Proposed White Stallion Coal-Fired Power Plant Water Demands and the Highland Lakes Water Supply

Prepared for:

Lone Star Chapter of the

SIERRA CLUB
FOUNDED 1892

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June 2011

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Introduction

White Stallion Energy Center, LLC, proposes to build a 1320-megawatt coal-fired electric power generating station on the Colorado River approximately eight miles south of Bay City in Matagorda County, Texas. According to a draft firm water contract,[1] White Stallion Energy Center, LLC would require 22,000 acre feet of water per year to operate the proposed power plant. The Lower Colorado River Authority (LCRA) has calculated 3,000 acre-feet per year of system losses to meet this water demand. A total of 25,000 acre-feet per year would be required to reliably provide the water required by the proposed White Stallion power plant.

This paper compares water volumes that would be required to meet the proposed White Stallion power plant water demand with predicted stored water availability from the Highland Lakes system during drought conditions. It finds –

Combined Firm Yield	*535,812 acre feet per year*
Firm Water Commitments	*-514,028 acre feet per year*
Uncommitted Water	*21,784 acre feet per year*

White Stallion Request 25,000 > Uncommitted 21,784 acre feet per year

This paper also assesses the impact of the proposed White Stallion water contract on combined Lakes Buchanan and Travis storage, and the consequences of diminished storage on interruptible and environmental flows. The report presents the results of recent analyses of the predicted effects of climate change on Highland Lake water supply.

Highland Lakes "Firm" Water Availability

LCRA operates six dams on the Colorado River that form the Highland Lakes: Buchanan, Inks, LBJ, Marble Falls, Travis and Lake Austin. Of these six lakes, four are maintained at constant levels. Two of the lakes, Buchanan and Travis, are operated with a variable lake level. Only these two lakes with

[1] *Firm Water Contract by and between Lower Colorado River Authority and White Stallion Energy Center, LLC,* based on Standard Form LCRA Board Approved 4-18-07, DRAFT 2/14/2011 2:00 pm.

variable water levels contribute to the system's capacity to supplement natural flows in the Colorado River to meet downstream water demands.

Through water permits granted by the State of Texas, LCRA has the right to hold inflows into Lakes Buchanan and Travis. This impoundment right is limited, however, by downstream Colorado River water rights with a senior priority. LCRA must pass any inflows to the Highland Lakes system through the lakes that are necessary to meet these senior water rights.

LCRA manages Lakes Buchanan and Travis as a single water supply system. Considering all senior water rights within the context of historical weather conditions, LCRA has determined the Combined Firm Yield of Lakes Buchanan and Travis to be 535,812 acre-feet per year. This Combined Firm Yield is the water that would be available in the lakes to meet LCRA's water supply commitments during critical drought conditions. It includes 90,546 acre-feet of water that must be supplied to O. H. Ivie Reservoir.[2]

Highland Lakes "Firm" Water Commitments

By exercising their State-granted water rights and operating releases from Lakes Buchanan and Travis, LCRA manages water supplies for cities, farmers, and industries that depend upon flow in 600 miles of the Colorado River from San Saba to the Gulf Coast.

LCRA's supply commitments to these water customers take one of two forms. "Firm" water commitments are those that LCRA is contractually obligated to meet during drought conditions up to conditions as severe as the drought of record. "Interruptible" commitments are those that will be curtailed or cutoff to protect the rights of "firm" water contract holders during drought conditions. Agricultural irrigation for rice production is the largest user of "interruptible" water. "Interruptible" water supplies are also used to achieve target instream flows that support a healthy fish community, dilute City of Austin effluent, sustain recreational use and sustain estuarine freshwater inflows to protect the productivity of Matagorda Bay.

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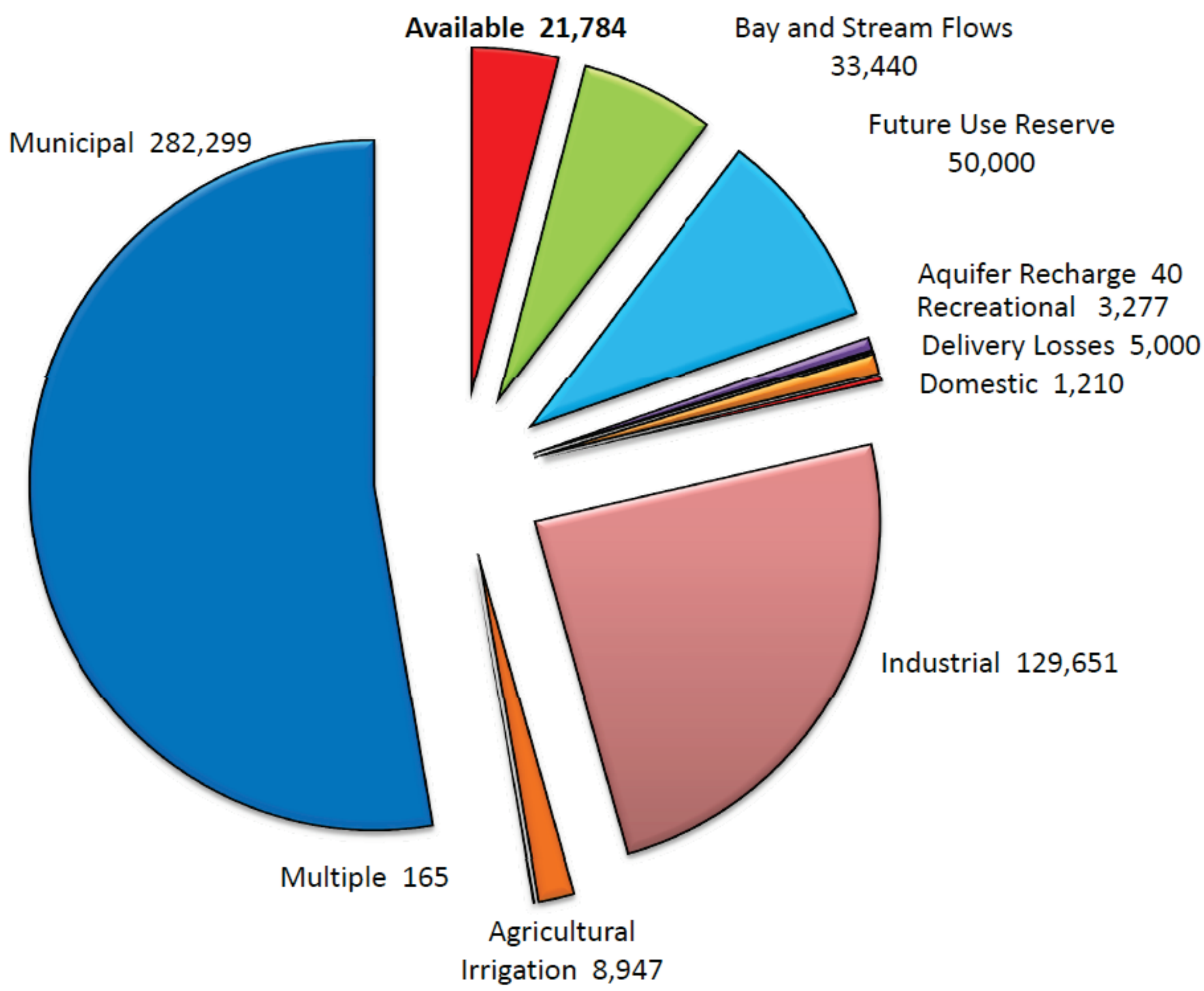
[2] LCRA, *Water Management Plan for the Lower Colorado River Basin,* effective September 20,1989 including amendments approved by Texas Commission on Environmental Quality through January 27, 2010 and Drought Contingency Plan Changes approved by the LCRA Board of Directors through June 16, 2010, page P-4.

Figure 1 illustrates the allocation of "firm" water among different uses. As of May 2, 2011, LCRA was committed to providing 425,548 acre-feet per year of "firm" water to 893 customers. In addition to these "firm" water contracts, LCRA has also committed an additional 88,480 acre-feet per year of "firm" water to account for delivery losses, critical environmental stream and bay flows, and the future needs of communities currently served by groundwater within the LCRA service area.[3]

Figure 1. LCRA Firm Water Commitments (acre-feet per year)



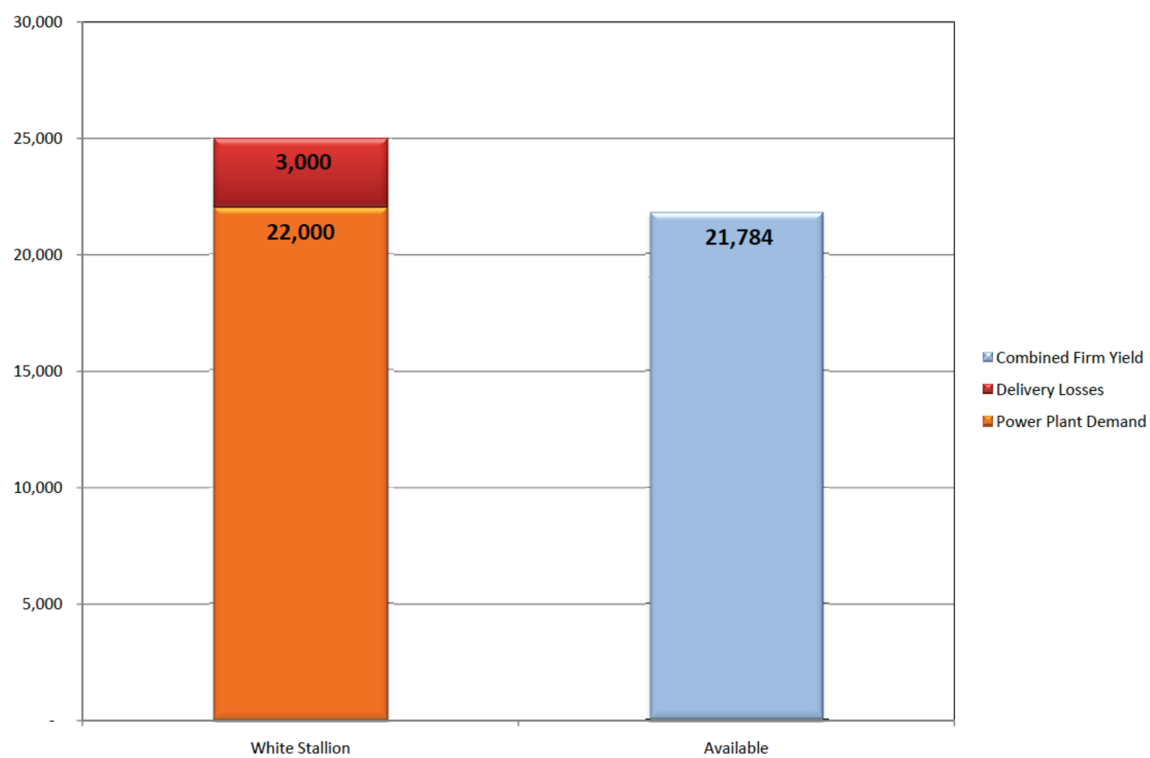
[3] http://www.lcra.org/library/media/public/docs/water/firm_contracts.pdf, June 6, 2011.

Currently Available "Firm" Water to Meet White Stallion Demands

The total of firm water contracts and additional firm water commitments by the LCRA Board is 514,028 acre-feet per year. The difference between the Combined Firm Yield of 535,812 acre-feet per year and the total firm water commitments is 21,784 acre-feet per year. As shown in Figure 2, the uncommitted 21,784 acre-feet per year of the Combined Firm Yield is less than the 25,000 acre-feet per year required to meet the water demands of the proposed White Stallion power plant. The current LCRA Water Management Plan states:

> *"The firm, uninterruptible commitments of water from lakes Buchanan and Travis should not exceed the Combined Firm Yield."*[4]

Figure 2. Available Firm Water to Meet White Stallion Demand (acre-feet per year)



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[4] LCRA, *Water Management Plan for the Lower Colorado River Basin,* effective September 20,1989 including amendments approved by Texas Commission on Environmental Quality through January 27, 2010 and Drought Contingency Plan Changes approved by the LCRA Board of Directors through June 16, 2010, page P-3.

Historical Water Use and Future Firm Yield

LCRA has submitted water rights amendment applications to Texas Commission on Environmental Quality (TCEQ) that would allow downstream agricultural irrigation rights to be used for municipal, industrial, mining and recharge purposes. If TCEQ were to grant these applications, LCRA estimates that the Combined Firm Yield would increase by as much as 155,000 to 200,000 acre-feet per year.[5] The actual amount of the increased firm supply cannot, however, be determined until TCEQ issues their final water rights amendments.

Historically, a portion of the water demands of LCRA's firm water customers has been supplied from run-of-river rights rather than from water stored in Lakes Buchanan or Travis. Furthermore, some of LCRA's water customers have contracted to meet the demands of anticipated future growth. The City of Austin, for example, has contracted with LCRA to meet anticipated water demands through the year 2100. The South Texas (nuclear) Project has contracted for water to serve two additional nuclear power generating stations that have not yet been permitted or constructed. Because of these differences between contracted amounts and current demands, the historical maximum use of all LCRA committed firm water[6] is less than the contracted amount.

Effects of Proposed White Stallion Water Demands on Combined Lakes Buchanan and Travis Storage Levels

A firm water contract to meet the 25,000 acre-feet per year demand of the proposed White Stallion power plant would affect water storage in Lakes Buchanan and Travis, especially during droughts. Since both interruptible agricultural irrigation and environmental flow releases are tied to lake storage, reductions in lake storage may reduce releases to meet these water needs.

As a basis for developing the 2010 Water Management Plan, LCRA implemented a Water Availability Model to simulate storable reservoir inflows[7] for the period from January 1940 through December 2009, 2010 water demands, and specific management strategies for interruptible agricultural irrigation,

[5] LCRA, *Water Services Quarterly Operations Report,* LCRA Board Agenda, April 2011, page 88.
[6] 151,665 acre-feet in 2008.
[7] Inflow measurements are adjusted to account for the legal requirement to pass water through the reservoirs to meet senior downstream water rights.

environmental instream flows, and bay and estuarine flows. The purpose of the modeling was to determine a set of water curtailment triggers that would maintain a minimum lake storage volume for the most severe drought conditions during the simulation period.

Although it isn't possible to precisely predict the effects of the proposed White Stallion water contract on lake storage without implementing the full Water Availability Model, a rough estimate of lake storage changes was made using output from the existing model. These lake storage changes indicate a diminishment of water releases for agricultural irrigation, instream environmental flows, flows to protect coastal estuaries, or other firm water demands from the proposed White Stallion contract. The process to estimate changes to the monthly combined lake storage volume from the proposed White Stallion contract was as follows:

1. Changes in reservoir storage volume were calculated for each month from January 1940 through December 2009 based on summary tables from LCRA's current Water Availability Model.[8]
2. For every month in which the reservoir volume does not change, or storage volumes increased, no adjustment was made to the change in storage volume. This rule conservatively assumes that, under these conditions, 100% of the White Stallion water demand could be met by run-of-river flows downstream from the reservoirs.
3. For any month in which reservoir volumes decreased, a value equal to 25,000 divided by 12, or 2,083 acre-feet per month, was added to the reservoir storage depletion. This rule simulates stored water releases to meet White Stallion demand during dry conditions;
4. If reservoir storage without White Stallion demand was full, the lakes were assumed to be full with White Stallion demand. Otherwise the reservoir storage for each month was set equal to the reservoir storage from the last month adjusted by the reservoir storage change from either Steps 2 or 3, (above).

Tables of combined lake storage volumes during the drought of record, as calculated by LCRA for 2010 demands (Table 1), and the White Stallion-adjusted lake storage levels (Table 2) were color-coded to represent LCRA drought management stages.

[8] Excel file: TABLES_2010_WMP_2010_DEM-protected.xlsx, downloaded from http://www.lcra.org/water/supply/advisory_committee_meetings.html, June 1, 2011.

Comparing the two charts indicates the following differences in LCRA water supply during the period from January 1947 through December 1957 between 2010 water demands only, and 2010 demands with the White Stallion contract in place:

- The number of months with a full supply of water would decrease from 17 to 16.
- Interruptible water supplies would cease for an entire year based on a January 1952 combined storage volume of less than 325,000 acre-feet. The number of months during which all interruptible supplies would cease would increase from one to twelve months.
- Releases to maintain bay flows would be reduced to only critical flow levels two months earlier, in September 1948 instead of November 1948.
- Combined storage would drop below the critical drought value of 600,000 acre-feet nine months earlier, in October 1950 instead of July 1951. The total number of months with storage levels in this critical storage condition below 600,000 acre-feet would more than double from 16 to 33.
- The minimum lake storage would decrease by a factor of three from 180,876 to 57,959 acre-feet in August 1952, representing a significant decrease in the factor of safety afforded to cities, communities, industries, businesses, farmers, and fishermen dependent upon the Highland Lakes water supply system.

Table 1. Combined Lakes Buchanan and Travis Storage during Drought of Record with 2010 Water Demands (No White Stallion Water Contract) (acre-feet per year)[9]

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1947	1,840,845	1,857,237	1,894,863	1,899,436	1,848,271	1,732,240	1,593,754	1,490,350	1,389,366	1,360,564	1,340,849	1,350,280
1948	1,343,161	1,344,649	1,324,339	1,315,225	1,280,979	1,317,452	1,288,463	1,195,439	1,129,109	1,104,592	1,083,047	1,071,552
1949	1,076,128	1,125,227	1,162,507	1,286,280	1,330,313	1,249,118	1,139,825	1,092,255	1,066,908	1,064,659	1,051,979	1,054,703
1950	1,055,871	1,077,538	1,042,460	1,041,575	996,662	876,626	769,312	711,438	705,288	682,337	665,237	655,399
1951	653,195	649,781	627,099	593,158	608,031	637,686	514,886	470,110	439,351	405,738	387,071	379,479
1952	373,098	368,203	337,873	374,310	435,317	329,662	229,524	180,876	1,149,369	1,123,504	1,140,192	1,265,689
1953	1,307,701	1,325,855	1,331,341	1,311,628	1,404,603	1,253,503	1,134,370	1,069,386	1,003,393	1,037,343	1,017,227	1,004,297
1954	999,362	978,877	934,509	1,005,301	1,028,923	873,084	744,777	680,749	634,940	616,297	625,407	616,958
1955	627,183	643,730	615,724	573,851	924,523	938,084	910,263	920,569	1,101,145	1,106,923	1,089,480	1,072,875
1956	1,060,029	1,058,601	1,010,385	986,917	1,244,308	1,095,244	968,500	907,037	852,783	828,254	811,010	797,098
1957	779,134	769,695	783,732	1,355,780	1,964,429	1,964,429	1,887,969	1,808,074	1,785,074	1,964,429	1,964,429	1,964,429

January Triggers:	Number of Months	Stage Restrictions
> 1,700,000	1	Open Supply
1,400,000 to 1,700,000	0	150% of Critical Needs
1,150,000 to 1,400,000	2	Irrigation Curtailment, Critical Needs Only
325,000 to 1,150,000	8	Additional Irrigation Curtailment
<325,000	0	Cease Interruptible Supplies

Anytime Triggers:	Number of Months	Stage Restrictions
> 1,400,000	16	Full Supply
1,100,000 to 1,400,000	32	Voluntary Drought Measurements, Critical Needs Only
900,000 to 1,100,000	32	Only Critical Bay Flows
600,000 to 900,000	26	Mandatory Drought Restrictions
200,000 to 600,000	14	Curtail Firm, Instream, and Bay flows, Interruptible Supplies Cease unless Drought < 36 months
<200,000	**1**	**Cease Interruptible Supplies**

[9] Based on summary tables from Water Availability Modeling for LCRA 2010 Water Management Plan, Excel file: TABLES_2010_WMP_2010_DEM-protected.xlsx, downloaded from http://www.lcra.org/water/supply/advisory_committee_meetings.html, June 1, 2011.

Table 2. Combined Lakes Buchanan and Travis Storage during Drought of Record with 2010 and White Stallion Water Demands (acre-feet per year)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1947	1,820,011	1,836,403	1,874,030	1,878,603	1,825,354	1,707,240	1,566,671	1,461,184	1,358,116	1,327,231	1,305,432	1,314,864
1948	1,305,661	1,307,149	1,284,755	1,273,558	1,237,229	1,273,702	1,242,629	1,147,522	1,079,109	1,052,509	1,028,880	1,015,302
1949	1,019,878	1,068,977	1,106,257	1,230,030	1,274,063	1,190,784	1,079,408	1,029,755	1,002,324	997,992	983,229	985,953
1950	987,121	1,008,788	971,626	968,659	921,662	799,542	690,145	630,188	621,954	596,920	577,737	565,815
1951	561,528	556,031	531,266	495,242	510,114	539,770	414,886	368,026	335,185	299,488	278,738	269,063
1952	260,598	253,619	221,206	257,643	318,650	210,912	108,691	57,959	1,026,452	998,504	1,015,192	1,140,689
1953	1,182,701	1,200,855	1,206,341	1,184,544	1,277,520	1,124,336	1,003,120	936,053	867,977	901,926	879,727	864,714
1954	857,695	835,127	788,675	859,468	883,089	725,168	594,777	528,666	480,773	460,047	469,157	458,625
1955	468,849	485,397	455,307	411,351	762,023	775,584	745,679	755,985	936,561	942,340	922,814	904,125
1956	889,196	885,684	835,385	809,833	1,067,225	916,077	787,250	723,704	667,366	640,754	621,427	605,431
1957	585,384	573,862	587,899	1,159,947	1,964,429	1,964,429	1,885,886	1,803,908	1,778,824	1,964,429	1,964,429	1,964,429

January Triggers:	Number of Months	Stage Restrictions
> 1,700,000	1	Open Supply
1,400,000 to 1,700,000	0	150% of Critical Needs
1,150,000 to 1,400,000	2	Irrigation Curtailment, Critical Needs Only
325,000 to 1,150,000	7	Additional Irrigation Curtailment
<325,000	12	Cease Interruptible Supplies

Anytime Triggers:	Number of Months	Stage Restrictions
> 1,400,000	15	Full Supply
1,100,000 to 1,400,000	22	Voluntary Drought Measurements, Critical Needs Only
900,000 to 1,100,000	27	Critical Bay Flows Only
600,000 to 900,000	25	Mandatory Drought Restrictions
200,000 to 600,000	30	Curtail Firm, Instream, and Bay flows, Interruptible Supplies Cease unless Drought < 36 months
<200,000	**2**	**Cease Interruptible Supplies**

The analysis presented here approximates lake storage volumes under the proposed White Stallion firm water contract terms. It only approximately captures run-of-river availability to meet the new firm water contract commitment. It underestimates lake storage releases to meet the White Stallion firm demand during wet-weather conditions. It fails to capture lake storage volume increases due to earlier implementation of LCRA drought management programs in response to earlier lake storage drawdowns. Nevertheless, the analysis indicates the importance of an accurate Water Availability Model analysis prior to any significant increases in LCRA's firm water commitments such as the one contemplated by the White Stallion contract. Such an analysis is necessary to assess changes to interruptible irrigation, instream, and bay inflow releases, as well reductions in the factor of safety afforded to firm water customers that would result from the proposed contract.

The LCRA Water Management Plan is currently being updated. Changes to the water management plan will likely alter the affect of any White Stallion water supply contract on other water customers, agricultural irrigation, instream, and bay inflow releases.

Climate Change Considerations

The Combined Firm Yield of Lakes Buchanan and Travis is defined by LCRA as:

> *"a specific amount or quantity of water stated in acre-feet that represent the maximum average annual demand that can be met from a reservoir system during a simulation of a repetition of the system's Drought of Record, while honoring the full extent of upstream and downstream senior water rights."* [10]

The Combined Firm Yield defines the availability of water for firm customers during the historical drought of record from 1947 to 1957.[11] By limiting firm water contracts, the LCRA Water Management Plan expresses LCRA's commitment to provide firm water customers their full contract allotment during all drought conditions up to and including conditions as severe as the drought of record. During a drought more severe than the Drought of Record, however, LCRA will curtail firm

[10] LCRA, *Water Management Plan for the Lower Colorado River Basin,* effective September 20, 1989 including amendments approved by Texas Commission on Environmental Quality through January 27, 2010 and Drought Contingency Plan Changes approved by the LCRA Board of Directors through June 16, 2010, page P-11.
[11] LCRA, *Water Management Plan for the Lower Colorado River Basin,* effective September 20, 1989 including amendments approved by Texas Commission on Environmental Quality through January 27, 2010 and Drought Contingency Plan Changes approved by the LCRA Board of Directors through June 16, 2010, page 3-2.

water supply customers on a *pro rata* basis.[12] The water supply safety for firm water customers is, therefore, directly linked to the future frequency and severity of drought.

LCRA defines a drought more severe than the drought of record when all of these three criteria are met:

1. It has been at least 24 months since both Lakes Buchanan and Travis were full.
2. The cumulative inflow deficit since the time when the lakes were last full exceeds the defining inflow deficit envelope curve by at least 5 percent for six consecutive months.
3. The combined water stored in Lakes Buchanan and Travis is less than 600,000 acre-feet.

Each of these three drought criteria arises out of deviations from normal conditions of precipitation, evapotranspiration, runoff, recharge, and/or lake evaporation. In Chapter 3 of a recently released second edition of *Impacts of Global Warming on Texas,*[13] water scientist George Ward analyzed the impacts of climate change on water resources and water supply based on predicted changes in these five water budget elements. A significant change in any one of these five elements will affect water stored in Lakes Buchanan and Travis and potentially will contribute to a declaration of a drought more severe than the drought of record.

Ward predicted annual volumes of these five water budget elements under four different climate conditions: 1) normal climate; 2) greenhouse-warmed normal; 3) drought; and 4) greenhouse drought. Normal climate represents historical average rainfall patterns and temperatures. Greenhouse-warmed normal represents historical average rainfall patterns with predicted temperature increases resulting from increased atmospheric greenhouse gases. Drought represents historical low rainfall conditions, but normal temperatures. The fourth climate condition, greenhouse drought, represents historical low rainfall conditions in combination with predicted temperature increases resulting from increased atmospheric greenhouse gases.

Table 3 presents Ward's predicted percentage changes in water budget elements associated with greenhouse-warmed normal, drought, and greenhouse drought conditions for Central Texas, a region that encompasses most of the Colorado River and Highland Lakes watersheds. The table expresses, for example, that for a hundred units of runoff under normal conditions, the predicted runoff would be 81

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[12] LCRA, *Water Management Plan for the Lower Colorado River Basin,* effective September 20, 1989 including amendments approved by Texas Commission on Environmental Quality through January 27, 2010 and Drought Contingency Plan Changes approved by the LCRA Board of Directors through June 16, 2010, page P-7.
[13] http://www.texasclimate.org/Home/ImpactofGlobalWarmingonTexas/tabid/481/Default.aspx, May 25,2011.

units during greenhouse warmed normal conditions, 42 units during drought, and only 34 units during greenhouse drought conditions.

Ward's analysis of the effects of climate change on water availability indicates that changes in runoff due to climate change will be significantly more severe than changes in precipitation. Where the decrease in precipitation is only 5% (from 100% to 95%), the decrease in runoff is 19% (from 100% to 81%). For each drop of rain that falls, less runoff occurs when temperatures are warm, evapotranspiration is high, and soils are desiccated. The Highland Lakes water supply system, dependent upon runoff inflows and open reservoir storage, is particularly vulnerable to the compounding factors of reduced precipitation, temperature increases, and higher levels of evaporation and evapotranspiration associated with climate change. In developing these predicted water budget element changes associated with climate change, nearly every assumption Ward made minimizes the estimated effect of climate change on the water supply.[14] Actual climate change impacts to the water budget elements are likely to be more severe than those presented by Ward and included here.

The effects of these climate change predictions would be to increase the reservoir water supply deficit in Central Texas during drought conditions from 0.7 to 3.9 million acre-feet per year by 2050, a factor of more than five. This significant increase in the water supply deficit is illustrated in Figure 3. LCRA must factor these predicted climate change effects into the determination of future Highland Lake reservoir water availability prior to committing additional firm water to the proposed White Stallion coal-fired power plant to assure the future reliability of water supplies to existing firm water customers.

[14] Ward, George, Chapter 3: Water Resources, in *The Impact of Global Warming on Texas*, second edition, edited by Jurgen Schmandt, Judith Clarkson and Gerald R. North, 2011, page 28.

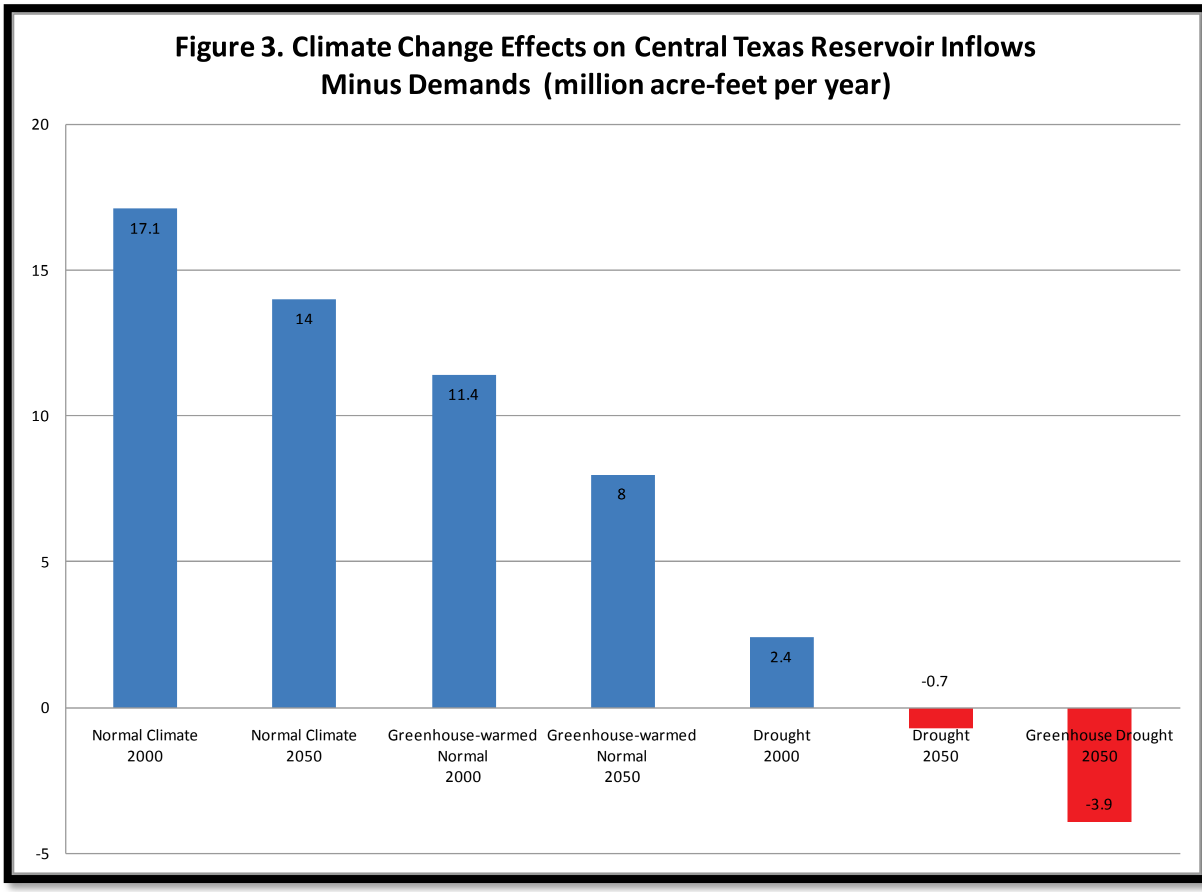

Table 3. Predicted Percentage Changes in Central Texas Water Budget Elements Attributable to Climate Change[15]

	Normal Climate	*Greenhouse-warmed Normal*	*Drought*	*Greenhouse Drought*
Precipitation	100%	95%	80%	76%
Evapotranspiration	100%	96%	85%	81%
Runoff	100%	81%	42%	34%
Recharge	100%	95%	80%	76%
Lake Evaporation	100%	120%	110%	132%

[15] Ward, George, Chapter 3 Water Resources, in *The Impact of Global Warming on Texas*, second edition, edited by Jurgen Schmandt, Judith Clarkson and Gerald R. North, 2011, page 25.

Conclusions

Operation of the proposed coal-fired White Stallion power plant will require a significantly large and consistent water supply even during drought conditions. This type of demand is appropriately met by LCRA using a firm water contract. The current balance between the Combined Firm Yield from the Highland Lakes and existing firm water commitments is only 21,784 acre-feet per year available, less than the 25,000 acre-feet per year required to supply the water demands of the proposed power plant. Provision of the water that would be demanded by White Stallion during drought conditions would significantly lower water storage in Lakes Buchanan and Travis. The difference in lake-stored water would curtail and interrupt water releases for irrigated agriculture, fish habitat, effluent dilution, recreation, and maintenance of the productivity of the Matagorda Bay estuaries.

An examination of the predicted effects of climate change on reservoir water supply availability indicates that future drought conditions will be more severe than those within the historical record. Until LCRA properly assesses the reliability of the Combined Firm Yield under projected future conditions and demonstrates a <u>permitted</u> capacity to increase their total Firm Yield to a level adequate to accommodate all of the currently committed and proposed firm water uses, the requested White Stallion firm water contract should be denied.