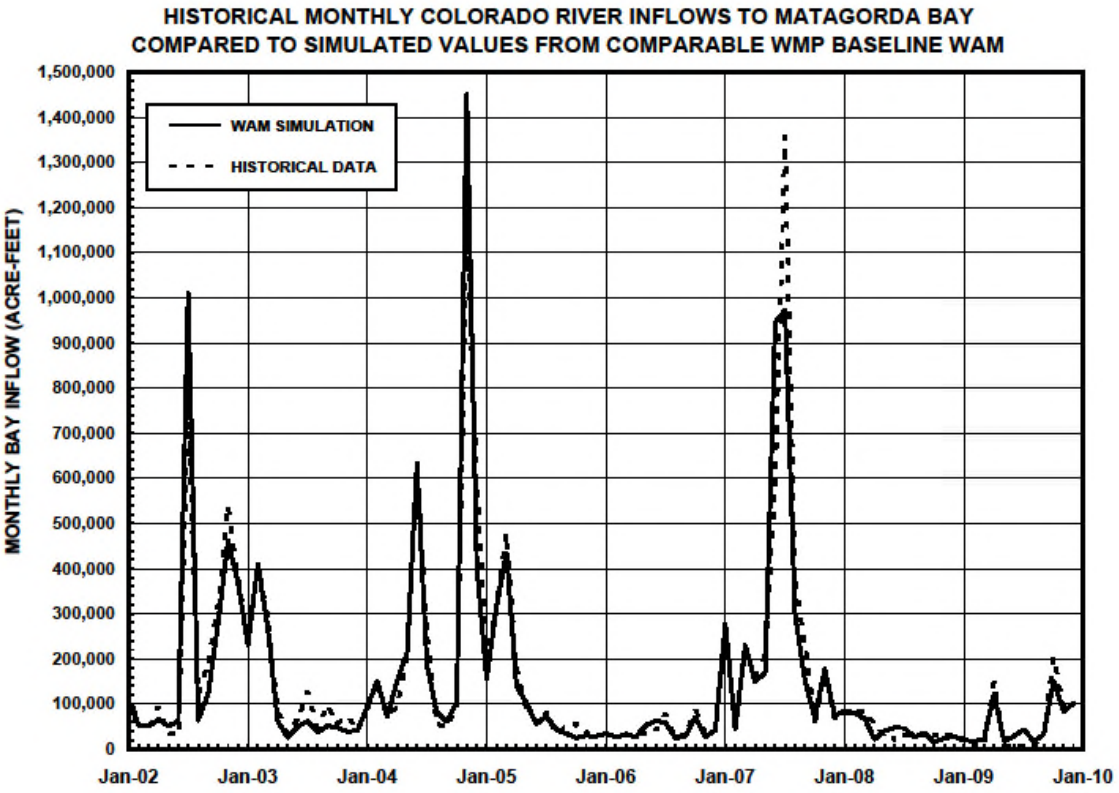


Figure 3-2
Comparison of Total Flow to Matagorda Bay



1. 30 Tex. Admin. Code § 297.20(1).
2. June 18, 2007, Settlement Agreement by and between the City of Austin and the Lower Colorado River Authority Regarding Joint Water Resource Management and the Resolution of Certain Regulatory Matters Pending at the Texas Commission on Environmental Quality, Section VIII.C
3. Sept. 7, 1989, Texas Water Commission Order Approving Lower Colorado River Authority's Water Management Plan Amending Certificates of Adjudication Nos. 14-5478 and 14-5482, Finding of Fact 47.

CHAPTER 4
ALLOCATION OF STORED WATER SUPPLIES, FIRM CUSTOMER DROUGHT CONTINGENCY PLAN, AND AGRICULTURAL CUSTOMER DROUGHT CONTINGENCY PLAN

4.1. Introduction 4-2
4.2. Process for Determining Applicable Curtailment Procedures 4-4
4.3. Curtailment Procedures for the Four Downstream Irrigation Operations 4-6
4.3.1 Introduction 4-6
4.3.2 Determination of total amount of interruptible stored water available for the four downstream irrigation operations 4-7
4.3.2.1. Separate determination of interruptible stored water for first and second crop 4-7
4.3.2.2. Annual limit for the supply of interruptible stored water 4-7
4.3.2.3. Curtailment curves for the supply of interruptible stored water 4-8
4.3.2.4. Anytime cutoff of interruptible stored water supplies 4-12
4.3.2.5. Resumption of supply of interruptible stored water in a first crop season 4-12
4.3.3. Allocation of interruptible stored water among the four downstream irrigation operations 4-12
4.3.4. Allocation of run-of-river supplies to the downstream irrigation operations 4-13
4.3.5. Total assumed supply available for contracting in the irrigation operations 4-14
4.3.6. Determination of irrigable acreage within LCRA irrigation operations 4-14
4.3.7. Allocation of water to individual customers within LCRA irrigation operations 4-15
4.3.8. Variances 4-16
4.3.9. Enforcement 4-16
4.4. Exceptions to the Allocation Procedures for the Irrigation Operations 4-16
4.4.1. Exceptions to standard curtailment procedures for the downstream irrigation operations under certain severe drought conditions 4-16
4.4.2. Exceptions to standard allocation procedures for the Gulf Coast Irrigation Division under certain wet conditions 4-18
4.5. Curtailment Procedures for Environmental Flows in Lower Colorado River Basin 4-19
4.5.1. Helping meet environmental flow needs with firm and interruptible stored water 4-19
4.5.2. Curtailment of water for instream flows 4-20
4.5.3. Curtailment of water for freshwater inflows to Matagorda Bay 4-23
4.6. Curtailment Procedures for Interruptible Stored Water Demands Other than the Downstream Irrigation Operations 4-24
4.7. Curtailment of Firm Water Demands 4-24
4.7.1. Introduction 4-24
4.7.2. LCRA drought response measures for firm water demands, including firm commitments for environmental flows 4-25
4.7.3. Monitoring and enforcement 4-26
4.7.4. Variances to firm water pro rata curtailment 4-26
4.7.5. Firm customer drought contingency plans 4-27
4.7.6. Notification of TCEQ Executive Director 4-27
4.8. Declaration and Cancellation of Drought Worse than Drought of Record 4-27
4.9. Impacts of the Recommended Curtailment Policies under this WMP 4-28
4.9.1. Firm water customers 4-28

4.9.2. Agricultural customers in downstream irrigation operations 4-29
4.9.3. Environmental flows 4-29
4.9.4. Lake storage levels 4-30
4.10 Drought Contingency Plan Updates 4-35
4.11 Administration of Allocation Procedures 4-35

4.1. INTRODUCTION

This Water Management Plan (WMP) contains a number of distinct trigger levels and conditions that are associated with determining the amount of interruptible stored water available from lakes Buchanan and Travis to try to help meet:

- Agricultural ~~(irrigation)~~ demands in the four downstream irrigation operations;
- A range of freshwater inflows for Matagorda Bay;
- A range of instream flows downstream of the Highland Lakes; and
- Demands for a small category of interruptible users, other than the downstream irrigation operations, when the combined storage in lakes Buchanan and Travis is above 1.9 million acre-feet (MAF).

Demands for interruptible stored water to supplement available run-of-river water supplies for agricultural ~~(irrigation)~~ purposes ~~(mainly rice production)~~ can be particularly high during drier conditions. These types of conditions, combined with a significant projected growth in firm demands through 2020, increase the likelihood of significant shortages of interruptible stored water. Thus, significant changes to the interruptible stored water curtailment policies from prior Water Management Plans are necessary to address this possibility.

When developing the triggers and curtailment mechanisms contained in this WMP revision, LCRA staff reviewed with the Water Management Plan Revision Advisory Committee (WMPRAC) numerous Water Availability Model (WAM) runs. These runs evaluated many different options for allocating available interruptible stored water from lakes Buchanan and Travis between irrigation and environmental needs.

When determining available interruptible stored water supplies, it is essential that firm water demands be protected during a repetition of the Drought of Record (DOR)[1]. This drought is the worst recorded to date on the lower Colorado River and is from 1947 through 1957. The curtailment procedures in this WMP revision have been designed to ensure supply is available to meet projected firm demands through the year 2020, through a DOR condition and through the short-term intense droughts that this region has experienced in recent decades, as required by the January 2010 TCEQ Order approving the 2010 WMP.[2]

The TCEQ Order also required an evaluation of the minimum combined storage in lakes Buchanan and Travis necessary or appropriate to protect firm customers through a DOR condition, or under conditions worse than the ~~a~~ Drought of Record. Since the evaluation of expected hydrologic and water demand conditions can only be simulated based on projected information, which is subject to some uncertainty, in all of its prior WMPs LCRA has determined it prudent to designate some minimum combined storage level. This served as a

safety factor to address model uncertainties and provide for hydrologic conditions other than those simulated.

The minimum combined storage in the model simulations for this WMP revision was maintained in a range of roughly 3~~7~~50,000 to 4~~0~~20,000 acre-feet. This safety factor is roughly equivalent to the volume needed in storage to meet approximately one year of firm demands under severe drought conditions. In all previous WMPs, a ~~safety factor~~minimum combined storage of about 200,000 acre-feet was used. The increase to 3~~7~~50,000-4~~0~~20,000 acre-feet roughly corresponds to the increase in total firm demands since the first WMP. Thus, the level of protection for firm demands under this WMP revision is roughly equivalent to that of the first WMP.

As discussed in Chapter 2, by 2020, demands of LCRA's firm water customers are projected to increase by approximately 48 percent from the projected year 2010 demand values used in the 2010 WMP. ~~Meeting t~~Those increased demands will be met in this revision ~~from lakes Buchanan and Travis can only be achieved~~ by decreasing the amount of interruptible stored water provided under the 2010 WMP. The increased demands could also be met by adding water supplies not identified in this plan.

This WMP revision includes a number of significant changes to the methods used to allocate interruptible stored water from lakes Buchanan and Travis for agricultural use in the four downstream irrigation operations and to other users. It also includes changes to the environmental criteria used to provide instream flow below Longhorn Dam and freshwater inflow into Matagorda Bay. These changes allow LCRA to be more responsive to changes in water supply conditions. Specifically, these changes include:

- LCRA will determine availability of interruptible stored water for the downstream irrigation operations separately for first and second crop;
- LCRA will determine applicable environmental flow criteria at two dates during the year for different periods of the year;
- LCRA will increase the total amount of interruptible stored water available for the downstream irrigation operations if combined storage increases between Jan. 1 and March 1 for first crop or, for second crop, between June 1 and Aug. 1;
- An annual cap on the total amount of interruptible stored water available for contracting in any given calendar year, and LCRA will adjust the amount of interruptible stored water available for second crop to stay within the annual cap;
- In the initial years in which this plan is in effect, LCRA will use less-restrictive curtailment procedures for determining available interruptible stored water. LCRA will shift to more restrictive curtailment procedures designed for year 2020 firm demands when specific triggering events occur (based on increases in actual demands, water supply conditions, or a time certain);
- LCRA will stop releasing interruptible stored water for the downstream irrigation operations other than Garwood when combined storage drops below 600,000 acre-feet, whether or not the LCRA Board has declared of Drought Worse than Drought of Record; and
- The LCRA Board will have increased discretion to determine the amount of interruptible stored water available to the downstream irrigation operations under certain severe dry

weather conditions, and to determine the amount of assumed run-of-river water available to the Gulf Coast irrigation operation under certain wet forecast conditions.

This Chapter also incorporates LCRA's Drought Contingency Plans (DCPs) for its firm water customers and its downstream irrigation operations. Updates to this chapter may be made as discussed in Section 4.10.

4.2. PROCESS FOR DETERMINING APPLICABLE CURTAILMENT PROCEDURES

For this WMP revision, LCRA used a planning horizon through year 2020 designed to protect firm demands through a repeat of the Drought of Record and other short-term intense droughts as have been experienced in recent decades. Firm demands are expected to increase through year 2020. However, to make the WMP more adaptive to actual firm demands and demand growth, LCRA has developed two separate sets of curtailment procedures, including curtailment curves for the four irrigation operations and environmental flow criteria. The first "interim" set applies immediately, and the second "2020" set will apply when certain specific conditions are met, including increasing firm demands or other conditions. (The curtailment procedures for the downstream irrigation operations are presented in section 4.3 and the environmental flow criteria are presented in section 4.5.) By creating two sets of curtailment procedures and a mechanism for shifting between the two, this WMP allows LCRA to be more adaptive. This provides more interruptible stored water in the initial years of operation under this WMP and implements more restrictive curtailment procedures over time.

Upon the effective date of this WMP, ~~T~~the interim demand phase curtailment procedures will be in effect for the next upcoming crop season ~~immediately upon the effective date of this WMP~~. The LCRA Board will determine whether to shift to the 2020 curtailment procedures after opportunity for public comment and in accordance with the criteria set forth below. Specifically, the shift to 2020 curtailment procedures would be effective for the next calendar year upon a finding by the LCRA Board that any one or more of the following criteria with respect to actual or projected demands for firm water from lakes Buchanan and Travis is met:

1. Actual demand ~~plus projected incremental water use from new or existing contracts expected to come on-line in the next year~~ ~~in any two consecutive years~~ is greater than or equal to 352,303 acre-feet per year (the firm water demand assumed for the interim curtailment procedures) for:
   a) any two consecutive years; or
   ~~a)~~b) any two consecutive years in which firm customers were not subject to a mandatory curtailment as a result of a Board declaration of Drought Worse than Drought of Record; or
2. Actual demand in any year is greater than 352,303 acre-feet and the actual plus projected incremental water use from new or existing contracts is expected to exceed 352,303 in the next year by more than 5%; or
3. ~~Actual demand exceeds 95 percent of 352,303 acre-feet per year (334,688 acre-feet per year) for two consecutive years;~~

~~4.~~2. ~~Actual demands exceeds 334,688 acre-feet (95 percent of interim firm water demand) and a cancellation of Drought Worse than Drought of Record has occurred in the year in which the finding is made; or~~

~~5.~~3. The next calendar year is 2020.

~~In determining whether If a shift should has occurred under provisions (1) or (2) described above, the LCRA Board will not factor any year in which the Board has declared a Drought Worse than the Drought of Record, if such year falls between two such years and the projected demand increase does not materialize (i.e. the total demand in a given year is less than 352,303 acre-feet), and none of the other criteria for triggering a shift are met (including provision 1), the curtailment procedures will revert back to the interim procedures for the next year.~~

To determine whether a shift in curtailment procedures is warranted based on ~~firm demand on lakes Buchanan and Travis~~provision (2~~1~~) described above, LCRA will calculate projected demands for the upcoming year by adding the following:

1. *Actual demands of firm water customers* – based on firm water customers' previous year's use as reported in the Water Use Reports prepared for TCEQ each year;
2. *Projections of water use from new contracts, contract amendments or existing contracts expected to come on-line in the next year* – short-term, forward-looking projections based on:
   - Increased demand projections of industrial customers with contracts or commitments greater than 5,000 acre-feet per year (AFY);
   - Increased demand projections for municipal customers with contracts or commitments greater than 2,500 AFY;
   - Miscellaneous growth in demand of 1,500 AFY to cover growth in demands for smaller users;
   - Factoring in the projected demands for any additional firm contracts issued by LCRA in the current or next year; and
3. *Additional projected demand components*
   - Factoring actual conveyance losses and emergency releases into the projection;
   - Adding back to the actual demands any reductions in demands in the previous year due to implementation of a customer's Drought Contingency Plan (DCP), based on actual documented savings;
   - Adding an amount to account for actual use under LCRA's firm water commitment to the ~~South Texas Project~~STP Nuclear Operating Company (STPNOC) as follows:
     - If the five-year rolling average is greater than 20,000 acre-feet, then the difference between the five-year rolling average and 20,000 acre-feet shall be added to the projected demands;
     - If the five-year rolling average is less than 20,000 acre-feet, then no adjustment shall be made based on STPNOC's water use;
   - LCRA will monitor Corpus Christi's plans to divert water under its Garwood water rights and will consider and factor into these calculations, if necessary,

any impact Corpus Christi's projected diversions will have on the LCRA system on a year-to-year basis.

Once actual demands exceed 95% of 352,303 acre-feet (334,688 acre-feet) then, on or before Jan. 1 of each year, LCRA will conduct the following review process to evaluate and decide whether to shift from the interim demand curtailment procedures to the 2020 demand procedures for the following years:

- Gather actual firm water demands based on Water Use Report data submitted to TCEQ in March;
- From March through August, LCRA will gather input from larger municipal and industrial firm water customers on the upcoming year's projected demand;
- Prior to LCRA's October Board meeting, LCRA will compile the upcoming year's projection of firm demands, post the draft projections on LCRA's website for review and comment, and notify firm and interruptible customers. The document will:
  - Identify the source(s) of all data used to compute the projected demands;
  - Define actual versus projected demands; and
  - Describe whether a shift in the curtailment curve is projected to occur.
- If any of the criteria above for a shift in curtailment procedures are met, LCRA will set the matter for consideration and possible action by the LCRA Board of Directors no later than at the December Board meeting; and
- LCRA will provide written notice to TCEQ if the LCRA Board acts to shift from the interim demand curtailment procedures to the 2020 demand curtailment procedures.

When the Water Management Plan is revised in the future, the planning process will incorporate demand projections developed at that time and not rely on projected demands in this plan revision.

4.3. CURTAILMENT PROCEDURES FOR THE FOUR DOWNSTREAM IRRIGATION OPERATIONS

4.3.1 Introduction

Section 4.3 presents the curtailment procedures that apply to releases of interruptible stored water for agricultural uses in the four downstream irrigation operations and serves as LCRA's Drought Contingency Plan for such uses. Interruptible stored water may be available in the downstream irrigation operations for a variety of agricultural purposes, including rice, turf grass, row crops, hay, pasture, aquaculture and wildlife management.

Throughout this document, references are made to "first" and "second" crop or crop season. These references are to the splitting of the full irrigation season (for which LCRA supplies water to agricultural interests within the three irrigation operations) into two parts that are coincident with the two watering seasons for rice production, i.e. first or the main crop and the second or

ratoon crop. The ratoon crop, also known as second crop, is the crop of rice that re-grows from the rice plant's root system following harvest of the main or first crop of rice. The ratoon crop matures more quickly than the main crop since it is supported by an established root system. The first or main crop season normally covers the March through July timeframe and the second or ratoon crop season normally covers the August through mid-October timeframe. Weather conditions, type of crops grown and location affect the timing of these seasons within the irrigation operations. Although, the first and second crop seasons are in general reference to the rice growing seasons, during these timeframes, subject to availability under contracts for such purposes of use, water may also be available in the irrigation operations for other agricultural purposes such as turf grass, row crops, hay, pasture, aquaculture, and wildlife management.

4.3.2 Determination of total amount of interruptible stored water available for the four downstream irrigation operations

The procedures for determining the total amount of interruptible stored water available for the four downstream irrigation operations include various elements and limitations as described in the following subsections. As with recent WMPs, evaluation of demands and the curtailment of interruptible stored water for Garwood and Pierce Ranch under this section will be accomplished pursuant to the terms of specific agreements related to the supply of interruptible water to those operations.

4.3.2.1. Separate determination of interruptible stored water for first and second crop

In previous versions of the WMP, LCRA used an annual allocation process based on the Jan. 1 combined storage level of lakes Buchanan and Travis to determine the amount of interruptible stored water available for diversion at the four downstream irrigation operations for both first and second crops of the irrigation season. This WMP has a separate allocation process for first and second crops. First crop availability of interruptible stored water will be based on Jan. 1 combined storage, with the possibility of increasing the supply if combined storage on March 1 is higher than on Jan. 1. Second crop availability of interruptible stored water will be based on June 1 combined storage, with the possibility of increasing the supply if combined storage on Aug. 1 is higher than on June 1.

4.3.2.2. Annual limit for the supply of interruptible stored water

Under this WMP, the maximum amount of ~~available~~ interruptible stored water supply that will be made available for diversions in any given year to the four downstream irrigation operations will be limited even when storage levels in lakes Buchanan and Travis are relatively high or near full. On an annual basis, no more than 273,500 acre-feet per year will be available for diversions for first and second crop during the interim demand phase, and no more than 249,000 acre-feet per year would be available for diversion during the 2020 demand phase. Based on a simulated repeat of historic hydrology, these amounts were determined to be the maximum amounts of interruptible stored water provided, in conjunction with available run-of-river supplies, for diversion at the four downstream irrigation operations to satisfy the full projected interim and 2020 levels of agricultural demands.

The annual supply limit shall be used to adjust the amount of water that may be made available to an individual irrigation operation in second crop if the following conditions exist:

- The use of interruptible stored water by an individual irrigation operation exceeded (or is projected to exceed) its allocation for first crop determined under Section 4.3.3; and
- The total use (or projected use) by all four irrigation operations in first crop, plus the total amount of interruptible stored water that would be made available for second crop under Section 4.3.2.3, would exceed the annual limit described above.

Under these conditions, the adjustment shall be limited to the amount necessary to stay within the annual limit.

The annual limit will be used to determine the water available during the contracting process. However, notwithstanding any adjustments made to water available for contracting during second crop, actual use could exceed the annual limit if necessary to complete a crop.

4.3.2.3. Curtailment curves for the supply of interruptible stored water

Interruptible stored water will be made available for diversion based upon the applicable curtailment procedures (interim demand phase or 2020 demand phase) in effect for the calendar year. For first crop, the greater of the Jan. 1 or March 1 combined storage values will be used in conjunction with the applicable curtailment curves. For second crop, the greater of the June 1 or Aug. 1 combined storage values will be used in conjunction with the applicable curtailment curves.

The Interim Demand Phase and 2020 Demand Phase curtailment curves for first and second crops are shown in Figures 4-1 and 4-2, respectively. These curtailment curves include increases in the combined storage level below which interruptible stored water to Lakeside, Pierce Ranch and Gulf Coast would be cut off prior to beginning a crop season. In previous WMPs, the cutoff of interruptible stored water supply for agricultural use for the coming year would occur when the combined storage in lakes Buchanan and Travis on Jan. 1 was less than or equal to 325,000 acre-feet. The total amount of interruptible stored water to be made available for diversion at the irrigation operations river pump stations for all four irrigation operations will be determined as follows:

During the Interim Demand Phase:

- First Crop:
  - For combined storage of 1.4 million acre-feet (MAF) or more, 198,500 acre-feet;
  - For combined storage between 1.399 MAF and 1 MAF, a sliding scale from 155,000 acre-feet at 1.399 MAF of storage to 120,000 acre-feet at 1 MAF of storage;
  - For combined storage from 999,999 acre-feet to 650,000 acre-feet, 120,000 acre-feet; and
  - Below 650,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.

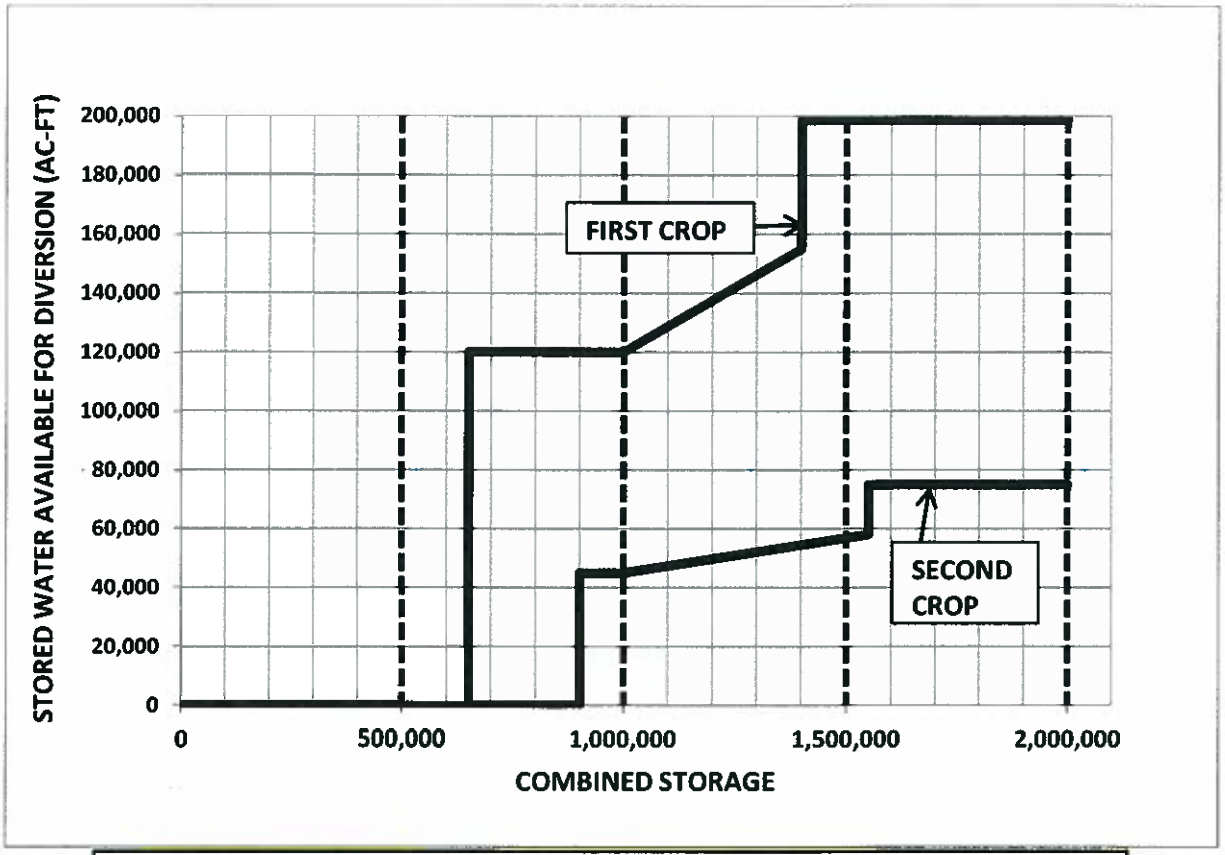
- Second Crop:
  - For combined storage of 1.55 MAF or more, 75,000 acre-feet;
  - For combined storage between 1.549 MAF and 1 MAF, a sliding scale from 58,000 at 1.549 MAF of storage to 45,000 acre-feet at 1 MAF of storage;
  - For combined storage from 999,999 acre-feet to 900,000 acre-feet, 45,000 acre-feet; and
  - Below 900,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.

During the 2020 Demand Phase:

a) First Crop:
  - For combined storage of 1.4 MAF or more, 180,500 acre-feet;
  - For combined storage between 1.399 MAF and 1.1 MAF, a sliding scale from 140,000 acre-feet at 1.399 MAF of storage to 102,000 acre-feet at 1.1 MAF of storage;
  - For combined storage between 1.099 MAF and 650,000 acre-feet, 77,500 acre-feet; and
  - Below 650,000 acre-feet, no water except for Garwood irrigation operation, consistent with prior agreements.

- Second Crop:
  - For combined storage of 1.55 MAF or more, 68,500 acre-feet;
  - For combined storage between 1.549 MAF and 1.~~0~~3 MAF, a sliding scale from 53,000 at 1.549 MAF of storage to 38,500 acre-feet at 1.~~0~~3 MAF of storage;
  - For combined storage between ~~999,999~~1.299 MAF~~acre-feet~~ and ~~900,000~~1.0 ~~acre-feet~~MAF, 29,500 acre-feet; and
  - Below ~~900,000~~1.0 ~~acre-feet~~MAF, no water except for Garwood irrigation operation, consistent with prior agreements.

Figure 4-1. Interruptible Stored Water Curtailment Curve for the Interim Demand Phase



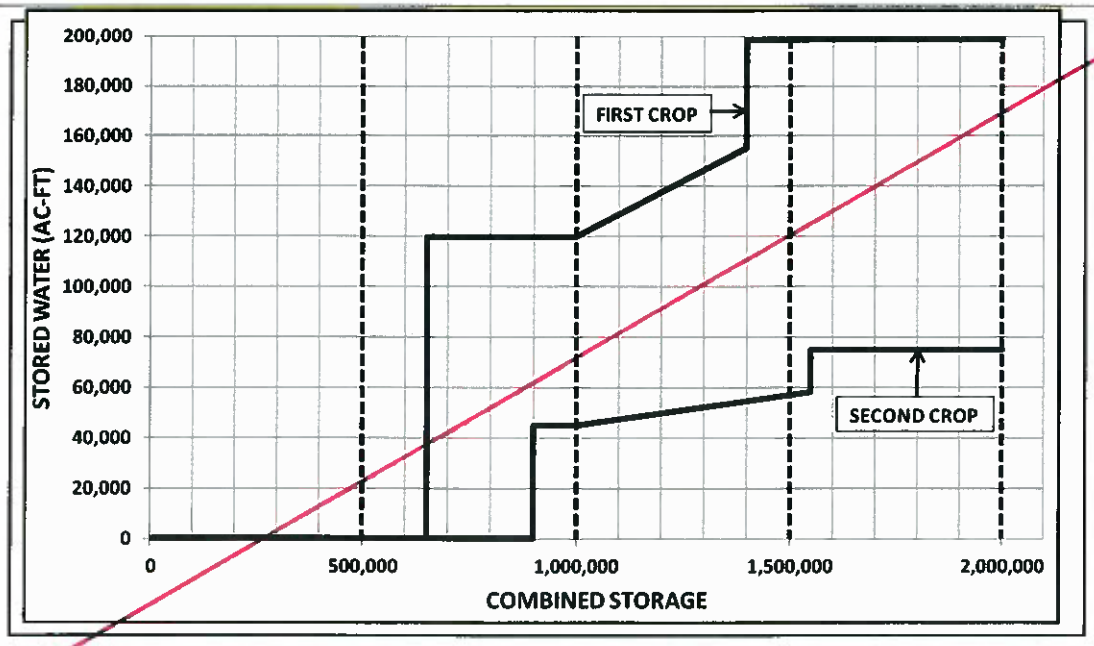
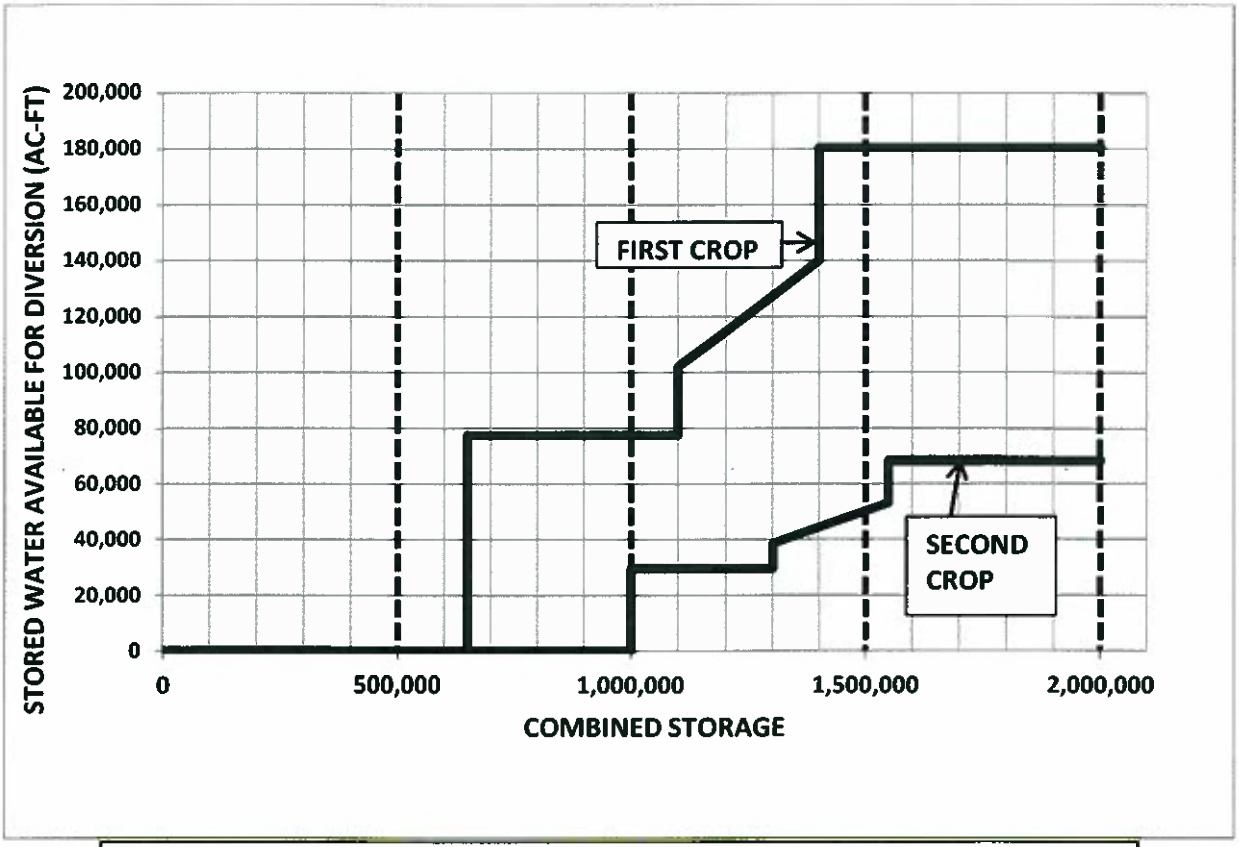
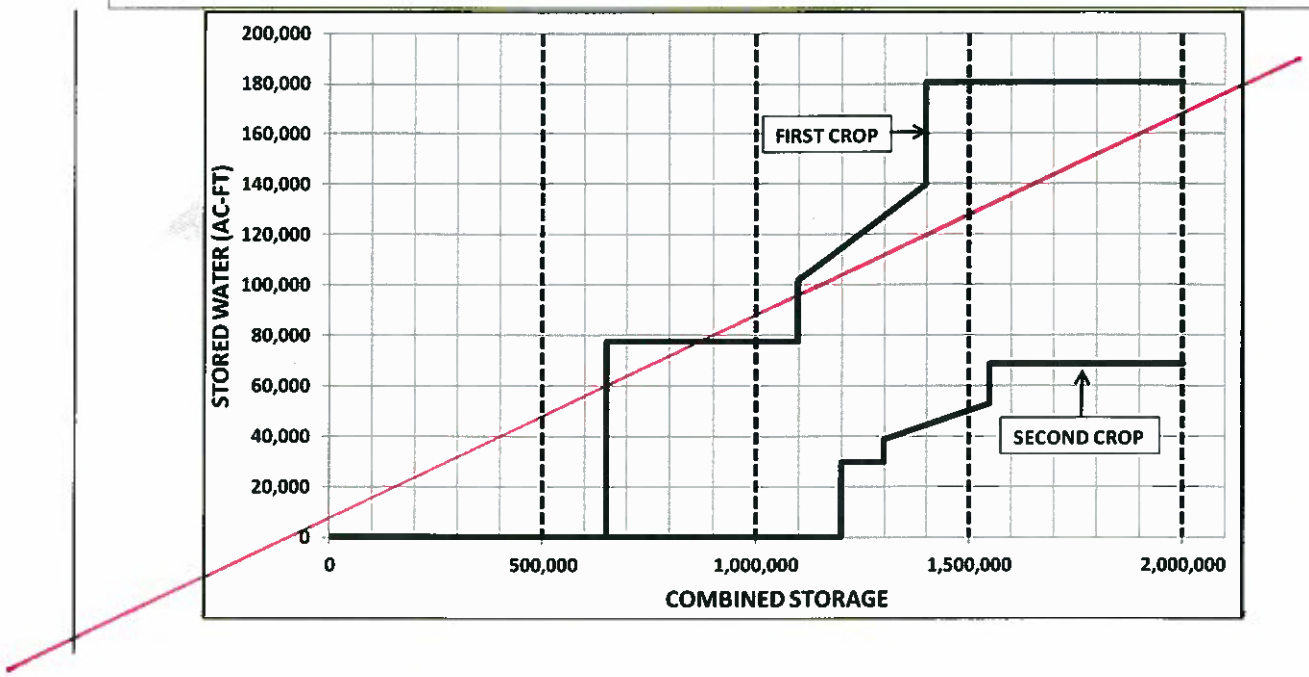


Figure 4-2. Interruptible Stored Water Curtailment Curve for Year 2020 Demand Phase





4.3.2.4. Anytime cutoff of interruptible stored water supplies

Under this WMP, LCRA will cease supplying interruptible stored water from lakes Buchanan and Travis for agricultural use to Lakeside, Pierce Ranch and Gulf Coast when combined storage falls to 600,000 acre-feet. Previous plans set this cutoff level at 200,000 acre-feet. This cutoff could occur at any time in a crop season.

Furthermore, in the event that the LCRA Board declares a Drought Worse than Drought of Record, the supply of interruptible stored water shall be ceased immediately and no interruptible stored water shall be made available to ~~all~~ any of the four downstream irrigation operations until the declaration is cancelled.

4.3.2.5. Resumption of supply of interruptible stored water in a first crop season

If the interruptible stored water supplies for first crop have been cut off and LCRA is not under a declaration of Drought Worse than Drought of Record, the Board may consider and take possible action, after public comment, to identify the conditions~~, including the time frame, required increase in combined storage level, and potential limitations~~ under which interruptible stored water supplies could be made available in that crop season. Conditions for consideration include the time frame, required increase in combined storage level, and potential limitations controlling resumption of interruptible releases for first crop irrigation.

4.3.3. Allocation of interruptible stored water among the four downstream irrigation operations

Interruptible stored water is allocated to the individual irrigation operations based on the historic demands for such water by the operations, after taking into account the amount of run-of-river supply, if any, that the operation can rely on.

Interruptible stored water is allocated to the Garwood irrigation operation based on specific contract obligations. The Garwood run-of-river water right is one of the most senior rights in the basin, and is senior to water rights associated with the other irrigation operations. Consequently, run-of-river supply is expected to meet most of the demands associated with the Garwood operation under typical circumstances. The demand for interruptible stored water for Garwood, and the amount of interruptible stored water to be allocated to Garwood will be determined consistent with the Garwood Purchase Agreement.[3]

Pierce Ranch has an interruptible contract with LCRA providing for a maximum of 20,000 acre-feet of interruptible stored water on a five-year rolling average, with a one-year maximum of 30,000 acre-feet.[4] Those maximum values apply when combined storage is above the upper trigger points for first and second crop (1.4 and 1.55 MAF, respectively). The interruptible stored water commitment will be proportionally reduced consistent with the overall reductions in interruptible stored water to all irrigation operations when combined storage falls below those initial trigger points. The actual amounts of interruptible stored water needed for Pierce Ranch will vary each year due to the five-year averaging approach. LCRA retains the right to meet its commitment to Pierce Ranch from any source available to LCRA and is not obligated to use only stored water. Indeed, LCRA may rely on run-of-river supplies authorized for diversion at the

Pierce Ranch diversion point in lieu of releasing interruptible stored water when that water is not otherwise needed to meet firm commitments.

The Gulf Coast and Lakeside irrigation operations typically divert significantly larger amounts of interruptible stored water than the Garwood and Pierce Ranch irrigation operations. Consistent with the historic reliance of these operations on interruptible stored water, after interruptible stored water is allocated to Garwood and Pierce Ranch, the remaining amount will be split evenly between the Gulf Coast and Lakeside operations.

4.3.4. Allocation of run-of-river supplies to the downstream irrigation operations

The allocation of run-of-river supplies to the downstream irrigation operations is based on prior agreements and the relative priority of the Garwood, Gulf Coast and Lakeside water rights. Run-of-river supply assumed to be available within each crop season (first or second crop) will be allocated to the Garwood irrigation operation first because of the senior priority of the Garwood water right. For purposes of determining available supply prior to the crop season, Pierce Ranch will be allocated only interruptible stored water based on its contract, even if some portion of its needs have been or may be met with run-of-river supply. The Gulf Coast water right is junior to the Garwood right but senior to the Lakeside water right. Consequently, consistent with recent availability under such rights, the remaining run-of-river water after Garwood will be split such that the Gulf Coast operation is allocated 80 percent and the Lakeside operation is allocated 20 percent of the remaining assumed quantity. Tables 4-1 and 4-2 list the current assumed run-of-river availability for each irrigation operation for the interim and year 2020 demand phases, respectively. The dates used for making the determination of assumed run-of-river availability will be the same as those established in Section 4.3.2.1 for the determination of interruptible stored water availability. These amounts are applicable only during normal conditions and could vary as a result of LCRA Board action under a dry weather or wet weather exception. (See Section 4.4.) The overall run-of-river water availability for the year 2020 demand phase is reduced for the Gulf Coast and Lakeside operations due to the increased demands of the City of Austin, whose water right has priority for access to run-of-river supplies after Garwood, but before Gulf Coast and Lakeside.

Table 4-1. Assumed Quantity of Run-of-River Water for the Interim Demand Phase

Storage Level	Garwood (ac-ft)	Gulf Coast (ac-ft)	Lakeside (ac-ft)	Total (ac-ft)
First Crop				
>1.4 MAF	66,500	42,800	10,700	120,000
1.399 - 1.0 MAF	63,000	29,600	7,400	100,000
0.999 - 0.650 MAF	59,500	24,400	6,100	90,000
Second Crop				
> 1.55 MAF	28,500	21,200	5,300	55,000
1.549 - 1.0 MAF	27,000	14,400	3,600	45,000
0.999 - 0.900 MAF	25,500	7,600	1,900	35,000

Table 4-2. Assumed Quantity of Run-of-River Water for the Year 2020 Demand Phase

Storage Level	Garwood (ac-ft)	Gulf Coast (ac-ft)	Lakeside (ac-ft)	Total (ac-ft)
First Crop				
>1.4 MAF	66,500	34,800	8,700	110,000
1.399 - 1.0 MAF	63,000	21,600	5,400	90,000
0.999 - 0.650 MAF	59,500	16,400	4,100	80,000
Second Crop				
> 1.55 MAF	28,500	16,400	4,100	49,000
1.549 - 1.30 MAF	27,000	10,000	2,500	39,500
1.299 - 1.~~20~~ 00 MAF	25,500	3,600	900	30,000

4.3.5. Total assumed supply available for contracting in the irrigation operations

The total amount of water available to each irrigation operation will be the combination of the allocated amount of interruptible stored water, as described in Section 4.3.3, and the allocated amount of assumed run-of-river quantities in Section 4.3.4 for either first crop or second crop season. This quantity represents the total amount assumed to be available at the irrigation operation's diversion point and would be committed for supply to each irrigation operation for the upcoming crop (first or second). This quantity is subject to cutoff any time during the crop season consistent with this WMP and interruptible agricultural contracts, including any special contract terms and conditions that control supply to Garwood and Pierce Ranch. The determination of the available amounts of water available for each irrigation operation will be made by LCRA's General Manager prior to the crop season for which the water will be available (first or second) and shared with the agricultural users within each irrigation operation in advance of the upcoming crop season.

4.3.6. Determination of irrigable acreage within LCRA irrigation operations

Through its annual contracting process in the Garwood, Gulf Coast and Lakeside irrigation operations, LCRA will, at the beginning of each crop season, contract to provide irrigation water up to a maximum amount of acreage consistent with the limits of the available allocated water supplies. The irrigable acreage will be calculated from the amount of water determined to be available for diversion for each irrigation operation for that crop season.

Since a portion of the water that is diverted from the river is lost in delivery through the canal system, system delivery losses will be deducted in determining the total amount of water available for on-farm use. System delivery losses will be estimated using the average of system delivery losses within the past five years for each individual irrigation operation.

On-farm duty is a measure of the amount of water used to irrigate an acre of land (in acre-feet/acre) measured at the point of delivery. On-farm duty varies by type of crop, weather conditions and for each of the operations. LCRA will maintain records of water use by field for both first and second crop seasons~~on an annual basis~~. For purposes of calculating irrigable

acreage, when combined storage on the applicable determination dates is greater than or equal to 1.4 million acre-feet for first crop or greater than or equal to 1.55 million acre-feet for second crop, LCRA will use the ~~second highest~~average on-farm water duty by crop category over the ~~last~~ preceding five years within each irrigation operation for the applicable crop season. When combined storage is below 1.4 million acre-feet or 1.55 million acre-feet on the applicable determination dates, LCRA will use the second highest on-farm water duty from the preceding five years.

Irrigable acreage commitments will be calculated based on the following general equation:

$$\text{Irrigable Acreage} = \frac{\text{Total Water Supply at River Diversion Point} * (1 - \text{System Delivery Loss \%})}{\text{On Farm Water Duty}}$$

For example, if LCRA commits to make 75~~70~~,000 acre-feet of water available for first crop diversion to an irrigation operation, system delivery losses are estimated to be 20 percent and on-farm duty is assumed to be 3 acre-feet/acre, then the maximum commitment on irrigable acreage will be 20,000 acres for first crop. The general equation above is for illustration purposes only and will need to be adjusted or modified for each operation due to the variability in cropping patterns and crops grown within each operation.

4.3.7. Allocation of water to individual customers within LCRA irrigation operations

LCRA does not operate the canal system or enter into contracts with individual farmers associated with Pierce Ranch. Pierce Ranch will determine how water will be allocated within its own operation. Within each LCRA irrigation operation (Lakeside, Garwood and Gulf Coast), each customer's average base acreage history will be determined based on an averaging period. The current averaging periods are as follows: Garwood – five years; Gulf Coast – two years; and Lakeside – six years.

Within the Lakeside and Garwood irrigation operations, the base acreage history will be based upon the lands irrigated historically. A customer will not be allowed to receive water to irrigate lands in a curtailment year unless those lands were previously irrigated by that customer. One exception is if the current owner of the land that contributed to the base acreage history grants express written consent for the history to follow the customer rather than the specific tract of land. Such consent must be provided to LCRA with the customer's request for water for an upcoming crop season (first or second). If a customer no longer farms land that has a history of being farmed, that history will be credited to the current landowner or a successor tenant farmer unless the landowner has granted consent for such base acreage to follow the customer to other lands, as described above.

Within the Gulf Coast irrigation operation, the base acreage history will follow the LCRA customer, and not be restricted to a particular tract of land.

Allocation of water to the various users within the irrigation operations will be based on the amount of irrigated acreage on each tract of land. This irrigated acreage will be determined by accounting for established crop rotations during the defined averaging period and include only those years during that same period that water was used on the tract of land. Irrigation operations

personnel will maintain this information for each irrigated tract of land. Separate base acreage histories will be maintained for the various crop types. During periods of curtailment, irrigation customer contracts will be limited to the base acreage as determined by the method described above and any reductions necessary will be made from this base acreage.

Water allocation among individual users within individual operations is not a property right and there are no procedures or policies that allow for individual users to obtain that right or to transfer an allocation to another user. All water available will be allocated on a pro rata basis as described above, which is consistent with state law governing pro rata curtailment.

4.3.8. Variances

Within each LCRA irrigation operation, the LCRA General Manager, after consultation with the operation's advisory committee, may adjust the averaging period for determining base acreages within the operation to account for established field rotations, changes in management practices, and other relevant factors.

4.3.9. Enforcement

All LCRA interruptible stored water contracts include a provision requiring that, in cases of a shortage of water resulting from drought, the water will be distributed in accordance with LCRA's WMP and Texas Water Code section 11.039. Interruptible stored water customers within the irrigation operations failing to comply with the allocation requirements (curtailment plan) are subject to surcharges or excess use rates as set by the LCRA Board for water use in excess of the customer's per-acre duty. They may also be subject to civil action to enjoin them for breach of contract. Customers failing to comply with contractual requirements to prevent the waste of water are also subject to denial of water until such time as the failure is corrected.

4.4. EXCEPTIONS TO THE ALLOCATION PROCEDURES FOR THE IRRIGATION OPERATIONS

4.4.1. Exceptions to standard curtailment procedures for the downstream irrigation operations under certain severe drought conditions

Notwithstanding the process set out in this Section, the LCRA reserves the right, at all times, to:

- take immediate action, consistent with state law, to respond to drought or any emergency condition threatening its water supply, and
- pursue any relief it deems appropriate with the Texas Commission on Environmental Quality (TCEQ) to deviate from or amend any of the provisions of this Water Management Plan (WMP).

During the development of this update to the WMP, an on-going drought event was in progress that had the potential to be more severe than droughts of similar duration and intensity contained in the historic period (1940-2009) used in the development and evaluation of this WMP update. Due to the intensity of this drought event, in October 2011, LCRA sought emergency relief from the TCEQ to deviate from the 2010 WMP with respect to the interruptible stored water

curtailment procedures for supply of the downstream irrigation operations. This WMP update now provides LCRA the express authority to deviate, consistent with the provisions of this Section, from the curtailment procedures set out in Section 4.3 without TCEQ approval, when specified extreme dry weather conditions exist. This deviation is intended to provide for quick, rational, adaptive responses to drought conditions that were not evaluated in the development of this updated WMP. This authorization does not include authority to deviate from aspects of the WMP other than the interruptible stored and run of river water curtailment procedures for the downstream irrigation operations. The circumstances and conditions under which this authority may be exercised are specified below.

The LCRA Board of Directors shall consider taking action, and may take action, after receiving and considering public comment, to deviate from the applicable interruptible stored and run of river water curtailment procedures for the downstream irrigation operations as described in Section 4.3 of this WMP (the "Standard Curtailment Procedures"), without seeking further TCEQ authorization, if each of the following Criteria for Potentially Deviating from the Standard Curtailment Procedures are met:

1. the inflow criteria for declaration of Drought Worse than the Drought of Record has been met;
2. the meteorological forecast from the National Oceanic Atmospheric Administration's National Weather Service for the period through the upcoming irrigation season forecasts below normal precipitation in the majority of the watershed above the Highland Lakes;
3. the drought duration criteria for declaration of a Drought Worse than the Drought of Record has been met or has a reasonable likelihood of being met before or during the upcoming irrigation season; and
4. the combined storage criteria for declaration of a Drought Worse than the Drought of Record has a reasonable likelihood of being met before or during the upcoming irrigation season.

For purposes of evaluating whether criteria 3 and 4, above, are met any projections shall be limited to a time-horizon of six months.

If the Board makes a finding that the Criteria for Potentially Deviating from the Standard Curtailment Procedures have been met, the Board may take action to deviate from such procedures and establish "Modified Curtailment Levels and Procedures" in accordance with the following provisions.

1. For first crop, the Board finding regarding the potential to deviate from the Standard Curtailment Procedures, and any action to establish Modified Curtailment Levels and Procedures for making water available shall occur no earlier than at the October Board meeting and no later than at the February Board meeting.
2. For second crop, the Board finding regarding the potential to deviate from the Standard Curtailment Procedures, and any action to establish Modified Curtailment Levels and Procedures for making water available shall occur no earlier than at the February Board meeting and no later than at the June Board meeting.
3. If the Board acts to establish Modified Curtailment Levels and Procedures:
    a. The Modified Curtailment Levels and Procedures shall make no more interruptible stored and run of river water available for use in the downstream

irrigation operations than would be made available under the applicable Standard Curtailment Procedures;

b. The Modified Curtailment Levels and Procedures may rely on combined storage in lakes Buchanan and Travis on a date no earlier than March 1 for purposes of determining the amount of interruptible stored and run of river water to be made available for first crop and a date no earlier than August 1 for purposes of determining the amount of interruptible stored and run of river water to be made available for second crop;

c. The Modified Curtailment Levels and Procedures shall include provisions for promptly reinstating the applicable Standard Curtailment Procedures or for responding to improved conditions;

d. Modified Curtailment Levels and Procedures shall only be in effect for the immediate upcoming crop season (first or second) after the Criteria are determined to be met. If the Board finds that criteria specified above for deviating from the curtailment procedures in Section 4.3 also are met prior to any subsequent crop season, the Board may take action at that time to deviate from the Standard Criteria and Procedures and establish Modified Curtailment Levels and Procedures for that subsequent crop season in accordance with this Section 4.4.1.

LCRA shall promptly inform TCEQ if it establishes Modified Curtailment Levels and Procedures pursuant to this Section and shall promptly reinstate the Standard Curtailment Procedures if the TCEQ issues an order directing LCRA to reinstate the Standard Curtailment Procedures.

4.4.2. Exceptions to standard allocation procedures for the Gulf Coast Irrigation Division under certain wet conditions

In the event of certain combined storage and wetter than normal weather forecast conditions, LCRA may allocate an additional amount of run-of-river water to the Gulf Coast Irrigation Division over and above the amount described in Section 4.3.4. The LCRA Board of Directors shall consider taking action, and may take action, after receiving and considering public comment, to deviate from the amount of run-of-river water assumed to be available in the allocation procedures for the Gulf Coast Irrigation Division as described in Section 4.3.4 without further TCEQ action subject to the following conditions and limitations:

1. The Board must find that the meteorological forecast from the National Oceanic Atmospheric Administration's National Weather Service for the upcoming irrigation season forecasts above normal precipitation in the majority of the Lower Colorado River basin including the watershed above and below the Highland Lakes.
2. The Board finding regarding the potential to allocate additional run-of-river water for the Gulf Coast Irrigation Division and any action to allocate such additional water shall occur no earlier than at the January Board meeting and no later than at the March Board meeting and will be based on one of the following conditions:
    a. If the combined storage on March 1 is below 1.4 million acre-feet, no additional water shall be allocated to the Gulf Coast Irrigation Division.
    b. If the combined storage on March 1 is between 1.4 million acre-feet and 1.75 million acre-feet:

i. If the interim curtailment procedures are in effect, the Board may allocate up to 10,000 acre-feet of additional run-of-river to the Gulf Coast Irrigation Division during the first crop season in addition to the amount described in Section 4.3.4; and

ii. If the year 2020 curtailment procedures are in effect, no additional run-of-river water shall be allocated.

c. If the combined storage on March 1 is above 1.75 million acre-feet, the Board may allocate up to 25,000 acre-feet of additional run-of-river to the Gulf Coast Irrigation Division during the first crop season in addition to the amount described in Section 4.3.4.

3. If, for a crop season in which the allocation was increased based upon provision 2 b or c above, the total diversions of interruptible stored water at the Gulf Coast Irrigation Division exceed the interruptible stored water allocation for that season as determined under Section 4.3.3, as a result of application of provision 2 b or c above, then water made available to the Gulf Coast Irrigation Division in the subsequent year will be reduced. Specifically, not later than during the first crop irrigation season in the next year in which interruptible stored water is available, the allocation of interruptible stored water to the Gulf Coast Irrigation Operation shall be reduced by the amount of excess interruptible stored water diversion provided in the prior year in accordance with provision 2 b or c above (water taken out of storage or storable inflows). If the combined storage in lakes Buchanan and Travis has been at its full capacity as described in Section 4.8 since the excess diversions of interruptible stored water occurred, then no reduction in interruptible stored shall occur in the following first crop season.
4. Notwithstanding this Section 4.4.2, the annual cap on interruptible stored water for contracting as described in Section 4.2.2.2 still applies.
5. The additional allocation of run-of-river water shall only be in effect for the immediate upcoming first crop season for which the conditions and limitations are determined to be met. If the Board finds the conditions and limitations for deviating from the allocation procedures in Section 4.3.4 also are met prior to any subsequent first crop season, the Board may take action at that time to deviate from allocation procedures for that crop season.

4.5. CURTAILMENT PROCEDURES FOR ENVIRONMENTAL FLOWS IN LOWER COLORADO RIVER BASIN

4.5.1. Helping meet environmental flow needs with firm and interruptible stored water

Under this WMP, as in past WMPs, a combination of firm and interruptible stored water is provided to help meet environmental flow needs. LCRA has previously set aside 33,440 acre-feet per year of its firm supply from lakes Buchanan and Travis for environmental flow purposes. No increase in that amount is included in this WMP. In the event of a pro rata curtailment of firm water supplies, the applicable instream flow and bay and estuary inflow criteria will be subject to the same percentage reduction as is imposed on LCRA's firm water customers.

This WMP reflects improvements to the operational procedures that will be used to help meet these needs based on more recent scientific studies. The applicable environmental flow criteria under this WMP can change during the year, similar to the determination of agricultural water based on separate dates for first crop and for second crop. The environmental flow criteria in place from March through June are based on the combined storage on Jan. 1, and the environmental flow criteria in place from July through the following February are based on the combined storage on June 1. This represents a change from prior WMPs in which the environmental flow criteria for the entire year were based on Jan. 1 combined storage. Other modifications to the manner in which water for environmental purposes is provided and tracked are set forth in more detail below.

4.5.2. Curtailment of water for instream flows

This WMP revision includes up to three levels of instream flow ~~targets~~criteria, located at four streamflow gauging station locations (Austin, Bastrop, Columbus and Wharton) as first presented in Table 2-4 and repeated here as Table 4-3. For this WMP revision, the Wharton gauge location has been added. Additionally, levels of instream flows have changed from "critical" and "target" to "Subsistence," "Base-Dry" and "Base-Average" based upon recent studies.

When providing water under this WMP to help meet instream flows, the water available to meet Base-Average and Base-Dry is limited to the storable inflows to lakes Buchanan and Travis. In addition to storable inflows, previously stored water will be released as necessary to maintain Subsistence flows. Tables 4-4 and 4-5 present the applicable instream flow criteria based on combined storage in lakes Buchanan and Travis for the interim and 2020 demand phases, respectively. In the event of a pro rata curtailment of firm supplies, the applicable instream flow criteria will be subject to the same percentage reduction as imposed on LCRA's firm water customers.

Table 4-3. Subsistence and Base Flow ~~Recommendations~~ Criteria by Gauge (cubic feet per second)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Austin												
Subsistence	50	50	50	50	50	50	50	50	50	50	50	50
Bastrop												
Subsistence	208	274	274	184	275	202	137	123	123	127	180	186
Base-Dry	313	317	274	287	579	418	347	194	236	245	283	311
Base- Average	433	497	497	635	824	733	610	381	423	433	424	450
Columbus												
Subsistence	340	375	375	299	425	534	342	190	279	190	202	301
Base-Dry	487	590	525	554	966	967	570	310	405	356	480	464
Base-Average	828	895	1,020	977	1,316	1,440	895	516	610	741	755	737
Wharton												
Subsistence	315	303	204	270	304	371	212	107	188	147	173	202
Base-Dry	492	597	531	561	985	984	577	314	410	360	486	470
Base-Average	838	906	1,036	1,011	1,397	1,512	906	522	617	749	764	746

Table 4-4. Instream Flow Triggers and Flow Levels for Interim and 2020 Demand Phases

When Combined Storage is…	On this date…	Instream Flow Level
Above 1.96 MAF	Jan. 1 or June 1	Base-Average
Between 1.90 and 1.96 MAF	Jan. 1 or June 1	Base-Dry
Less than 1.90 MAF	Jan. 1 or June 1	Subsistence

For purposes of this WMP revision, the Subsistence and Base Flow ~~targets~~ criteria for gauges other than the Austin gauge, are daily (or daily average) flow ~~targets~~values. The Subsistence ~~target~~ criteria at Austin ~~is a~~represent minimum (or instantaneous) flow requirements. Furthermore, for the Bastrop gauge, the following minimum flow requirements apply:

- During those times when Base-Average criteria are in effect, the minimum (or instantaneous) flow requirements, subject to availability of storable inflows, ~~and inflows are sufficient to meet Base-Average at Bastrop on a daily average basis, the minimum flow criteria~~ shall be 70 percent of the Base-~~Dry~~ Average criteria for the given month.
- During those times when Base-Dry criteria are in effect, the minimum (or instantaneous) flow requirements, subject to availability of storable ~~and~~ inflows ~~are sufficient to meet Base-Dry at Bastrop on a daily average basis, the minimum flow criteria~~ shall be ~~the Subsistence~~ 70 percent of the Base-Dry criteria for the given month.
- During those times that Subsistence criteria are in effect, releases shall be scheduled such that the minimum flow does not drop below:
  a. ~~7~~90 percent of Subsistence criteria when combined storage is equal to or greater than 1.4 million acre-feet; or

~~a.~~b. 80 percent of Subsistence criteria when combined storage is less than 1.4 million acre-feet.

In order to help meet the instream flow ~~targets~~ criteria in the lower Colorado River, LCRA will schedule releases of inflows in amounts sufficient to meet the applicable ~~targets~~criteria, to the extent of storable inflows or, for Subsistence, using previously stored water. In scheduling releases, LCRA will rely on best available data sources, including but not limited to: measurements of rainfall and water levels in streams and reservoirs; flow ratings for streams, canals, hydroelectric turbines, spillways, floodgates, and pumps; elevation/area/capacity ratings for reservoirs; model results for predicted storm runoff and ungauged gains or losses of flow along the Colorado River; simulated routing and attenuation of flows along channels and through reservoirs; effluent discharge as reported by wastewater treatment plant operators, and; scheduled and actual pumping as reported by major diverters.

By scheduling releases in this manner, LCRA will meet its obligation under the Water Management Plan. In rare instances, LCRA's ability to meet the flow ~~targets~~criteria, despite reasonable efforts to do so, may be impaired by unavoidable constraints such as unforeseen diversions, unforeseen changes in flow conditions downstream, unforeseen or unscheduled operations at Longhorn Dam, and adjustments to gauges or flow ratings. LCRA shall operate in such a manner that flows at any applicable gauge do not deviate below the applicable ~~targets~~ criteria for that gauge on more than 18 days in any calendar year. Furthermore, to the extent that the deviation is a result of inaccuracies in LCRA's estimates of downstream diversions by LCRA operations, downstream contributing inflows, downstream return flows, or the effects of routing and attenuation as releases pass downstream, the collective impact of such constraints may not be relied upon to excuse a deviation of more than a 15 percent ~~or 50 cfs, whichever is greater,~~ below applicable criteria~~targets~~ on any individual day ~~or a deviation of more than 15 percent below applicable minimum (or instantaneous) requirements at the Austin and Bastrop gauges~~. In the event that the deviation is caused by events outside of LCRA's reasonable control – such as operations at Longhorn Dam, ERCOT requirements, a change in rating at a gauge, or diversions by others that could not reasonably have been predicted by LCRA – such deviation is not subject to the 15 percent ~~or 50 cfs~~ limitation and shall not count towards the number of calendar days in which a deviation occurred. Furthermore, in the event of flow data that indicate a deviation has occurred, and after inspection of relevant data and/or the gauge itself to determine the reasonableness of such data, if LCRA determines that the flow data ~~was~~ were inaccurate and that the actual flow rate was above the applicable threshold requirement, the event shall not be deemed to be a deviation. Additionally, in the event that storable inflows are sufficient to meet a Base-Average~~Flow~~ or Base-Dry flow ~~target~~ criterion for a given day, but not a consecutive day, or that applicable ~~targets~~ criteria change on the first day of a month, compliance with applicable ~~targets~~ criteria at gauges where the time to deliver water from Miller Dam to such gauge is not an even multiple of 24-hours may be determined over continuous 24-hour periods other than midnight-to-midnight. In the event of an impairment on an individual day or days, LCRA will schedule releases over the subsequent days to ensure that the average flow for any consecutive 10-day period that begins with the day of any such impairment does not fall below the applicable instream flow ~~target~~criterion, subject to the availability of storable inflows, or for Subsistence, the availability of a combination of storable inflows and previously stored water.

Although LCRA will not manage water in the lower basin to specifically provide for pulse flows as part of this WMP, LCRA will monitor pulse flows in the lower river basin during the time period when this WMP update is in effect in order to help assess whether pulse flows are occurring with the frequency recommended in the 2008 comprehensive instream flow study.

4.5.3. Curtailment of water for freshwater inflows to Matagorda Bay

The 2010 WMP included three levels (critical, intermediate and target) of freshwater inflow criteria. This WMP includes five levels based upon the Matagorda Bay Health Evaluation (MBHE) study.

For purposes of this WMP, new "Operational Criteria" have been developed to ~~help~~ guide implementation aimed at helping to meet the range of freshwater inflow needs from the Colorado River ~~associated with~~identified in the MBHE study. Instead of the monthly requirement that has been used in prior WMPs, the MBHE three-month "spring" and "fall" and six-month "intervening" flow totals for a given inflow category have been converted into equivalent two-month Operational Criteria (OP 1-4) as first presented in Table 2-8 and repeated here in Table 4-5. (See Section 2.4.2 for further explanation of these criteria.) At the end of each month, to the extent that storable inflows are available, such inflows will be provided as necessary to meet the two-month Operational Criteria. In all months, at least the "Threshold" level of 15,000 acre-feet per month will ~~also~~ be provided to the extent of storable inflows. In the event of a pro rata curtailment of firm supplies, the applicable inflow criteria (including the Threshold criteria) will be subject to the same percentage reduction as imposed on LCRA's firm water customers.

Table 4-5. Operational Criteria for Colorado River Inflows to Matagorda Bay

Inflow Category	Two-Month Operational Criteria (ac-ft) applicable in the individual months			Monthly (ac-ft)
	Spring March-June	Fall July-Oct	Intervening Nov-Feb	-
OP-4	289,000	205,000	133,000	-
OP-3	164,000	117,000	76,000	-
OP-2	112,000	80,000	52,000	-
OP-1	76,000	54,000	35,000	-
Threshold	-	-	-	15,000

When providing water under this WMP to help meet freshwater inflow needs, the water available will be limited to the storable inflows to lakes Buchanan and Travis. Tables 4-6 and 4-7 present the applicable freshwater inflow criteria based on combined storage in lakes Buchanan and Travis for the interim and 2020 demand phases, respectively.

Table 4-6. Interim Demand Phase Freshwater Inflow Triggers and Flow Levels

When Combined Storage is…	On this date…	Freshwater Inflow Criteria
Greater than 1.95 MAF	Jan. 1 or June 1	OP – 4
Less than 1.95 MAF	Jan. 1 or June 1	OP – 3
Less than 1.50 MAF	Jan. 1 or June 1	OP – 2
Less than 1.30 MAF	Jan. 1 or June 1	OP – 1
Less than 1.00 MAF	Jan. 1 or June 1	Threshold Only

Table 4-7. 2020 Demand Phase Freshwater Inflow Triggers and Flow Levels

When Combined Storage is…	On this date…	Freshwater Inflow Criteria
Greater than 1.95 MAF	Jan. 1 or June 1	OP – 4
Less than 1.95 MAF	Jan. 1 or June 1	OP – 3
Less than 1.80 MAF	Jan. 1 or June 1	OP – 2
Less than 1.70 MAF	Jan. 1 or June 1	OP – 1
Less than 1.00 MAF	Jan. 1 or June 1	Threshold Only

4.6. CURTAILMENT PROCEDURES FOR INTERRUPTIBLE STORED WATER DEMANDS OTHER THAN THE DOWNSTREAM IRRIGATION OPERATIONS

LCRA will limit additional sales or commitments of interruptible stored water, other than for the four downstream irrigation operations, based on the combined volume of water in lakes Buchanan and Travis at certain times of the year. Sales of water in this category will be limited to not more than a combined total of 4,000 acre-feet per year as follows:

- If combined storage on Jan. 1 is greater than 1.9 MAF, up to 2,000 acre-feet will be made available for the period from Jan. 1 through June 30.
- If combined storage on June 1 is greater than 1.9 MAF, up to 2,000 acre-feet will be made available for the period from July 1 through Dec. 31.

Within two weeks of the Jan. 1 and June 1 trigger dates, the LCRA General Manager will notify, in writing, each holder of a contract under this provision of the availability of supply for the six months following the trigger dates.

LCRA will not enter into any new contracts or extend any existing contracts for this category of water sales for a term beyond Dec. 31, 2018. As of Jan. 1, 2019, this category of water supply will be eliminated.

4.7. CURTAILMENT OF FIRM WATER DEMANDS

4.7.1. Introduction

Pursuant to its water rights for lakes Buchanan and Travis, LCRA must follow water supply allocation procedures to ensure that there is sufficient stored water to meet firm demands during a repeat of the Drought of Record. This WMP revision includes procedures intended to ensure

that firm demands can be met without shortage through year 2020 under a repeat of the Drought of Record.

LCRA cannot determine with absolute certainty whether a particular drought event will be more or less severe than the Drought of Record until the event has concluded. Therefore, LCRA will engage its firm customers and seek voluntary reductions of firm demands from its customers in the early stages of a drought, as more specifically described below.

Consistent with state law, LCRA cannot invoke mandatory curtailments of firm water demand unless a particular drought is declared to be a Drought Worse than the Drought of Record, or some other water emergency exists that drastically reduces the available firm water supply. LCRA has developed a "drought monitoring procedure" for identifying when a drought may become worse than the Drought of Record for the Highland Lakes watershed. (See Section 4.8.)

4.7.2. LCRA drought response measures for firm water demands, including firm commitments for environmental flows

LCRA's drought response measures for firm water demands are as follows:

- LCRA will encourage its firm water customers to implement long-term water conservation measures year-round to meet the goals included in their water conservation plans. LCRA will, as needed, implement a public awareness program on water use and conservation.
- Drought Contingency Plan, Stage 1. If the total combined storage in lakes Buchanan and Travis drops below 1.4 MAF and interruptible stored water supplies to the irrigation operations are being curtailed, LCRA will request its firm water customers to implement drought response measures in their individual drought contingency plans with a target demand reduction goal of 5 percent. In this stage, at a minimum, firm water customers should implement voluntary drought response measures. If the combined storage in lakes Buchanan and Travis subsequently increases, the request will be withdrawn on a schedule determined by the LCRA Board.
- Drought Contingency Plan, Stage 2. If the total combined storage in lakes Buchanan and Travis drops below 900,000 acre-feet and interruptible stored water supplies to the irrigation operations are being curtailed, LCRA will request its firm customers to implement additional drought response measures in their individual drought contingency plans with a target demand reduction goal of 10 to 20 percent. In this stage, firm customers should implement mandatory water use reduction measures. At this stage LCRA will also implement an aggressive public information campaign to provide up-to-date information on water supply conditions and promote voluntary action to reduce water use. If the combined storage in lakes Buchanan and Travis subsequently increases, the request will be withdrawn or replaced by Stage 1 measures on a schedule determined by the LCRA Board.
- Drought Contingency Plan, Stage 3. If the LCRA Board of Directors declares a Drought Worse than the Drought of Record, LCRA will curtail and distribute the available supply of stored water among its firm water supply customers and firm environmental flow

commitments on a pro rata basis according to the amount of stored water to which they are legally entitled consistent with the Pro Rata Plan for Firm Water Demands previously approved by TCEQ. (See Appendix C-7.) All uses of interruptible stored water will be cut off prior to and during any mandatory pro rata curtailment of firm water supplies. The initial curtailment of firm demands under pro rata will be 20 percent, unless the LCRA Board determines an alternative percentage reduction prior to or at the time of a declaration of Drought Worse than Drought of Record. LCRA's firm water contract rules[5] include specific procedures and requirements related to a pro rata curtailment of firm demands. If the combined storage in lakes Buchanan and Travis continues to decrease after the declaration of a Drought Worse than Drought of Record, the LCRA Board may increase the mandatory pro rata curtailment percentage. In the event that a declaration of a Drought Worse than Drought of Record is cancelled, a mandatory pro rata curtailment would be lifted. The LCRA Board may also set additional criteria for ending or easing pro rata curtailment, such as combined storage increasing to a given level.

4.7.3. Monitoring and enforcement

LCRA will monitor firm customers' compliance with LCRA's Drought Contingency Plan requirements. Monitoring and enforcement of water-use restrictions at the end-user level generally will be the customers' responsibility. Customers who exceed their allotted supply during a pro rata curtailment will be subject to excess use rates or surcharges, to be specified by the LCRA Board, in addition to LCRA's firm water rate.

4.7.4. Variances to firm water pro rata curtailment

LCRA's General Manager may, in writing, grant a temporary variance to the pro rata water allocation requirement in Section 4.7.2 if it is determined that failure to grant such a variance would cause an emergency condition adversely affecting the public health, welfare or safety, and if one or more of the following conditions are met:

1) Compliance with the requirement cannot be technically accomplished during the duration of the water supply shortage or other condition for which the plan is in effect; and/or
2) Alternative methods can be implemented that will achieve the same level of reduction in water use.

Details regarding the procedures by which a customer may seek a variance are found in LCRA's firm water contract rules.

In addition, LCRA's General Manager may, in writing, grant a temporary variance to the pro rata curtailment of water supplied to meet environmental flow criteria under sections 4.5.2 and 4.5.3 if the Texas Parks and Wildlife Department submits a written variance request, and the General Manager determines that a variance is justified in order to avoid severe adverse biological conditions and/or that a variance would not result in an increase in the amount of water made available for environmental flows during the curtailment.

4.7.5. Firm customer drought contingency plans

As part of its contracts, LCRA will continue to require its firm water customers to prepare and adopt a legally enforceable local drought contingency plan that specifies the actions to be taken to comply with this Drought Contingency Plan regarding the curtailment of firm supplies. Such plans should be developed pursuant to LCRA guidelines and submitted for LCRA review and acceptance within a reasonable time.

4.7.6. Notification of TCEQ Executive Director

The LCRA General Manager will notify the TCEQ Executive Director of implementation of any mandatory provisions related to the supply of firm water.

4.8. DECLARATION AND CANCELLATION OF DROUGHT WORSE THAN DROUGHT OF RECORD

As discussed above, the WMP is designed so that LCRA can meet all firm demands through a repeat of the Drought of Record. If drought conditions reach a stage where an ongoing drought has a real likelihood of becoming a new Drought of Record, LCRA must cut off interruptible stored water and curtail firm demands to extend the supply for critical human needs. To measurably extend the supply, LCRA may need to take these actions before it is determined with absolute certainty that the drought is indeed a new Drought of Record. This section presents the conditions under which LCRA will respond to a severe drought by making a declaration of Drought Worse than Drought of Record (DWDOR). A DWDOR declaration would trigger action to cut off interruptible stored water and implement mandatory pro rata curtailment of firm demands. The criteria for making a DWDOR declaration represent circumstances that have not ~~occurred in~~been recorded during the historic period used in developing this WMP. However, even if the criteria are satisfied, there is still a possibility that the drought would not be a new Drought of Record. Thus, the declaration of a Drought Worse than Drought of Record is actually a declaration that a particular drought is *potentially* worse than the Drought of Record and warrants more significant response measures.

The LCRA Board of Directors will make a Drought Worse than Drought of Record declaration when the following three conditions are simultaneously met:

1. Drought duration of at least 24 consecutive months; and
2. Drought intensity greater than that of the Drought of Record as measured by inflows into the Highland Lakes; and
3. The combined storage in lakes Buchanan and Travis is less than 600,000 acre-feet.

Additionally, the LCRA Board of Directors will declare a DWDOR when a drought's duration is at least 10 years and the combined storage in lakes Buchanan and Travis is less than 600,000 acre-feet.

For purposes of measuring drought duration, the beginning of the drought is based on the last time lakes Buchanan and Travis were both full. For purposes of this declaration, full is defined when either of the following criteria is met:

- Combined storage is at or above 98 percent of the combined managed conservation storage. This managed conservation storage may vary based on seasonal operational guidelines or other constraints on storage; or
- Lakes Buchanan and Travis have each been at their respective managed conservation storage capacity within 30 days of each other.

For purposes of measuring drought intensity relative to the Drought of Record, the cumulative inflows since the beginning of the drought will be compared to a Drought of Record inflow envelope curve that reflects the cumulative inflows in the critical periods of the Drought of Record. The envelope curve consists of a uniform slope of 56,798 acre-feet per month for the first 62 months of the drought and a slope of 73,241 acre-feet per month for the remainder of the drought.

LCRA will cancel a DWDOR declaration if combined storage increases to 900,000 acre-feet or other cancellation criteria as established by the LCRA Board upon declaration of a DWDOR are met.

See Technical Paper A-6 found in Appendix A for additional information regarding the evaluations of historic period (1940-2009) droughts for comparisons to the Drought of Record.

4.9. ~~IMPACTS~~ RESULTS OF THE RECOMMENDED CURTAILMENT POLICIES UNDER THIS WMP

This section summarizes potential impacts of this WMP revision on various interests based on modeling simulations. It also provides comparisons to simulations of the 2010 WMP. It should be noted that the specific values presented in this section are based on model simulations that include many assumptions, including a repeat of historic hydrologic conditions through 2009. Actual observed conditions while this plan is in effect may vary.

4.9.1. Firm water customers

All projected interim phase and 2020 level demands for firm water customers can be fully satisfied under a simulated repeat of hydrologic conditions during the historic period of 1940-2009, including during the Drought of Record and during short-term intense droughts experienced in recent decades. The minimum storage in the model simulations for this WMP revision was maintained in a range of 3~~7~~50,000 to 4~~0~~20,000 acre-feet, which represents an increase in the safety factor from 200,000 acre-feet in previous WMPs. This safety factor is intended to allow for one year of firm demands to be met under continued severe drought conditions. The largest firm water demand is for the City of Austin. In most years of the simulations, the majority of Austin's projected annual demand in 2020 of 203,880 acre-feet is met from run-of-river flows (about 93 percent on average) diverted under its senior water rights. Approximately 82 percent of the demand during the critical drought years in the 1947-1957 is

estimated to be supplied by these flows with the remainder supplied by firm stored water. These percentages could change in the future based on the availability of run-of-river flows in the watershed above Austin's diversion points.

4.9.2. Agricultural customers in downstream irrigation operations

With the increase in projected firm water needs for 2020, there is less interruptible stored water supply from lakes Buchanan and Travis because firm water needs take priority over interruptible stored water uses. To avoid shortages to firm water users under this WMP, LCRA will reduce the availability of interruptible stored water supplies from lakes Buchanan and Travis as compared to what is available under the WMP approved in 2010. This reduction in supplies primarily impacts agriculture (irrigation).

This WMP revision includes curtailment procedures with various elements (such as the separate evaluation of supply for first and second crop, and a higher trigger for providing full supply) that are more restrictive on the supply of interruptible stored water for the downstream irrigation operations than the procedures in the 2010 WMP. ~~As a result of these more restrictive curtailment procedures in place f~~For the 2020 demand phase~~ under this WMP~~, the average percent of time that the projected full annual (first and ratoon crops) agricultural demands in the four downstream irrigation operations can be met is reduced from 98 percent (2010) to 88 percent (2020) over the simulation of the historic period (1940-2009) evaluated. The 2010 WMP provides sufficient supplemental stored water from lakes Buchanan and Travis to meet ~~100~~ full ~~percent of~~ first crop demands in 100 percent of the years in the simulation period and can meet full second crop demands in 8~~1~~3 percent of ~~second crop demands~~ the years in same period~~ over the simulation of the 1940-2009 evaluation period~~. Under this WMP revision those percentages are reduced to 73 percent and 61 percent, respectively, over the same evaluation period for the 2020 demand phase.

Agricultural users in the four downstream irrigation operations would be most affected during a repeat of the 10-year Drought of Record. In that period, the modeling analysis of the 2020 demand phase indicates that no interruptible stored water would be available for first crop in ~~three~~ four of the 10 years and no interruptible stored water would be available for second crop in ~~seven~~ four of the 10 years.

Of course, as noted previously, the actual interruptible stored water curtailments may differ from the values reflected in this simulation, depending on factors such as future hydrologic conditions and actual demands associated with firm and interruptible users.

4.9.3. Environmental flows

Under simulations of this WMP revision, roughly the same amount of total stored water (firm and interruptible) will be made available specifically for environmental flow purposes as under the simulations of the 2010 WMP. During a repeat of the Drought of Record, simulations indicate that an annual average of about ~~46,187~~47,100~~089~~ acre-feet would be provided specifically for instream flows and Matagorda Bay under the 2020 curtailment procedures compared to about 42,60~~01~~ acre-feet under the 2010 WMP.

During the simulated repeat of the Drought of Record, there will be more curtailments and cutoffs of interruptible stored water under this WMP. As a result, less water would be flowing in the lower Colorado River to meet downstream agricultural demands, which means less of that water is available to help meet environmental flow needs. Thus, dedicated releases for environmental flows are needed on a more frequent basis under simulations of this WMP revision. Furthermore, although the total amount of stored water specifically made available for environmental flow purposes is roughly the same for this WMP as the 2010 WMP, the average flow in the lower Colorado River and the average flow reaching Matagorda Bay is reduced as compared to the 2010 WMP. For a simulated repeat of the Drought of Record, the average annual flow of the Colorado River at Bay City is about ~~696~~692,~~0~~200 acre-feet under the 2020 curtailment procedures, compared to 766,~~0~~200 acre-feet under the 2010 WMP. For a repeat of the 1940-2009 evaluation period, the simulated annual flow at Bay City averages about 1.565~~6~~ million acre-feet under the 2020 curtailment procedures. This flow consists of dedicated releases of storable inflows to lakes Buchanan and Travis to help meet the range of freshwater inflow needs, dedicated releases to help meet a range of instream flow needs at several gauging locations below Longhorn Dam, releases made for downstream agricultural demands that were not diverted, and runoff originating below Lake Travis.

As mentioned in Section 4.5.1, LCRA is not recommending any changes to the level of firm commitment for environmental flows as part of this WMP. The current total firm water allocation of 33,440 acre-feet for environmental flow purposes represents about 8 percent of the total firm supply available from lakes Buchanan and Travis.

4.9.4. Lake storage levels

The simulated lake water surface elevations and storage levels for each demand phase (Interim and 2020) are shown in Figures 4-3 through 4-6, for lakes Buchanan and Travis. The average lake water surface levels under the WAM simulations of the full historic period of 1940-2009 with the 2010 WMP are about 1013 feet msl on Lake Buchanan and 662 feet msl on Lake Travis. For comparison, the average lake water surface levels during the same simulation period (1940-2009) using the interim and 2020 curtailment procedures would be lower:

- Interim - about 1,012 feet msl on Lake Buchanan and 660 feet msl on Lake Travis; and
- 2020 ~~at~~ about 1,012 feet msl on Lake Buchanan and 659 feet msl on Lake Travis.

The average lake water surface elevations using the interim and 2020 curtailment procedures as compared to the 2010 WMP during the drought of record period hydrology of 1946-1957 are:

- 2010 WMP - about 1003 feet msl on Lake Buchanan and 634 feet msl on Lake Travis;
- Interim - about 1004 feet msl on Lake Buchanan and 633 feet msl on Lake Travis; and
- 2020 - about ~~1,004~~1003 feet msl on Lake Buchanan, and ~~631~~628 feet msl on Lake Travis.

The minimum lake surface levels simulated using the interim and 2020 curtailment procedures as compared to the 2010 WMP during the drought of record period hydrology of 1946-1957 are:

- 2010 WMP - about 967 feet msl on Lake Buchanan and 551 feet msl on Lake Travis;
- Interim - about 986 feet msl on Lake Buchanan and 577 feet msl on Lake Travis; and

- 2020 - about ~~984~~ 982 feet msl on Lake Buchanan, and ~~574~~ 571 feet msl on Lake Travis.

Figure 4-3: Simulated Water Surface Levels and Storage for Lake Buchanan: Interim WAM

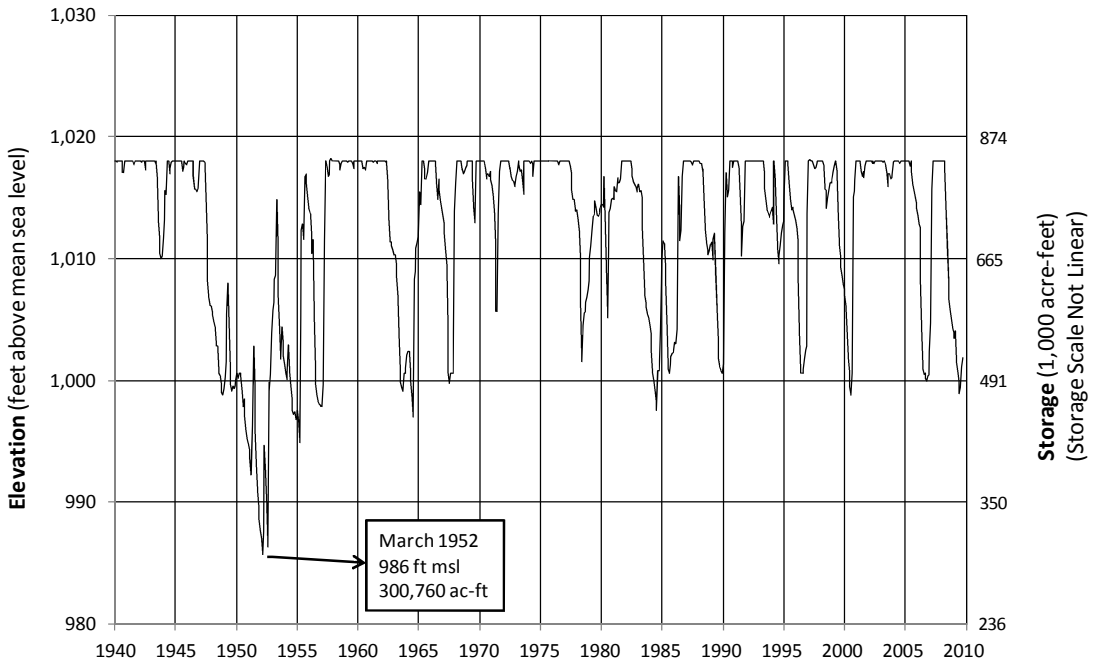


Figure 4-4: Simulated Water Surface Levels and Storage for Lake Travis: Interim WAM

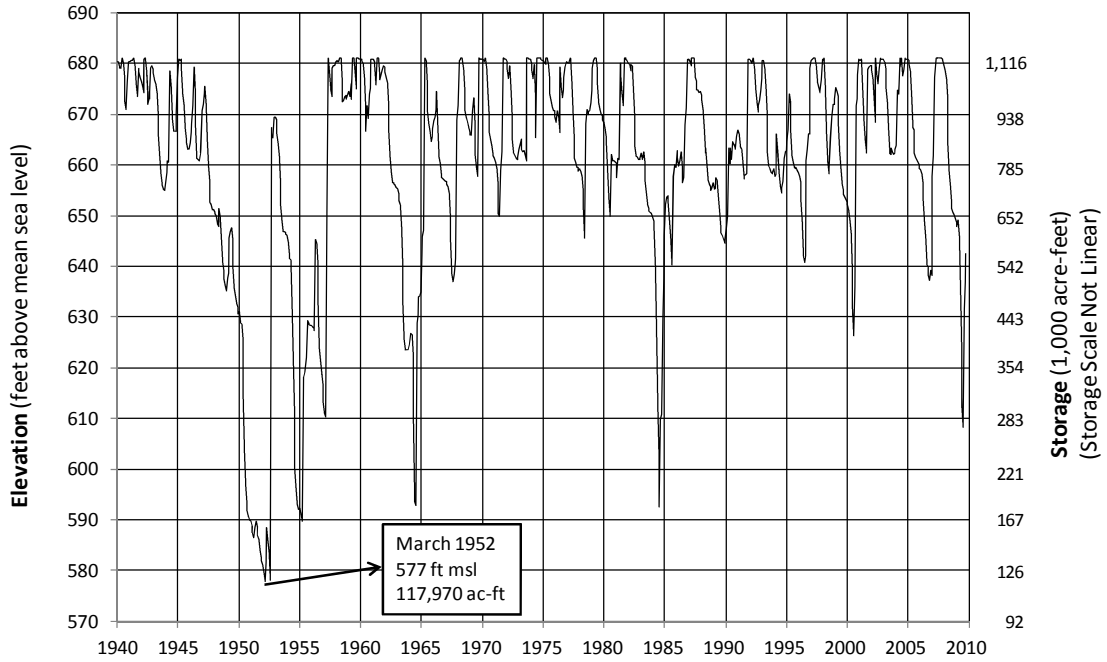
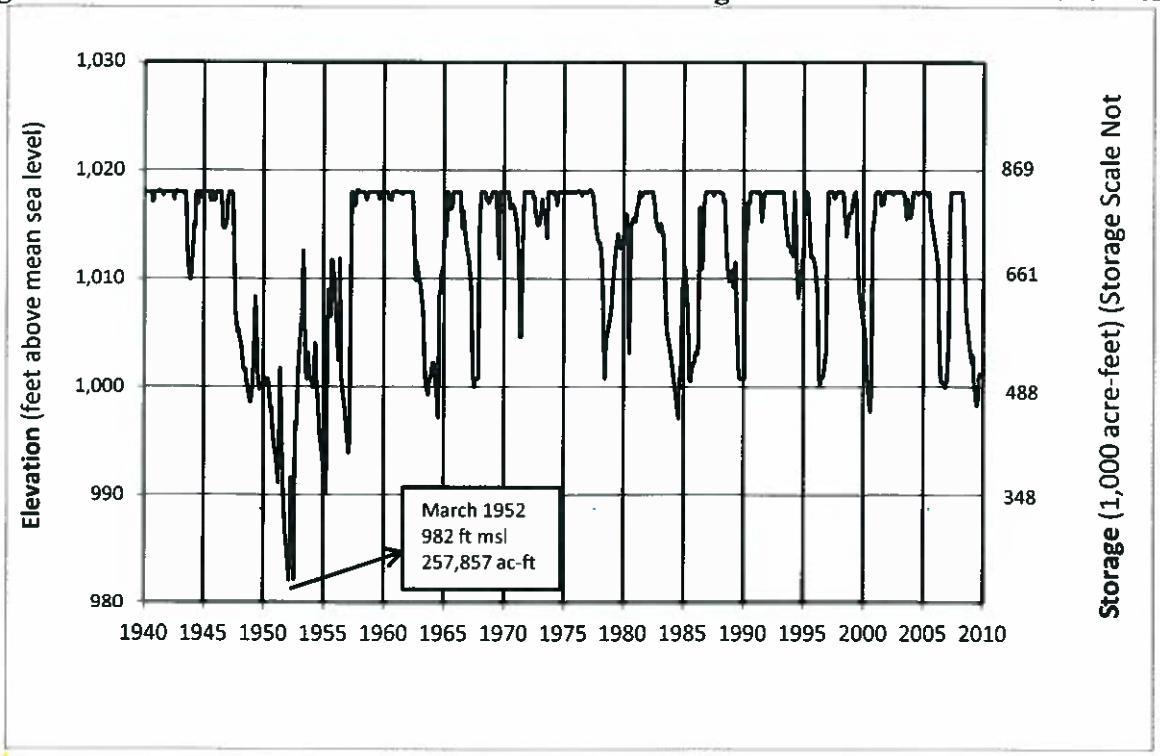


Figure 4-5: Simulated Water Surface Levels and Storage for Lake Buchanan: 2020 WAM



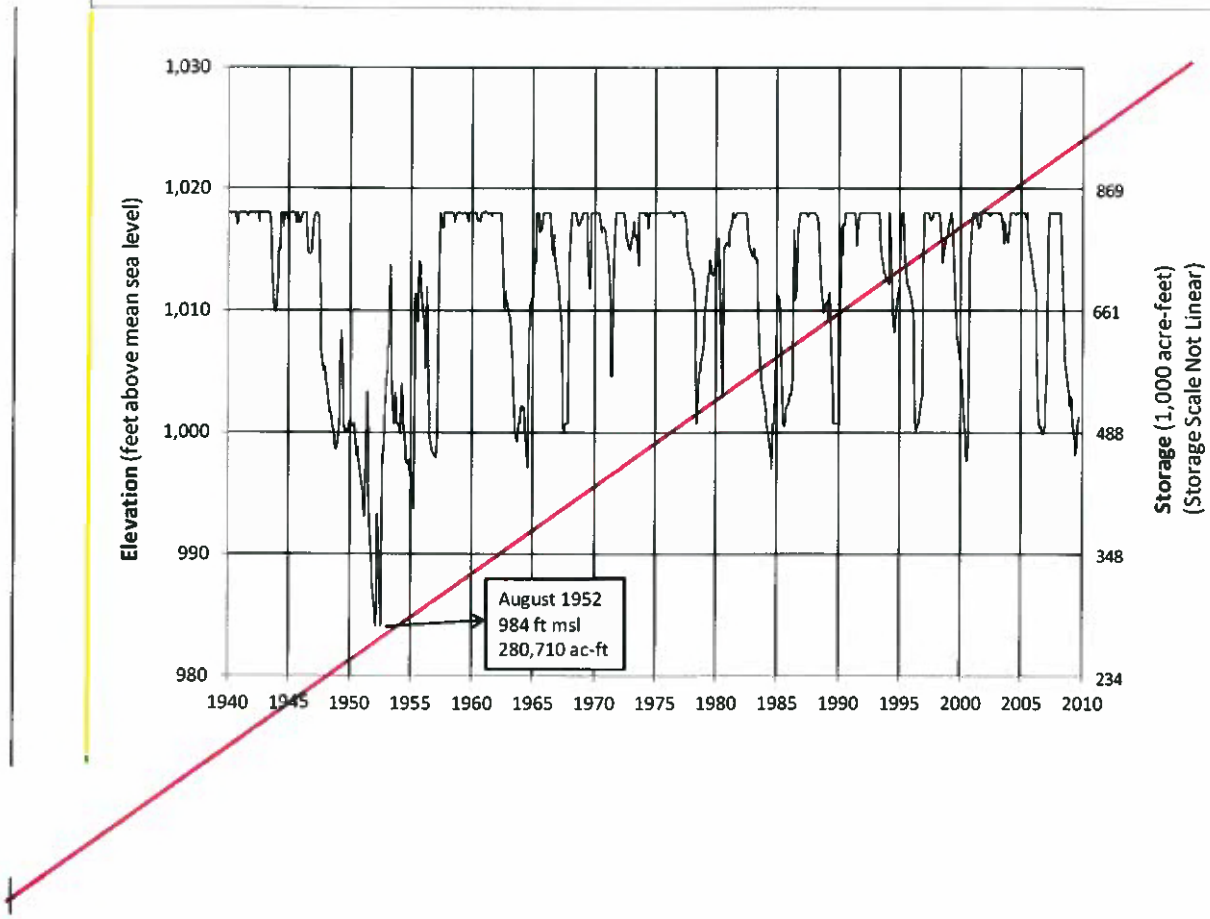
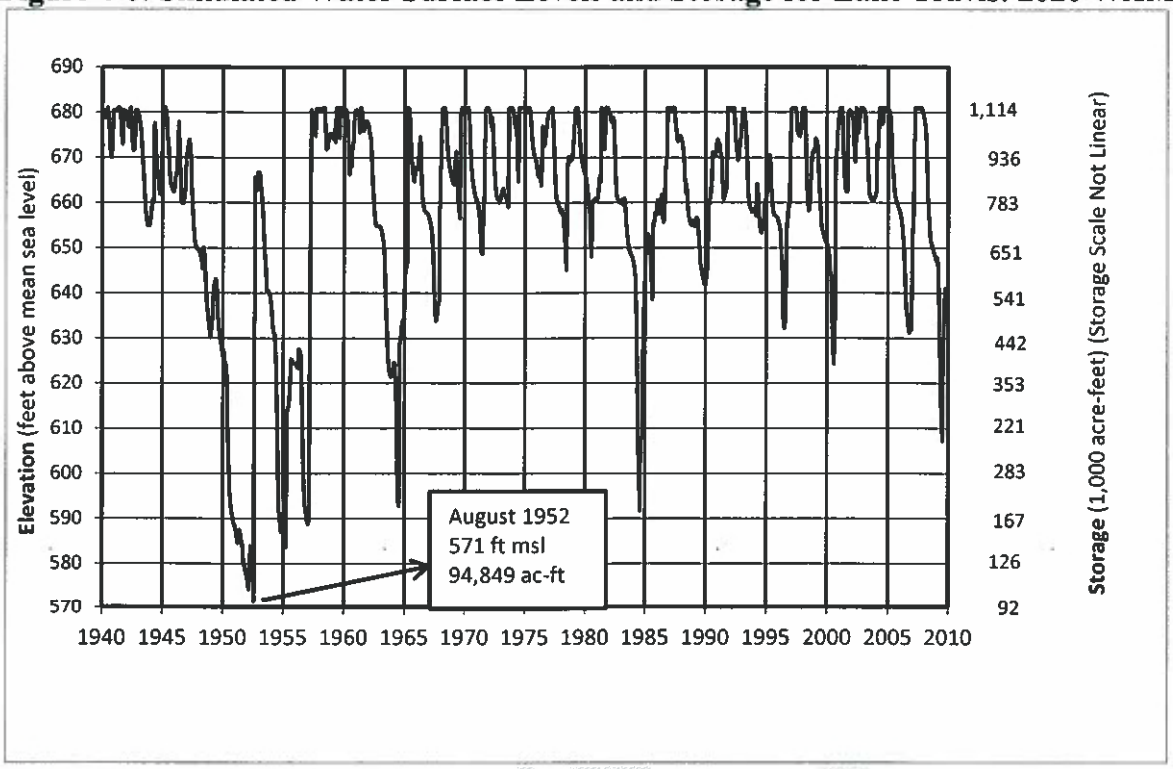
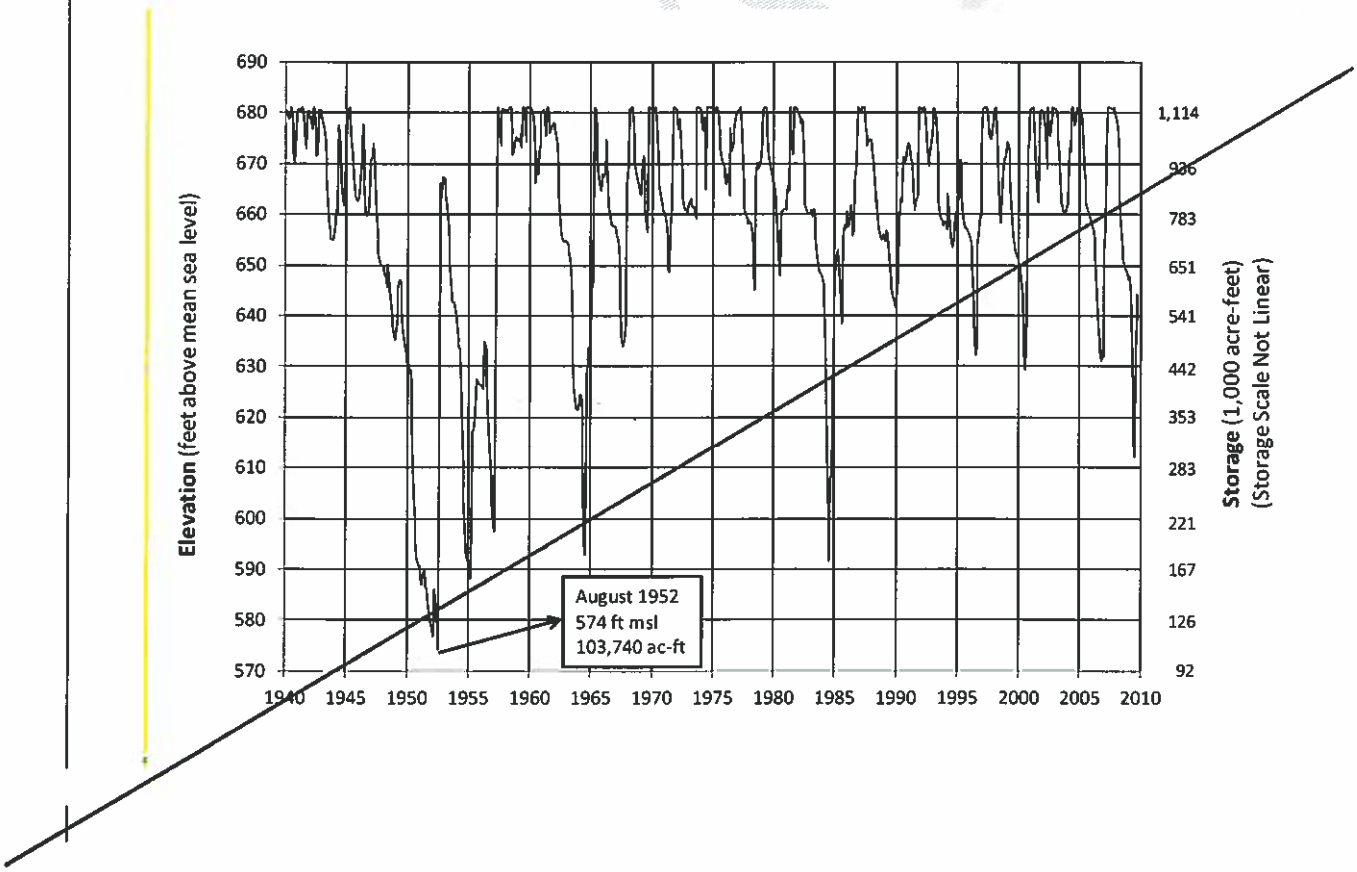


Figure 4-6: Simulated Water Surface Levels and Storage for Lake Travis: 2020 WAM





4.10 DROUGHT CONTINGENCY PLAN UPDATES

This chapter of the Water Management Plan incorporates LCRA's Drought Contingency Plans (DCPs) for its firm water customers, environmental flow needs, downstream irrigation operations and other interruptible stored water customers.

This chapter consists of Water Management Plan and Drought Contingency Plan elements. Elements of the Water Management Plan that are subject to TCEQ approval, including notice and the opportunity for a contested case hearing, are limited to those that relate to the allocation of water from lakes Buchanan and Travis between interruptible and firm uses. These include the determination of the amount of interruptible stored water available, environmental flow criteria and criteria for declaring a Drought Worse than Drought of Record.

Consistent with 30 Tex. Admin. Code Ch. 288, LCRA will review and update, as appropriate, in accordance with the schedule required by such rules, those portions of each of its Drought Contingency Plans that do not change the triggers, amount of curtailment of interruptible supply, or the triggers related to instream flows and bay and estuary inflows. As recognized by prior TCEQ orders, such changes do not constitute an amendment to the Water Management Plan requiring notice and an opportunity for contested case hearing, but must otherwise comply with the public notice requirements of Chapter 288 of the Commission's rules.

4.11 ADMINISTRATION OF ALLOCATION PROCEDURES

LCRA Board action is required for the following actions under this Chapter:

- Shift from interim to 2020 curtailment procedures. (Section 4.2.)
- Establishing criteria for resuming supply of interruptible stored water within the same calendar year following a cutoff of first crop. (Section 4.3.2.5.)
- Establishing surcharges or excess use rates applicable to interruptible agricultural customers. (Section 4.3.10.)
- Deviation from standard curtailment procedures under a wet weather or dry weather exception. (Section 4.4.)
- Establishing criteria for lifting of firm demand Drought Contingency Plan stages. (Section 4.7.2.)
- Initiation of pro rata curtailment of firm demands, and determination of pro rata reduction percentages for firm demands. (Section 4.7.2.)
- Determination of surcharges or excess use rates applicable to firm water customers. (Section 4.7.3.)
- Declaration of Drought Worse than Drought of Record (Section 4.8.)
- Establishing of additional criteria for cancellation of a declaration of Drought Worse than Drought of Record. (Section 4.8.)
- Updates to Drought Contingency Plan under TCEQ Chapter 288 rules. (Section 4.10.)

LCRA Board action is not required for actions under this chapter other than those itemized above. Acts not requiring Board action include, but are not limited to: determination of interruptible supply available consistent with the standard curtailment procedures, determination of applicable environmental flow criteria, and determination of interruptible stored water available to customers outside of the irrigation operations.

LCRA will notify the TCEQ within 30 days of the following:

- Board determination of a shift from the interim to 2020 curtailment procedures.
- Board action to deviate from the standard curtailment procedures for the downstream irrigation operations under certain severe drought conditions.
- Board declaration of Drought Worse than Drought of Record.
- Board action implementing pro rata curtailment of firm demands.
- Updates to its Drought Contingency Plan under TCEQ Chapter 288 rules.

In response, and/or in anticipation of the following actions, LCRA will carry out a public information campaign that is appropriate to the action:

- Any of the above items requiring Board action;
- Initiation or cancellation of firm water demand drought contingency stages.

Additionally, LCRA will communicate with its interruptible agricultural customers prior to the beginning of a crop season (first or second) regarding the potential supply available during the upcoming crop season.

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1. Pursuant to the certificates of adjudication for Lakes Buchanan and Travis, LCRA shall curtail the supply of interruptible water under such water rights to the extent necessary to allow LCRA to satisfy all firm demands. (Certificates of Adjudication Nos. 14-5478 and 14-5482, provision 2.B.(7).)
2. See section 1.3 for the list of items to be addressed pursuant to the January 2010 TCEQ Order.
3. Purchase Agreement by and Between Garwood Irrigation Company and LCRA, July 20, 1998.
4. Agreement to Supply Interruptible Stored Water by and Between LCRA and Testamentary Trusts created under the Wills and Codicils of Lacy Withers Armour, deceased, and the Amended & Restated Laurance H. Armour, Jr. and Margot Boyd Armour 1989 Trust, May 23, 2000.
5. The most current version of LCRA's water contract rules may be found at: http://www.lcra.org/water/supply/contracts/index.html

CHAPTER 5
RIVER OPERATIONS

5.1 Introduction 5-1
5.2 Data Sources 5-1
5.3 Decision Support Models 5-2
5.3.1 Water Supply Operations Models 5-2
5.3.2 Flood Operations Model 5-2
5.4 Standard Guidelines and Procedures for River Operations 5-3
5.4.1 Water Supply Operations 5-3
5.4.1.1 Releases from Lake Travis 5-4
5.4.1.2 Releases from Lake Buchanan 5-5
5.4.2 Alternative Operations 5-6
5.4.3 Flood Operations 5-6

5.1 INTRODUCTION

LCRA operates the Colorado River and the Highland Lakes as a system to efficiently manage water supply and mitigate flood damage. To accomplish these goals, LCRA uses a number of tools and practices that it regularly updates. To manage its river operations, LCRA develops and maintains data acquisition systems, decision support models and standard operating guidelines and procedures. This chapter provides a general description of river operations as of January 2012.

These tools and practices are regularly updated and any references to specific tools and practices in this chapter does not bind LCRA to continue to use the specific tools and practices described herein, nor does it limit LCRA from using modified or additional tools and practices at any point.

Furthermore, LCRA may deviate from this general description of river operations to respond to emergency incidents, to accommodate requests for public events on a lake, to lower lakes below their normal operating range, to operate floodgates for testing and maintenance, or for other reasons. In the event of deviation from the general description contained in this chapter, LCRA will operate in a manner intended to minimize or avoid the risk of injury to life and property, and to conserve and protect water supply whenever reasonably possible.

5.2 DATA SOURCES

LCRA maintains and operates a Hydro-meteorological Data Acquisition System (Hydromet) of about 265 gauges located throughout the lower Colorado River basin. The Hydromet gauges send water levels, rainfall and other weather data to LCRA computers every 15 minutes. Once stored on LCRA computers, the data can be validated, automatically shared with other partner agencies, and used to analyze the quantity and movement of water through the Colorado River basin and the Highland Lakes.

LCRA has executed an agreement with the U.S. Geological Survey (USGS) to share the maintenance and operation of 17 Hydromet gauges, and receives data from an additional 12

gauges that USGS operates cooperatively with other agencies. The USGS and LCRA share data from stream discharge measurements and discharge ratings (stage vs. flow ratings). This collaboration improves the timeliness of updates to ratings for ongoing operations and provides an independent review of basic data on quantities of flow. USGS publishes final stream discharge estimates upon completion of its quality assurance/quality control processes. Because of the real-time nature of river operations, LCRA must necessarily rely on "provisional" data which is subject to change.

LCRA shares Hydromet data with the National Weather Service, West Gulf Coast River Forecast Center in Fort Worth, Texas (RFC). The RFC uses rainfall data from the Hydromet system to calibrate radar estimates of rainfall and to produce Quantitative Precipitation Estimates (QPE). The RFC then shares the QPE data with LCRA. This improves the hydro-meteorological information available to LCRA and the RFC, and allows each agency to more accurately predict lake levels and flow conditions along creeks and rivers in the Colorado River basin.

LCRA develops and maintains computer systems and protocols to collect data from its reservoirs and pump stations, and to communicate with major water users that operate reservoirs, pump stations, and wastewater treatment plants that contribute significant amounts of return flows to the Colorado River below Mansfield Dam. Data on expected and actual storage, diversions and return flows is used to plan water supply operations, to coordinate pumping operations and to report on water use.

5.3 DECISION SUPPORT MODELS

LCRA uses a number of specialized computer models to analyze the movement of water, help make decisions for river operations and allocate and report on water use.

5.3.1 Water Supply Operations Models

LCRA has developed a suite of models for water supply operations including RiverWare models of the Colorado River and spreadsheet models for water supply operations.[1] Combined, these models make use of a variety of data sources described above, and are used to perform the following functions:

- Estimate the amount of flows entering the Colorado River;
- Evaluate the routing or timing and attenuation of flows released from the Highland Lakes to the lower Colorado River;
- Determine the necessary releases of stored water and pass-through of run-of-river flows to meet downstream demands;
- Schedule daily releases from dams; and
- Allocate releases and diversions for users to the appropriate source of supply (run-of-river or stored water) based on water rights priority.

5.3.2 Flood Operations Model

LCRA has developed a Corps Water Management System (CWMS) model of the Colorado River basin for flood operations.[2] LCRA worked with the U.S. Army Corps of Engineers to

adapt CWMS software for real-time flood forecasting.

The CWMS model for flood operations uses rainfall, streamflow and lake level data to predict Highland Lake inflows and lake levels and to recommend flood releases according to flood control regulations and agreements. The CWMS model can use a variety of sources of rainfall data, including Hydromet rain gauge data and data from the RFC. Results from the flood operations model are used to evaluate alternative operational scenarios and to support final operational decisions.

5.4 STANDARD GUIDELINES AND PROCEDURES FOR RIVER OPERATIONS

LCRA develops and maintains standard guidelines and procedures for three modes of River Operations: Water Supply Operations, Flood Operations and Alternative Operations. Water Supply Operations involve the release of water through a dam by means of hydroelectric turbines, and coordination of pumping by water supply customers to efficiently meet requirements for water supply, environmental flows, and hydroelectric generation. Alternative Operations, which is a variation of Water Supply Operations, involve the release of water through a dam by means of floodgates or spillways, for purposes of water supply. Flood Operations involve dam operations to mitigate damages due to uncontrolled inflows to the Highland Lakes. Each of these modes of operation is described below.

5.4.1 Water Supply Operations

Water Supply Operations involve the scheduled release of water through hydroelectric generation for water supply, environmental and power production purposes, and for system storage adjustment.

During Water Supply Operations, water is captured and stored in lakes Buchanan and Travis up to the top of their conservation pool elevations, subject to available inflows. (Top of conservation pool for Lake Travis is elevation 681 feet msl and for Lake Buchanan it is 1020 feet msl; however, LCRA limits Lake Buchanan to 1018 feet in the months of May through October as discussed in Section 5.4.3.) The pass-through lakes (Inks, LBJ, Marble Falls and Austin) are normally maintained within a specified range of elevations at the dams shown in Table 5-1. Lake Austin is operated consistent with an agreement between LCRA and the City of Austin.[3] During flood operations, additional water may be temporarily stored in Lakes Buchanan and Travis and in the pass-through lakes.

Table 5-1. Target Elevation Ranges for Pass-Through Lakes

Lake Level at the Dam (Headwater Gauge)	Lower Elevation (Legacy Datum[1])	Upper Elevation (Legacy Datum)	Adjustment to NAVD88
Inks	886.9	887.7	+0.31 ft.
LBJ	824.4	825.0	+0.68 ft.
Marble Falls	736.2	737.0	+0.69 ft.
Austin	491.8	492.8	+0.31 ft.

1. Elevations are based on the "legacy" datum for each dam. Legacy data are elevation benchmarks set for construction of the dams forming the Highland Lakes that have not been adjusted to a standard datum such as the National Geodetic Vertical Datum of 1929 (NGVD29) or the North American Vertical Datum of 1988 (NAVD88).

Within LCRA, Water Supply Operations involve a variety of key activities including:

- maintaining Hydromet field equipment and ratings to measure and report~~ing~~ on rainfall, evaporation, streamflow, water levels and irrigation diversions;
- monitoring LCRA's water supply in the Colorado River and Highland Lakes on a daily basis; evaluating demands for water based upon specific orders and pumping status of certain customers, including the City of Austin, power plant customers and the irrigation operations, among others; determining the required releases of water from the Highland Lakes to most efficiently meet demands, consistent with water rights and agreements; and coordinating pumping operations of downstream customers;
- monitoring and reporting daily evaporation at lakes Travis and Buchanan; monitoring lake levels and river inflows on a 24/7 basis; determining availability of hydroelectric generating units; setting the final Hydro Schedule at each of the dams that form the Highland Lakes; and controlling hydroelectric generation operations; and
- coordinating hydroelectric generation with the Electric Reliability Council of Texas (ERCOT).

The following subsections describe the manner in which LCRA supplies demands and needs to be met or backed up with water from lakes Buchanan and Travis.

5.4.1.1 Releases from Lake Travis

Miller Dam, which forms Lake Austin, is the dam downstream of Mansfield Dam, which forms Lake Travis. Lake Austin is the most downstream of the six Highland Lakes controlled by LCRA. The majority of LCRA's major irrigation and industrial customers divert water along the 300 river miles from Miller Dam to Matagorda Bay. Requirements for Instream Flows and Freshwater Inflows to Matagorda Bay apply along the Colorado River below Longhorn Dam. (Longhorn Dam, which forms Lady Bird Lake, is immediately downstream of Lake Austin and is operated by the City of Austin). LCRA determines the daily release from Miller Dam to deliver water and regulate the flow in the lower river below Longhorn Dam. Releases from Mansfield Dam are determined as needed to maintain Lake Austin within its normal operating range.

Releases from Miller Dam require up to a week to flow along the river channel to reach the

points of delivery. Therefore, the timing of a release is as important as the quantity to ensure that the right amount of water is made available at the right place and the right time.

When making decisions regarding the daily operations of the Colorado River and Highland Lakes, LCRA first considers the location, amount and timing of the demands of major customers that take water from the Colorado River below Mansfield Dam and the environmental requirements for instream flows and freshwater inflows to Matagorda Bay. LCRA next considers the requirements of all water rights and agreements that apply to each demand and uses the best information available at the time to estimate the amount and timing of run-of-river inflows to the Colorado River below Mansfield Dam, and to the Highland Lakes above Mansfield Dam. Finally, LCRA determines the minimum amount of stored water that must be released from Mansfield Dam to meet any demands that do not have access to run-of-river sources of supply. Releases are then scheduled from Miller Dam and Mansfield Dam to meet all demands as efficiently as possible (i.e., with the least amount of stored water released from the Highland Lakes) and according to all applicable requirements.

For example, downstream demands that can be met from downstream run-of-river water rights are first supplied with run-of-river flows entering the Colorado River below Mansfield Dam. If this source is not sufficient to meet all such demands, then the remaining demands are supplied with run-of-river flows entering the Colorado River above Mansfield Dam. Finally, any remaining demands are met with stored water from the Highland Lakes.

Demands and releases from Miller Dam are determined on a daily basis, but travel time to the points of diversion or stream gauges varies and is not necessarily an exact number of days. For example, the travel time may be three and a half days, rather than exactly three or four days. Furthermore, water released from Miller Dam tends to attenuate as it moves downstream, so that one day's release at Miller Dam may arrive at a downstream location over several days. Therefore, in practice, releases from Miller Dam may be averaged over one or more days as needed to efficiently supply downstream demands.

Various factors affect the movement and delivery of water to locations below Miller Dam. The amounts of water actually released through hydroelectric generation typically do not match precisely the amounts scheduled for release. Releases from Miller Dam to the lower river pass through Lady Bird Lake and Longhorn Dam, which are controlled by the City of Austin. The operation of Longhorn Dam can change the timing and flow rate of water released by LCRA upstream. Many diversions from the Colorado River, and return flows to the river are not controlled by LCRA. The natural characteristics of the channel along the lower river are constantly changing. Furthermore, flow measurements at gauging stations on tributary creeks and along the main stem of the Colorado River have a generally accepted margin of error. All these factors affect LCRA's ability to forecast the exact rate, timing, attenuation and gain or loss of flows along the lower river.

5.4.1.2 Releases from Lake Buchanan

LCRA's water supply needs are met from both lakes Buchanan and Travis. Thus, releases from Lake Buchanan are routed through the intervening lakes and Lake Travis to help meet the

demands of LCRA's customers and environmental flow needs. Releases also maintain lakes Inks, LBJ, and Marble Falls within their normal operating ranges and are used to meet LCRA customer demands from these lakes. Allocation guidelines provide guidance in the determination of the amount of Lake Travis releases that should be supplied from corresponding releases from Lake Buchanan.

5.4.2 Alternative Operations

Alternative Operations is a variation on Water Supply Operations that generally involves the release of water through a dam by means of floodgates or spillways at a rate that does not exceed the discharge capacity of the turbines at the dam. At Inks and Miller dams, Alternative Operations involve the release of water through the dams at a rate that does not exceed the discharge capacity of turbines at Buchanan or Mansfield dams, respectively, and when releases from Buchanan and Mansfield dams are not due to Flood Operations. Alternative Operations do not trigger emergency flood notifications to the public. Alternative Operations are used when necessary to compensate for hydroelectric generation units that are out of service, to provide for maximum hydroelectric generation capability, or to allow floodgates to be exercised during routine maintenance activities. Alternative operations at any dam would include use of partial floodgate openings or spillways to release the equivalent of any loss in turbine capacity at that dam.

5.4.3 Flood Operations

LCRA conducts Flood Operations at the six dams that form the Highland Lakes to mitigate downstream damages due to uncontrolled inflows to the lakes. Flood Operations take precedence over scheduled water supply and environmental release operations.

Lake Travis is the only one of the Highland Lakes with a dedicated flood pool. Except for lakes Buchanan and Travis, the reservoirs formed by the dams do not have the ability to capture and store large volumes of runoff. Releases from one reservoir are generally passed through the next downstream reservoir.

At Buchanan Dam, Flood Operations begin when the level of Lake Buchanan is forecast or observed to exceed its conservation pool elevation. At Inks, Wirtz and Starcke dams, Flood Operations begin when flows into Inks Lake, Lake LBJ or Lake Marble Falls respectively are forecast or observed to exceed the normal discharge capacity of turbines at ~~either~~ the dam and require the use of floodgates or spillways to pass the flow.

Flood Operations at Buchanan, Inks, Wirtz, and Starcke dams are pursuant to an agreement between LCRA and the Federal Emergency Management Agency (FEMA) dated March 8, 1990. (See Appendix B-2.) Under this agreement, conservation storage in Lake Buchanan is limited to elevation 1018 feet (two feet below maximum conservation storage) in the more flood-prone months of May through October.

At Mansfield Dam, Flood Operations begin when the level of Lake Travis is forecast or observed to exceed its conservation pool elevation. At Miller Dam, Flood Operations begin when releases exceed the discharge capacity of its two turbines.

Flood Operations at Mansfield Dam and Lake Travis are governed by U.S. Army Corps of Engineers (USACE) regulations and require LCRA to consult with USACE in their implementation. (See Appendix B-1.)[4] The current rules also provide that the U.S. Bureau of Reclamation will schedule flood releases as required for the safety of the dam when the reservoir level is forecast to exceed 722 feet msl. Operations at Miller Dam are governed by an agreement between LCRA and the City of Austin.[5]

Under the rules, the plan of operations for the release from Mansfield Dam is determined by: specified ranges of observed or forecasted reservoir levels; the pool condition (i.e., rising or falling); the month of year; and stage and flow criteria at three designated downstream locations. When the pool is rising, forecasted reservoir levels (based on actual water on the ground) are used in determining flood release requirements. When the pool is falling, observed reservoir levels are used in determining release requirements. The amount of the release from Mansfield Dam increases with higher ranges of reservoir level as long as downstream stage and flow limitations are not exceeded.

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1. RiverWare is a modeling environment developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado.
2. CWMS is a software program developed by the U.S. Army Corps of Engineers.
3. Lease and Agreement between City of Austin and Lower Colorado River Authority, February 5, 1938
4. Guidance in the implementation of these rules may be obtained from the USACE Marshall Ford (Mansfield) Dam Water Control Manual (1999) and Bureau of Reclamation Marshall Ford (Mansfield) Dam Standing Operating Procedures (1993).
5. See endnote 3.