Section II - Sources of Supply and Water Rights

2.1 Summary of BRA Reservoir System

The Brazos River basin is the largest of the 15 major river basins in Texas, with a contributing drainage area of approximately 36,028 square miles. The BRA is the largest provider of wholesale surface water within the basin. BRA stores water in three wholly-owned and operated reservoirs: Possum Kingdom Lake, Lake Granbury, and Lake Limestone. BRA also contracts for conservation storage space in eight USACE reservoirs in the basin: Lakes Whitney, Aquilla Proctor, Belton, Stillhouse Hollow, Georgetown, Granger, and Somerville.

Figure 2.1 is a general map of the Brazos River basin showing the location of the BRA System reservoirs. Starting from the northern, most upstream reservoir and working down, Lakes Possum Kingdom, Granbury and Whitney are in series along the main stem of the Brazos River in the upper and central portion of the basin north of McLennan County. Lake Aquilla is situated on Aquilla Creek, which joins the main stem of the Brazos in McLennan County just above the City of Waco. Lakes Proctor and Belton are in series on the Leon River with Proctor being upstream in Comanche County and Belton lying downstream in Bell and Coryell Counties. Lake Stillhouse Hollow is located on the Lampasas River in Bell County. The Little River is formed by the confluence of the Leon and Lampasas Rivers in Bell County downstream of Lakes Belton and Stillhouse Hollow. Lakes Georgetown and Granger are in series on the San Gabriel River in Williamson County. The San Gabriel River flows into the Little River downstream of Lake Granger in Milam County. The Little River then joins the main stem of the Brazos River further downstream in Milam County. Lake Somerville is situated on Yegua Creek, which forms the boundary between Burleson and Washington Counties, approximately 15 miles from where the creek joins the Brazos River. Lake Limestone is located in Limestone, Leon, and Robertson Counties near the headwaters of the Navasota River, which joins the Brazos River downstream near the City of Navasota. An additional permitted, yet unconstructed off-channel reservoir, Allens

Creek Reservoir, is located in Austin County adjacent to the main stem of the Brazos River near the City of Wallis.

This system of reservoirs is managed for both flood control and water supply. The USACE reservoirs serve the dual purpose of flood control and water supply while the BRA reservoirs are limited to water supply. Table 2.1 contains pertinent data for each of the System reservoirs.

Figure 2.1

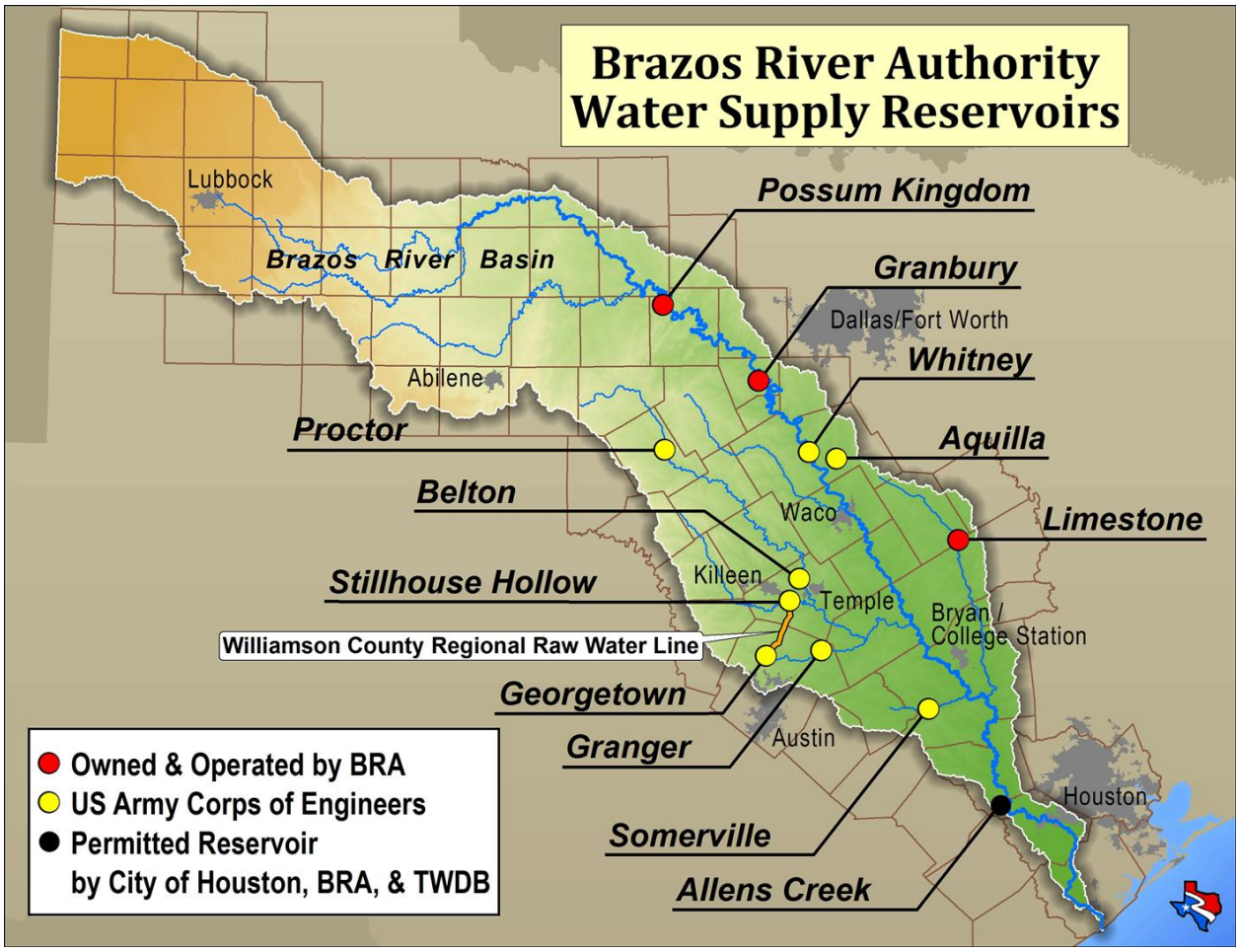


Table 2.1 - Reservoir Data

Reservoir Name	Owner	Date of Impoundment or Completion	Most Recent Hydrographic Survey	Elevation at [1]TOC (ft msl)	[2]Surface Area at TOC (acres)	[2]Volume Below TOC (acft)	Flood Pool Storage (acft)
Possum Kingdom	BRA	1941	2005	1000.0	16,716	540,340	NA
Granbury	BRA	1969	2003	693.0[3]	7,945	129,011	NA
Whitney	USACE	1951	2005	533.0	23,220	554,203	1,372,400
Aquilla	USACE	1983	2008	537.5	3,061	44,577	86,700
Proctor	USACE	1962	2005	1162.0	4,537	55,457	341,500
Belton	USACE	1954	2003	594.0	12,135	435,225	640,000
Stillhouse Hollow	USACE	1968	2005	622.0	6,484	227,825	390,600
Georgetown	USACE	1980	2005	791.0	1,287	36,904	87,600
Granger	USACE	1980	2008	504.0	4,203	50,779	162,200
Limestone	BRA	1978	2002	363.0	12,553	208,017	NA
Somerville	USACE	1967	2003	238.0	11,555	147,104	337,700
[4]Allens Creek	City of Houston/BRA/ TWDB	NA	NA	121.0	7,003	145,533	NA

1 TOC = Top of Conservation
2 Based on most recent published TWDB Hydrographic survey
3 Measured from BRA Datum. The BRA Datum was established in the mid-1960s prior to the construction of DeCordova Bend Dam and was used during the construction of the project. The North American Vertical Datum (NAVD) 88 is a commonly used vertical datum in the surveying industry and is approximately 1.1 feet higher than the BRA Datum.
4 Based on Permit No. 2925B.
NA = Not Applicable

2.2 Description of BRA Water Rights

The BRA holds 17 water rights in the Brazos River basin, 11 of which are associated with the reservoirs mentioned above. In addition to these reservoirs, the BRA is a joint owner with the City of Houston and the TWDB in the water right for the proposed Allens Creek Reservoir. BRA has a 30 percent ownership interest in the project, with the City of Houston being the 70 percent owner (with TWDB holding half of each share due to the funding arranged for the purchase of the site from HL&P (Houston Lighting & Power).

The five remaining rights are associated with the system operation of the reservoirs, use of excess flows in the lower Brazos basin, and interbasin transfers to the San Jacinto-Brazos coastal basin. Copies of the water rights are included in Appendix A-1. Certificate of Adjudication No. 12-2939, a water right formerly used for steam electric cooling purposes just downstream of Lake Belton, was abandoned by BRA on April 30, 2013.

The BRA has a water right application for the System Operation Permit, pending approval by the TCEQ. This proposed System Operation Permit will allow the BRA to supply additional water through coordinated operation of the existing System reservoirs with downstream run-of-river flows and wastewater discharge return flows.

2.2.1 Reservoir Water Rights

The water rights associated with the 11 existing reservoirs authorize priority diversions totaling 661,901 acft/yr for multiple uses. These water rights authorize a total collective impoundment of 2,222,949 acft. The water right for the proposed Allens Creek Reservoir authorizes impoundment of 145,533 acft, diversions of up to 202,000 acft/yr from the Brazos River for storage in the reservoir, and diversions of up to 99,650 acft/yr from Allens Creek Reservoir for municipal, industrial, and irrigation purposes.

The major provisions of these reservoir water rights are summarized in Table 2.2.

2.2.2 System Operation Order

A key feature of the BRA's reservoir water rights is the System Operation Order (System Order). The System Order was originally issued in 1964 and authorizes coordinated operation of the BRA's 11 existing reservoirs. The System Order provides flexibility in how water is managed and used from the reservoirs; however, it does not provide for appropriation of the additional water that could be made available from this type of operation.

The original System Order has been amended periodically as new reservoirs were added to the BRA System. During the water rights adjudication process, its provisions were incorporated into the special conditions of BRA's Certificates of Adjudication (COA) for each reservoir.

The System Order provides flexibility and allows for water to be released and used from "wet" parts of the basin in excess of the amounts authorized in each individual reservoir's water right. However, there are limits with regard to quantity and type of use for each reservoir. The total amount diverted annually basin-wide cannot exceed the sum of the authorized diversion amounts in the 11 individual reservoir water rights (661,901 acft/yr). The total amount of water diverted or released from any one System reservoir for a particular purpose may exceed the authorization for that purpose under that reservoir's certificate of adjudication, as shown in the two right-hand columns of Table 2.2, but may not exceed the total authorized diversions for all purposes from that reservoir in any calendar year. Additionally, the System Order contains a special condition that requires each reservoir to be excluded from operation under the System Order when the BRA's permitted storage in the reservoir is less than 30 percent full, so long as BRA permitted storage in any other reservoir that can meet system needs is above 30 percent full. The intent of this special condition is to "assure that system operations will not impair the ability of each system reservoir to supply water for local needs within that reservoir's watershed." However, local demands at some reservoirs are large enough that the 30 percent limitation is not sufficient to protect local supplies. At other reservoirs, demands are low enough that the 30 percent limit may not be necessary to protect local use, potentially freeing up additional water for system

operation. This issue is addressed in Section 4.3.5 of this Technical Report – System Order Modification.

Table 2.2- Summary of Brazos River Authority Reservoir Water Rights

Water Right ID	Reservoir Name	Authorized Storage (acft)	Priority Date	Priority Diversion (acft/yr)	Max Diversion Rate (cfs)	*System Order Diversions	
						Amount (acft/yr)	Type Use
COA 12-5155	Possum Kingdom	724,739	4/6/1938	230,750	Unspecified	175,000	Mun
						250,000	Ind
						250,000	Irr
						49,800	Min
						--	Hydro
COA 12-5156	Granbury	155,000	2/13/1964	64,712	Unspecified	40,000	Mun
						45,000	Ind
						14,500	Irr
						500	Min
COA 12-5157	Whitney	50,000	8/30/1982	18,336	5,000	25,000	Mun
						25,000	Ind
COA 12-5158	Aquilla	52,400	10/25/1976	13,896	2,100 releases through dam & 90 from reservoir perimeter	17,000	Mun
						18,200	Ind
						200	Min
COA 12-5159	Proctor	59,400	12/16/1963	19,658	Unspecified	18,000	Mun
						17,800	Ind
						18,000	Irr
						200	Min
COA 12-5160	Belton	457,600	12/16/1963	100,257	Unspecified	95,000	Mun
						150,000	Ind
						149,500	Irr
						500	Min
COA 12-5161	Stillhouse Hollow	235,700	12/16/1963	67,768	Unspecified	74,000	Mun
						74,000	Ind
						73,700	Irr
						300	Min
COA 12-5162	Georgetown	37,100	2/12/1968	13,610	Unspecified	16,500	Mun
						16,400	Ind
						4,100	Irr
						100	Min
COA 12-5163	Granger	65,500	2/15/1968	19,840	Unspecified	30,000	Mun
						29,800	Ind
						5,500	Irr
						200	Min
COA 12-5164	Somerville	160,110	12/16/1963	48,000	Unspecified	49,500	Mun
						50,000	Ind
						50,000	Irr
						500	Min
COA 12-5165	Limestone	225,400	5/6/1974 for 217,494 acft & 9/4/1979 for 7,906 acft	65,074	Unspecified	69,500	Mun
						70,000	Ind
						77,500	Irr
						500	Min
P 2925B	Allens Creek	145,533	9/1/1999	202,000 from Brazos, 99,650 from reservoir	2,200 from Brazos, 300 from perimeter of reservoir, and 700 downstream releases		

*The total amount of water diverted or released from any one System reservoir for a particular purpose may exceed the authorization for that purpose under that reservoir's certificate of adjudication, but may not exceed the total authorized diversions for all purposes from that reservoir in any calendar year.

2.2.3 Excess Flows Permit

BRA's Excess Flows Permit allows for non-priority diversion and use of run-of-river flows at multiple diversion locations along the Brazos River in Austin and Fort Bend Counties, without a release being made from an upstream reservoir. Diversions are limited to times when flows in the Brazos River at the United States Geological Survey (USGS) gaging station near Richmond (Gage No. 08114000) exceed 1,100 cfs, or some lesser rate of not less than 650 cfs, during periods when all holders of appropriative rights to divert water downstream of the Richmond gage agree in writing upon any lesser rate. This permit authorizes diversions of up to 650,000 acft/yr for municipal, industrial, and irrigation purposes. However, as with the System Order, this right does not provide an additional appropriation. Diversions under the Excess Flows Permit must be assigned to one of the priority water rights associated with BRA's existing reservoirs. BRA requested and the TCEQ amended the Excess Flows Permit in February 2013 to add two additional diversion points that are also authorized by Water Rights Permit No. 2925B (the Allens Creek Permit). The diversion locations authorized in the Excess Flows Permit include the same diversion points authorized in Water Rights Permit No. 2925B, NRG's existing diversion point from which water is transferred to Smithers Lake, GCWA's existing Canal B diversion location, and GCWA's existing Juliff diversion location.

2.2.4 Leon River Water Right Downstream of Lake Belton

The BRA acquired COA 12-2939 from the Brazos Electric Power Cooperative, Inc. (BEPC) in 2005. This water right was formerly used for cooling purposes at an electric power generating facility just downstream of Lake Belton. The right has a priority date of February 7, 1949, which is senior to Lake Belton. It authorizes diversion of 38,800 acft/yr from the Leon River for steam electric cooling purposes; however, a special condition of the right stipulates that all water diverted must be returned to the Leon River. Since the initial submission of the Water Management Plan (WMP) and Technical Report in Support of the Water Management Plan in November 2012, the BRA has abandoned COA 12-2939.

2.2.5 Interbasin Transfers

The BRA has three existing water rights that authorize the transfer of water to locations outside of the Brazos River basin:

- COA 12-5167 authorizes the transfer of up to 30,000 acft/yr for municipal purposes and 170,000 acft/yr for industrial purposes from the Brazos River basin to the San Jacinto-Brazos coastal basin. This water right does not increase the priority diversions from the BRA System or the Brazos River. The water must be released from one of the BRA's existing reservoirs and is considered part of the priority diversions from that reservoir.
- COA 12-5155 (Possum Kingdom Lake water right) authorizes the transfer of up to 5,240 acft/yr of water to the Trinity basin for municipal purposes.
- COA 12-5156 (Lake Granbury water right) authorizes the transfer of up to 20,000 acft/yr of water to the Trinity basin for municipal purposes.

The BRA also contracts with the LCRA for up to 25,000 acft of water to be transferred annually from the Colorado River basin into the Brazos River basin for use in Williamson County.

2.2.6 Contractual Rights to Water Supply

In addition to its own water rights, the BRA has water supply agreements with the City of Stamford (Lake Stamford), the City of Abilene (Hubbard Creek Reservoir), the Palo Pinto County Municipal Water District No. 1 (Lake Palo Pinto), and the LCRA. These four agreements provide an additional total supply of 43,000 acft/yr. Under the LCRA agreement, 25,000 acft/yr of surface water is authorized for import from the Highland Lakes system in the Colorado River basin into the Brazos River basin in Williamson County. This agreement resulted from passage of House Bill 1437 by the Texas Legislature in 1995. This is the only BRA water supply agreement where additional water supply is physically introduced into the basin. The remaining three water supply agreements authorize the BRA to divert under the other parties' respective water rights.

A brief summary of each water supply agreement is provided below in Table 2.3. Copies of the agreements and associated water rights are included in Appendix A-2.

Table 2.3 – BRA Contractual Rights to Water Supply

Water Supply Agreement	Annual Amount (acft)	Effective Date	End Date
Colorado(LCRA)	25,000	10-05-2001	10-9-2050
Hubbard Creek	14,000	03-10-2005	Perpetual (Life of Water Rights)
Stamford	3,000	9-10-2001	8-31-2041
Palo Pinto	1,000	8-31-2007	Perpetual (Life of Water Rights)

2.2.7 Proposed System Operation Permit

In 2004, BRA filed its application for the System Operation Permit, seeking to appropriate 421,449 acft/yr for multiple uses from the Brazos River on a firm basis. BRA further requested authorization to use up to 90,000 acft/yr of the firm supply to produce, along with other unappropriated flows, an interruptible supply of 670,000 acft/yr. During the initial phase of action on the application, both the TCEQ Executive Director (ED) and BRA prepared draft permits reflecting favorable action on the application. Significant authorizations that would be granted in both of those prior draft versions of the System Operation Permit include:

- Authorization to annually impound, divert, and use the volumes of water listed in Tables 2.4 and 2.5 below for domestic, municipal, agricultural, industrial, mining and recreational purposes, subject to special conditions of the Permit. Table 2.4 represents the appropriation recommended by the ED with construction of Allens Creek Reservoir. Each location shown in the table represents the maximum amount of the new appropriation determined by the ED assuming it is all diverted or used at that location. Table 2.5 provides the amount of water, including both firm and non-firm, determined to be available for appropriation by the BRA draft permit. Because the Commission indicated that additional water that is available prior to construction of Allens Creek Reservoir should be handled as a term use

authorization, that water is not reflected in Tables 2.4 and 2.5, but is addressed in Section 2.4 below.

Table 2.4– ED's New Appropriation Amounts with Allens Creek in Place (acft/yr)

Location	Firm Water Volume	Non-firm Water Volume
Glen Rose	131,363	157,000
Highbank	144,306	303,000
Richmond	188,005	670,000
Gulf of Mexico	191,044	670,000

Table 2.5– BRA's New Appropriation Amounts with Allens Creek in Place (acft/yr)

Location	Volume of Water
Glen Rose	217,538
Highbank	357,306
Richmond	1,001,449
Gulf of Mexico	1,001,449

- Under the ED's draft permit, authorization to divert and use wastewater return flows discharged from BRA facilities or originating from diversions pursuant to BRA water rights, for multiple uses (domestic, municipal, agricultural, industrial, mining), subject to special conditions to protect other water rights granted based on the presence of these return flows as well as other senior water rights. Under BRA's draft permit, such authorization is not limited to return flows originating from BRA facilities or derived from BRA water rights.

- Authorization to use the bed and banks of the Brazos River below Possum Kingdom Lake, its tributaries, and BRA authorized reservoirs for the conveyance, storage, and subsequent diversion of the appropriated water, subject to identification of specific losses and special conditions.

- Authorization to transfer and use the appropriated water in the adjoining San Jacinto-Brazos coastal basin and the Brazos-Colorado coastal basin. Additionally, the proposed System Operation Permit would authorize the transfer

of water to the part of the geographic area of any county or municipality or a retail public utility's retail service area that is partially within the Brazos River basin for use within the Trinity, Red, Colorado, Guadalupe, Lavaca, and San Jacinto river basins.

- Authorization to divert and use the appropriated water at the following locations:

  1) Diversion points authorized by the BRA's existing water rights (rights issued prior to approval of the proposed System Operation Permit).

  2) At USGS Gage No. 08091000, Brazos River near Glen Rose at Latitude 31.2589°N, Longitude 97.7022°W in Somervell County.

  3) At USGS Gage No. 08098290, Brazos River near Highbank at Latitude 31.1339°N, Longitude 96.8247°W in Falls County.

  4) At USGS Gage No. 08114000, Brazos River at Richmond at Latitude 29.5822°N, Longitude 95.7575°W in Fort Bend County.

  5) At the mouth of the Brazos River at the Gulf of Mexico at Latitude 28.8783°N, Longitude 95.379111°W in Brazoria County.

  6) Along the bed and banks of the Brazos River below Possum Kingdom Lake, its tributaries, and BRA authorized reservoirs.

  7) At diversion points identified and included in the initial WMP approved as part of the proposed System Operation Permit.

As discussed further in Section 2.4 below, except for the treatment of return flows and as reflected in the proposed System Operation Permit noticed by TCEQ in 2013, BRA and the Executive Director have resolved all other differences reflected in their respective 2011 Draft Permits (referred to sometimes herein as the context requires, and attached as Attachments A and B to the ALJs' October 17, 2011 Proposal for Decision).

2.3 Reservoir Firm Yield Estimates

The BRA contracts the majority of its water sales on a long-term basis. While the original and current firm yields of System reservoirs are both important, the future firm yield of a reservoir is of greater interest when determining supplies available for long-term contracts. In estimating the firm yield of a particular reservoir only the specific set of water rights associated with the reservoir are modeled to determine the amount of

water that can be reliably diverted from the reservoir year after year through the drought of record without shortages. Individual reservoir firm yields are estimated to monitor water availability by reservoir through time. Estimates of firm yield provide a baseline to monitor and manage contracts such as evaluating requests for new contracts and renewals. Firm yield estimates are also used to aid in planning for new supplies within the State Water Plan.

The major factor affecting the future firm yield for a reservoir is sedimentation. Storage capacity decreases as suspended sediments are deposited into the reservoir over time through inflows and surface runoff, decreasing the firm yield of the reservoir. In order to track the accumulation of sediment, the BRA periodically contracts with the TWDB to perform volumetric surveys of the System reservoirs. Volumetric surveys allow for monitoring and estimation of sediment deposition within each System reservoir. Extrapolating the reduction in volume due to sedimentation allows estimates of firm yield to be made for various points in the future. Information regarding the estimation of sedimentation rates for each BRA System reservoir and incorporating that data within the firm yield modeling can be found in Appendix G-2.

Firm yields were estimated for each existing reservoir in the BRA System, with the exception of Lake Proctor, using the Brazos Basin Water Availability Model (WAM) Full Authorization (Brazos-WAM Run 3) obtained from the TCEQ on March 12, 2012. Updates to the net evaporation rates for the Brazos-WAM Run 3 were made in February 2014 and were adopted for all water availability modeling documented within this Technical Report. This modified model (modified Brazos-WAM Run 3) assumes the full use of all water rights. Six scenarios, listed in Table 2.6 below, were applied by modifying the baseline TCEQ version of the Brazos-WAM Run 3 (modified Brazos-WAM Run 3) with the listed changes below to evaluate yield at each of the System reservoirs except Lake Proctor. Comparisons of results from the firm yield analysis are listed in Table 2.6.

The following is a summary list of changes that were made to the Brazos-WAM Run 3 to construct the modified Brazos-WAM Run 3. Additional information related to

modifications and other assumptions used for the firm yield analysis may be found in Appendix G-2.

1. Yields were estimated using various assumptions regarding the availability of return flows. Average values of historically discharged return flows from 2008 to 2011 were adopted as current available return flows and were modeled in the 2012 scenario. Current permitted return flows were modeled for the 2025 and 2060 scenarios.

2. The dual simulation option was employed to avoid overestimating firm yields for under-permitted reservoirs. (An under-permitted reservoir has a firm yield that is greater than the priority diversions in the reservoir's water right.) Dual simulation options in WAM are designed primarily for scenarios where multiple rights with different priorities divert water from the same reservoir system. In the current scenario, firm yield simulations are completed for each reservoir with the original priority date in the water right and a junior priority date to calculate additional unpermitted yield within the reservoir. Without the dual simulation option, reservoir drawdowns associated with junior diversions may be inappropriately refilled in subsequent months by senior rights at the same reservoir, potentially impacting other water rights. The dual simulation option allows reservoir refills under the senior priority date during the initial simulation to be used as upper limits constraining refills at the senior priority date during the second or final simulation. Implementing the dual simulation option in this manner prevents overestimation of firm yield in under-permitted reservoirs.

3. The elevation-area-capacity (EAC) tables and reservoir storage volumes were adjusted to reflect the estimated capacity at each BRA System reservoir for the years 2012, 2025 and 2060.

4. Fort Phantom Hill Reservoir and Lake Waco area-capacity tables and reservoir storage were updated to the same sediment conditions as the BRA System reservoirs because these impoundments significantly impact the BRA's water

rights. Remaining water rights within the Brazos-WAM still reflect the original area-capacity conditions in Run 3.

5. Reservoir setup at Lake Whitney was altered to include only the storage above elevation 520 feet mean sea level (ft msl), which consists of BRA's existing permitted storage and the hydropower pool. This storage is divided into two "pools": Pool 1 representing BRA's portion of the reservoir and Pool 2 representing the hydropower pool. This setup is different than the original TCEQ Brazos WAM that included an additional pool representing the "dead" storage in the reservoir, for a total of 3 pools. The 3-pool modeling approach allowed diversions and releases when reservoir elevations were below elevation 520 ft msl, which is below the level authorized by BRA's permit.

6. The FERC minimum flow requirements (per Article 402 of FERC License 1490-003-Texas) at Possum Kingdom Lake and an environmental flow release from Lake Granbury were incorporated into the WAM datasets. The Brazos-WAM was updated to include the operational rules of the FERC minimum flow releases based on the time of year and reservoir elevation. Notwithstanding the surrender of this FERC license, BRA has agreed to include the FERC minimum flow release requirements in the proposed System Operation Permit. Additionally, the low flow release from Lake Granbury is not a requirement under BRA's existing water right for Lake Granbury, but it has been maintained by BRA since the early 1980s.

Firm yield values for Lake Proctor (2012, 2025 and 2060 runs) were estimated using the computational firm yield model from the December 2001 Freese and Nichols, Inc. (FNI) report entitled "Update of Proctor Lake Hydrology to Include Inflow from 1997 through 2000." Between June 1998 and October 2000 Lake Proctor experienced a severe drought which prompted the BRA to commission FNI to perform the hydrologic study. The findings of the study indicated that Lake Proctor experienced a new critical drought period which resulted in a reduction of the project's yield. The results of this study prompted BRA to reduce the current long-term commitments from the lake to stay within the firm yield of the project. Because the current Brazos-WAM does not include

hydrology after 1997, the FNI firm yield model was used to determine the firm supply from Lake Proctor.

Table 2.6 - System Reservoir Firm Yield Analysis

All values in acft per year	2012 Conditions		2025 Conditions		2060 Conditions	
Reservoir	**Base WAM Run[1]**	**No Return Flows**	**All Current Return Flows**	**No Return Flows**	**All Permitted Return Flows**	**No Return Flows**	**All Permitted Return Flows**
Aquilla	14,570	13,050	14,020	12,720	14,530	11,920	13,710
Belton[2]	104,190	104,670	109,650	104,520	116,280	103,810	115,580
Georgetown	11,110	11,550	12,070	11,540	12,270	11,510	12,240
Granbury	62,990	72,930	80,590	70,980	82,400	59,640	70,250
Granger	18,190	15,270	18,600	14,580	21,040	12,120	18,370
Limestone	69,720	66,730	67,380	64,430	64,430	58,320	61,050
Possum Kingdom	372,560	284,990	288,030	269,870	281,240	222,580	236,330
Proctor[3]	20,098	15,359	15,714	14,925	15,983	13,859	14,894
Somerville	44,880	42,400	43,510	41,940	44,850	40,740	43,670
Stillhouse Hollow	61,510	62,030	67,050	61,760	71,860	61,120	70,670
Whitney	49,345	41,660	43,990	41,760	44,630	42,110	43,810
Total	829,163	730,639	760,604	709,025	769,513	637,729	700,574

[1] Base run was executed using the March 2012 Brazos WAM full authorization (Run 3) dataset and February 2014 updated evaporation data.

[2] Firm yield of BRA water right at Lake Belton only. The firm yield of water rights of the U.S. Department of the Army (Fort Hood) are not included in this estimate.

[3] Simulations were executed using the computational firm yield model from the December 2001 FNI report entitled "Update of Proctor Lake Hydrology to Include Inflow from 1997 through 2000."

2.4 Proposed System Operation Permit – New Appropriation at Actual and Proposed Diversion Points

The draft permit noticed by TCEQ in 2013 reflects the maximum appropriation that could be made under the proposed System Operation Permit. (The only difference in approach between the BRA and the Executive Director is the treatment of return flows. All other terms of the proposed System Operation Permit have been agreed on, including the way that the appropriation was included in the permit.) In consideration of the ALJs' PFD from the 2011 hearing, the TCEQ Commissioners had determined that the appropriation set out in the draft permit should not be made without completion of the BRA's WMP, which would allow consideration of the impacts resulting from use of the proposed System Operation Permit's appropriation at actual and proposed diversion points, based on authorized rates of diversion and quantities of use at those diversion points.

The WMP's analysis of implementing the new appropriation under the proposed System Operation Permit, along with use of the water under BRA's existing water rights, allows consideration of both water availability and potential impact on other water rights at actual and anticipated points of diversion and use. In most cases, water use at a given point will be a combination of water appropriated under the BRA's existing permits and water appropriated under the System Operation Permit. The WMP shows how the new appropriation would be used, given conditions expected over the 10-year period covered by the Plan. For these analyses, this section:

- Summarizes the appropriation in the draft permit, under both the TCEQ ED's and the BRA's approaches to return flows;
- Analyzes water availability based on the current contracts, current operations, and future demands from the BRA System identified in regional water planning;
- Determines the proposed System Operation Permit appropriation needed to satisfy current contracts and future water supplies from the regional water plans, assuming that the System Operation Permit has been granted;
- Determines the additional firm and non-firm supply that could be available from the BRA System after satisfying current contracts and demands identified in the

regional water plans, as well as the proposed System Operation Permit appropriation associated with this additional supply;

- Evaluates how the use of the proposed System Operation Permit appropriation changes due to return flows, diversions by the proposed expansion at the CPNPP, and the construction of the Allens Creek Reservoir; and
- Examines the potential impact of the proposed System Operation Permit on other permanent water rights.

The firm supply from the BRA System is analyzed in two ways. The first way, referred to as the Variable Demand Scenarios, has a large water supply component that is only used when called for by BRA customers. Many of the larger BRA customers have their own water rights; the Variable Demand Scenarios assume that these customers use their own water rights first, only using BRA contract water during drier periods. These scenarios represent the supply of the System based on expected operations. The second way, referred to as the Firm Use Scenarios, looks at the firm yield of the System using only the BRA System water rights, including the proposed System Operation Permit. In these scenarios all BRA contracts are assumed to be fully exercised in each year. These scenarios are explained in more detail below.

As conditions and demands change in the future, the way that the BRA uses the System Operation Permit appropriation may change. These changes will be addressed in future Water Management Plans.

2.4.1 Appropriation in Draft Permit

The ED's and the BRA's respective 2011 Draft Permits used different approaches for return flows. In both 2011 Draft Permits, the appropriation is identified at four locations, both before and after construction of the Allens Creek Reservoir. These four locations are designed to show how the amount of available water varies with location in the basin; however, the most downstream location effectively defines the new appropriation, and the upstream locations are informational. Three of the locations are at USGS stream gages on the main stem of the Brazos River: the Brazos River near Glen Rose (USGS 08091000), the Brazos River near Highbank (USGS 08098290), and the Brazos

River at Richmond (USGS 08114000). The fourth location, the Gulf of Mexico, is located at the mouth of the Brazos River. The appropriations are not additive as the analysis proceeds downstream. In other words, the appropriation at Richmond includes the appropriation at the upstream points (Glen Rose and Highbank). To avoid confusion, the BRA and the Executive Director have agreed to eliminate the three upstream informational locations (i.e., Glen Rose, Highbank, and Richmond), and to simply provide in the draft permit the total amount of water appropriated at the Gulf of Mexico. The water available prior to the construction of the Allens Creek Reservoir is the result of using water that has already been appropriated in the Allens Creek Permit (Permit No. 2925B) by the BRA (an owner of the permit) prior to construction of the reservoir. The use of this water increases the amount of water available through system operation. This appropriation is a term authorization and will no longer be available once the Allens Creek Reservoir is built.

The ED's approach limits reuse to return flows derived from water supplied by BRA or from wastewater treatment plants owned or operated by BRA. Under the BRA approach to return flows, all return flows not previously dedicated to others are subject to appropriation as state water following discharge. Appropriation of return flows is not limited to those derived from water supplied by BRA or discharged from BRA wastewater treatment facilities. As a result, the BRA approach results in more water being available from the BRA System than under the ED's return flows approach.

One of the functions of the WMP is to define the firm water and non-firm water that is available from the BRA System with the approval of the proposed System Operation Permit. Because the legal issue regarding treatment of return flows in the appropriation process has not yet been definitively resolved, the WMP must consider both alternatives. For this reason, alternative scenarios examined by the WMP include no return flows ("no return flow"), return flows only from BRA facilities and BRA-supplied water ("BRA return flows"), and all return flows, other than those that are already permitted and reused ("all return flow").

2.4.2 Water Available with the Proposed System Operation Permit

This initial WMP includes three sets of WAM runs. The first set determines the firm yields of the existing reservoirs in the BRA System and is described in Section 2.3 above. The second set uses the TCEQ Brazos Basin Water Availability Model Full Authorization Model (Brazos-WAM), as modified for this WMP, to examine how the BRA System performs under current demands, projected 2025 demands, and projected 2060 demands (2025 is the expected date of the next revision of the WMP). That modeling is described in Section 4.3 of this Technical Report. This section describes the third set, which is system modeling designed to show: (a) how the appropriation by the proposed System Operation Permit would be used given current BRA diversion locations and the additional demands identified during the regional water planning process; (b) how much water is appropriated by the proposed System Operation Permit using these demands, and (c) how much additional supply can be developed from the BRA System after meeting contractual obligations. This third set includes the Variable Demand and Fixed Use Scenarios described at the beginning of Section 2.4. Specifically, these analyses assume:

- Customers that do not have their own water rights make full use of their contracts with the BRA.
- In the Variable Demand Scenarios, customers that do have their own water rights use those water rights first, with their BRA contracts used when their own water rights are not available, creating a reliable supply. In some cases, the backing up of customer water rights does not fully use the BRA contract amount. In these cases, an additional constant demand is added so that the maximum diversion amount available through these contracts occurs during at least one year of the simulation.
- In the Firm Use Scenarios, customers that have their own water rights make full use of their BRA contracts.
- The BRA will supply additional demands not covered by its current contracts, as identified in the 2011 Brazos G and Region H Regional Water Plans.

- In some scenarios, additional water supply is diverted from Lake Granbury for the proposed expansion of the CPNPP.
- Original sediment conditions in all reservoirs.
- In some scenarios, use of return flows is based on the minimum monthly discharge between 2007 and 2011, in accordance with the TCEQ's WAM Resolved Technical Issues.
- There will be additional supplies from groundwater in the vicinity of Lake Georgetown. The amount of groundwater is dependent on the availability of return flows appropriated by the BRA.
- There will be a new pipeline that connects Lake Belton to Lake Stillhouse Hollow, and infrastructure that allows demands in the Lake Georgetown area to also be met from Lake Granger.
- In scenarios without the Allens Creek Reservoir, a term authorization to use the flows appropriated by that water right has been granted as part of the proposed System Operation Permit.

2.4.2.1 Appropriation Model

These analyses use a modified version of the TCEQ Brazos-WAM, referred to as the Appropriation Model. The Brazos-WAM is a hydrologic computer model of the entire Brazos basin that includes every permanent water right in the basin. The Brazos-WAM uses historical monthly naturalized hydrology from 1940 to 1997. The WAM is an application of the Water Rights Analysis Package (WRAP) developed by Dr. Ralph Wurbs of Texas A&M University. This model is specifically designed to simulate operations under the priority rights system used in the State of Texas.

The Appropriation Model includes some of the modifications used to calculate the firm yields of System reservoirs discussed in Section 2.3 above: removal of the BEPC water right (abandoned by BRA), and instream flow releases from Possum Kingdom Lake. The modeling also includes hydropower releases from Lake Whitney. These changes are described in Section 2.3 and detailed in Appendix G-2.

In the Appropriation Model, modeling of the proposed System Operation Permit is based on the approach developed by the BRA and the ED for analyzing the application for the System Operation Permit. However, instead of using the entire BRA System to meet demands at one or two points, the Appropriation Model uses the locations of existing BRA contracts and future demands identified as being met from the System Operation Permit in the regional water plans. An additional diversion is added at the Rosharon gage to determine the amount of unused System yield available after satisfying existing contracts and future demands identified in the regional water plans. The Rosharon gage was chosen because the most likely location of future demands to be met from the BRA System is in the reach between the Richmond gage and the Rosharon gage.

The Appropriation Model uses the adopted SB 3 environmental flow standards for the Brazos basin, found in Section 298.480 of Title 30 of the Texas Administrative Code. These standards are described in Section 4.4.4 of this Technical Report. The farthest downstream measurement point in the adopted criteria is the Brazos River near Rosharon gage (USGS 08116650). In the Model, no diversions of run-of-river flows by the System Operation Permit occur below Rosharon, so environmental flows conditions are applied to all diversions under the Permit. However, there are BRA customers located below Rosharon. In the Variable Demand Scenarios, run-of-river flows from the proposed System Operation Permit are not available when these customers need water, so the needs of these customers must be met from reservoir releases, which are not subject to environmental flow requirements. In the Firm Use Scenarios, contracts under which water is diverted below Rosharon are moved upstream to the Rosharon gage so that the instream flows conditions will be applied.

Hydropower releases from Lake Whitney are an important part of the operation of water supplies in the lower Brazos basin. During dry times, regular hydropower releases provide more water for lower basin use than would have been available without hydropower releases. However, during drought the hydropower pool of Lake Whitney can be emptied and regular hydropower generation ceases, potentially reducing supplies in the lower basin. This situation occurred during the drought of 2011,

exacerbating the impact of the drought on water supplies in the lower basin. The TCEQ Brazos-WAM does not include hydropower generation at Lake Whitney, primarily because it is not associated with a Texas water right. The BRA and the Executive Director agree that inclusion of hydropower is necessary to give a realistic assessment of how the proposed System Operation Permit appropriation will be used under this initial WMP. The Model assumes that hydropower operation will be similar to historical operation. Hydropower modeling is described in more detail in Appendix G-2. Future changes to hydropower operation, and the resulting impact on BRA operations, can be addressed in future Water Management Plans.

The BRA does not have authority over releases from Lake Whitney for hydropower production, but to the extent possible, the BRA coordinates its water supply releases with hydropower releases to meet needs downstream of Lake Whitney. In the modeling for this Section 2.4, water for hydropower generation is released from non-priority storage in Lake Whitney. The releases are distributed to water rights in priority order, with the most senior water right having access to the flows first. Since many of these senior water rights are BRA customers, hydropower operations impact BRA operations and contractual commitments. The storage in Lake Whitney used to generate hydropower is modeled as the most junior water right in the basin, so that refilling of storage occurs after all other rights have been satisfied.

COA 12-5166 (as amended), the Excess Flows Permit, is a non-priority right that authorizes the use of run-of-river flows at locations in the lower Brazos basin. Diversions under that permit must be charged to one of BRA's existing reservoir rights. In general, non-priority rights like that permit are not considered in water availability analyses for permanent rights, so this water right is not included in the TCEQ Brazos-WAM. Currently, NRG is the only BRA customer that uses water authorized under the Excess Flows Permit. (NRG diversions under the Excess Flows Permit are not explicitly modeled. A post-processor assigns diversions under NRG's own water rights to the Excess Flows Permit when available, in accordance with NRG's contract with BRA.) One of the intended uses for that permit was to provide Brazos River water to fill the Allens Creek Reservoir. The BRA has amended the Excess Flows Permit so that the

diversion points are consistent with those found in the Allens Creek Permit. In the modeling scenarios with the Allens Creek Reservoir, the Excess Flows Permit is used to supplement diversions from the Brazos River when unappropriated water is available, there is empty storage in the reservoir, and the 202,000 acft/yr maximum diversion from the Brazos River has already been fully used. The Excess Flows Permit is modeled as the most junior water right in the basin. A post-processor checks that diversions do not exceed the authorizations under BRA's existing water rights.

Because of the complexities associated with modeling the proposed System Operation Permit, the Appropriation Model does not directly track use under the individual BRA water rights. Therefore, diversions under the various BRA authorizations (priority diversions from and filling of BRA System reservoirs, System Order, System Operation Permit, and Excess Flows Permit) are tracked in an Excel spreadsheet post-processor of the raw output of the WRAP model. The accounting performed in this spreadsheet is consistent with the Accounting Plan that is proposed as part of this WMP and discussed in Section 5 and Appendices H-1 and H-2 of this Technical Report. The modeling techniques used in this study and the methodology used to account for diversions by water rights is described in detail in Appendix G-2. The WRAP program TABLES could be used for this analysis, but the spreadsheet method is more efficient for these complex calculations.

In general, the accounting spreadsheet assigns diversions and releases from reservoirs to the priority rights associated with that reservoir. If the diversions and releases exceed the priority rights from the reservoir, then the diversions and releases may be assigned to other BRA water rights as defined in the System Order. If System Order water is not available, then these diversions and releases are assigned to the System Operation Permit.

Run-of-river diversions are almost always assigned to the System Operation Permit, except for (1) NRG diversions that are assigned to the Excess Flows Permit (COA 12-5166, as amended), and (2) diversions to fill the Allens Creek Reservoir that are assigned to either the Allens Creek Permit (Permit No. 2925B) or the Excess Flows Permit. The modeling approach assures that depletions of natural flows or return flows

under the proposed System Operation Permit only occur after the associated instream flow requirements are satisfied.

Although the Allens Creek Reservoir is not expected to be built by 2025, it is included in some scenarios to determine the impact of the reservoir on the appropriation. The Allens Creek Permit is jointly owned by the BRA, the City of Houston, and the State of Texas through the TWDB. The State's share of the reservoir will eventually be purchased by the other participants, leaving the City of Houston and the BRA as owners. This WMP assumes that an agreement will be in place to fully use the Allens Creek Reservoir as part of the BRA System. In other words, the City of Houston's share in the Allens Creek Permit will be available from the BRA System to the same extent that it would be if the Allens Creek Reservoir were not operated as part of the BRA System. This assumption increases the reliability and overall amount of water available in the lower Brazos basin, which benefits all users of Brazos River water in the area.

This WMP also assumes that the water from the Allens Creek Reservoir will be primarily used to satisfy water supply needs in Fort Bend County, regardless of the ownership of the water from the reservoir. This assumption is consistent with the 2011 Region H Water Plan.

In order to meet the full contract demands used in this Section 2.4, additional infrastructure and groundwater supplies are needed. Groundwater supplies are assumed to be available in the vicinity of Lake Georgetown and are modeled as a reduction in demand from that source. The BRA is currently in the process of developing these groundwater supplies. The BRA plans to interconnect Lakes Belton, Stillhouse Hollow, Georgetown and Granger in order to meet future demands from the Little River subsystem of reservoirs. Currently, the WCRRWL connects Lake Stillhouse Hollow and Lake Georgetown. The BRA has plans to build another pipeline that connects Lake Belton to Lake Stillhouse Hollow, as well as additional infrastructure that will increase the ability to use water from Lake Granger.

Rather than modeling pipelines that pump water from one reservoir for storage in another, the interconnections in the Little River subsystem are modeled as “shared demand” that can be met from one reservoir when it is relatively full, and then shifted to another reservoir during drought periods. For example, the scenarios assume that, in addition to the local demand from Lake Granger, 10,000 to 15,000 acft/yr are used from Lake Granger when it is relatively full. When Lake Granger drops below a specified level, that demand is shifted to Lake Georgetown. Similar methods are used to model the WCRRWL and the proposed pipeline between Lakes Belton and Stillhouse Hollow. This approach is used to simplify the assignment of diversions to the appropriate water rights in the accounting spreadsheet. The modeling is described in more detail in Appendix G-2.

Table 2.7 shows the twelve Appropriation Scenarios developed for this part of the WMP. These scenarios were designed to determine the impact of return flows, the Allens Creek Reservoir, and the proposed expansion at the CPNPP on the potential use of appropriations by the BRA under its existing water rights and the proposed System Operation Permit. Four different demand levels are used in the scenarios, referred to using the letters A through D. The demands change because of assumptions about the CPNPP expansion and the presence of the Allens Creek Reservoir. These two projects are addressed separately because of the significant impact of these projects on water supply. Demand levels A and C do not include the CPNPP expansion. Demand levels B and D assume that the CPNPP expansion is in place. Demands levels A and B do not include the Allens Creek Reservoir, while demand levels C and D assume that supplies are available from that source. Each of these demand levels is evaluated with three different levels of return flows shown in Table 2.9: (1) no return flows, which is consistent with analyses typically performed by TCEQ when evaluating a new water right; (2) return flows from BRA sources only, which is consistent with the ED’s preferred approach to return flows; and (3) all return flows, which is the approach preferred by the BRA. The different approaches to return flows are discussed in Section 2.4.1 above.

Table 2.7 – Water Management Plan Appropriation Scenarios				
No.	**Scenario**	**CPNPP Expansion**	**Return Flows**	**Allens Creek Reservoir**
1	Demand Level A, No Return Flows	N	None	N
2	Demand Level A, ED Approach to Return Flows	N	BRA only	N
3	Demand Level A, BRA Approach to Return Flows	N	All	N
4	Demand Level B, No Return Flows	Y	None	N
5	Demand Level B, ED Approach to Return Flows	Y	BRA only	N
6	Demand Level B, BRA Approach to Return Flows	Y	All	N
7	Demand Level C, No Return Flows	N	None	Y
8	Demand Level C, ED Approach to Return Flows	N	BRA only	Y
9	Demand Level C, BRA Approach to Return Flows	N	All	Y
10	Demand Level D, No Return Flows	Y	None	Y
11	Demand Level D, ED Approach to Return Flows	Y	BRA only	Y
12	Demand Level D, BRA Approach to Return Flows	Y	All	Y
Notes: All reservoirs are at 2025 sediment conditions CPNPP Expansion assumes 90,152 acft/yr for new units, with 40% return flow				

2.4.2.2 Variable Demand Appropriation Scenarios

One of the benefits of the System Operation Permit is the ability to generate additional supply, not only from the coordinated operation of the BRA System and its associated rights, but also from coordinated operation with BRA customers' water rights. Several of the BRA's larger customers have their own water rights and contract for water with the BRA to back up those rights when additional supplies are needed, primarily during drought. These customers include the City of Temple, TMPA, Alcoa, NRG, the GCWA and Dow Chemical. For example, GCWA, a major water provider in Fort Bend, Brazoria and Galveston counties, owns the water rights for almost 380,000 acft/yr of run-of-river diversions from the Brazos River. This amount is also approximately equal to the projected demand for GCWA in 2025. Because these are run-of-river rights with little associated storage, they are not fully reliable under drought conditions. Although the current BRA contracts with GCWA are not sufficient to fully cover this potential shortage, the Variable Demand Scenarios assume that BRA will provide sufficient water to make the GCWA rights fully reliable. This assumption is consistent with the 2011 Region H Water Plan, which also uses BRA water for GCWA, although the Region H Plan uses less BRA water than what is assumed here. (In the Firm Use Scenarios,

these customers are limited to their current contract amounts, which are assumed to be fully used every year.)

NRG is another customer that has its own water rights as well as a contract for 83,000 acft/yr from the BRA System. The NRG contract stipulates that when the flows at the Richmond gage are more than 2,000 cfs, diversions by NRG are assigned to BRA's Excess Flows Permit (COA 12-5166, as amended) rather than to NRG's water rights. NRG is also assumed to use water from the BRA System during dry periods when water is not available from its own rights. However, the amount of water needed for either diversion under the Excess Flows Permit or during drought is never as much as 83,000 acft/yr. In the Variable Demand Scenarios, an additional constant diversion is assumed for NRG so that the full contract is diverted in at least one year of the simulation. This assumption shows that the full use of water contracted to NRG is available from the BRA System. (In the Firm Use Scenarios, NRG is assumed to use its full contract amount in every year.)

Table 2.8 shows the assumed demands by reach for the four demand levels used in the Variable Demand Scenarios. The reaches in Table 2.8 are used for all of the hydrologic modeling in this Section 2.4 and in Section 4.3 of this Technical Report, as well as in the Accounting Plan described in Section 5 of this Technical Report. All these scenarios assume 2025 sediment conditions. These scenarios model the supply from the BRA System based on expected operations with the proposed System Operation Permit, using both firm and non-firm supply from the BRA System to create an overall firm supply for BRA's customers.

The demands in Table 2.8 are based on current long-term contract amounts for the BRA, plus additional demands identified in the 2011 Brazos G and Region H Water Plans that are not covered by existing contracts. Two of these additional demands are the Allens Creek Reservoir and the expansion of the CPNPP. Other additional water supply needs from the regional plans are included in all demand scenarios. These water supply needs include both demands that the regional plans specifically identify as being met by the System Operation Permit as well as demands that are met from other water management strategies. The water availability analyses in this WMP show more

water available in the lower basin than assumed in the 2011 Region H Water Plan. The BRA believes that the System Operation Permit is a viable and affordable alternative to the water management strategies recommended to meet these water supply needs in the 2011 Region H Water Plan.

Table 2.8 – Demands Used in Variable Demand Scenarios (acft/yr)

Reach	Demand Level A – Current Contracts [a]	Demand Level B – Contracts plus CPNPP Expansion [a]	Demand Level C – Contracts plus Allens Creek [a]	Demand Level D – Contracts plus Allens Creek and CPNPP Expansion [a]
Possum Kingdom Lake [b]	88,566	61,119	88,566	61,119
Possum Kingdom Lake Dam to Palo Pinto gage	1,200	1,200	1,200	1,200
Palo Pinto gage to Dennis gage	1,050	1,050	1,050	1,050
Dennis gage to Lake Granbury Dam [c]	89,401	179,553	89,401	179,553
Lake Granbury Dam to Glen Rose gage	1,200	1,200	1,200	1,200
Glen Rose gage to Lake Whitney Dam	12,260	12,260	12,260	12,260
Lake Whitney Dam to Aquilla Creek/Brazos Rv confluence	11,722	11,722	11,722	11,722
Lake Aquilla	11,403	11,403	11,403	11,403
Lake Aquilla Dam to Aquilla Creek gage	0	0	0	0
Aquilla Creek gage to Aquilla Creek/Brazos Rv confluence	0	0	0	0
Aquilla Creek/ Brazos confluence to Highbank gage	2,300	2,300	2,300	2,300
Lake Proctor	13,089	13,089	13,089	13,089
Lake Proctor Dam to Leon Rv at Gatesville gage	0	0	0	0
Leon Rv at Gatesville to Lake Belton Dam	76,062	76,062	76,062	76,062
Lake Belton Dam to Leon Rv nr Belton gage	30,453	30,453	30,453	30,453
Leon Rv nr Belton gage to Little River gage	200	200	200	200
Lake Stillhouse Hollow	39,255	39,255	39,255	39,255
Lake Stillhouse Hollow Dam to Lampasas Rv nr Belton gage	8	8	8	8
Lampasas Rv nr Belton gage to Little River gage	0	0	0	0
Little River gage to Little Rv/San Gabriel Rv confluence	0	0	0	0
Lake Georgetown	74,561	74,561	74,561	74,561
Lake Georgetown Dam to N San Gabriel gage	0	0	0	0
N San Gabriel gage to Lake Granger Dam	13,015	13,015	13,015	13,015
Lake Granger Dam to Laneport gage	0	0	0	0
Laneport gage to Little Rv/San Gabriel confluence	0	0	0	0
Little/San Gabriel confluence to Little Rv at Cameron gage	5,000	5,000	5,000	5,000
Cameron gage to Brazos Rv/Little Rv confluence	0	0	0	0
Highbank gage to Brazos Rv/Little Rv confluence	0	0	0	0
Brazos Rv/Little Rv confluence to Bryan gage	200	200	200	200
Bryan gage to Brazos Rv/Yegua Crk confluence	2,650	2,650	2,650	2,650
Lake Somerville	4,200	4,200	4,200	4,200
Lake Somerville Dam to Yegua Crk gage	0	0	0	0
Yegua Crk gage to Brazos Rv/Yegua Crk confluence	0	0	0	0
Brazos/Yegua Crk confluence to Brazos/Navasota confluence	540	540	540	540
Lake Limestone	50,875	50,875	50,875	50,875
Lake Limestone Dam to Easterly gage	0	0	0	0
Easterly gage to Brazos Rv/Navasota Rv confluence	7,600	7,600	7,600	7,600
Brazos Rv/Navasota Rv confluence to Hempstead gage	0	0	0	0
Hempstead gage to Richmond gage	83,050	83,050	83,050	83,050
Richmond gage to Gulf of Mexico [d]	204,151	204,151	251,195	251,195
Total	*824,011*	*886,716*	*871,055*	*933,760*

a All demand levels assume other demands from 2011 Region G and H Regional Water Plans that are expected to be met from the System Operation Permit.
b Levels without the CPNPP expansion include the 27,447 acft/yr Luminant contract from Possum Kingdom.
c Levels with the CPNPP expansion move the 27,447 acft/yr Luminant contract to Lake Granbury to partially satisfy the demand for the expansion. An additional new contract for 62,705 acft/yr provides the rest of the demand for the expansion.
d Assumes a maximum of 164,180 acft/yr for GCWA. Actual amount provided to GCWA depends on the reliability of its water rights, which change depending on assumptions.

The demand for the expansion of the CPNPP (Units 3 and 4) is assumed to be 90,152 acft/yr, with approximately 40 percent of the diversion returning to Lake Granbury. Of this 90,152 acft/yr of new demand, 27,447 acft/yr is assumed to come from an existing Luminant contract with the BRA that is currently not assigned to a particular use. The remaining 62,705 acft/yr would come from a new contract. Scenarios without the CPNPP expansion include the 27,447 acft/yr existing Luminant contract as a demand out of Possum Kingdom Lake.

All of the modeling scenarios in this section assume some groundwater supplies to supplement the BRA System in the vicinity of Lake Georgetown. These supplies are incorporated as a reduction in demand at Lake Georgetown. In the Variable Demand Scenarios without return flows, 33,000 acft/yr of groundwater is needed to satisfy all contracts and future demands. 21,000 acft/yr of groundwater is required if only BRA return flows are considered part of the available water. 17,000 to 18,000 acft/yr of groundwater is used for the runs with all return flows.

Demands in the Gulf of Mexico reach assume a maximum of 164,180 acft/yr to back up the GCWA rights, which is the approximate maximum annual shortage for the GCWA water rights determined with the TCEQ Brazos-WAM. The Variable Demand Scenarios assume that the demand for GCWA is approximately equal to its water rights. The amount provided by the BRA is the amount needed to make the GCWA water rights firm, so the maximum amount provided is equal to the shortage experienced by the GCWA rights. The amount of the shortage varies depending on assumptions about return flows, hydropower operation, and other factors. In the Variable Demand Scenarios, the shortage for GCWA varies from about 138,000 acft/yr to 158,000 acft/yr, depending on assumptions.

The scenarios without the Allens Creek Reservoir assume use of water appropriated to the Allens Creek water right. The BRA's System Operation Permit application seeks authorization to use water appropriated to the Allens Creek Reservoir as a term authorization prior to construction of the reservoir.

2.4.2.3 Firm Use Appropriation Scenarios

The twelve Firm Use Scenarios use the same scenarios described in Table 2.7. However, instead of assuming that BRA customers with their own water rights make use of water from BRA contracts to firm up their own water rights, the Firm Use Scenarios assume that full use under BRA's existing contracts is made each year by all BRA customers. The Firm Use Scenarios are also limited to only those Regional Water Plan demands that have been specifically identified to be met by either the System Operation Permit or the Allens Creek Reservoir. Other assumptions are the same as described in Section 2.4.2.2 above. Table 2.9 shows the demands by reach assumed for each demand level. Table 2.10 shows the assumed groundwater supplies used in each scenario. These analyses reflect the firm supply available from the BRA System using the proposed System Operation Permit, with the System acting independently of customer supplies.

Table 2.9 – Demands Used in Firm Use Scenarios (acft/yr)

Reach	Demand Level A – Current Contracts [a]	Demand Level B – Contracts plus CPNPP Expansion [a]	Demand Level C – Contracts plus Allens Creek [a]	Demand Level D – Contracts plus Allens Creek and CPNPP Expansion [a]
Possum Kingdom Lake [b]	88,566	61,119	88,566	61,119
Possum Kingdom Lake Dam to Palo Pinto gage	1,200	1,200	1,200	1,200
Palo Pinto gage to Dennis gage	1,050	1,050	1,050	1,050
Dennis gage to Lake Granbury Dam [c]	89,401	179,553	89,401	179,553
Lake Granbury Dam to Glen Rose gage	1,200	1,200	1,200	1,200
Glen Rose gage to Lake Whitney Dam	12,260	12,260	12,260	12,260
Lake Whitney Dam to Aquilla Creek/Brazos Rv confluence	11,722	11,722	11,722	11,722
Lake Aquilla	11,403	11,403	11,403	11,403
Lake Aquilla Dam to Aquilla Creek gage	0	0	0	0
Aquilla Creek gage to Aquilla Creek/Brazos Rv confluence	0	0	0	0
Aquilla Creek/ Brazos confluence to Highbank gage	2,300	2,300	2,300	2,300
Lake Proctor	13,089	13,089	13,089	13,089
Lake Proctor Dam to Leon Rv at Gatesville gage	0	0	0	0
Leon Rv at Gatesville to Lake Belton Dam	76,062	76,062	76,062	76,062
Lake Belton Dam to Leon Rv nr Belton gage	30,453	30,453	30,453	30,453
Leon Rv nr Belton gage to Little River gage	200	200	200	200
Lake Stillhouse Hollow	39,255	39,255	39,255	39,255
Lake Stillhouse Hollow Dam to Lampasas Rv nr Belton gage	8	8	8	8
Lampasas Rv nr Belton gage to Little River gage	0	0	0	0
Little River gage to Little Rv/San Gabriel Rv confluence	0	0	0	0
Lake Georgetown	74,561	74,561	74,561	74,561
Lake Georgetown Dam to N San Gabriel gage	0	0	0	0
N San Gabriel gage to Lake Granger Dam	13,015	13,015	13,015	13,015
Lake Granger Dam to Laneport gage	0	0	0	0
Laneport gage to Little Rv/San Gabriel confluence	0	0	0	0
Little/San Gabriel confluence to Little Rv at Cameron gage	5,000	5,000	5,000	5,000
Cameron gage to Brazos Rv/Little Rv confluence	0	0	0	0
Highbank gage to Brazos Rv/Little Rv confluence	0	0	0	0
Brazos Rv/Little Rv confluence to Bryan gage	200	200	200	200
Bryan gage to Brazos Rv/Yegua Crk confluence	2,650	2,650	2,650	2,650
Lake Somerville	4,200	4,200	4,200	4,200
Lake Somerville Dam to Yegua Crk gage	0	0	0	0
Yegua Crk gage to Brazos Rv/Yegua Crk confluence	0	0	0	0
Brazos/Yegua Crk confluence to Brazos/Navasota confluence	540	540	540	540
Lake Limestone	50,875	50,875	50,875	50,875
Lake Limestone Dam to Easterly gage	0	0	0	0
Easterly gage to Brazos Rv/Navasota Rv confluence	7,600	7,600	7,600	7,600
Brazos Rv/Navasota Rv confluence to Hempstead gage	0	0	0	0
Hempstead gage to Richmond gage	83,050	83,050	83,050	83,050
Richmond gage to Gulf of Mexico [d]	102,150	102,150	201,800	201,800
Total	*722,010*	*784,715*	*821,660*	*884,365*

Notes:
a All demand levels assume other demands from 2011 Region G and H Regional Water Plans that are expected to be met from the System Operation Permit.
b Levels without the CPNPP expansion include the 27,447 acft/yr Luminant contract from Possum Kingdom.
c Levels with the CPNPP expansion move the 27,447 acft/yr Luminant contract to Lake Granbury to partially satisfy the demand for the expansion. An additional new contract for 62,705 acft/yr provides the rest of the demand for the expansion.
d In addition to existing contracts, all demand levels assume 25,350 acft/yr from the proposed System Operation Permit, which is the supply from the 2011 Region H Water Plan. Demand levels C and D have an additional 99,650 acft/yr from the Allens Creek Reservoir .

Table 2.10 – Groundwater Supplies in Firm Use Scenarios		
No.	**Scenario**	**Groundwater Supply (acft/yr)**
1	Demand Level A, No Return Flows	37,000
2	Demand Level A, ED Approach to Return Flows	26,000
3	Demand Level A, BRA Approach to Return Flows	21,000
4	Demand Level B, No Return Flows	37,000
5	Demand Level B, ED Approach to Return Flows	26,000
6	Demand Level B, BRA Approach to Return Flows	21,000
7	Demand Level C, No Return Flows	37,000
8	Demand Level C, ED Approach to Return Flows	26,000
9	Demand Level C, BRA Approach to Return Flows	22,000
10	Demand Level D, No Return Flows	37,000
11	Demand Level D, ED Approach to Return Flows	26,000
12	Demand Level D, BRA Approach to Return Flows	22,000

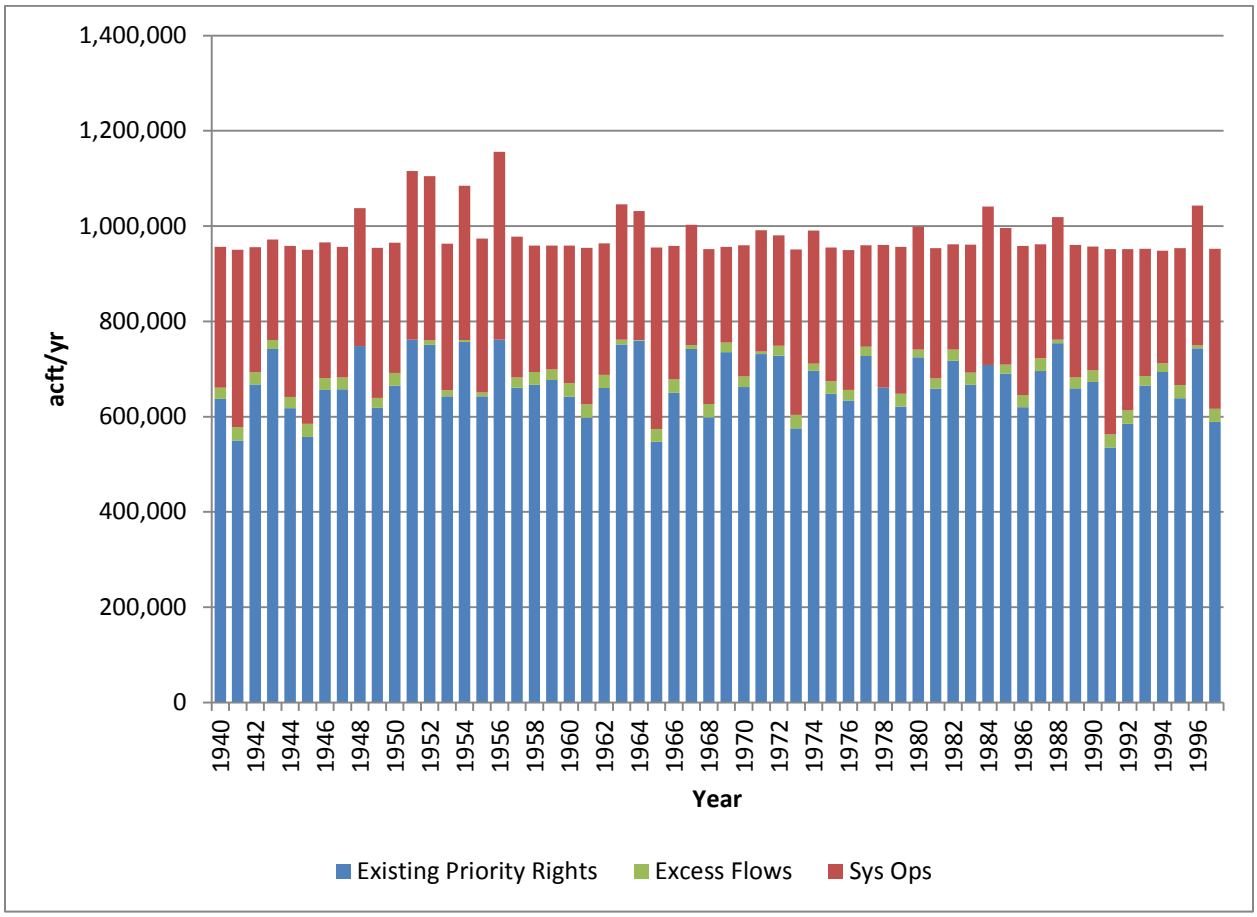
2.4.3 Results

Figure 2.2 shows the annual use from Variable Demand Scenario 12, which includes both the Allens Creek Reservoir and the CPNPP expansion and utilizes the BRA's approach to return flows. Other Variable Demand Scenarios show similar trends. In Figure 2.2, use from the BRA System has been assigned to water rights using the accounting procedures described above in Section 2.4.2.1. The data in Figure 2.2 is the amount that is charged to the water right. For reservoir releases, this amount does not include channel losses, so in most cases the amount charged to a water right is slightly higher than the actual demand from the System. For example, the Brazos-WAM includes channel losses of approximately 15 percent between Possum Kingdom and the Richmond gage. So, if a 100 acft demand at Richmond is met by releases from Possum Kingdom, 118 acft must be released from the reservoir. (This is sometimes different than the actual operation of the BRA System, where many customers are responsible for losses in the system.) The blue bars in Figure 2.2 are the use assigned

to one of the existing BRA water rights, either as a priority diversion or under the System Order. The green bars are water diverted under the Excess Flows Permit by NRG and assigned to existing water rights. (Water used to fill the Allens Creek Reservoir is not directly used to meet demands, so it is not included in this graph.) The red bars are the portion of the use that has been assigned to the proposed System Operation Permit.

Note that under the Variable Demand Scenarios the total use from the BRA System can vary significantly from year to year. The typical total use from the System is approximately 960,000 acft/yr. Some of the variation is due to the use of multiple sources to meet demands. Releases from reservoirs vary for the same demand, depending on the channel losses between the reservoir and the diversion point. Releases from reservoirs located farther away from the diversion point have higher channel losses than releases from reservoirs located closer to the diversion. During drier periods, use from the System exceeds 1,000,000 acft/yr. Use is higher in drier years because several of the BRA's largest customers have their own water rights but supplement these rights with water from the BRA System during dry periods. The highest use occurs during the 1950s drought, which is the drought-of-record for most of the Brazos basin. The maximum use from the System is almost 1,156,000 acft/yr in 1956, at the end of the 1950s drought.

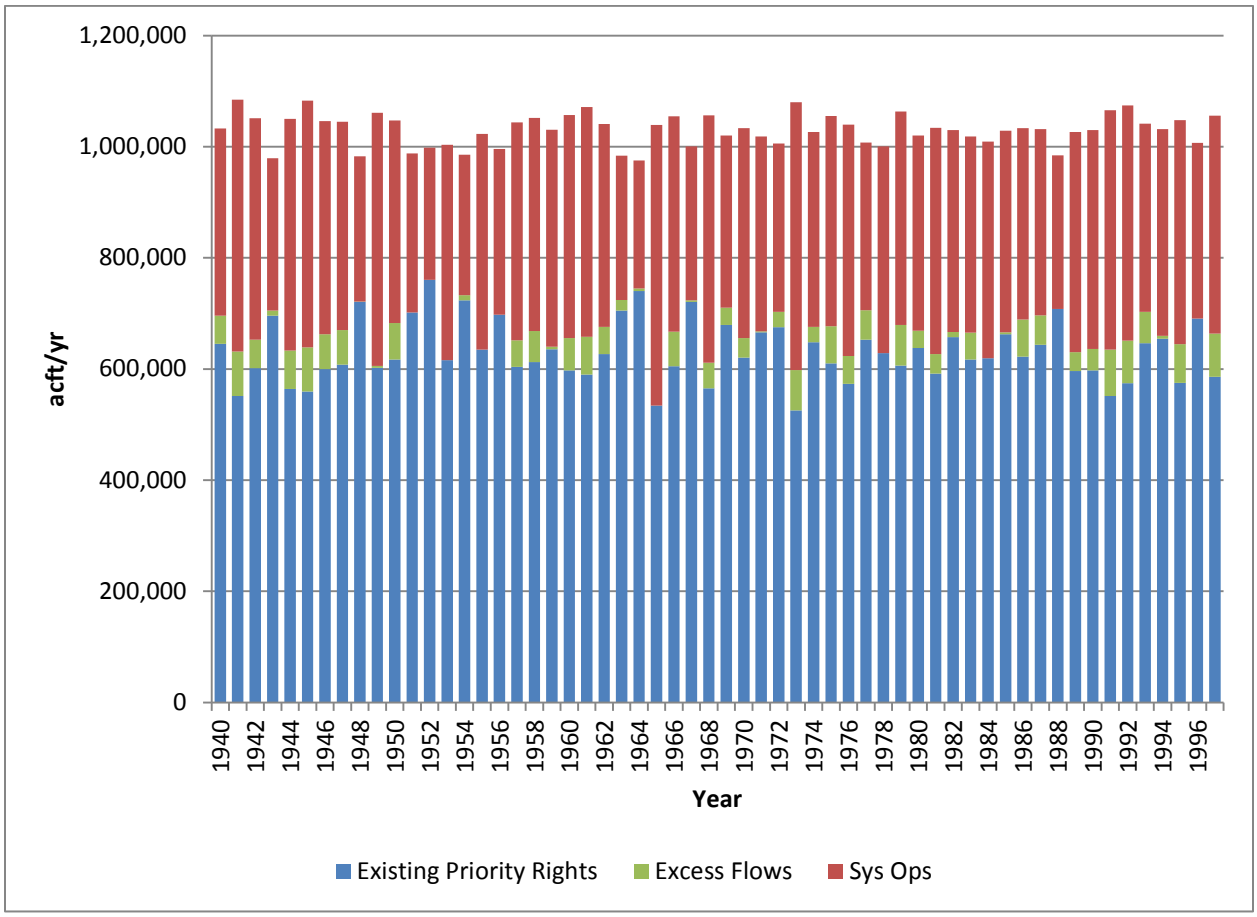
Figure 2.2 – Annual Variable Demand Scenario 12 Water Use



Note that in Figure 2.2 the amount of water assigned to existing BRA water rights (blue and green bars) and the proposed System Operation Permit (red bars) varies considerably from year to year. System Operation Permit use varies from a minimum of 200,401 acft/yr in 1969 to a maximum of 394,326 acft/yr in 1956. The average use is 291,975 acft/yr. Years with the highest use of existing BRA water rights tend to be drier years, where most of the water use must come from reservoir storage. Years with higher use of System Operation Permit water tend to be wetter years, where more run-of-river flows are available to meet available demands, although in some cases drier years are higher as well because of the additional firm reservoir yield made available by the permit. This graphic illustrates the nature of system operation, where multiple appropriations are used to meet demands.

Figure 2.3 shows the annual water use for Firm Use Scenario 12. Other Firm Use Scenarios show similar trends. Like Figure 2.2, the use from the BRA System in Figure 2.3 has been assigned to BRA water rights using the accounting procedures in Section 2.4.2.1 above. Use varies from year to year even though demand from the System is constant in these runs. However, it does not show the large swings shown in Figure 2.2. Different reservoirs, with different channel losses to the delivery points, have been used to meet downstream demands, causing the variation seen in the figure. The blue bars in Figure 2.3 are the use assigned to one of the existing BRA water rights, either as a priority diversion or under the System Order. The green bars are water diverted under the Excess Flows Permit by NRG and assigned to existing BRA water rights. (Water used to fill the Allens Creek Reservoir is not directly used to meet demands, so it is not included in this graph.) The red bars are the portion of the use that has been assigned to the proposed System Operation Permit.

Figure 2.3 – Annual Firm Use Scenario 12 Water Use



As in Figure 2.2, water use in the Firm Use Scenarios under the System Operation Permit varies considerably over the simulation period. The minimum use is 229,989 acft/yr in 1964. The maximum use is 505,389 acft/yr in 1965. The average use is 364,482 acft/yr. Use under the System Operation Permit is generally higher during wetter years, where run-of-river flows can be used to meet downstream demands. Less run-of-river water is available during drier years, reducing the amount of water use assigned to the proposed System Operation Permit.

Table 2.11 shows the maximum annual water use assigned to the proposed System Operation Permit under the twelve Variable Demand Scenarios and the twelve Firm Use Scenarios. Information on diversions by reach for each of these scenarios is available in Tables G.3.2 through G.3.25 of Appendix G-3.

Table 2.11 – Maximum Diversions Under the System Operation Permit (acft/yr)

Scenario Number	1	2	3	4	5	6	7	8	9	10	11	12
Demand Level	Level A – Current Contracts			Level B – Current Contracts with CPNPP Expansion			Level C – Current Contracts with Allens Creek			Level D – Current Contracts with Allens Creek and CPNPP Expansion		
Return Flow	No Return Flow	BRA Return Flows	All Return Flow	No Return Flows	BRA Return Flows	All Return Flows	No Return Flow	BRA Return Flows	All Return Flow	No Return Flow	BRA Return Flows	All Return Flow
Variable Demand Scenarios	327,388	338,871	369,553	327,433	331,563	361,651	407,675	424,613	453,613	352,664	370,110	394,326
Firm Use Scenarios	354,081	366,350	381,474	304,793	321,849	344,625	477,774	496,602	516,955	424,361	447,379	482,035

Table 2.12 is a summary of the supplies available under the Variable Demand Scenarios. The first three rows of this table show the demands for water from the BRA System. The row labeled "Fixed Demand" is the total annual demand from current long-term BRA contracts plus demands from the 2011 Region G and H Water Plans that are met exclusively from the BRA System. This demand varies among the four demand levels (A, B, C and D) because of assumptions about the expansion of CPNPP and the availability of water from the Allens Creek Reservoir. The demand for Scenario 4 is less than for Scenarios 5 and 6 because, without return flows, supplies are not sufficient to meet all contractual and projected regional demands. The second row, labeled "Variable Demand (Max)," is the maximum demand from the BRA System for customers that have their own water rights. It is assumed that these customers use their own supplies first. These customers use water from the BRA System when supplies from their own rights are not sufficient (or, in the case of NRG, when flows at the Richmond gage are greater than 2,000 cfs). Note that the variable demand is different for each scenario. This is because of demands for GCWA. For these analyses, it was assumed that the BRA System would be used to back up the shortages of GCWA's water rights, and these shortages vary for each scenario. The third line, labeled "Total Demand (Max)," is the sum of the fixed demands and the maximum variable demand, and is the maximum demand from the BRA System in each scenario.

The fourth line of Table 2.12 shows the amount of groundwater used in each scenario. The BRA plans to develop groundwater to help meet demands in Williamson County near Lake Georgetown. Without the appropriation of return flows, it is necessary to have 33,000 acft/yr of groundwater. With the appropriation of return flows, only 21,000 acft/yr is required if only return flows from BRA sources are considered. 17,000 to 18,000 acft/yr is required if all return flows are considered. The demand at Lake Georgetown is reduced by the amount of groundwater assumed to be available.

Lines 5 through 7 in Table 2.12 show the maximum demand from the BRA surface water supplies in each scenario. The line labeled "Net Demand from System (Max)" is the total demand from line 3 less the groundwater supply from line 4. Line 6, labeled "Additional Yield (Fixed)," is the amount of additional yield that is available at the

Rosharon gage after meeting all contractual obligations and demands from the regional water plans. This is a firm supply, available every year. The line labeled “Total Available from System (Max)” is the sum of the maximum net demand from the BRA System in line 5 and the additional yield in line 6.

Line 8 in Table 2.12, labeled “Existing Water Rights (Fixed),” is the sum of the current BRA priority rights available in each scenario. The amount in Scenarios 1 through 6 is the priority diversions associated with the eleven existing BRA System reservoirs. Scenarios 7 through 12 add the Allens Creek Reservoir.

Line 9 in Table 2.12, labeled “Supply Increase due to SysOps (Max),” is the difference between the maximum available from the BRA System in line 7 and the currently available BRA water rights in line 8. This represents the maximum increase in available supply from the BRA System due to the System Operation Permit.

Table 2.12 – Supply and Demand in Variable Demand Scenarios (acft/yr)												
Scenario Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand Level	**Level A – Current Contracts**			**Level B – Current Contracts with CPNPP Expansion**			**Level C – Current Contracts with Allens Creek**			**Level D – Current Contracts with Allens Creek and CPNPP Expansion**		
Return Flow	**No Return Flow**	**BRA Return Flows**	**All Return Flow**	**No Return Flows**	**BRA Return Flows**	**All Return Flows**	**No Return Flow**	**BRA Return Flows**	**All Return Flows**	**No Return Flows**	**BRA Return Flows**	**All Return Flows**
Fixed Demand	569,570	569,570	569,570	632,275	632,275	632,275	628,519	628,519	628,519	691,224	691,224	691,224
Variable Demand (Max)	248,428	237,714	224,382	248,428	237,714	228,147	236,536	225,814	216,242	236,536	225,814	216,242
Total Demand (Max)	*817,998*	*807,284*	*793,952*	*880,703*	*869,989*	*860,422*	*865,055*	*854,333*	*844,761*	*927,760*	*917,038*	*907,466*
Groundwater Supply (Fixed)	33,000	21,000	17,000	33,000	21,000	17,000	33,000	21,000	18,000	33,000	21,000	18,000
Net Demand from System (Max)	784,998	786,284	776,952	847,703	848,989	843,422	832,055	833,333	826,761	894,760	896,038	889,466
Additional Yield (Fixed)	165,000	178,000	216,000	108,000	115,000	151,000	255,000	273,000	302,000	188,000	207,000	238,000
Total Available from System (Max)	*949,998*	*964,284*	*992,952*	*955,703*	*963,989*	*994,422*	*1,087,055*	*1,106,333*	*1,128,761*	*1,082,760*	*1,103,038*	*1,127,466*
Existing Water Rights (Fixed)	661,901	661,901	661,901	661,901	661,901	661,901	761,551	761,551	761,551	761,551	761,551	761,551
Increase due to SysOps (Max)	288,097	302,383	331,051	293,802	302,088	332,521	325,504	344,782	367,210	321,209	341,487	365,915

Under this initial WMP, many large customers of the BRA will not be taking water from the System every year. In a way, Variable Demand Scenarios represent the firm yield operation of the BRA System and the water rights available to its major customers. Using the assumptions in Variable Demand Scenario 12, the combination of BRA water rights and customer rights can produce well over a million acft of firm supply every year.

Table 2.13 is a summary of the supplies available under the Firm Use Scenarios. These scenarios have a "fixed" demand every year, even for BRA customers that have their own water rights. The demand is shown in the first row of the table, labeled "Total Demands." Demands vary among the demand levels (A, B, C and D) because of assumptions about the expansion of CPNPP and the availability of water from the Allens Creek Reservoir. The second line in this table shows the amount of groundwater used in each scenario. The demand at Lake Georgetown is reduced by the amount of groundwater assumed to be available.

Lines 3 through 5 in Table 2.13 show the maximum demand from BRA surface water supplies in each scenario. The line labeled "Net Demand from System" is the total demand from the first line less the groundwater supply in the second line. Line 4, labeled "Additional Yield," is the amount of additional yield from the BRA System that is available at the Rosharon gage after meeting all of the demands in line 1. The line labeled "Total Available from System" is the sum of the maximum net demand from the BRA System in line 3 and the additional yield in line 4.

Line 6 in Table 2.13, labeled "Existing Water Rights," is the sum of the current BRA priority rights available in each scenario. The amount in Scenarios 1 through 6 is the total priority diversions associated with the eleven existing BRA System reservoirs. Scenarios 7 through 12 add the Allens Creek Reservoir.

Line 7 in Table 2.13, labeled "Supply Increase due to SysOps," is the difference between the maximum available from the BRA System in line 5 and the currently available BRA water rights in line 6. This represents the maximum increase in available supply from the BRA System due to the System Operation Permit.

Table 2.13 – Supply and Demand in Firm Use Scenarios (acft/yr)												
Scenario Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Demand Level	**Level A – Current Contracts**			**Level B – Current Contracts with CPNPP Expansion**			**Level C – Current Contracts with Allens Creek**			**Level D – Current Contracts with Allens Creek and CPNPP Expansion**		
Return Flow	**No Return Flow**	**BRA Return Flows**	**All Return Flow**	**No Return Flows**	**BRA Return Flows**	**All Return Flows**	**No Return Flow**	**BRA Return Flows**	**All Return Flows**	**No Return Flows**	**BRA Return Flows**	**All Return Flows**
Demand	696,660	696,660	696,660	759,365	759,365	759,365	696,660	696,660	696,660	759,365	759,365	759,365
Lower Basin RWP Demand	25,350	25,350	25,350	25,350	25,350	25,350	125,000	125,000	125,000	125,000	125,000	125,000
Total Demand	*722,010*	*722,010*	*722,010*	*784,715*	*784,715*	*784,715*	*821,660*	*821,660*	*821,660*	*884,365*	*884,365*	*884,365*
Groundwater Supply	37,000	26,000	21,000	37,000	26,000	21,000	37,000	26,000	22,000	37,000	26,000	22,000
Net Demand from System	685,010	696,010	701,010	747,715	758,715	763,715	784,660	795,660	799,660	847,365	858,365	862,365
Additional Yield	219,650	230,650	246,650	156,650	160,650	175,650	252,000	270,000	291,000	195,000	201,000	224,000
Total Available from System	*904,660*	*926,660*	*947,660*	*904,365*	*919,365*	*939,365*	*1,036,660*	*1,065,660*	*1,090,660*	*1,042,365*	*1,059,365*	*1,086,365*
Existing Water Rights	661,901	661,901	661,901	661,901	661,901	661,901	761,551	761,551	761,551	761,551	761,551	761,551
Increase due to SysOps	242,759	264,759	285,759	242,464	257,464	277,464	275,109	304,109	329,109	280,814	297,814	324,814

2.4.4 Availability of Non-Firm Water

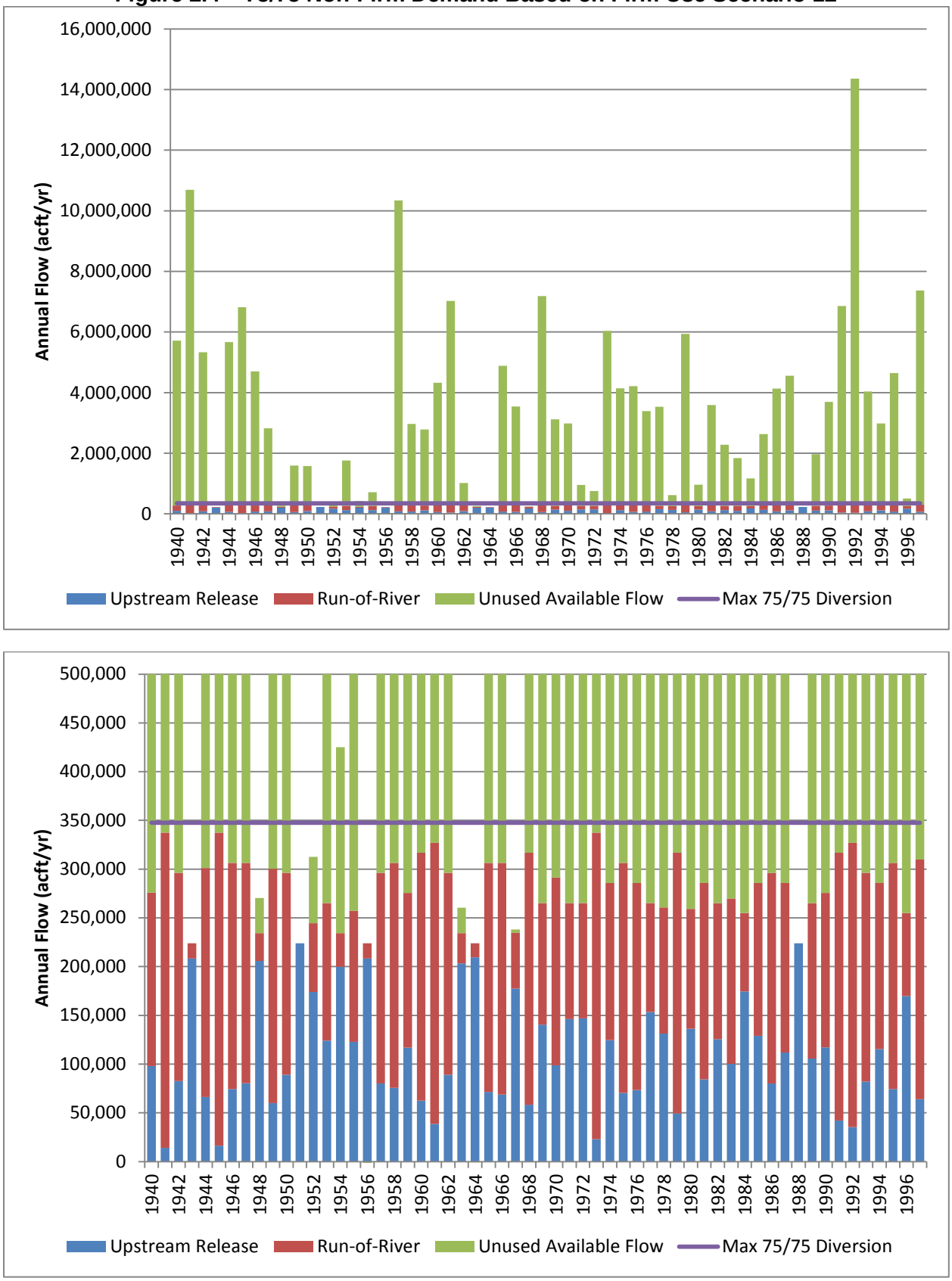
At this time, the BRA has not identified specific customers or developed policies for long-term use of non-firm water that would be available through the System Operation Permit. In general, this type of water would be curtailed during drier periods. Specific uses of this water will be identified in future WMPs. Use of some of this non-firm water has been analyzed in the 2011 Brazos G Water Plan, for the Lake Granger Conjunctive Use project. Non-firm water could also be used for environmental purposes under an amendment to the System Operation Permit, as discussed in Section 4.4.7 of this Technical Report. This supply also could be used with other groundwater sources besides those considered in the Lake Granger project, or to meet irrigation or other needs that do not require a continuous firm supply. The amount of non-firm water needed would depend on the type of use and the location of the demand.

A series of analyses was developed to illustrate how much non-firm water could be available using uncommitted water from the proposed System Operation Permit at the Rosharon gage. These analyses use the upstream reservoir releases for the uncommitted firm yield at Rosharon from the Firm Use Scenarios. However, instead of the firm yield demand, an additional constant demand is applied against the available unappropriated run-of-river flows at the Rosharon gage, after applying the instream flow criteria. This demand is adjusted until the diversion achieves an annual “75/75” reliability (at least 75% of the annual target demand is available in 75% of the years in the analysis). These analyses were performed using an Excel spreadsheet and the output data from the Appropriation Model. The calculations are described in more detail in Appendix G-2. Table 2.14 shows the results for the twelve Firm Use Scenarios.

Table 2.14 – Potential 75/75 Non-Firm Supplies at Rosharon (acft/yr)		
No.	**Scenario**	**Maximum Annual Non-Firm Supply**
1	Demand Level A, No Return Flows	351,410
2	Demand Level A, ED Approach to Return Flows	369,010
3	Demand Level A, BRA Approach to Return Flows	394,610
4	Demand Level B, No Return Flows	257,810
5	Demand Level B, ED Approach to Return Flows	272,250
6	Demand Level B, BRA Approach to Return Flows	295,890
7	Demand Level C, No Return Flows	378,000
8	Demand Level C, ED Approach to Return Flows	405,000
9	Demand Level C, BRA Approach to Return Flows	440,760
10	Demand Level D, No Return Flows	297,960
11	Demand Level D, ED Approach to Return Flows	309,240
12	Demand Level D, BRA Approach to Return Flows	347,720

Figure 2.4 is a graphical illustration of the analysis using Firm Use Scenario 12. Other scenarios would have similar results. The top graph in the figure shows the total amount considered in the analysis in each year. The bottom figure shows the same data with the x-axis limited to 500,000 acft/yr. The blue bars in the graph are the annual reservoir releases (after applying losses). These are identical to the reservoir releases in Firm Use Scenario 12 used to create 224,000 acft/yr of uncommitted firm yield at Rosharon. (The uncommitted yield is the reliable supply after meeting existing contractual demands and demands identified in the regional water plans.) The red bars are the run-of-river diversions used to create the 75/75 non-firm supply identified in the analysis. The purple line is the annual maximum supply for the 75/75 demand. Actual diversions are less than the annual target in all years because of the timing of the available flow. Even in years with substantial quantities of available water, that water may not be available in all months of the year. The green bars are the remaining unappropriated water after the non-firm supply has been taken from the System. Note that there is still a substantial quantity of unappropriated water in almost every year, even after using the non-firm supplies.

Figure 2.4 – 75/75 Non-Firm Demand Based on Firm Use Scenario 12



2.4.5 Impact on Senior Water Rights

All water rights analyses associated with the proposed System Operation Permit use the TCEQ Brazos-WAM. This model inherently protects senior water rights. Therefore, the supply that is available for the proposed System Operation Permit is limited to the supply available after all other water rights with a senior priority date have been fully satisfied.

In the analyses presented in this WMP there have been several modifications to the TCEQ Brazos-WAM that may impact water availability for water rights when compared to Brazos-WAM Run 3, which is the benchmark for water availability of permanent water rights. The most significant of these modifications include:

- *Hydropower at Lake Whitney.* Because this is modeled as a release from non-priority storage, negative impacts on other water rights have been minimized. The hydropower releases increase the reliability of a large number of water rights because senior water rights in the lower basin can be satisfied with the hydropower releases to a greater extent than they would have been satisfied by natural flow alone. The hydropower releases also reduce the need for upstream junior water rights to pass water to these senior rights.
- *Changes to use patterns.* Some major water rights with multi-use authorizations had part of their diversions changed to reflect the current use of the water. For example, the Dow Chemical diversions (COA 12-5328) were changed so that all records were industrial. (Some Dow diversions were municipal in the TCEQ Brazos-WAM.) Another example is the NRG Richmond irrigation rights (COA 12-5425). Portions of those diversions were changed from industrial to irrigation to reflect current usage. This change can occasionally affect reliability in isolated months.
- *Return flows.* The Brazos-WAM Run 3 does not have any return flows, while many of the analyses in this Section 2.4 have either all return flows or return flows from BRA sources. The presence of return flows tends to increase reliability for almost all water rights because return flows are distributed in priority

order. In the comparisons for scenarios with return flows, equivalent return flows were added to the TCEQ Brazos-WAM Run 3 so that the effects of other changes could be seen.

Table G.3.1 of Appendix G-3 compares the reliability of non-BRA water rights in the TCEQ Brazos-WAM Full Authorization Model (Run 3) to their reliability under the twelve Firm Use Scenarios. This analysis shows that in the WMP runs most water rights are more reliable than in the TCEQ Brazos-WAM.

Furthermore, the newly approved Watermaster for the lower Brazos basin is expected to be in operation by the time diversions under the System Operation Permit are implemented. BRA will conduct its operations under the System Operation Permit, as with its other existing water rights, in compliance with TCEQ's rules governing watermaster operations, found in Chapter 304 of Title 30 of the Texas Administrative Code. The Brazos Basin Watermaster will be responsible for overseeing the priority system within the lower basin (Possum Kingdom Lake and below), further protecting existing water rights.

2.4.6 Summary and Conclusions

This Section 2.4 describes a series of System Operation modeling runs that demonstrate how the appropriations from the proposed System Operation Permit could be used in conjunction with existing BRA water rights and, potentially, the water rights of BRA customers. Diversions were modeled at the locations of existing contracts. In the Variable Demand Scenarios, BRA customers that have their own water rights were assumed to use their rights first, using water from the BRA System as needed. In the Firm Use Scenarios, all customers were assumed to divert their full contract amounts in every year. Other diversions were added for the supplies identified in the 2011 Region G and H Water Plans that are not covered by existing BRA contracts, also at the expected locations of the diversions. The additional yield available at the Rosharon gage after meeting contractual demands and the demands from the 2011 Region G and H Water Plans was determined for each scenario. These analyses show that sufficient water is available for appropriation under the System Operation Permit to meet

expected demands, and that additional yield could also be developed from the BRA System without affecting senior water rights.

Tables 2.12 and 2.13 show the maximum amount of water appropriated by the proposed System Operation Permit for the twelve Variable Demand Scenarios and the twelve Firm Use Scenarios. Tables G.3.2 through G.3.25 of Appendix G-3 show information on the appropriation for the same scenarios by reach. These tables demonstrate how water available from the proposed System Operation Permit varies with assumptions about demands, return flows, infrastructure, and geographic location.

Tables 2.15 and 2.16 below show the increase in overall BRA System supply that results from the appropriation of return flows. Table 2.15 shows the change in maximum use from the System in the Variable Demand Scenarios. Table 2.16 shows the change in firm supply in the Firm Use Scenarios. The increase using the ED's return flow approach for demand level A is the difference in the maximum supply between Scenarios 1 and 2, and the increase from using the BRA's return flow approach is the difference in maximum supply between Scenarios 1 and 3. The increase for demand level B is the difference between Scenarios 3 and 4 and 3 and 5, and so forth. These analyses show that appropriation of return flows increases the reliable supply from the BRA System.

Table 2.15 – Change in Maximum Supply Due to Return Flows, Variable Demand Scenarios (acft/yr)

Demand Level	Increase using ED Approach	Increase using BRA Approach
Level A – Current Contracts	14,286	42,954
Level B – Current Contracts with CPNPP Expansion	8,286	38,719
Level C – Current Contracts with Allens Creek	19,278	41,706
Level D – Current Contracts with Allens Creek and CPNPP Expansion	20,278	44,706

Table 2.16 – Change in Firm Supply Due to Return Flows, Firm Use Scenarios (acft/yr)

Demand Level	Increase using ED Approach	Increase using BRA Approach
Level A – Current Contracts	22,000	43,000
Level B – Current Contracts with CPNPP Expansion	15,000	35,000
Level C – Current Contracts with Allens Creek	29,000	54,000
Level D – Current Contracts with Allens Creek and CPNPP Expansion	17,000	44,000

There is a substantial benefit to available supply from adding the Allens Creek Reservoir to the BRA System. This benefit is shown in Tables 2.17 and 2.18 below. Table 2.17 shows the increase in maximum annual use for the Variable Demand Scenarios, and Table 2.18 shows the increase in System yield for the Firm Use Scenarios. The benefit with no return flows and without the CPNPP expansion is the difference in maximum supply between Scenarios 1 and 7. The benefit with the ED's approach to return flows is the difference between Scenarios 2 and 8, and so forth. In all cases, the increase in supply is greater than the 99,650 acft/yr authorized in the Allens Creek water right (Permit No. 2925B), as shown in the column labeled "Amount over Allens Creek Water Right."

The supplies that are shown in this Section 2.4, as well as other sections of the WMP Technical Report, are available assuming full use of all BRA's existing priority rights. These analyses only use unappropriated water that is available after meeting the environmental flow conditions. Therefore, the proposed System Operation Permit has no impact on existing permanent water rights.

Table 2.17 – Change in Maximum Supply Due to Allens Creek Reservoir, Variable Demand Scenarios (acft/yr)

Demand Scenario	Increase in Supply	Amount over Allens Creek Water Right
Current Contracts – No Return Flows	137,057	37,407
Current Contracts – ED Return Flow Approach	142,049	42,399
Current Contracts – BRA Return Flow Approach	135,809	36,159
Current Contracts with CPNPP Expansion – No Return Flows	127,057	27,407
Current Contracts with CPNPP Expansion – ED Return Flow Approach	139,049	39,399
Current Contracts with CPNPP Expansion – BRA Return Flow Approach	133,044	33,394

Table 2.18 – Increase in Firm Supply Due to Allens Creek Reservoir, Firm Use Scenarios (acft/yr)

Demand Scenario	Increase in Supply	Amount over Allens Creek Water Right
Current Contracts – No Return Flows	132,000	32,350
Current Contracts – ED Return Flow Approach	139,000	39,350
Current Contracts – BRA Return Flow Approach	143,000	43,350
Current Contracts with CPNPP Expansion – No Return Flows	138,000	38,350
Current Contracts with CPNPP Expansion – ED Return Flow Approach	140,000	40,350
Current Contracts with CPNPP Expansion – BRA Return Flow Approach	147,000	47,350

This Page Left Blank Intentionally