Exhibit A

Proposed revised Water Management Plan,

with Appendices

LAKES BUCHANAN AND TRAVIS

WATER MANAGEMENT PLAN

AND

DROUGHT CONTINGENCY PLANS

SUBMITTED TO:

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

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Based on LCRA Board action Feb. 2012, as modified Sept. 2014
Originally submitted to TCEQ March 2012 and supplemented May 2012
Amended and Restated Filing Oct. 2014

Lower Colorado River Authority

Filed Oct. 2014

TABLE OF CONTENTS

Chapter **Page**

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-6
E. Determination of Interruptible Stored Water Availability and Water for Environmental Flow Needs ES-7
F. River Operations ES-9
G. Glossary ES-9

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 Interests Affected by Water Management Plan 1-5
1.4 Development of Current Water Management Plan 1-7

Chapter 2 DEMANDS
2.1 Background 2-1
2.2 Firm Water 2-1
2.3 Agricultural Demands in the Downstream Irrigation Operations 2-4
2.4 Environmental Needs for Instream Flows and Bay and Estuary Inflows 2-6
2.5 Hydroelectric Power Generation 2-9

Chapter 3 FIRM YIELD OF LAKES BUCHANAN AND TRAVIS
3.1 Introduction 3-1
3.2 Combined Firm Yield Computation 3-1

Chapter 4 DETERMINATION OF INTERRUPTIBLE STORED WATER AVAILABILITY AND WATER FOR ENVIRONMENTAL FLOW NEEDS
4.1 Introduction 4-2
4.2 Determination of Water Supply Conditions 4-4
4.3 Curtailment Procedures for Agricultural Operations at Gulf Coast, Lakeside, and Pierce Ranch 4-6
4.4 Curtailment Procedures for Environmental Flows in Lower Colorado River Basin 4-11
4.5 Curtailment Procedures for Interruptible Stored Water Demands Other than the Downstream Irrigation Operations 4-17
4.6 Curtailment of Firm Water Demands 4-18
4.7 Declaration and Cancellation of Drought Worse than Drought of Record 4-19
4.8 Results of the Recommended Curtailment Policies under this WMP 4-20

Chapter 5 RIVER OPERATIONS
5.1 Introduction 5-1

5.2 Data Sources 5-1
5.3 Decision Support Models 5-2
5.4 Standard Guidelines and Procedures for River Operations 5-3

Tables

Table 2-1 WMP Firm Water Demand Projections 2-3
Table 2-2 Projected Diversions by Irrigation Operations 2-5
Table 2-3 Subsistence and Base Flow Recommendations by Gauge (cubic feet per second) 2-7
Table 2-4 Summary of Matagorda Bay Health Evaluation Inflow Levels 2-8
Table 2-5 Matagorda Bay Health Inflow Values (acre-feet) 2-9
Table 2-6 Operational Criteria for Matagorda Bay Inflows 2-9
Table 2-7 Hydroelectric Capacities 2-10
Table 3-1 Firm Yield Model –Key Assumptions 3-2
Table 4-1 Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside, and Pierce Ranch agricultural operations under Normal Water Supply Condition 4-8
Table 4-2 Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside, and Pierce Ranch agricultural operations under Less Severe Drought condition 4-10
Table 4-3 Subsistence and Base Flow Criteria by Gauge (cubic feet per second) 4-12
Table 4-4 Instream Flow Triggers and Flow Levels 4-13
Table 4-5 MBHE Three-Month Freshets into Matagorda Bay 4-15
Table 4-6 Operational and Threshold Criteria for Colorado River Freshwater Inflows to Matagorda Bay 4-15
Table 4-7 Freshwater Inflow Triggers and Flow Levels 4-16
Table 5-1 Target Elevation Ranges for Intervening Lakes 5-4

Figures

Figure 1-1 LCRA Water Service Area as of October 2014 1-3
Figure 2-1 Historic Water Diversions by the Four Downstream Irrigation Operations 2-6
Figure 4-1 Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside, and Pierce Ranch agricultural operations under Normal Water Supply Condition 4-9
Figure 4-2 Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside, and Pierce Ranch agricultural operations under Normal Water Supply Conditions 4-10
Figure 4-3 Drought intensity curve for Drought Worse than Drought of Record declaration 4-20

Appendix A – Technical Papers

A-1. Development of Projected Firm Demands

A-2. Development of Projected Agricultural Demands by the Four Downstream Irrigation Operations

A-3. Water Availability Modeling and Calibration

A-4. Assumptions Underlying LCRA 2010 Water Management Plan Baseline Water Availability Model

A-5. Assumptions Underlying the Water Availability Model Used to Support Development of the LCRA Water Management Plan Revision

A-6. Development of Combined Firm Yield of Lakes Buchanan and Travis

A-7. Proposed Methodology for Identifying a Drought Potentially Worse than the Drought of Record

Appendix B - Flood Control Regulations

B-1. Agreement between LCRA and the Federal Emergency Management Agency

B-2. U.S. Army Corps of Engineers Flood Control Regulations Governing Releases from Mansfield Dam

Appendix C – Previous Orders and Amendments

C-1. Order Approving LCRA's Water Management Plan and Amending Certificate of Adjudication Nos. 14-5478 and 14-5482, dated September 20, 1989

C-2. Order Approving LCRA's Drought Management Plan, dated December 23, 1991

C-3. Agreed Order Approving Amendments to LCRA's Water Management and Drought Management Plan, dated December 18, 1992

C-4. Order Approving Amendments to LCRA's Water Management Plan Including Its Drought Management Plan, dated March 1, 1999

C-5 Order Overruling Objections to LCRA's System of Priorities Set Forth in its Water Management Plan – June 3, 2003

C-6. Agreed Order Approving Amendments to LCRA's Water Management Plan, dated January 27, 2010

C-7 Order Approving LCRA's Firm Water Curtailment Plan – December 12, 2011

Appendix D – 1988 Final Judgment and Decree

Final Judgment and Decree dated April 20, 1988

Appendix E – LCRA Board Water Policies

LCRA Board Policy 501 - Water Resources, December 15, 2010

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-6
E. Determination of Interruptible Stored Water Availability and Water for Environmental Flow Needs ES-7
F. River Operations ES-9
G. Glossary ES-9

A. BACKGROUND

LCRA's operation of lakes Buchanan and Travis is subject to the water rights for these lakes,[1] special conditions and criteria set forth by the court order (the "1988 Adjudication Order") that adjudicated these and other water rights in the lower Colorado River basin,[2] and the state statutes and regulations that generally govern use of state water. LCRA's exercise of its water rights pursuant to these requirements is subject to continuing jurisdiction of the Texas Commission of Environmental Quality (TCEQ), the state agency with primary authority over surface water rights in Texas.

The 1988 Adjudication Order specifically required LCRA to submit a reservoir operations plan for lakes Buchanan and Travis,[3] and this requirement is also incorporated into the water rights for these lakes.[4] Certificates of Adjudication 14-5478 and 14-5482 state that "LCRA shall interrupt or curtail the supply of water . . . pursuant to commitments that are specifically subject to interruption or curtailment, to the extent necessary to allow LCRA to satisfy all demand for water under such certificates pursuant to all firm, uninterruptible water commitments."[5] The Water Management Plan (WMP), which is subject to review and approval of the TCEQ, is LCRA's required reservoir operations plan and provides the framework by which LCRA implements this requirement and sets forth the procedures by which LCRA makes water available from these lakes to help meet "firm" water customer needs, downstream "interruptible" agricultural demands, and environmental flow needs of the lower Colorado River and Matagorda Bay within LCRA's service area. The WMP also sets forth criteria for declaring a Drought Worse than Drought of Record[6] and includes a calculation of the Combined Firm Yield of Lakes Buchanan and Travis, which is the amount of water that can be supplied annually from lakes Buchanan and Travis through a repeat of the Drought of Record.[7]

The WMP is not a static document. LCRA's first WMP was developed by LCRA, approved by its Board of Directors, and approved by the Texas Water Commission, predecessor to the TCEQ, in 1989. The WMP is revised periodically to address changing conditions such as increased demands from Firm Water customers and updated science related to environmental flows. As the actual water demands from lakes Buchanan and Travis for Firm Water users continue to increase, the amount of Interruptible Stored Water available from the lakes is expected to

continue to decrease. Revisions to the WMP have been approved by the TCEQ (or its predecessors) in 1991, 1992, 1999 and 2010.

As in previous WMP 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 continued through the Fall of 2011. Near consensus among stakeholders was reached on many issues and, on the heels of the worst one-year drought in recorded history in 2011, the LCRA Board voted to move forward with an application to amend the WMP, which was filed in March 2012 and later supplemented in May 2012. As the drought has persisted, and LCRA operated pursuant to emergency orders in 2012, 2013, and 2014, it became evident that further changes to the WMP were needed beyond those originally requested by LCRA in March 2012. Further revisions were evaluated by LCRA staff during the summer of 2014 based on input from the TCEQ Executive Director received in May 2014. In August 2014, the LCRA Board directed staff to once again meet with interested stakeholders, and after several open stakeholder meetings and further analyses, the LCRA Board approved further amendments to LCRA's application as embodied in this application. Although LCRA did not reconvene the advisory committee for a consensus vote, the stakeholders who addressed the LCRA Board in September 2014 were generally supportive of the staff proposal.

More information about the history of the WMP and amendment process is provided in Chapter 1 of this WMP.

B. CHANGES FROM THE 2010 WATER MANAGEMENT PLAN

In many respects, this WMP implements the most significant changes since the inception of the WMP and is designed to respond to recent and dramatic drought conditions that have rivaled the Drought of Record. Further, the WMP implements a more sophisticated approach to helping meet environmental flow needs of the lower Colorado River and Matagorda Bay system based on the most recent and best available scientific studies. The following is a list of some of the key changes:

Interruptible Stored Water Availability:

- LCRA will determine availability of Interruptible Stored Water for LCRA's Gulf Coast and Lakeside operations and Pierce Ranch separately for First and Second Crop and apply strict volumetric limits (or caps) on availability of Interruptible Stored Water in each Crop Season;
- The amounts of Interruptible Stored Water for LCRA's Gulf Coast and Lakeside agricultural operations, and Pierce Ranch will be determined taking into consideration what Water Supply Condition is in effect: "Normal," "Less Severe Drought," or "Extraordinary Drought," combined with the implementation of a look-ahead test;
- Under the look-ahead test, LCRA will not begin releasing water for the non-Garwood operations for a Crop Season if the LCRA Board determines that the Combined Storage would drop below 900,000 acre-feet in the upcoming Crop Season or below 600,000 acre-feet within 12 months; and

- LCRA will stop releasing Interruptible Stored Water for the Gulf Coast, Lakeside and Pierce Ranch agricultural operations in the middle of a Crop Season when Combined Storage drops below certain levels, whether or not the LCRA Board has declared a Drought Worse than Drought of Record.

Environmental Flows:

- LCRA used the most recent scientific studies to identify the environmental flow needs and to develop environmental flow criteria;
- LCRA will determine applicable environmental flow criteria on two dates for different periods of the year; and
- The water available to help meet environmental flow needs may be adjusted based upon changes in storage during the crop season.

Other Key Changes:

- The Combined Firm Yield of Lakes Buchanan and Travis has been recalculated, and reflects a reduction from 445,266 acre-feet per year to 434,154 acre-feet per year. 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 continues to maintain its reservation of 50,000 acre-feet of the Combined Firm Yield;
- Revised criteria for declaration and cancellation of a Drought Worse than Drought of Record are included;
- Those elements of LCRA's Raw Water Drought Contingency Plan (DCP) that are required by TCEQ's rules (30 Tex. Admin. Code ch. 288), but not required by prior WMP orders, are removed from the WMP. Instead, once this amendment to the WMP is approved by the TCEQ, LCRA will develop conforming, stand-alone DCPs for its customers consistent with TCEQ's DCP rules (including those related to public input) and this revised WMP, which will address required elements of TCEQ's DCP rules that are not otherwise required as part of the WMP.; and
- The plan includes a revised definition of "emergency shortage of electricity" to better align with new ERCOT protocols.

C. DEMANDS

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 further enhance our understanding of the environment's water needs.

As discussed in detail in Chapter 2, for purposes of this WMP, LCRA used Interim Demands for surface water that generally correspond to expected dry year demands. For Firm Water customers, this WMP uses a level of demand about halfway between year 2010 and year 2020 projected demands. Interim Demands for the downstream agricultural operations are based on year 2010 demands.

LCRA supplies two general categories of water from lakes Buchanan and Travis: Firm Water and Interruptible Stored Water.

- **Firm Water** is water that can be supplied on a consistent (or "firm") basis from lakes Buchanan and Travis through a repeat of the worst drought in recorded history for the lower Colorado River basin, which is the drought of the 1940s and 50s, while honoring all downstream water rights. This drought is known as the Drought of Record. Firm Water is primarily made available through contracts with cities and industries within LCRA's service area, but is also used in more limited cases for irrigation, recreation, domestic use, and environmental needs.

- **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 Water customer demands. Currently, Interruptible Stored Water is used almost entirely for agricultural purposes in the downstream agricultural operations (LCRA's Garwood, Gulf Coast and Lakeside agricultural 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.

The Firm Water 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). The WSRP includes demand projections through year 2100. This WMP revision, however, is designed to meet projected demands over the next several years, as shown below.

WMP Firm Water Demands in 2010 WMP and this WMP
(acre-feet/year)

	2010 WMP	Current WMP
City of Austin Municipal[2]	182,788	193,334
LCRA Power Plants	25,866	25,500
City of Austin Power Plants[2]	13,500	19,000
Other Municipal & Industrial[3]	46,452	92,252
Other (conveyance and emergency release)	20,000	20,000
Total Firm Water Demand	288,606	350,086
STPNOC Firm Water Back-up	20,000	20,000
Other Major Run-of-River Diverters		
Garwood - Corpus Christi	-	35,000
STPNOC/LCRA	102,000	102,000

Notes:
1. Future projections of water demands based on LCRA Water Supply Resource Plan & Region K.
2. By contract, these customers 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 Water demands such as recreation and irrigation Also included is domestic use around the Highland Lakes.

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 2011. The demand for agricultural water varies from year to year based on the number of acres irrigated and weather conditions. From 2000 to 2011, agricultural diversions at the four agricultural operations ranged from a maximum of about 464,000 acre-feet in 2011 to a minimum of 199,000 acre-feet in 2007. In 2012, 2013 and 2014, Interruptible Stored Water for agriculture was curtailed pursuant to emergency orders issued by the Commission and total agricultural diversions were significantly reduced.

The supply used to meet agricultural demands at the four agricultural operations is made up of Interruptible Stored Water from lakes Buchanan and Travis and LCRA's run-of-river water rights. To the extent that LCRA is able to make water available under its run-of-river rights, LCRA does not have to release water from storage. However, the timing and availability of run-of-river water (whether originating above or below the Highland Lakes) is often insufficient to meet all agricultural needs.

The Texas Water Development Board (TWDB) forecasts that agricultural diversions by the downstream agricultural operations will decrease over time. The 2010 WMP 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. However, recent water use exceeded the Regional Water Plan's projection for 2010, particularly in the Gulf Coast operation. This WMP thus incorporates some adjustments to demands for the Gulf Coast operation based on recent water use. The adjusted projected year 2010 diversions are

reflective of the current ("Interim") demands and were used to develop the curtailment procedures for this WMP. These demands are expected to be exceeded only about 10 percent of the time for the period of historic record and therefore represent agricultural demands during drought conditions. LCRA also developed procedures to address variability in demand due to weather.

Projected Diversions by Agricultural Operation
(acre-feet/year)

	Agricultural Operation				
Year	Garwood	Lakeside	Gulf Coast	Pierce Ranch	Total
Current WMP	92,400	139,700	178,700*	27,700	438,500
Notes: *Adjusted upward from WSRP and TWDB year 2010 projections to the 2008 and 2009 average use					

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. The environmental flow needs are described in more detail in Chapter 2 and reflect the best available science as required by the January 2010 TCEQ Order approving the 2010 WMP ("TCEQ 2010 Order").[8]

D. WATER AVAILABILITY MODELING

LCRA developed specific 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. The models use historic streamflow and evaporation data to calculate the supply of available surface water. Separate models were created to: 1) develop and evaluate the curtailment procedures in this WMP revision; and 2) determine the Combined Firm Yield of Lakes Buchanan and Travis.

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 available historic hydrologic data, including the recent intense droughts experienced in 1999-2013 period. The hydrologic period of record in the WAM used for this WMP is 1940-2013. These models are discussed in detail in Technical Papers A-3 through A-6.

E. DETERMINATION OF INTERRUPTIBLE STORED WATER AVAILABILITY AND WATER FOR ENVIRONMENTAL FLOW NEEDS

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. This 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 demands in the downstream agricultural operations;
- A range of freshwater inflows goals for Matagorda Bay;
- A range of instream flows goals for the Colorado River downstream of the Highland Lakes;
- Demands for a small category of Interruptible Stored Water users, other than the downstream agricultural 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 purposes can be particularly high during drier conditions. Moreover, recent and dramatic drought conditions that have rivaled the Drought of Record demonstrate the need to impose greater limitations on the availability of Interruptible Stored Water. These types of conditions, combined with a significant growth and projected growth in Firm Water demands, increase the likelihood of significant shortages of Interruptible Stored Water. Thus, this WMP revision includes significant changes to the Interruptible Stored Water curtailment policies from prior Water Management Plans, which are described in detail in Chapter 4 of this WMP.

When determining available Interruptible Stored Water supplies, it is essential that Firm Water demands be protected during a repeat of the historic 1950s Drought of Record (DOR).[9] This drought is the worst recorded to date on the lower Colorado River. The curtailment procedures in this WMP revision have been designed to ensure supply is available to meet Firm Water demands as described in Chapter 2, through a DOR condition and through the short-term intense droughts that this region has experienced in recent decades, as required by the TCEQ 2010 Order. Specifically, this WMP revision has been simulated for a repeat of historic hydrology from 1940 to 2013.

The TCEQ 2010 Order also required an evaluation of the minimum Combined Storage in lakes Buchanan and Travis necessary or appropriate to protect Firm Water customers through a DOR condition, or under conditions worse than the 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. This WMP establishes a minimum Combined Storage goal of 600,000 acre-feet and the model simulations for this WMP revision maintained storage at or above this goal. This safety factor avoids the triggering of a Drought worse than Drought of Record in the event of a repeat of historic hydrology, including recent and dramatic drought conditions that have rivaled

the Drought of Record, and is consistent with input received from TCEQ in May 2014 and the emergency orders issued by TCEQ for the 2012, 2013, and 2014 irrigation seasons.

This WMP revision includes a number of significant changes in procedures used to determine the availability of Interruptible Stored Water for agricultural use in the four downstream agricultural operations and to other customers, and in the criteria used to determine the availability of water to help meet the environmental flow 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 Stored 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.

Determination of Water Supply Condition

Previous versions of the WMP determined how much Interruptible Stored Water was available based on Combined Storage on January 1 of each year. This WMP evaluates not only Combined Storage, but also inflow conditions to determine the amounts of Interruptible Stored Water available for the downstream agricultural operations in Lakeside, Gulf Coast, and Pierce Ranch and the criteria in effect to help meet environmental flow needs. The Water Supply Condition will be evaluated on each March 1 and July 1.

Separate limits and procedures for First and Second Crop

LCRA will determine which Water Supply Condition is in effect for purposes of this WMP (Normal, Less Severe Drought, or Extraordinary Drought) on March 1 and July 1. For the upcoming Crop Season, LCRA will implement the curtailment procedures and provide specific volumes of Interruptible Stored Water as prescribed by the Water Supply Condition in place, unless the LCRA Board determines that Combined Storage would drop below 600,000 acre-feet in the next 12 months or below 900,000 acre-feet in the upcoming crop season. If releases of Interruptible Stored Water for the First Crop Season are cut off for the entire season, then releases of Interruptible Stored Water are also cut off for the Second Crop Season.

Helping meet environmental flow needs

Under this WMP, as in past WMPs, LCRA provides a combination of Firm Water and Interruptible Stored Water to help meet environmental flow needs. This WMP retains LCRA's commitment of 33,440 acre-feet per year of Firm Water supply from lakes Buchanan and Travis for environmental flow purposes.

This WMP reflects improvements to the operational procedures that will be used to help meet environmental flow needs based on more recent scientific studies and also includes an increase in the total average annual combination of Firm Water and Interruptible Stored Water supplied to help meet environmental flows needs compared to the 2010 WMP. 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 March 1, and the environmental flow criteria in place from July through the following February are based on the Combined Storage on July 1. (This represents a change from prior WMPs in which the environmental flow criteria for the entire year were based on January 1 Combined Storage.) Environmental flow criteria also take into account the availability of Interruptible Stored Water for agriculture.

F. RIVER OPERATIONS

Chapter 5 of this WMP describes how 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. Chapter 5 provides a general description of river operations as of September 2014. LCRA's operations are updated as needed to respond to actual conditions and 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.

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, particularly where capitalized, 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.

1988 Adjudication Order – the court order adjudicating water rights in the Lower Colorado River segment of the Colorado River basin, cited as *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*, No. 115, 414-A-1 (264th Dist. Ct., Bell County, Tex. April 20, 1988).

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 water 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 of Lakes Buchanan and Travis – the calculated firm yield of lakes Buchanan and Travis when operated as a system, incorporating LCRA's agreements and operating assumptions regarding calls on the upper basin. The Combined Firm Yield is based on the 1940s to 1950s historic Drought of Record. *See* "firm yield" definition below.

Combined Storage – the total volume of water stored in lakes Buchanan and Travis at a given point in time. For purposes of making various determinations under this WMP, the Combined Storage means the total of the daily average volume of water in Lake Buchanan and the daily average volume of water in Lake Travis, when excluding any water in Lake Buchanan above elevation 1,018 ft mean sea level (msl) and any water in Lake Travis above elevation 681 ft msl. A determination that relies on Combined Storage will not be based on a single reading during the day, but instead is the average for the day.

Crop Season – the period of time in which water is supplied either for first crop or second crop. S*ee* "First or Main Crop Season" and "Second or Ratoon Crop Season."

curtail or cutback (water) – to reduce the amount of water supply 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 state law and rules of the Texas

Commission on Environmental Quality that outlines drought response measures to be taken in response to specific drought conditions. (*See* Tex. Water Code § 11.1272 and 30 Tex. Admin. Code ch. 288).

Drought of Record (DOR) – the worst hydrologic drought for which streamflow records are available and is considered to be the period of time during recorded history when natural hydrological conditions provided the least amount of water supply. For the WMP, the Drought of Record is the drought of the 1940s and 50s.

Drought Worse than Drought of Record (DWDR) – a drought condition identified by the LCRA Board of Directors where an ongoing drought has a real likelihood of becoming a new Drought of Record. A DWDR declaration would trigger action to cut off interruptible stored water and implement mandatory pro rata curtailment of Firm Water demands. (*See* Sec. 4.7.)

Evaluation Date – the date, either March 1 or July 1, on which LCRA will determine the Water Supply Condition, Interruptible Stored Water available for agriculture and effective environmental flow criteria, as more fully described in Chapter 4.

Firm Water – water that can be supplied on a consistent (or "firm") basis from lakes Buchanan and Travis through a repeat of the worst drought in recorded history for the lower Colorado River basin, which is the drought of the 1940s and 50s, while honoring all downstream water rights. This drought is known as 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. (*See* 30 Tex. Admin Code § 297.1(20).)

First or Main Crop Season – refers to the first part of the irrigation season when LCRA may be providing water to the downstream agricultural 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.

Inflows into Lakes Buchanan and Travis – the total inflows into lakes Buchanan and Travis based upon flow readings at certain gauges upstream of lakes Buchanan and Travis (without any adjustment for the Pass-Through of water to meet downstream demands associated with senior water rights).

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

Interim Demands – for Firm Water demands, a level of demand about halfway between year 2010 and year 2020 projected demands. Interim Demands for Firm Water 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. Interim Demands for the downstream agricultural operations are based on year 2010 demands.

Interruptible Stored Water – 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 Water customer demands.

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.

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 Season – refers to the second part of the irrigation season when LCRA may be providing water to the downstream agricultural 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 second or "ratoon" 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. During the Second Crop Season, rice, turf, row crop, hay, pasture and wildlife management are types of agricultural uses that may be supplied with water.

Storable Inflows – For purposes of making the determination of water available from lakes Buchanan and Travis to help meet certain environmental flows, the term "Storable Inflows" means the Inflows into lakes Buchanan and Travis based upon flow readings at certain gauges upstream of lakes Buchanan and Travis minus any required Pass-Through of inflows

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.

TCEQ 2010 Order – the order issued by the Texas Commission on Environmental Quality approving amendments to the LCRA Water Management Plan in January 2010, citied as TEX. COMM'N ENVTL. QUAL., *Agreed Order Approving Amendments to Lower Colorado River Authority's Water Management Plan* (Jan. 27, 2010).

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.

Water Supply Condition – a condition based upon Combined Storage and Inflows into Lakes Buchanan and Travis that is used to determine availability of Interruptible Stored Water and environmental flow criteria. The three Water Supply Conditions are: Normal, Less Severe Drought and Extraordinary Drought.

Acronyms:

AF	acre-feet
B&E	bay and estuary
CFS	cubic feet per second
DCP	Drought Contingency Plan
FEMA	Federal Emergency Management Agency
LCRA	Lower Colorado River Authority
MAF	million acre-feet
MBHE	Matagorda Bay Health Evaluation
msl	mean sea level (or above mean sea level)
STPNOC	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

1. Certificates of Adjudication 14-5478, as amended, and 14-5482, as amended.
2. *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*, No. 115, 414-A-1 (264th Dist. Ct., Bell County, Tex. April 20, 1988) ("1988 Adjudication Order"), Lake Buchanan Conclusion of Law 4 and Lake Travis Conclusion of Law 6.
3. 1988 Adjudication Order, Lake Buchanan Conclusion of Law 4 and Lake Travis Conclusion of Law 6.
4. Certificate of Adjudication 14-5478 ¶ 2.B.(1); and Certificate of Adjudication 14-5482 ¶ 2.B.(1).
5. Certificate of Adjudication 14-5478 ¶ 2.B.(7); Certificate of Adjudication 14-5482 ¶ 2.B.(7).
6. TEX. COMM'N ENVTL. QUAL., *Order Approving Lower Colorado River Authority's Drought Management Plan*, Ordering Provision 1(f) (Dec. 18, 1991).
7. *See* 1988 Adjudication Order, Lake Buchanan: Conclusion 4(a), Lake Travis: Conclusion 6(a) (requiring that LCRA determine the Combined Firm Yield of Lake Travis and Buchanan).
8. *See* TEX. COMM'N ENVTL. QUAL., *Agreed Order Approving Amendments to Lower Colorado River Authority's Water Management Plan*, Ordering Provision 1.f. (Jan. 27, 2010). Section 1.3 of this WMP provides a list of items to be addressed pursuant to the January 2010 TCEQ Order.
9. 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, ¶ 2.B.(7) and 14-5482, ¶ 2.B.(7)).

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 Interests Affected by Water Management Plan 1-5
1.3.1 Municipal and Industrial Customers 1-5
1.3.2 Agricultural Users 1-5
1.3.3 Other Water Customers 1-6
1.3.4 Environmental & Water Quality Interests 1-6
1.3.4.1 Freshwater Inflows 1-6
1.3.4.2. Instream Flows and Water Quality 1-6
1.3.5 Lake/River Recreation and Economic Interests 1-7
1.4 Development of Current Water Management Plan 1-7
1.4.1 Texas Commission on Environmental Quality January 2010 Order 1-7
1.4.2. Advisory Committee & Stakeholder Processes 1-8

1.1 BACKGROUND

LCRA's operation of lakes Buchanan and Travis is subject to the water rights for these lakes,[1] special conditions, and criteria set forth by the court order (the "1988 Adjudication Order") that adjudicated these and other water rights in the lower Colorado River basin,[2] and the state statutes and regulations that generally govern use of state water. LCRA's exercise of its water rights pursuant to these requirements is subject to the continuing jurisdiction of the Texas Commission of Environmental Quality (TCEQ), the state agency with primary authority over state water rights.

The 1988 Adjudication Order specifically required LCRA to submit a reservoir operations plan for lakes Buchanan and Travis,[3] and this requirement is also incorporated into the water rights for these lakes.[4] Certificates of Adjudication 14-5478 and 14-5482 state that "LCRA shall interrupt or curtail the supply of water . . . pursuant to commitments that are specifically subject to interruption or curtailment, to the extent necessary to allow LCRA to satisfy all demand for water under such certificates pursuant to all firm, uninterruptible water commitments."[5] The Water Management Plan (WMP), which is subject to review and approval of the TCEQ, is LCRA's required reservoir operations plan and provides the framework by which LCRA implements this requirement and sets forth the procedures by which LCRA makes water available from these lakes to help meet "firm" water customer needs, downstream interruptible agricultural demands, and environmental flow needs of the lower Colorado River and Matagorda Bay within LCRA's service area. (*See* Figure 1-1.) The WMP also sets forth criteria for declaring a Drought Worse than the Drought of Record (DWDR)[6] and includes a calculation of the Combined Firm Yield of Lakes Buchanan and Travis, which is the amount of water that can be supplied annually from lakes Buchanan and Travis through a repeat of the Drought of Record (DOR).[7]

- **Firm Water** is water that can be supplied on a consistent (or "firm") basis from lakes Buchanan and Travis through a repeat of the worst drought in recorded history for the lower Colorado River basin, which is the drought of the 1940s and 50s, while honoring

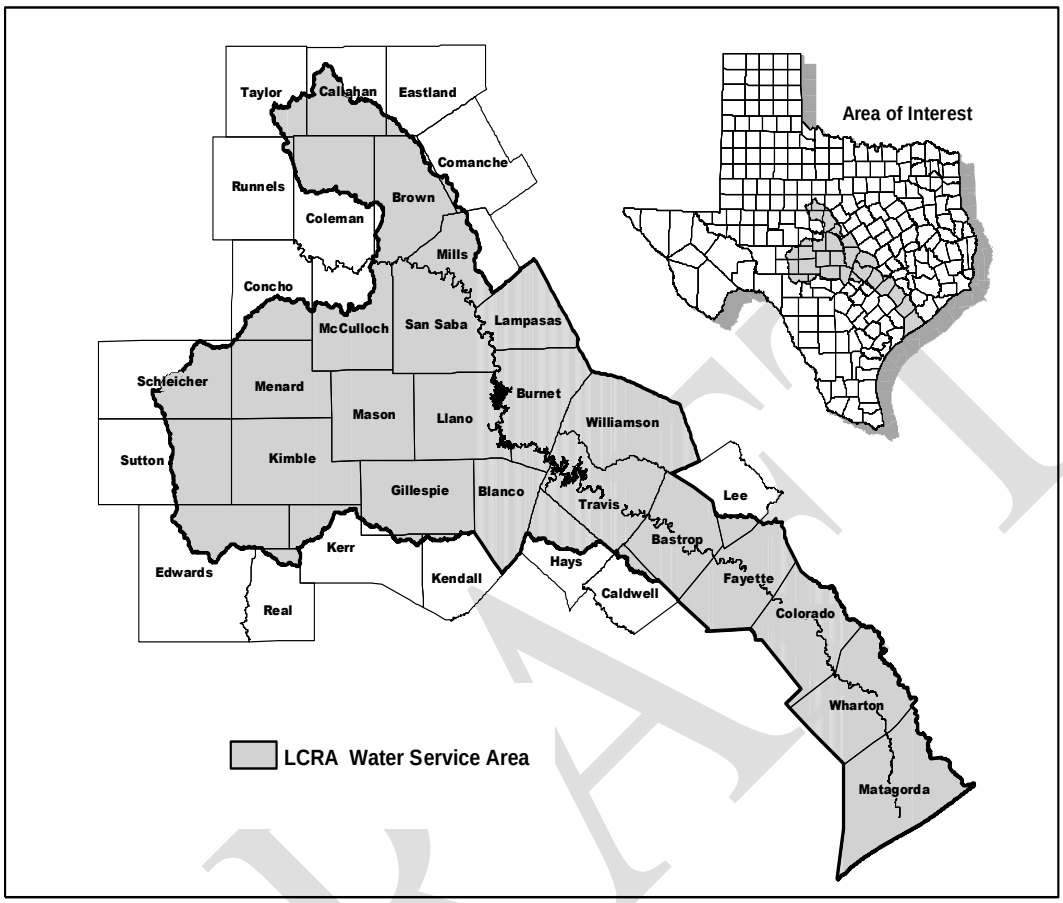
all downstream water rights. This drought is known as the Drought of Record. Firm Water is primarily made available through contracts with cities and industries within LCRA's service area, but is also used in more limited cases for irrigation, recreation, domestic use, and environmental needs.

- **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 Water customer demands. Currently, Interruptible Stored Water is used almost entirely for agricultural purposes in the downstream agricultural operations (LCRA's Garwood, Gulf Coast and Lakeside agricultural 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.

LCRA's first WMP was developed by LCRA, approved by its Board of Directors, and approved by the Texas Water Commission (predecessor to the TCEQ) in 1989. The WMP is revised periodically to address changing conditions, such as increased demands from Firm Water customers and updated science related to environmental flows. As the actual water demands from lakes Buchanan and Travis for Firm Water users continue to increase, the amount of Interruptible Stored Water available from the lakes is expected to continue to decrease. Revisions to the WMP have been approved by the TCEQ (or its predecessors) in 1991, 1992, 1999 and 2010.

In many respects, this WMP implements the most significant changes since the inception of the WMP and is designed to respond to recent and dramatic drought conditions that have rivaled the Drought of Record. Further, the WMP implements a more sophisticated approach to helping meet environmental flow needs of the lower Colorado River and Matagorda Bay system based on the most recent and best available scientific studies.

Figure 1-1. LCRA Water Service Area as of Oct. 2014.



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 Adjudication Order:

- 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.[8]

To achieve the goals stated above, LCRA manages the system according to the following guidelines from the 1988 Adjudication Order:[9]

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 Combined 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.[10]

The amount of Interruptible Stored Water that can be made available while honoring Firm Water demands has also been determined historically according to the following guidelines:

1. Water may be available on an interruptible basis at any time that the actual demand for firm water is less than the firm yield. Interruptible stored water should be made available to the extent that demands for such water exist;[11]
2. The extent to which interruptible stored water will be available in any year can be defined pursuant to an operational rule curve or other analysis that guarantees the supply of water for firm demands and identifies an amount of water for interruptible purposes;[12] and
3. The use of an operational rule curve is an acceptable approach to insure utilization of the lakes' storage while guaranteeing that firm demands will be met dependably.[13]

Further, in response to the exceptional drought conditions in the lower Colorado River basin that prompted three years of emergency orders superseding the 2010 WMP,[14] and based on input from the TCEQ Executive Director, the LCRA Board adopted a four-point framework that underlies this WMP:

1. Combined Storage is maintained above 600,000 acre-feet through a repeat of historic hydrology.
2. The WMP was developed based on hydrology through year 2013.
3. Demands associated with Corpus Christi's Garwood water right were included in the analysis.
4. The WMP includes a three-tier regime for interruptible agricultural curtailment that considers Combined Storage and inflow conditions, plus the use of a look-ahead test (as further explained in Chapter 4).

1.3 INTERESTS AFFECTED BY WATER MANAGEMENT PLAN

Lakes Buchanan and Travis are operated as a single water supply system and are designed to supply water and address varied interests within LCRA's service area, as described more fully below.

1.3.1 Municipal and Industrial Customers

The bulk of LCRA's Firm supply is provided to cities and industries within LCRA's service area. LCRA's municipal customers together supply water for over 1 million people in one of the fastest growing regions in the country. LCRA also supplies water on a firm basis to a number of industrial customers, including several power plants.

1.3.2 Agricultural Users

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. In the 1930s, not long after LCRA was created, it entered into contracts to provide a combination of stored water and run-of-river water to help meet the needs of irrigators within the Garwood, Gulf Coast and Lakeside irrigation companies' service areas.

LCRA has a handful of Firm Water customers who purchase water for agricultural use, but most of the water provided by LCRA for agricultural use is purchased on an interruptible basis. The Water Management Plan is the mechanism that determines how much interruptible water is available for this and other purposes. Historically, under the WMP, agricultural customers within the LCRA's agricultural operations have had first claim to available interruptible supply over other interruptible users.[15] LCRA contracts to provide a very limited supply of interruptible water for agricultural use outside these four operations when the lakes are nearly full.

1.3.3 Other Water Customers

LCRA also supplies water, primarily on a firm basis, for other beneficial uses, such as golf course and landscape irrigation and household use.

1.3.4 Environmental & Water Quality Interests

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. LCRA makes water available from lakes Travis and Buchanan under the WMP from a combination of Firm and Interruptible Stored Water supply to help meet varying environmental flow needs for both the health of the lower Colorado River and Matagorda Bay. Water that LCRA provides for instream flows also helps protect water quality, particularly when combined with other LCRA programs to monitor and protect water quality in the river and the Highland Lakes.

1.3.4.1 Freshwater Inflows

The Colorado River, along with other area rivers and streams, provides 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.

1.3.4.2. Instream Flows and Water Quality

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. As discussed more fully in Chapter 2, a range of flow conditions is necessary to maintain healthy ecosystems.

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: stormwater runoff that carries pollutants and contaminants (nonpoint source pollution); soil erosion; discharges from industry and wastewater treatment plants (point source pollution); reservoir sedimentation; and dissolved oxygen problems.

While the WMP is designed to manage lakes Buchanan and Travis to provide Firm and Interruptible Stored Water supply and help meet environmental needs, the instream flow recommendations also provide for water quality protection. Currently, there are several LCRA programs in place to protect and enhance river and lake water quality. In fact, LCRA is actively involved in the Colorado River Watch Network and Texas Clean Rivers Program, has developed water quality models for the Highland Lakes, and administers a permitting program to address threats to water quality from septic systems and stormwater runoff near the Highland Lakes.

1.3.5 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 on the lakes, the demands for higher lake levels can be difficult to accommodate. Similarly, providing water specifically to maintain river recreation below Austin would also impact the available water supply. The WMP nonetheless addresses these interests, in part, by only making available a small amount of Interruptible Stored Water on a temporary basis to areas outside of the four agricultural operations under conditions that require the lakes to be nearly full.

1.4 DEVELOPMENT OF CURRENT WATER MANAGEMENT PLAN

1.4.1 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 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.[16]

1.4.2. Advisory Committee & Stakeholder Processes

LCRA has used input from an advisory committee to develop every WMP. The TCEQ 2010 WMP Order specifically 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. A list of the advisory committee members, which included members from each of the major interests that depend on the lower Colorado River, is included in Exhibit F-4.

From July 2010 through the Fall of 2011, 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.

The advisory committee spent several months 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. Throughout the process, LCRA staff worked diligently 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 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.

Although near consensus was reached at the close of the advisory committee process in the Fall of 2011, this effort was overshadowed by the worst one-year drought in recorded history in 2011. As the drought has persisted, and LCRA operated pursuant to emergency orders in 2012, 2013, and 2014, it became evident that further changes to the WMP were needed beyond those considered by the advisory committee.

Further revisions were evaluated by LCRA staff during the summer of 2014 based on input from the TCEQ Executive Director and the four-point framework discussed in Section 1.2 above. In August 2014, the LCRA Board directed staff to meet with interested stakeholders in an expedited process and to return to the Board the following month with a proposal. To that end, LCRA staff

held open stakeholder meetings on three separate occasions, met with county judges and their representatives, and conducted further analysis based on requests and input from stakeholders and brought a proposal for the Board's consideration in September 2014, which is embodied in this WMP. Although LCRA did not reconvene the advisory committee for a consensus vote, the stakeholders who addressed the LCRA Board in September 2014 were generally supportive of the staff proposal.

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1. Certificates of Adjudication 14-5478, as amended, and 14-5482, as amended.
2. *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*, No. 115, 414-A-1 (264th Dist. Ct., Bell County, Tex. April 20, 1988) ("1988 Adjudication Order"), Lake Buchanan Conclusion of Law 4, Lake Travis Conclusion of Law 6.
3. *Id.*
4. Certificate of Adjudication 14-5478 ¶ 2.B.(1); Certificate of Adjudication 14-5482 ¶ 2.B.(1).
5. Certificate of Adjudication 14-5478 ¶ 2.B.(7); Certificate of Adjudication 14-5482 ¶ 2.B.(7).
6. TEX. COMM'N ENVTL. QUAL., *Order Approving Lower Colorado River Authority's Drought Management Plan*, Ordering Provision 1(f) (Dec. 18, 1991).
7. *See* 1988 Adjudication Order, Lake Buchanan: Conclusion 4(a), Lake Travis: Conclusion 6(a) (requiring that LCRA determine the Combined Firm Yield of Lake Travis and Buchanan).
8. 1988 Adjudication Order, Lake Buchanan: Finding 19, Lake Travis: Finding 26.
9. *Id.*
10. *Id.*
11. *Id.* Lake Buchanan: Finding 19(e), Lake Travis: Finding 26(e).
12. *Id.* Lake Buchanan: Finding 24; Lake Travis: Finding 31; TEX. COMM'N ENVTL. QUAL., *Order Approving Lower Colorado River Authority's Water Management Plan and Amending Certificates of Adjudication Nos. 14-5478 and 14-5482*, Finding of Fact 51 (Sept. 7, 1989) ("1989 WMP Order").
13. 1989 WMP Order, Finding of Fact 90.
14. TEX. COMM'N ENVTL. QUAL., Docket No. 2014-1044-WR, *Order Affirming an Order Granted by the Executive Director that Grants an Emergency Order Requested by the Lower Colorado River Authority* (Aug. 15, 2014); TEX. COMM'N ENVTL. QUAL., Docket No. 2014-0124-WR, *Order Affirming an Order issued by the Executive Director that grants a renewal of the Emergency Order issued to the Lower Colorado River Authority* (June 17, 2014); TEX. COMM'N ENVTL. QUAL., Docket No. 2014-0124-WR, *Order Affirming in Part, and Modifying in Part, the Executive Director's Emergency Order Authorizing the Lower Colorado River Authority to Amend its Water Management Plan* (Feb. 27, 2014); TEX. COMM'N ENVTL. QUAL., Docket No. 2013-0225-WR, *Order Granting an Emergency Authorization to the Lower Colorado River Authority* (July 26, 2013); TEX. COMM'N ENVTL. QUAL., Docket No. 2013-0225-WR, *Order Affirming, with Modification, an Emergency Order Granted by the Executive Director to the Lower Colorado River Authority* (June 10, 2013); TEX. COMM'N ENVTL. QUAL., Docket No.

2013-0225-WR, *Order Affirming, with Modification, an Emergency Order Granted by the Executive Director to the Lower Colorado River Authority* (Feb. 19, 2013); TEX. COMM'N ENVTL. QUAL., Docket No. 2011-2096-WR, *Order Affirming an Emergency Order Granted by the Executive Director to the Lower Colorado River Authority* (Dec. 12, 2011).

15. TEX. COMM'N ENVTL. QUAL., Docket No. 1995-1317-WR, *Order Overruling Objections to LCRA's System of Priorities Set Forth in its Water Management Plan* (June 3, 2003).
16. TEX. COMM'N ENVTL. QUAL., *Agreed Order Approving Amendments to Lower Colorado River Authority's Water Management Plan*, Ordering Provision 1.f. (Jan. 27, 2010).

CHAPTER 2
DEMANDS

2.1 Background 2-1
2.2 Firm Water 2-1
2.2.1 Demands 2-1
2.2.2 Board Reservation 2-3
2.3 Agricultural Demands in the Downstream Irrigation Operations 2-4
2.4 Environmental Needs for Instream Flows and Bay and Estuary Inflows 2-6
2.4.1 Instream Flows 2-6
2.4.2 Bay and Estuary Inflows 2-7
2.5. Hydroelectric Power Generation 2-9

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 further enhance our understanding of the environment's water needs.

As discussed further in this Chapter, for purposes of this WMP, LCRA used Interim Demands for surface water that generally correspond to dry year demands. For Firm Water customers, this WMP uses a level of demand about halfway between year 2010 and year 2020 projected demands. Interim Demands for the downstream agricultural operations are based on year 2010 demands.

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 historic 1950s 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 Water 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 October 2014, LCRA has included existing and projected domestic water use in the demands for this WMP revision as it did in the 2010 WMP. LCRA has issued a significant number of Firm Water contracts for domestic use. Absent a contract, most if not all of diverters around the lakes who take water for domestic use have no legal claim to the water they are diverting. In recent years, LCRA has been working to bring these diverters into compliance.

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

The Firm Water demands for LCRA's customers 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. That plan includes demand projections through year 2100, however the WMP is only designed for near-term demands. 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. Demands were calculated using the same per capita water use approach used in the 2006 Region K plan;
6. New and pending contracts for municipal demand were included;
7. Projected demands for domestic use on the Highland Lakes were added;
8. Region K industrial demand, and new and pending contracts for industrial use were included;
9. Conveyance losses from the point of release of water from the Highland Lakes to the point of delivery for existing contracts were added; and
10. Other demands such as emergency hydrogeneration were included.

The projected 2020 and 2030 Firm Water demands are summarized in Table 2-1. The projected 2020 and 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 not been developed for the 2020 and 2030 demands as part of this WMP revision.

Firm Water demands representing a scenario roughly halfway between year 2010 and 2020 were developed and used for the development of curtailment procedures under this WMP. In developing these "Interim" demands, LCRA took into account the actual water use at power plants in 2011 (a recent high demand year), the surface water demand reduction due to groundwater supplies available at the Lost Pines Power Park, and the expected use by Corpus Christi of its Garwood water right beginning in 2015. These demands are also summarized in Table 2-1.

Table 2-1. WMP Firm Water Demand Projections (acre-feet/year)

	WMP	WMP Future Projections[1]		
	2010	Interim	2020	2030
Firm Demands:				
City of Austin Municipal[2]	182,788	193,334	203,880	232,923
LCRA Power Plants	25,866	25,500	25,866	25,866
City of Austin Power Plants[2]	13,500	19,000	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 Water Demand	288,606	350,086	416,000	494,134
STPNOC Firm Water Back-up	20,000	20,000	40,000	40,000
Other Major Run-of-River Diverters:				
City of Corpus Christi	-	35,000	35,000	35,000
STPNOC/LCRA	102,000	102,000	102,000	102,000

Notes:
1. Future projections of water demands based on LCRA Water Supply Resource Plan & 2006 Region K plan.
2. By contract, these customers 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 Water demands such as recreation and irrigation. Also included is domestic use around the Highland Lakes.

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 groundwater 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.

2.3 AGRICULTURAL DEMANDS IN THE DOWNSTREAM IRRIGATION OPERATIONS

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 has been from the waters of the Colorado River, either under LCRA's 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 2011. The demand for agricultural water varies from year to year based on the number of acres irrigated and weather conditions. From 2000 to 2011, agricultural diversions at the four irrigation operations ranged from a maximum of about 464,000 acre-feet in 2011 to a minimum of 199,000 acre-feet in 2007. In 2012, 2013 and 2014, Interruptible Stored Water supply for agriculture was curtailed pursuant to emergency orders issued by TCEQ[3] and total agricultural diversions were significantly reduced.

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.[4] To the extent that LCRA is able to make water available under its run-of-river rights, LCRA does not have to release water from storage. However, the timing and availability of run-of-river water (whether originating above or below the Highland Lakes) is often insufficient to meet all agricultural needs.[5] For example, in recent dry years such as 2009 and 2011, the percent of diversions originating from stored water was about 68 and 79 percent, respectively. In 2010, a wetter year, the percent of diversions originating from stored water was about 31 percent, with the majority of diversions, about 69 percent, originating from run-of-river supplies.

The Texas Water Development Board (TWDB) forecasts that agricultural diversions by the downstream irrigation operations will decrease over time.[6] The 2010 Water Management Plan similarly forecast future reductions in demand. For this WMP revision, the projected agricultural demands were primarily based on the Lower Colorado Regional Planning Group's (Region K) 2006 Regional Water Plan. However, recent water use exceeded the Regional Water Plan's projection 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 are reflective of the current (Interim) demands and were used to develop the curtailment procedures for this WMP. The year 2020 and 2030 demands are presented in Table 2-2 for reference purposes.

Table 2-2 represents demands that are expected to be exceeded only about 10 percent of the time for the period of historic record and therefore represent irrigation demands during drought

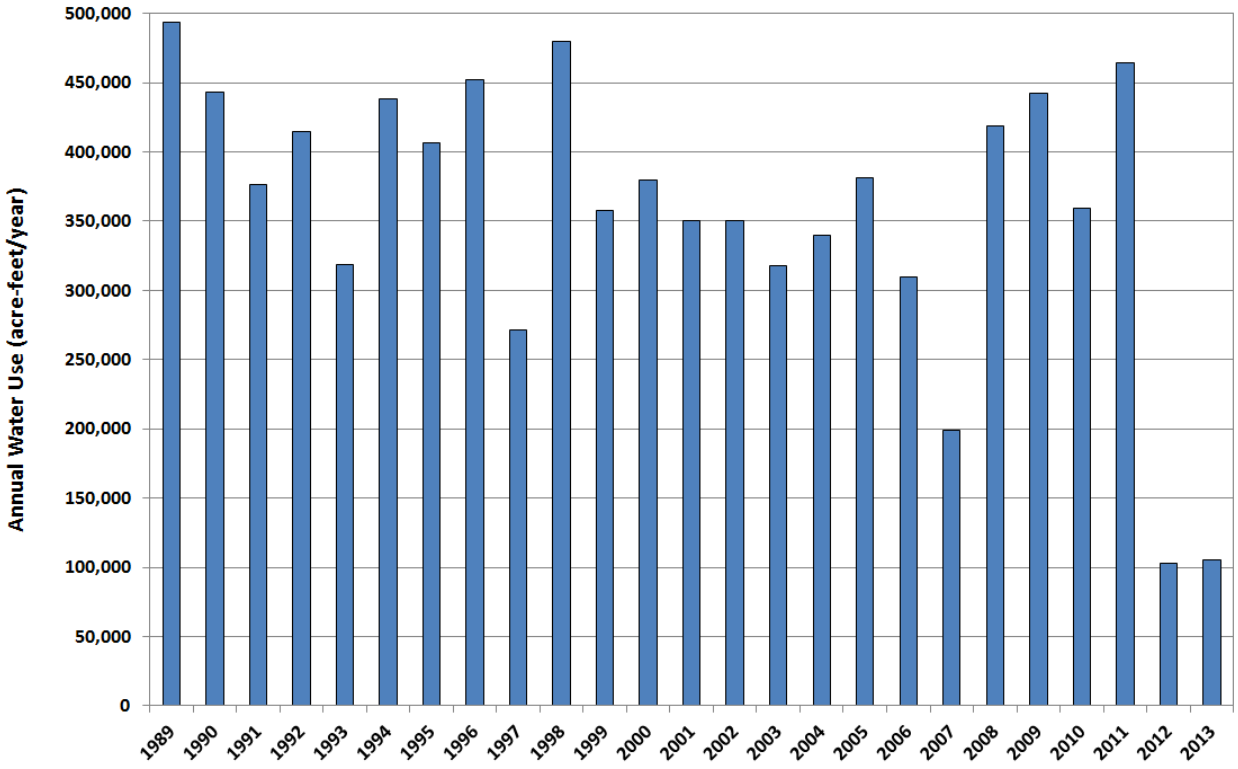
conditions. The period of 1940-2013 was used for modeling this WMP revision. There was significant weather variability during this period, which resulted in variability in agricultural demands. For example, *see* Figure 2-1, which illustrates the irrigation water demand variability since 1989 based upon 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.

Table 2-2. Projected Diversions by Irrigation Operation (acre-feet/year)

Year	Irrigation Operation				
	Garwood	Lakeside	Gulf Coast	Pierce Ranch	Total
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 average of 2008 and 2009 use.
**Adjusted to the average of the adjusted 2010 value and the 2020 value.

Figure 2-1. Historic Water Diversions by the Four Downstream Irrigation Operations



Note: Diversions in 2012 and 2013 were reduced as a result of curtailment of supplies.

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 and in Matagorda Bay. Under the WMP, water is made available to help meet varying environmental flow levels downstream of Austin 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 gauges. 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 2-3.

Table 2-3. 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 Inflows

Many factors, including freshwater inflows, contribute to the high natural productivity of Matagorda Bay and estuary. The seasonality of these freshwater 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 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%. 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 2-4. The inflow values associated with these inflow levels are presented in Table 2-5.

Table 2-4. Summary of Matagorda Bay Health Evaluation Inflow Levels

Inflow 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 2-5. Matagorda Bay Health Inflow 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 MBHE levels 1 through 4. To help meet MBHE 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 2-6. These running two-month values are applied in seasonal periods representing spring, fall and intervening. The spring Operational Criteria apply for the two-month periods ending in March, April, May and June. The fall Operational Criteria apply for the two-month periods ending in July, August, September and October. Finally, the intervening Operational Crtieria apply for the two-month periods ending in November, December, January, and Februrary. 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. To determine whether the criteria was met at the end of March, LCRA will look at total inflows from February 1 through March 31. The monthly Threshold bay inflow need applies in every month, regardless of the season or inflow level sought to be achieved. While Table 2-5 represents the general criteria for attempting to meet MBHE inflows, Chapter 4 includes the full suite of criteria applied to determine how much stored water will be made available from lakes Buchanan and Travis for environmental flows, including some limitations on the amounts of water that would be made available to meet the Operational Criteria.

Table 2-6. Operational Criteria for Matagorda Bay Inflows

Inflow Category	Two-Month Operational Criteria (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 294 megawatts of capacity as shown in Table 2-7. Until the 1960s, the hydroelectric plants represented LCRA's total capability for generating electric energy. LCRA's Enabling Act and its water rights (as well as those of the City of Austin for Tom Miller Dam) include provisions that largely subordinate the right to generate hydropower. In essence, this subordination[10] recognizes the competing needs for the stored water in the reservoirs, and hydrogeneration is allowed only when LCRA needs to release water to meet other water demands, when hydrogeneration will not impair LCRA's ability to satisfy all water demands, or when there is an "emergency shortage of electricity." To the maximum extent possible, releases of water are made in a manner to take maximum advantage of the energy produced by those releases. Because water released for hydrogeneration but retained in or above Lake Austin is still available to meet a water supply demand, these limitations generally apply only to water released for hydrogeneration that leaves Tom Miller Dam that cannot be used to meet a downstream water demand.

Table 2-7. Hydroelectric Capacities

Lake	Dam	Generation Capacity (megawatts)	Discharge Capacity (cfs)
Buchanan	Buchanan	54	5,941
Inks	Inks	14	3,217
LBJ	Wirtz	60	10,134
Marble Falls	Starke	42	10,372
Travis	Mansfield	108	7,578
Austin	Miller	16	3,415

To conform to current ERCOT protocols and LCRA operations, LCRA employs a definition of "emergency shortage of electricity" that allows LCRA to release water for hydroelectric generation absent a downstream water demand when such releases are:

1. made while ERCOT is in an Energy Emergency Alert (EEA) for a short supply condition;
2. in response to an ERCOT-issued Reliability Directive or other emergency order;
3. required to comply with ERCOT's Responsive Reserve Service release and dispatch orders; or
4. required to comply with a Security-Constrained Economic Dispatch (SCED) dispatch instruction to generation at the ERCOT's current System Wide Offer Cap (SWOC), which indicates a market-based shortage of supply.

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1. LCRA, WATER SUPPLY RESOURCE PLAN, and supporting spreadsheets (October 2010).
2. PARSONS CORP., FINAL REPORT: FUTURE IRRIGATION WATER DIVERSIONS, 2010-2090, Prepared for LCRA and SAWS (Sept. 1, 2006).
3. *See* Chapter 1, Note 14.
4. LCRA, AN UPDATE TO IRRIGATION WATER USE PREDICTIONS FOR THE FOUR AGRICULTURAL WATER OPERATIONS IN THE LOWER COLORADO RIVER SERVICE AREA (June 14, 2010).
5. LCRA, WATER SUPPLY STRATEGIES FOR AGRICULTURE (June 2011).
6. TEX. WATER DEV. BD. & LOWER COLORADO REG'L PLANNING GRP., 2001 ADOPTED REGIONAL WATER PLAN (Dec.2000); TEX. WATER DEV. BD. & LOWER COLORADO REG'L PLANNING GRP., 2006 ADOPTED REGIONAL WATER PLAN (Jan. 2006).
7. BIO-WEST, Inc., FINAL REPORT: COLORADO RIVER FLOW RELATIONSHIPS TO AQUATIC HABITAT AND STATE THREATENED SPECIES: BLUE SUCKER, Prepared for LCRA and SAWS (2008).
8. TEX. COMM'N ON ENVTL. QUAL., TEX. PARKS & WILDLIFE DEPT., & TEX. WATER DEV. BD., TEXAS INSTREAM FLOW PROGRAM STUDIES: TECHNICAL OVERVIEW REPORT 369 (May 2008).
9. FINAL REPORT: MATAGORDA BAY INFLOW CRITERIA (COLORADO RIVER), MATAGORDA BAY HEALTH EVALUATION, Prepared for LCRA and SAWS (Dec. 2008).
10. The only water accounted for in the WMP model specifically for hydrogeneration is for emergency shortages of electricity, consistent with the special conditions in LCRA's water rights. The WMP model does not otherwise reflect the "subordination" of its hydrogeneration rights required by LCRA's water rights because any non-emergency hydrogeneration is a byproduct of releases that LCRA makes for other downstream demands. The special conditions affecting LCRA's exercise of its hydrogenation rights are identical in all of its rights for the Highland Lakes. *See, e.g.*, Certificate of Adjudication No. 14-5478 (Lake Buchanan), ¶ 2.D (Use) at 6.

CHAPTER 3
FIRM YIELD OF LAKES BUCHANAN AND TRAVIS

3.1 Introduction 3-1
3.2 Combined Firm Yield Computation 3-1

3.1 INTRODUCTION

The 1988 Adjudication Order adjudicating LCRA's Highland Lakes water rights requires that LCRA calculate the Combined Firm Yield of Lakes Travis and Buchanan (Combined Firm Yield).[1] TCEQ rules define firm yield as follows:

> 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.[2]

As part of this WMP revision, LCRA has recalculated the Combined Firm Yield. For purposes of this WMP, the Combined Firm Yield of Lakes Buchanan and Travis is the firm yield of those lakes when operated as a system, incorporating LCRA's agreements and operating assumptions as discussed below. 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. For lakes Buchanan and Travis, 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 historic 1950s Drought of Record. It is also possible for a drought more severe than the historic Drought of Record to occur in the future, in which case the full firm yield amount would not be available.

3.2 COMBINED FIRM YIELD COMPUTATION

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'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 incorporates LCRA's agreements regarding O.H. Ivie Reservoir and certain other upstream water rights whereby LCRA would not make a call on such water rights. This model

also incorporates the settlement agreement between LCRA and the City of Austin[3] regarding treatment of return flows discharged by the City of Austin as it impacts the Combined Firm Yield of Lakes Buchanan and Travis. Key model assumptions are summarized in Table 3.1. The model assumptions are addressed in detail in Appendix A, Technical Paper A-5.

Table 3-1. Firm Yield Model – Key Assumptions

Model Parameter	Firm Yield Model
Period of record	1940-2013
Reservoir sedimentation conditions	Year 2010
Priority "cutoff" assumption[1]	Ivie and Brownwood
Municipal and industrial demands	Authorized Amount
Downstream water rights	Authorized Amount
City of Austin return flows included	Yes
Environmental flows represented	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. This assumption is appropriate at and above Ivie and Brownwood reservoirs 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.

Although this basin has experienced exceptional drought conditions in recent years, for the period of record from 1940 to 2013, the model results indicated that the critical period for determining the Combined Firm Yield remains the historic 1950s Drought of Record. The Combined Firm Yield of Lakes Buchanan and Travis as calculated in this WMP revision is 434,154 acre-feet per year. This replaces the value of 445,266[4] acre-feet per year calculated in the original WMP as documented in the 1989 Order approving that WMP and referenced in Certificates of Adjudication Nos. 14-5478A and 14-5482A.[5] A more detailed explanation of the Combined Firm Yield calculation can be found in Appendix A, Technical Paper A-5.

1. *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*, No. 115, 414-A-1 (264th Dist. Ct., Bell County, Tex. April 20, 1988) ("1988 Adjudication Order"),
2. 30 TEX. ADMIN. CODE § 297.1(20).
3. *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*, § VIII.C. (June 18, 2007).
4. The initial and prior WMPs also reported as part of the Combined Firm Yield an additional 90,546 acre-feet per year associated with O.H. Ivie Reservoir for a total of 535,812 acre-feet per year.
5. TEX. COMM'N ENVTL. QUAL., *Order Approving Lower Colorado River Authority's Water Management Plan and Amending Certificates of Adjudication Nos. 14-5478 and 14-5482*,

Finding of Fact 51 (Sept. 7, 1989) Finding of Fact 47 & Ordering Paragraph 1(m) (specifically noting that the firm yield "is subject to adjustment and refinement from time to time as additional studies and simulations are developed that more accurately reflect assumption s and operations required by law.") Certificates of Adjudication 14-5478A, ¶ 1(b) and 14-5482A ¶ 1(b), which were issued at the same time as the 1989 Order, also expressly state that this calculation may be modified from time to time. The revised calculation reflects recent sedimentation survey data that shows a reduction in the total Combined Storage capacity in the lakes, which is important to reflect for operational purposes. However, LCRA is not requesting any amendments to the authorizations contained in the underlying water rights for lakes Travis and Buchanan.

CHAPTER 4

DETERMINATION OF INTERRUPTIBLE STORED WATER AVAILABILITY AND WATER FOR ENVIRONMENTAL FLOW NEEDS

4.1. Introduction 4-2
4.2. Determination of Water Supply Condition 4-4
4.2.1. Introduction 4-4
4.2.2. Normal Condition 4-4
4.2.3. Less Severe Drought Condition 4-5
4.2.3.1. Entering Less Severe Drought Condition 4-5
4.2.3.2. Exiting Less Severe Drought Condition 4-5
4.2.4. Extraordinary Drought 4-6
4.2.4.1. Entering Extraordinary Drought Condition 4-6
4.2.4.2. Exiting Extraordinary Drought Condition 4-6
4.3. Curtailment Procedures for Agricultural Operations at Gulf Coast, Lakeside, and Pierce Ranch 4-6
4.3.1. Introduction 4-6
4.3.2. Determination of Interruptible Stored Water Available for Agricultural Operations at Gulf Coast, Lakeside, and Pierce Ranch 4-7
4.3.2.1. Curtailment Procedures for Normal Conditions 4-7
4.3.2.2. Curtailment Procedures for Less Severe Drought Condition 4-9
4.3.2.3. Curtailment Procedures for Extraordinary Drought Condition 4-11
4.3.2.4. Curtailment Procedures under the Look-Ahead Test 4-11
4.4. Curtailment Procedures for Environmental Flows in the Lower Colorado River Basin 4-11
4.4.1. Providing Stored Water for Environmental Flow Needs 4-11
4.4.2. Curtailment of Water for Instream Flows 4-12
4.4.3. Curtailment of Water for Freshwater Inflows to Matagorda Bay 4-14
4.4.4. Annual and Multi-year Caps on Water for Environmental Flows 4-17
4.5. Curtailment Procedures for Interruptible Stored Water Demands Other than the Downstream Agricultural Operations 4-17
4.6. Curtailment of Firm Water Demands 4-18
4.7. Declaration and Cancellation of Drought Worse than Drought of Record 4-19
4.8. Results of the Recommended Curtailment Policies under this WMP 4-20
4.8.1. Firm Water Customers 4-21
4.8.2. Agricultural Customers in Downstream Agricultural Operations 4-21
4.8.3. Environmental Flows 4-21
4.8.4. Individual Lake Storage and Elevations 4-22

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 demands in the downstream agricultural operations;
- A range of freshwater inflow goals for Matagorda Bay;
- A range of instream flow goals downstream of the Highland Lakes; and
- Demands for a small category of Interruptible Stored Water users, other than the downstream agricultural 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 purposes can be particularly high during dry conditions. Moreover, recent and dramatic drought conditions that have rivaled the Drought of Record demonstrate the need to impose greater limitations on the availability of Interruptible Stored Water to ensure that LCRA can meet Firm Water demands if such conditions persist. These types of conditions, combined with a significant growth in Firm Water demands, increase the likelihood of significant shortages of Interruptible Stored Water. Thus, this WMP revision includes significant changes to the Interruptible Stored Water curtailment policies from prior Water Management Plans.

When determining available Interruptible Stored Water supplies, it is essential that Firm Water demands be protected during a repeat of the historic 1950s Drought of Record (DOR)[1]. This drought is the worst recorded to date on the lower Colorado River. The curtailment procedures in this WMP revision have been designed to ensure supply is available to meet Firm Water demands as described in Chapter 2, 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 ("TCEQ 2010 Order").[2] Specifically, this WMP revision has been simulated for a repeat of historic hydrology from 1940 to 2013.

The TCEQ 2010 Order also required an evaluation of the minimum Combined Storage in lakes Buchanan and Travis necessary or appropriate to protect Firm Water customers through a DOR condition, or under conditions worse than the 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, LCRA has designated some minimum Combined Storage level in all of its prior WMPs. This served as a safety factor to address model uncertainties and provide for hydrologic conditions other than those simulated.

This WMP establishes a minimum Combined Storage goal of 600,000 acre-feet and the model simulations for this WMP revision maintained Combined Storage at or above this goal. This safety factor avoids the triggering of a Drought Worse than Drought of Record (DWDR) in the event of a repeat of historic hydrology and is consistent with input received from TCEQ in May 2014 and the emergency orders issued by TCEQ for the 2012, 2013, and 2014 irrigation seasons.[3]

As discussed in Chapter 2, demands of LCRA's Firm Water customers have increased and are projected to continue to increase. To meet those demands without shortage through a repeat of historic hydrology, this WMP revision includes decreases in the amount of Interruptible Stored Water provided as compared to the 2010 WMP.

This WMP revision includes a number of significant changes to the methods used to determine the availability of Interruptible Stored Water from lakes Buchanan and Travis for agricultural use in the Gulf Coast, Lakeside, and Pierce Ranch operations and for 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:

Interruptible Stored Water Availability

- LCRA will determine availability of Interruptible Stored Water for LCRA's Gulf Coast and Lakeside operations and Pierce Ranch separately for the First and Second Crop Seasons and apply strict volumetric limits (or caps) on availability of Interruptible Stored Water in each Crop Season;
- The amounts of Interruptible Stored Water for LCRA's Gulf Coast and Lakeside agricultural operations, and Pierce Ranch will be determined taking into consideration what Water Supply Condition is in effect: "Normal," "Less Severe Drought," or "Extraordinary Drought," combined with the implementation of a look-ahead test;
- Under the look-ahead test, LCRA will not begin releasing water for the non-Garwood operations for a Crop Season if the LCRA Board determines that the Combined Storage of lakes Buchanan and Travis would drop below 900,000 acre-feet in the upcoming Crop Season or below 600,000 acre-feet within 12 months; and
- LCRA will stop releasing Interruptible Stored Water for the Gulf Coast, Lakeside and Pierce Ranch agricultural operations in the middle of a Crop Season when the Combined Storage of lakes Buchanan and Travis drops below certain levels, whether or not the LCRA Board has declared of Drought Worse than Drought of Record.

Environmental Flows:

- LCRA used the most recent scientific studies to identify the environmental flow needs and to develop environmental flow criteria;
- LCRA will determine applicable environmental flow criteria at two dates during the year for different periods of the year; and
- The water available to help meet environmental flow needs may be adjusted based upon changes in the Combined Storage during the Crop Season.

This WMP revision does not incorporate LCRA's Raw Water Drought Contingency Plans (DCPs) for its Firm Water customers or its downstream agricultural operations. While those DCPs will take into account elements of this WMP revision, they are developed and approved pursuant to a separate process consistent with Texas Water Code § 11.1272 and TCEQ's rules (30 Tex. Admin. Code Ch. 288).

The following terms are used throughout this chapter:

- **Combined Storage** – The total volume of water stored in lakes Buchanan and Travis at a given point in time. For purposes of making various determinations under this WMP, the "Combined Storage" means the total of the daily average volume of water in Lake Buchanan and the daily average volume of water in Lake Travis, when excluding any water in Lake Buchanan above elevation 1,018 ft mean sea level (msl) and any water in Lake Travis above elevation 681 ft msl. A determination that relies on Combined Storage will not be based on a single reading during the day, but instead is the average for the day.

- **Inflows into Lakes Buchanan and Travis** – For purposes of making the determination of the Water Supply Condition or evaluating drought intensity, "Inflows into Lakes Buchanan and Travis" means the total inflows into lakes Buchanan and Travis based upon flow readings at certain gauges upstream of lakes Buchanan and Travis (without any adjustment for the Pass-Through of water to meet downstream demands associated with senior water rights).

- **Storable Inflows** – For purposes of making the determination of water available from lakes Buchanan and Travis to help meet certain environmental flows, the term "Storable Inflows" means the Inflows into lakes Buchanan and Travis based upon flow readings at certain gauges upstream of lakes Buchanan and Travis minus any required Pass-Through of inflows.

4.2. DETERMINATION OF WATER SUPPLY CONDITION

4.2.1. Introduction

This Section 4.2 presents the Water Supply Conditions that are used to determine the amounts of Interruptible Stored Water available for the downstream agricultural operations in Lakeside, Gulf Coast, and Pierce Ranch and the criteria in effect to help meet environmental flow needs. The Water Supply Condition will be evaluated on each March 1 and July 1 (the "Evaluation Date"), taking into account inflows into and the Combined Storage of Lakes Buchanan and Travis as presented below. That Water Supply Condition will be considered in the determination of Interruptible Stored Water and environmental flow criteria on that Evaluation Date. The Water Supply Condition remains in effect until criteria for entering a new Water Supply Condition or for exiting the Water Supply Condition are met on a subsequent Evaluation Date.

4.2.2. Normal Condition

The Normal condition is in effect under either of the following two conditions:

1. Condition 1:

   (a) for the period prior to the Evaluation Date, neither the Less Severe Drought nor the Extraordinary Drought condition was in effect, and

(b) on the Evaluation Date, neither the criteria for entering Less Severe Drought nor the criteria for entering Extraordinary Drought are met.

2. Condition 2:

(a) for the period prior to the Evaluation Date, the Less Severe Drought or Extraordinary Drought condition was in effect, and
(b) on the Evaluation Date, the criteria for lifting Less Severe Drought are met.

4.2.3. Less Severe Drought Condition

The Less Severe Drought condition can be entered or exited from either a Normal condition or an Extraordinary Drought condition, as discussed below. The Less Severe Drought condition remains in effect until either the criteria for entering the Extraordinary Drought condition (*see* Section 4.2.4.1) are met or the criteria for exiting the Less Severe Drought condition and returning to the Normal condition are met, as determined on the Evaluation Date (*see* Section 4.2.3.2).

4.2.3.1. Entering Less Severe Drought Condition

To enter the Less Severe Drought condition from a Normal condition, one of the following two criteria must be met on the Evaluation Date:

1. Combined Storage is below 1.6 million acre-feet and cumulative Inflows into Lakes Buchanan and Travis for the preceding three months (i.e. for the March 1 Evaluation Date, the inflows for December, January and February) are less than 50,000 acre-feet; or
2. Combined Storage is below 1.4 million acre-feet and cumulative Inflows into Lakes Buchanan and Travis for the preceding three months are less than the 33rd percentile of Inflows into Lakes Buchanan and Travis for that three-month period. The 33rd percentile will be based upon stream flow data that the United States Geological Survey (USGS) has approved for publication as of the Evaluation Date.

The Less Severe Drought condition is also entered upon exiting the Extraordinary Drought condition unless, on the Evaluation Date, the criteria for exiting Less Severe Drought (described below) are also met.

4.2.3.2. Exiting Less Severe Drought Condition

To exit the Less Severe Drought condition and return to the Normal condition, the following criteria must be met on the Evaluation Date:

1. Combined Storage has been above 1.6 million acre-feet for one or more days during the period preceding the Evaluation Date (i.e. for a July 1 evaluation, the period preceding the Evaluation Date is March 1 to June 30) and neither of the criteria for entering the Less Severe Drought condition are met on the Evaluation Date; or
2. Combined Storage has been above 1.4 million acre-feet for one or more days during the period preceding the Evaluation Date and cumulative inflows for the preceding

three months are equal to or above the 50th percentile of inflows for that three-month period and neither of the criteria for entering the Less Severe Drought condition are met on the Evaluation Date. The 50th percentile of inflows will be based stream flow data that USGS has approved for publication as of the Evaluation Date.

4.2.4. Extraordinary Drought

4.2.4.1. Entering Extraordinary Drought Condition

To enter the Extraordinary Drought condition, the following criteria must be met on the Evaluation Date:

1. Combined Storage is below 1.3 million acre-feet;
2. the drought duration (as described in Section 4.7) is at least 24 months; and
3. the inflow intensity test for a declaration of a Drought Worse than a Drought of Record (as described in Section 4.7) is met.

4.2.4.2. Exiting Extraordinary Drought Condition

The Extraordinary Drought condition remains in effect until the following criteria for exiting Extraordinary Drought have been met:

1. Combined Storage has been above 1.3 million acre-feet for one or more days during the period preceding the Evaluation Date; and
2. The criteria for entering the Extraordinary Drought condition are not met on the Evaluation Date.

If the criteria for exiting the Extraordinary Drought condition are met, the Less Severe Drought condition takes effect, unless the criteria for exiting Less Severe Drought is also met, in which case the Normal condition takes effect.

4.3. CURTAILMENT PROCEDURES FOR AGRICULTURAL OPERATIONS AT GULF COAST, LAKESIDE, AND PIERCE RANCH

4.3.1. Introduction

Section 4.3 presents the curtailment procedures that apply to releases of Interruptible Stored Water for agricultural uses in LCRA's Gulf Coast and Lakeside divisions and Pierce Ranch. Interruptible Stored Water may be available for these operations for a variety of agricultural purposes, including rice, turf grass, row crops, hay, pasture, aquaculture and wildlife management.

Throughout this chapter, references are made to "first" and "second" crop or to the First or Second Crop Season. These references are to the splitting of the full irrigation season (for which LCRA supplies water for agricultural use in the four agricultural operations) into two parts that are coincident with the two watering seasons for rice production, i.e. the First Crop Season and

the Second Crop Season. The second or 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. The First Crop Season normally covers the March through July timeframe and the Second 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 agricultural operations. Although the First and Second Crop Seasons are, in general, references to the rice growing seasons, during these timeframes and subject to availability under contracts for such purposes of use, water may also be available in the agricultural operations for other agricultural purposes such as turf grass, row crops, hay, pasture, aquaculture, and wildlife management.

4.3.2. Determination of Interruptible Stored Water Available for Agricultural Operations at Gulf Coast, Lakeside, and Pierce Ranch

The procedures for determining the total amount of Interruptible Stored Water available for the agricultural operations at Gulf Coast, Lakeside, and Pierce Ranch 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. Because LCRA's agreement to provide interruptible water to Pierce Ranch is subject to the WMP, as it may be amended from time to time, the curtailment procedures set forth in this WMP apply to Pierce Ranch.

The Interruptible Stored Water available for the Gulf Coast, Lakeside and Pierce Ranch agricultural operations will be determined separately for the First Crop Season and the Second Crop Season. On each Evaluation Date, LCRA will determine which Water Supply Condition is in effect for purposes of this WMP (Normal, Less Severe Drought, or Extraordinary Drought) in accordance with Section 4.2, above. The curtailment procedures for that Water Supply Condition will be followed for the upcoming Crop Season unless the LCRA Board determines that Combined Storage would drop below 600,000 acre-feet in the next 12 months or below 900,000 acre-feet in the upcoming Crop Season. If releases of Interruptible Stored Water for the First Crop Season are cut off for the entire First Crop Season, then releases of Interruptible Stored Water are also cut off for the Second Crop Season.

4.3.2.1. Curtailment Procedures for Normal Conditions

If the Normal condition is in effect, LCRA will make available for diversion the total amounts shown in Table 4.1 and Figure 4.1 at the Gulf Coast, Lakeside and Pierce Ranch agricultural operations. These amounts are limits on the total supply of Interruptible Stored Water available for diversion during the Crop Season. If the total diversions of Interruptible Stored Water in a Crop Season for Gulf Coast, Lakeside and Pierce Ranch agricultural operations reach the total available amount, no additional Interruptible Stored Water will be made available for diversion for those operations. However, if all available Interruptible Stored Water has been diverted in the First Crop Season, but there will be Interruptible Stored Water available for the Second Crop Season, then all or part of the Interruptible Stored Water available for the Second Crop Season can be used to finish the First Crop Season.

If Combined Storage falls below 900,000 acre-feet at any time during the either the First Crop or the Second Crop Season, all releases of Interruptible Stored Water to Gulf Coast, Lakeside and Pierce Ranch will be cut off for the remainder of the Crop Season. If releases of Interruptible Stored Water are cut off in the middle of a Crop Season (due to either the diversions reaching the total Interruptible Stored Water available or Combined Storage falling to the cutoff level), LCRA will not provide any Pass-Through run-of-river water under LCRA's water rights historically associated with the Gulf Coast, Lakeside and Pierce Ranch operations that originates upstream of Lake Travis unless and until Combined Storage is above 1.3 million acre-feet. During the remainder of the Crop Season, if Combined Storage exceeds 1.3 million acre-feet, LCRA will make these Pass-Through run-of-river supplies available, limited to the amounts needed to finish the crop. If releases of Interruptible Stored Water for the First Crop Season are cut off for the entire season, then releases of Interruptible Stored Water are also cut off for the Second Crop Season. Garwood operations will be provided Interruptible Stored Water consistent with the Garwood Purchase Agreement.

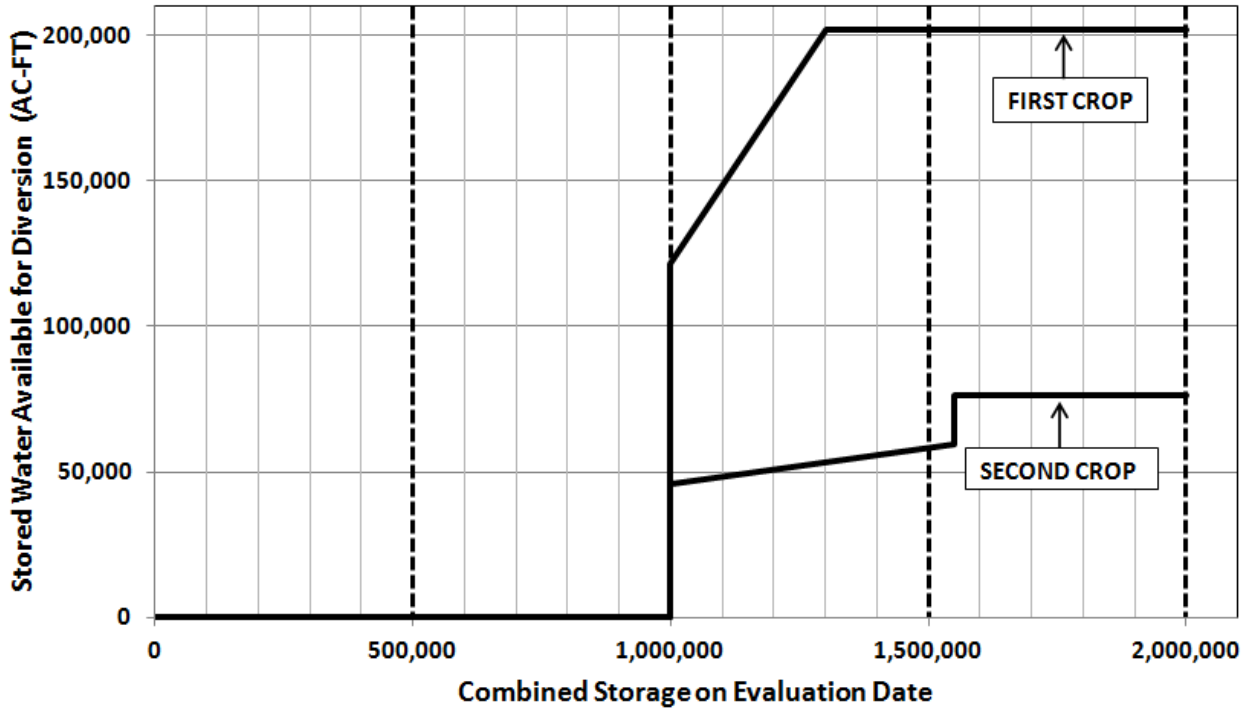
Table 4.1. Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside and Pierce Ranch agricultural operations under Normal Water Supply Condition

First Crop Season		**Second Crop Season**	
Combined Storage on March 1 (million acre-feet)	Interruptible Stored Water (acre-feet)*	Combined Storage on July 1	Interruptible Stored Water (acre-feet)*
Below 1.0 MAF	0	Below 1.0 MAF	0
1.0 to 1.3 MAF	121,500 to 202,000**	1.0 to 1.55 MAF	46,000 to 59,500**
1.3 MAF or above	202,000	1.55 MAF or above	76,500
Anytime cutoff* if Combined Storage drops to or below 900,000 acre-feet		Anytime cutoff* if Combined Storage drops to or below 900,000 acre-feet	

* Non-Garwood

** For Combined Storage within the specified ranges, the Interruptible Stored Water supply available follows a linear scale between the values shown.

Figure 4.1. Total Interruptible Stored Water available for Gulf Coast, Lakeside and Pierce Ranch agricultural operations under Normal Water Supply Condition



4.3.2.2. Curtailment Procedures for Less Severe Drought Condition

If the Less Severe Drought condition is in effect, LCRA will make available for diversion the total amounts shown in Table 4.2 and Figure 4.2 at the Gulf Coast, Lakeside and Pierce Ranch agricultural operations. These amounts are limits on the Interruptible Stored Water available for diversion during the Crop Season. If the total diversions of Interruptible Stored Water in a Crop Season for Gulf Coast, Lakeside and Pierce Ranch agricultural operations reach the total available amount, no additional Interruptible Stored Water will be made available for diversion in those operations. However, if all available Interruptible Stored Water has been diverted in the First Crop Season, but there will be Interruptible Stored Water available for the Second Crop Season, then all or part of the interruptible stored water available for the Second Crop Season can be used to finish the First Crop Season.

If Combined Storage falls below 950,000 acre-feet at any time during the Crop Season, then all releases of Interruptible Stored Water to Gulf Coast, Lakeside and Pierce Ranch will be cut off for the remainder of the Crop Season. If releases of Interruptible Stored Water are cut off in the middle of a Crop Season (due to either the diversions reaching the volumetric limit or Combined Storage falling to the cutoff level), then LCRA will not provide any Pass-Through run-of-river water under LCRA's water rights historically associated with the Gulf Coast, Lakeside and Pierce Ranch operations that originates upstream of Lake Travis unless and until Combined Storage is above 1.3 million acre-feet. During the remainder of the Crop Season, if Combined Storage exceeds 1.3 million acre-feet, LCRA will make these Pass-Through run-of-river supplies available, limited to the amounts needed to finish the crop. If releases of Interruptible Stored

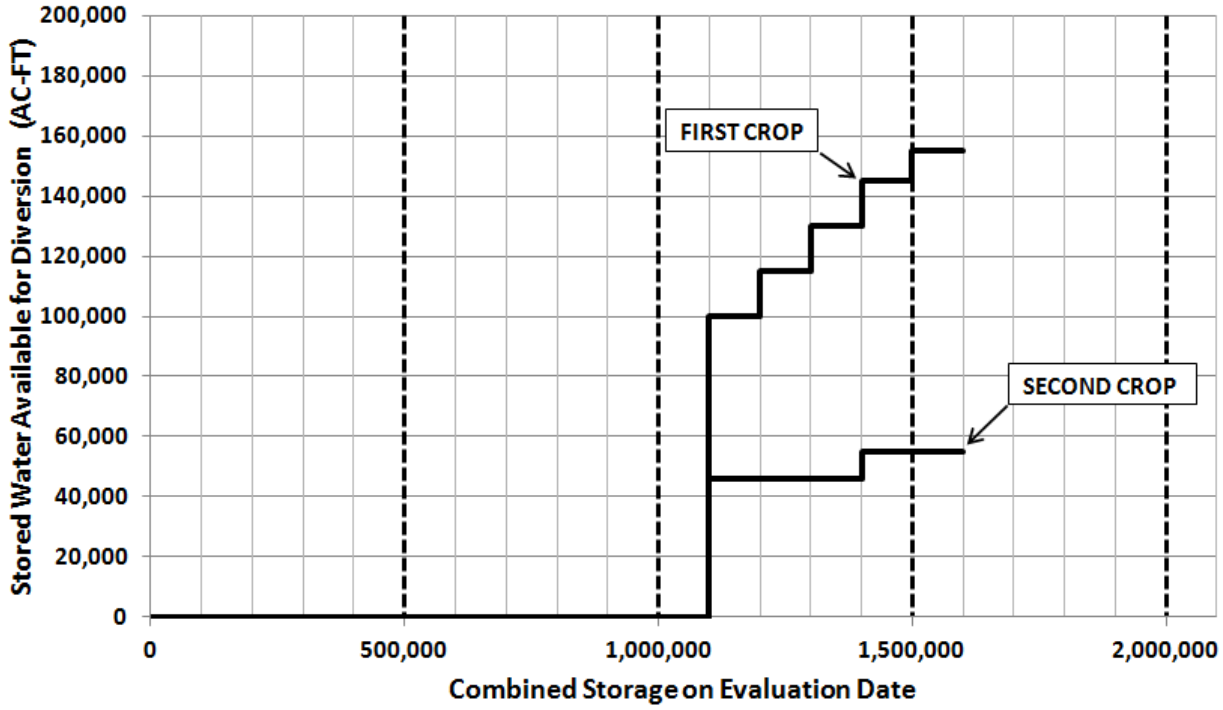
Water for the First Crop Season are cut off for the entire season, then releases of Interruptible Stored Water are also cut off for the Second Crop Season. Garwood operations will be provided Interruptible Stored Water consistent with the Garwood Purchase Agreement.

Table 4.2. Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside and Pierce Ranch agricultural operations under Less Severe Drought condition

First Crop Season		Second Crop Season	
Combined Storage on March 1 (million acre-feet)	Interruptible Stored Water (acre-feet)*	Combined Storage on July 1	Interruptible Stored Water (acre-feet)*
Below 1.1 MAF	0	Below 1.1 MAF	0
1.1 to 1.199 MAF	100,000	1.1 to 1.399 MAF	46,000
1.2 to 1.299 MAF	115,000	1.4 to 1.599 MAF	55,000
1.3 to 1.399 MAF	130,000		
1.4 to 1.499 MAF	145,000		
1.5 to 1.599 MAF	155,000		
Anytime cutoff* if storage drops to or below 950,000 acre-feet		Anytime cutoff* if storage drops to or below 950,000 acre-feet	

* Non-Garwood

Figure 4.2. Total Interruptible Stored Water available for diversion in Gulf Coast, Lakeside and Pierce Ranch agricultural operations under Less Severe Drought condition



4.3.2.3. Curtailment Procedures for Extraordinary Drought Condition

If the Extraordinary Drought condition is in effect, no Interruptible Stored Water or Pass-Through run-of-river water under LCRA's water rights historically associated with the Gulf Coast, Lakeside and Pierce Ranch operations will be made available for diversion in the Gulf Coast, Lakeside and Pierce Ranch operations during the Crop Season. However, LCRA will provide Interruptible Stored Water for the Garwood operation, consistent with the Garwood Purchase Agreement.

4.3.2.4. Curtailment Procedures under the Look-Ahead Test

If the LCRA Board determines, considering antecedent conditions, current storage, and forecasted conditions, that the release of Interruptible Stored Water under either the Normal condition or the Less Severe Drought condition (whichever is in effect) in the upcoming Crop Season would result in Combined Storage dropping below 600,000 acre-feet in the next twelve months or below 900,000 acre-feet in the upcoming Crop Season, then no Interruptible Stored Water or Pass-Through run-of-river water under LCRA's water rights historically associated with the Gulf Coast, Lakeside and Pierce Ranch operations will be released for diversion in the Gulf Coast, Lakeside or Pierce Ranch operations for the upcoming Crop Season. However, LCRA will provide Interruptible Stored Water for the Garwood operation, consistent with the Garwood Purchase Agreement.

4.4. CURTAILMENT PROCEDURES FOR ENVIRONMENTAL FLOWS IN THE LOWER COLORADO RIVER BASIN

4.4.1. Providing Stored Water for Environmental Flow Needs

Under this WMP, as in past WMPs, LCRA provides a combination of Firm and Interruptible Stored Water to help meet environmental flow needs. This WMP retains LCRA's commitment of 33,440 acre-feet per year of Firm Water supply from lakes Buchanan and Travis for environmental flow purposes. In the event of a pro rata curtailment of Firm Water supplies, the applicable instream flow and bay and estuary freshwater 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 environmental flow needs based on more recent scientific studies and also includes an increase in the total average annual combination of Firm and Interruptible Stored Water supplied to help meet environmental flow needs compared to the 2010 WMP. 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 the First Crop Season and for the Second Crop Season. The environmental flow criteria in place from March through June are based on Combined Storage on March 1, and the environmental flow criteria in place from July through the following February are based on the Combined Storage on July 1. (This represents a change from prior WMPs in which the environmental flow criteria for the entire year were based on January 1 storage levels.) The manner in which water for environmental purposes is provided and tracked are set forth below.

4.4.2. Curtailment of Water for Instream Flows

This WMP revision includes three levels of instream flow criteria, located at four streamflow gauging station locations (Austin, Bastrop, Columbus and Wharton), as first presented in Chapter 2 and repeated here as Table 4-3. Compared to prior WMPs, this WMP adds an additional location (the Wharton gauge), This WMP has also replaced the "critical" and "target" levels with new levels ("Subsistence," "Base-Dry" and "Base-Average") that are based on the most recent instream flow studies,[4] which are generally consistent with the environmental flow standards adopted by TCEQ for the lower Colorado River basin.

This WMP limits LCRA's obligation to help meet instream flows at the Base-Average and Base-Dry levels to releasing no more than the Storable Inflows to lakes Buchanan and Travis. By contrast, in addition to Storable Inflows, LCRA will release previously stored water as needed to maintain Subsistence flows. Table 4-4 presents the applicable instream flow criteria for this WMP. In the event of a pro rata curtailment of Firm Water 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 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

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

For purposes of this WMP revision, the Subsistence, Base-Dry and Base-Average criteria for gauges other than the Austin gauge, are daily (or daily average) flow values. The Subsistence criteria at Austin represent minimum (or instantaneous) flow requirements. Furthermore, for the Bastrop gauge only, the following minimum flow requirements apply:

1. During those times when Base-Average criteria are in effect, the minimum flow requirements, subject to availability of Storable Inflows, shall be 70 percent of the Base-Average criteria for the given month.
2. During those times when Base-Dry criteria are in effect, the minimum flow requirements, subject to availability of Storable Inflows shall be 70 percent of the Base-Dry criteria for the given month.
3. During those times that Subsistence criteria are in effect, releases shall be scheduled such that the minimum flow does not drop below:
    a. 90 percent of Subsistence criteria when Combined Storage is equal to or greater than 1.4 million acre-feet; or
    b. 80 percent of Subsistence criteria when Combined Storage is less than 1.4 million acre-feet.

To help meet the instream flow criteria in the lower Colorado River, LCRA will schedule releases in amounts sufficient to meet the applicable criteria, to the extent of Storable Inflows or, for Subsistence, using previously stored water in addition to Storable Inflows. 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 this WMP. In rare instances, LCRA's ability to meet the flow 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 criteria for that gauge on more than 18 days

in any calendar year. Furthermore, to the extent that a deviation event 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 as releases pass downstream, the collective impact of such constraints may not be relied upon to excuse a deviation of more than 15 percent below applicable criteria on any individual day.

The following events shall not count towards the number of calendar days in which a deviation occurred, nor be subject to the 15 percent limitation:

1. Events in which the initial flow data indicated a deviation, but after inspection of relevant data and/or the gauge, LCRA determines that the initial flow data were inaccurate and the actual flow rate was at or above the applicable flow requirement;
2. Events in which the deviation was 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;
3. Events in which the applicable criteria had increased at the start of a new month and the initial release for the higher criteria is attenuated or arrives at the gauge in a 24-hour period other than midnight to midnight; and
4. Events in which LCRA passes through Storable Inflows to meet a Base-Dry or Base-Average criteria and the effects of attenuation or the timing of the arrival of the release at the downstream gauge is such that the released water reaches the gauge spread across two or more days.

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 criterion, subject to the availability of Storable Inflows, or for Subsistence, the availability of a combination of Storable Inflows and previously stored water, if that impairment is identified at the start of that 10-day period.

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 revision is in effect to help assess whether pulse flows are occurring with the frequency recommended in the 2008 comprehensive instream flow study.[5]

4.4.3. 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.[6] Storable Inflows that are available to help meet freshwater inflow criteria are determined on a monthly basis and exclude any Storable Inflows that have already been released to help meet instream flow criteria.

This WMP incorporates new criteria to guide implementation, and which are aimed at helping to meet the range of freshwater inflow needs from the Colorado River identified in the MBHE

study. In all months, LCRA will release Storable Inflows to help meet at least the "Threshold" level of 15,000 acre-feet per month, to the extent of Storable Inflows. For higher flow levels, instead of the monthly requirement that has been used in prior WMPs, the criteria is designed to achieve seasonal freshwater inflow freshets. The MBHE three-month "spring" and "fall" freshets (shown in Table 4-5) 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 Chapter 2 and repeated here in Table 4-6. (*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 Storable Inflows will be provided as necessary to help meet the two-month Operational Criteria. In May and June, LCRA will also determine if the three-month MBHE "spring" freshet for the given inflow category has been met within the Spring period, and if so, the two-month Operational Criteria will be reduced to the corresponding amount for the intervening period. In September and October, LCRA will similarly determine if the "fall" freshet has been met within the Fall period, and if so, the two-month Operational Criteria will be reduced to the corresponding amount for the intervening period. In the event of a pro rata curtailment of Firm Water supplies, the applicable freshwater 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. MBHE Three-Month Freshets into Matagorda Bay

Inflow Category	Seasonal Three-Month Freshet (acre-feet)	
	Spring	Fall
MBHE-4	433,200	307,800
MBHE-3	246,200	175,000
MBHE-2	168,700	119,900
MBHE-1	114,000	81,000

Table 4-6. Operational and Threshold Criteria for Colorado River Freshwater Inflows to Matagorda Bay

Inflow Category	Two-Month Operational Criteria (acre-feet) applicable in the individual months			Monthly (acre-feet)
	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. In the event that the Storable Inflows in a given month are greater than the amounts released for that month's

environmental flow needs, and Combined Storage is greater than 1.0 million acre-feet at the end of the month, the remainder of the Storable Inflows less the actual release for environmental flow needs ("Remaining Storable Inflows") will be carried forward for one month. If in the subsequent month, the Threshold criteria cannot be met using Storable Inflows from that month, up to 5,000 acre-feet of the prior month's Remaining Storable Inflows will be released to help meet the Threshold criteria. Table 4-7 presents the applicable freshwater inflow criteria.

Table 4-7. Freshwater Inflow Triggers and Flow Levels

When Combined Storage is…	On this date…	Freshwater Inflow Criteria
Greater than 1.95 MAF	March 1 or July 1	OP-4/ MBHE-4
Less than 1.95 MAF	March 1 or July 1	OP-3 / MBHE-3
Less than 1.50 MAF	March 1 or July 1	OP-2 / MBHE-2
Less than 1.30 MAF	March 1 or July 1	OP-1 / MBHE-1
Less than 1.00 MAF	March 1 or July 1	Threshold Only

The freshwater inflow criteria are further subject to the following specific limitations, which may reduce the amount of stored water LCRA must provide to help meet freshwater inflow needs:

1. Any time releases of Interruptible Stored Water for agricultural operations in Gulf Coast, Lakeside, and Pierce Ranch are cut off, the only freshwater inflow criteria in effect is Threshold. However, if releases of Interruptible Stored Water for agricultural operations in Gulf Coast, Lakeside, and Pierce Ranch are cut off for the Second Crop Season but Combined Storage is greater than 1.3 million acre-feet on July 1, the Operational Criteria shall be in effect pursuant to Table 4-6. In that instance, LCRA's releases of Storable Inflows to meet the Operational Criteria will be limited to no more than 50 percent of the Storable Inflows for the month remaining after the release of Storable Inflows for instream flow critieria and/or Threshold inflow needs, with a maximum release for the Operational Criteria in a single month of 82,000 acre-feet. (LCRA's releases of Storable Inflows to Meet Threshold will not be subject to this limitation.)
2. If Combined Storage falls below 1.0 million acre-feet at any time, the only freshwater inflow criteria in effect for that month and continuing until the next Evaluation Date is Threshold.
3. If Combined Storage is below 1.3 million acre-feet at the end of a month, the maximum release of Storable Inflows specifically to meet freshwater inflow criteria will be 25,000 acre-feet.
4. When Less Severe Drought conditions are in effect, releases of Storable Inflows to meet the Operational Criteria will be limited to no more than 50 percent of the Storable Inflows for the month remaining after the release of Storable Inflows for instream flow critieria and/or Threshold inflow needs, with a maximum release for the Operational Criteria in a single month of 82,000 acre-feet if storage is above 1.3

million acre-feet at the end of the month and a maximum release to for all freshwater inflow criteria of 25,000 acre-feet if storage is below 1.3 million acre-feet.

In the event that more than one of the above limitations would apply, the most restrictive limitation on releases shall apply.

4.4.4. Annual and Multi-year Caps on Water for Environmental Flows

The amounts of water made available for environmental flows are subject to limits to ensure that the actual amounts made available do not exceed the amounts simulated in the development of this WMP revision for periods when Combined Storage was below 1.3 million acre-feet on the Evaluation Date for a given season. In the event that the cumulative amounts made available in such periods equals or exceed the annual or multi-year caps below, dedicated releases to help meet environmental flow needs that are subject to these annual or multi-year caps are suspended for the remainder of the year. For purposes of the multi-year caps, the cumulating of water made available starts when Combined Storage drops below 98 percent of managed available capacity and multi-year caps are reset when storage increases to 98 percent or higher. The annual and multi-year caps on water made available for environmental flow needs when Combined Storage is below 1.3 million acre-feet on the Evaluation Date are as follows:

1. 75,000 acre-feet in any one year;
2. 133,000 acre-feet in any two consecutive years;
3. 195,000 acre-feet in any three consecutive years;
4. 241,000 acre-feet in any four consecutive years;
5. 306,000 acre-feet in any five consecutive years;
6. 327,000 acre-feet in any six consecutive years;
7. 389,000 acre-feet in any seven consecutive years;
8. 437,000 acre-feet in any eight consecutive years;
9. 437,000 acre-feet in any nine consecutive years;
10. 455,000 acre-feet in any 10 consecutive years;
11. 455,000 acre-feet in any 11 consecutive years; and
12. 455,000 acre-feet in any 12 consecutive years.

4.5. CURTAILMENT PROCEDURES FOR INTERRUPTIBLE STORED WATER DEMANDS OTHER THAN THE DOWNSTREAM AGRICULTURAL OPERATIONS

LCRA will limit additional sales or commitments of Interruptible Stored Water, other than for the downstream agricultural operations at Gulf Coast, Lakeside, Garwood, and Pierce Ranch or environmental flow needs, based on the Combined Storage 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:

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

LCRA will notify 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, LCRA will eliminate this category of water supply.

4.6. CURTAILMENT OF FIRM WATER DEMANDS

Pursuant to its water rights for lakes Buchanan and Travis, LCRA must follow reservoir operations procedures to ensure that it can meet Firm Water demands during a repeat of the Drought of Record.

Consistent with state law, LCRA will not 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. However, consistent with state law and Commission rules regarding drought contingency planning, LCRA will engage its Firm Water customers and seek voluntary reductions of Firm Water use in the early stages of a drought through its adoption and implementation of a separate Drought Contingency Plan (DCP). Moreover, as part of its contracts, LCRA will continue to require each of its Firm Water customers to prepare and adopt a legally enforceable local drought contingency plan consistent with LCRA's rules and state law.

It is not possible to determine with absolute certainty whether a particular drought event is more or less severe than the Drought of Record until the event has concluded. However, 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 4.7.) When these conditions are reached, the LCRA Board of Directors will declare a Drought Worse than the Drought of Record (DWDR) (as described in Section 4.7) and LCRA will curtail and distribute the available supply of stored water among its Firm Water supply customers on a pro rata basis according to the amount of water to which they are legally entitled, consistent with the Pro Rata Plan for Firm Water Demands approved by TCEQ. (*See* Appendix C-7.) All releases of Interruptible Stored Water will be cut off prior to and during any mandatory pro rata curtailment of Firm Water supplies. Following a DWDR declaration, if conditions improve, pro rata curtailment of Firm Water customers will be lifted consistent with criteria determined by the LCRA Board.

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

As discussed above, the WMP is designed so that LCRA can meet all Firm Water demands through a repeat of the historic 1950s 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 suspend all releases of Interruptible Stored Water and curtail Firm Water 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 (DWDR). A DWDR declaration would trigger action to cut off Interruptible Stored Water and implement mandatory pro rata curtailment of Firm Water demands. The criteria for making a DWDR declaration represent circumstances that have not 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 Lakes Buchanan and Travis; and
3. Combined Storage in lakes Buchanan and Travis is less than 600,000 acre-feet.

Additionally, the LCRA Board of Directors will declare a DWDR when a drought's duration is at least 10 years and 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 measuring drought duration under this WMP, full is defined when either of the following criteria are met:

1. Combined Storage is at or above 98 percent of the combined managed conservation storage. This managed conservation storage excludes any water in the flood pool and may vary based on seasonal operational guidelines or other constraints on storage; or
2. 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 into Lakes Buchanan and Travis since the beginning of the drought will be compared to a Drought of Record inflow envelope curve that reflects the cumulative inflows in the Drought of Record. The envelope is represented by the following equation and is demonstrated in Figure 4.3.

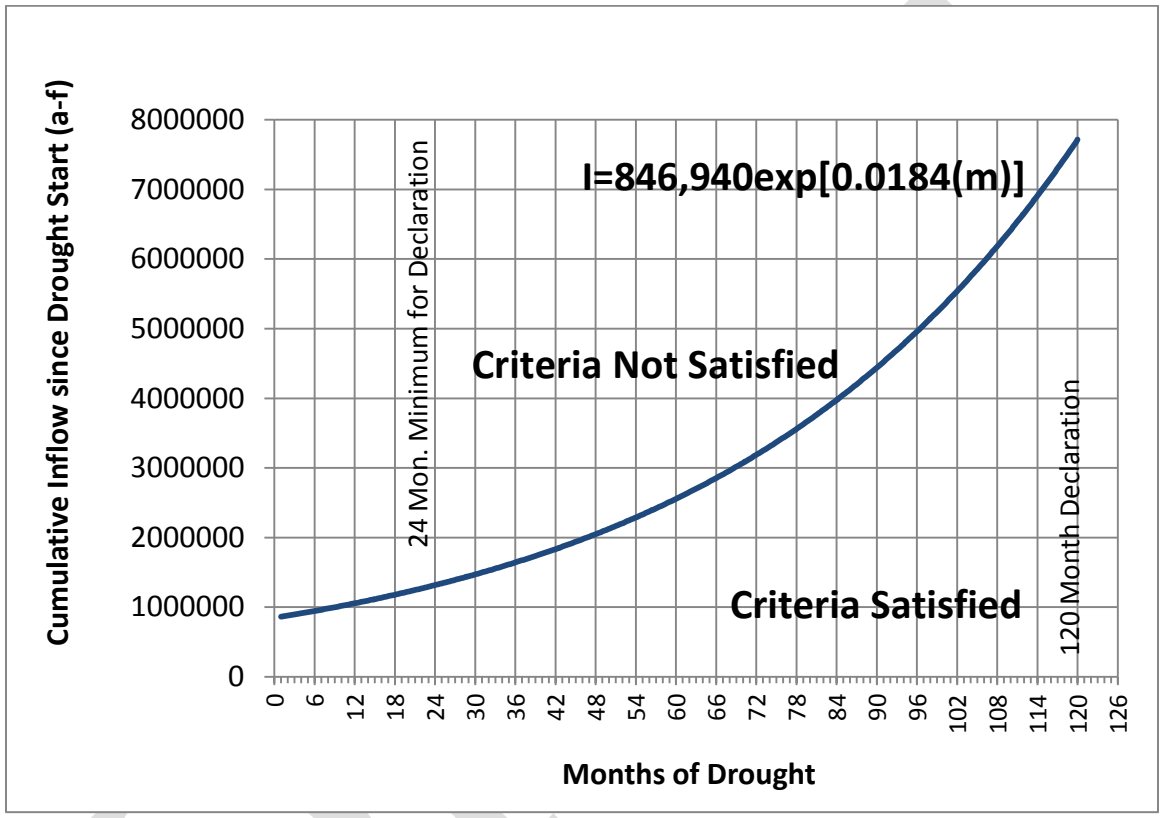
$I = 846{,}940e^{(0.0184m)}$

Where:

I = cumulative inflow in acre-feet since Travis and Buchanan were each full, using the determination of full described above.

m = months of drought duration using the criteria described above.

Figure 4.3. Drought intensity curve for Drought Worse than Drought of Record declaration



LCRA will cancel a DWDR declaration if Combined Storage increases to 1,400,000 acre-feet. LCRA will notify TCEQ within 30 days of the declaration or cancellation of a DWDR.

See Appendix A, Technical Paper A-7 for additional information regarding the evaluations of historic period (1940-2013) droughts for comparisons to the Drought of Record.

4.8. 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 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 2013. Actual observed conditions while this plan is in effect may vary.

4.8.1. Firm Water Customers

All simulated demands for Firm Water customers can be fully satisfied under a simulated repeat of hydrologic conditions during the historic period of 1940-2013, including during the Drought of Record and during short-term intense droughts experienced in recent decades. The minimum storage in the model was maintained above 600,000 acre-feet at all times, providing a safety factor for more severe drought conditions than were simulated.

4.8.2. Agricultural Customers in Downstream Agricultural Operations

With the increase in Firm Water needs, and additional safety factors included in this WMP to respond to severe drought conditions, there is less Interruptible Stored Water supply from lakes Buchanan and Travis as compared to the 2010 WMP because Firm Water needs take priority over Interruptible Stored Water uses. This WMP includes curtailment procedures with various elements (such as the separate evaluation of supply for the First and Second Crop Seasons, and a higher trigger at which no Interruptible Stored Water will be made available) that are more restrictive on the supply of Interruptible Stored Water for the downstream agricultural operations than the procedures in the 2010 WMP. The percent of overall agricultural demands (including first and second crop) in the four downstream agricultural operations that are met in the simulation of this WMP revision is about 80 percent over the simulation of the historic period (1940-2013) evaluated.

Agricultural users in the four downstream agricultural operations would be most affected during a repeat of the Drought of Record. The modeling analysis indicates that no Interruptible Stored Water would be available for both the First and Second Crop Seasons in 7 years out of the 12-year period for the Drought of Record.

The actual frequency and magnitude of 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.

4.8.3. Environmental Flows

The average annual amount of total stored water made available as dedicated releases for environmental purposes during the Drought of Record in simulations of this WMP revision of about 70,000 acre-feet per year represents an increase from the amounts estimated in the 2010 WMP of about 56,470 acre-feet per year. During the simulated repeat of the Drought of Record and the full historic period from 1940-2013, there are more curtailments and cutoffs of Interruptible Stored Water for the downstream agricultural operations 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 expected to be needed on a more frequent basis under simulations of this WMP revision.

As mentioned in Section 4.4.1, LCRA is not recommending any changes to the level of Firm Water commitment for environmental flows as part of this WMP. The current total Firm Water reservation of 33,440 acre-feet for environmental flow purposes represents about 8 percent of the total Firm Water supply available from lakes Buchanan and Travis.

4.8.4. Individual Lake Storage and Elevations

As noted in Section 4.8.1, the minimum Combined Storage in lakes Buchanan and Travis in the WMP is maintained above 600,000 acre-feet at all times. This represents a significant increase as compared to the 2010 WMP. The percent of months in which simulated Combined Storage is below 900,000 acre-feet is about 4 percent. As noted in Section 5.4.1.3, the model simulations were not performed to represent with a high level of precision how the total Combined Storage in lakes Buchanan and Travis would be split between those two reservoirs. Thus, separate lake storage and elevation results are not presented herein.

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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. Certificate of Adjudication 14-5478 ¶ 2.B.(7); Certificate of Adjudication 14-5482 ¶ 2.B.(7).
2. TEX. COMM'N ENVTL. QUAL., *Agreed Order Approving Amendments to Lower Colorado River Authority's Water Management Plan*, Ordering Provision 1.f. (Jan. 27, 2010). Section 1.3 of this WMP provides a list of items to be addressed pursuant to the TCEQ 2010 Order.
3. *See* Chapter 1, note 14.
4. BIO-WEST, Inc., COLORADO RIVER FLOW RELATIONSHIPS TO AQUATIC HABITAT AND STATE THREATENED SPECIES: BLUE SUCKER, FINAL REPORT PREPARED FOR LCRA AND SAWS (2008).
5. *Id*. § 4.3 at 91-95 (2008).
6. FINAL REPORT: MATAGORDA BAY INFLOW CRITERIA (COLORADO RIVER), MATAGORDA BAY HEALTH EVALUATION, Prepared for LCRA and SAWS (Dec. 2008).

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 5-6
5.4.1.3 Operating Guidelines 5-6
5.4.2 Flood Operations 5-7

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 September 2014.

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 Hydrological-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 River Forecast Center in Fort Worth, Texas (WGRFC). The WGRFC uses rainfall data from the Hydromet system to calibrate radar estimates of rainfall and to produce Quantitative Precipitation Estimates (QPE). The WGRFC then shares the QPE data with LCRA. This improves the hydro-meteorological information available to LCRA and the WGRFC, and allows each agency to more accurately project 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 WGRFC. 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 two modes of River Operations: Water Supply Operations and Flood Operations. Water Supply Operations involve the provision of water to meet or help meet the demands or needs of customers, other water right holders, or environmental flow obligations, to adjust system storage or lake levels, or to produce hydroelectric power. Flood Operations occur when the discharge of water through a dam exceeds the normal discharge capacity of hydroelectric generating units at the dam, or when water is continuously discharged over the spillway of a dam. At Mansfield Dam, Flood Operations occur when water is discharged through Mansfield Dam because the level of Lake Travis exceeds or is expected to exceed the conservation pool elevation of 681 feet mean sea level (msl). Each of these modes of operation is described below.

5.4.1 Water Supply Operations

Water Supply Operations involve the management of the system to: (1) provide water to customers, (2) help meet environmental flow requirements, (3) honor senior water rights, (4) adjust system storage or lake levels, or (5) produce hydroelectric power.

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. (The top of the conservation pool for Lake Travis is elevation 681 feet msl and for Lake Buchanan is 1,020 feet msl; however, LCRA limits Lake Buchanan to 1,018 feet in the months of May through October and, recently, has limited Lake Buchanan to 1,018 feet year round, as discussed in Section 5.4.2.) The intervening 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 intervening lakes.

Table 5-1. Target Elevation Ranges for Intervening 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[2]	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).
2. Although LCRA typically operates Lake Austin within a one-foot range, the long-term agreement between the LCRA and Austin actually allows for operations within a 3-foot range

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

- maintaining Hydromet field equipment and ratings to measure and report 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 evaporation at lakes Travis and Buchanan; monitoring lake levels and river inflows; 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

Tom Miller Dam, which forms Lake Austin, is downstream of Mansfield Dam, which forms Lake Travis, and is the most downstream of the six Highland Lakes dams operated by LCRA. Lake Austin is owned by the City of Austin, but operated by the LCRA pursuant to a long-term agreement. Longhorn Dam, which forms Lady Bird Lake, is immediately downstream of Lake Austin and is operated by the City of Austin. The majority of LCRA's major irrigation and industrial customers divert water along 300 miles of the lower river from Tom Miller Dam to Matagorda Bay. Requirements for instream flows and freshwater inflows to Matagorda Bay apply along the lower river below Longhorn Dam. Therefore, LCRA determines the daily release

from Tom Miller Dam to deliver water and regulate the flow in the lower river. Releases from Mansfield Dam are determined, as needed, to satisfy diversions from Lake Austin by the City of Austin and other municipal customers and to maintain Lake Austin within its normal operating range, consistent with the long-term agreement between LCRA and the City of Austin.

Releases from Tom Miller Dam typically require up to a week (or even longer during low flow conditions) 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 Tom 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 Tom 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 Tom Miller Dam tends to attenuate as it moves downstream, so that one day's release at Tom Miller Dam may arrive at a downstream location over several days. Therefore, in practice, releases from Tom 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 Tom Miller Dam. The amounts of water actually released through hydroelectric generation on a daily basis generally match the amounts scheduled for release within the constraints of the capacity of each hydroelectric unit. Releases from Tom Miller Dam to the lower river pass through Lady Bird Lake and Longhorn Dam, which are operated by the City of Austin. The operation of Longhorn Dam can affect the timing and flow rate of water released from Tom Miller Dam by LCRA as the water flows through Lady Bird Lake to the lower river. 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 level of precision. 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 downstream of Mansfield Dam. Releases from Lake Buchanan also maintain lakes Inks, LBJ, and Marble Falls within their normal operating ranges and are used to meet LCRA customer demands.

5.4.1.3 Operating Guidelines

LCRA determines the amount of water to be released from both Lake Travis and Buchanan on a daily basis according to internal operating guidelines that provide general guidance on the allocation of releases from each lake. These allocation guidelines and river operations in general are intended to optimize the capture of inflows to the lakes, reduce evaporative losses, and minimize risks to life and property. In practice, the allocation of releases from lakes Buchanan and Travis is adaptive, based on actual conditions at the time, and may vary from the guidelines. Conditions considered by LCRA include lake levels and capacities, inflows to each lake, the location of needs for water, intake elevations, and planned operation and maintenance activities. LCRA regularly projects changes to lake elevations to assist customers in their planning efforts, consistent with these operating guidelines. Although LCRA's operating guidelines are regularly updated and refined to reflect new information, LCRA does not anticipate substantial changes to the guidelines related to allocating releases from lakes Buchanan and Travis as a result of this version of the WMP.

The WMP models include as output the Combined Storage of lakes Buchanan and Travis as well as individual storage levels for each reservoir. Because the WMP's primary focus is to preserve sufficient Combined Storage in *both* lakes Buchanan and Travis to meet Firm Water customers' demands relative to the amount of Interruptible Stored Water that can be provided, the models only allocate water between lakes Travis and Buchanan at a very coarse level. While the WMP models are limited to only two zones for determining which reservoir provides the entire release, in actual operations, lakes Buchanan and Travis are divided into four to five zones for which a percentage of the total release is specified for each reservoir. In other words, there is a greater level of control over the balance of releases between the reservoirs than can be simulated by the model, resulting in significant differences in the simulated Combined Storage split compared to what would actually occur under LCRA's operating guidelines.

The WMP model results related to lake elevations, therefore, do not represent specific anticipated lake elevations for any given Combined Storage amount. Rather, the actual allocation of releases from the two reservoirs – and the resulting lake elevations – will be based on LCRA's operational decisions governed by LCRA's internal operating guidelines and specific facts, as discussed above.

5.4.2 Flood Operations

In addition to managing the Highland Lakes for water supply, LCRA also operates the lakes for flood control purposes. Flood Operations occur when the total discharge of water through a dam exceeds the normal discharge capacity of hydroelectric generating units at the dam, or when water is continuously discharged over the spillway of a dam. At Mansfield Dam, Flood Operations occur when water is discharged through Mansfield Dam because the level of Lake Travis exceeds or is expected to exceed the conservation pool elevation of 681 feet msl. 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 discharge of water through Buchanan Dam exceeds the normal discharge capacity of hydroelectric generating units at Buchanan Dam, or when water is continuously discharged over the spillway. Flood Operations at Buchanan Dam are typically initiated by LCRA when the level of Lake Buchanan is forecast or observed to exceed its conservation pool elevation. At Inks, Wirtz, Starcke and Tom Miller dams, Flood Operations begin when the discharge of water through the dam exceeds the normal discharge capacity of hydroelectric generating units at the dam, or when water is continuously discharged over the spillway. Flood Operations at these dams are typically initiated by LCRA when flows into lakes Inks, LBJ, Marble Falls or Austin are forecast or observed to exceed the normal discharge capacity of turbines at the dam and require the use of floodgates or spillways to pass the flow and manage lake levels.

Flood Operations at Buchanan, Inks, Wirtz, and Starcke dams are conducted pursuant to an agreement between LCRA and the Federal Emergency Management Agency (FEMA) dated March 8, 1990. (*See* Appendix B-1.) Under the FEMA agreement, conservation storage in Lake Buchanan is limited to elevation 1,018 feet (two feet below maximum conservation storage) in the more flood-prone months of May through October. In recent years, LCRA has also limited Lake Buchanan at 1,018 feet elevation year round while repairs to the floodgates are underway. Flood Operations at Tom Miller Dam are pursuant to a long-term agreement between LCRA and the City of Austin.[4]

Lake Travis has dedicated flood control storage above elevation 681 feet msl. Thus, at Mansfield Dam, Flood Operations occur when water is discharged through Mansfield Dam because the level of Lake Travis exceeds or is expected to exceed 681 feet msl.

Flood Operations at Mansfield Dam and Lake Travis are governed by rules and associated requirements of the U.S. Army Corps of Engineers (USACE) pursuant to Section 7 of the Flood Control Act of 1944.[5] (*See* Appendix B-2.) LCRA implements these requirements in consultation with USACE consistent with agreements between LCRA and USACE. Under the USACE requirements, Flood Operations at Mansfield Dam are determined by: specified ranges of

observed or forecasted lake 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 lake levels (based on actual water on the ground) are used in determining flood release requirements. When the pool is falling, observed lake levels are used in determining release requirements. The amount of the release from Mansfield Dam increases with higher ranges of lake 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. *See* Endnote 3.
5. *See* 33 C.F.R. part 208.11; and Guidance in the implementation of these rules may be obtained from the USACE Mansfield (Marshall Ford) Dam Water Control Manual (September 2013).