Appendix 3-B

Water Availability Technical Memorandum

The TWDB requires regional water planning groups to use Full Authorization Water Availability Models (WAM Run 3) maintained by the Texas Commission on Environmental Quality (TCEQ) to develop water availability for regional water plans (RWPs). The Region I Consultant Team, on behalf of the East Texas Regional Water Planning Group (Region I), utilized WAMs to calculate surface water availability for the three basins within Region I: the Trinity River, Neches River, and Sabine River Basins.

For the Trinity River Basin, Region I adopted the updated Trinity Basin WAM developed by the Region C Water Planning Group. Region I also includes part of the Neches-Trinity Coastal Basin. As no changes were proposed by Region I to the Neches-Trinity WAM, surface water supplies in that basin were developed using the unmodified Neches-Trinity Coastal Basin WAM Run 3. This memorandum included as Appendix 3-B describes the modifications made to the Neches River and Sabine River WAMs by Region I.

Run-of-river supplies were also calculated using the TCEQ WAM Run 3. The firm supply was determined as the minimum annual diversion from the river for all use types (municipal, industrial, mining, recreational, and irrigation). Since all municipal users in ETRWPA have multiple sources of water, it was assumed that the run-of-the-river supplies would be used conjunctively with these sources and a monthly analysis was not appropriate to determine availability. The run of river supplies associated with City of Beaumont (WR 4415) increase over time because of this reason. Appendix 3-B also includes a memorandum summarizing the WAM analysis for the City of Beaumont municipal water right.

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Summary of WAM Modifications in the Development of Surface Water Supplies for the East Texas 2021 Regional Water Plan

The Texas Water Development Board (TWDB) requires regional water planning groups (RWPG) to use Full Authorization Water Availability Models (WAM Run 3) maintained by the Texas Commission on Environmental Quality (TCEQ) in the development of surface water availability for regional water plans (RWPs). In a letter submitted to TWDB on July 3, 2018, the Region I Consultant Team on behalf of the East Texas Regional Water Planning Group (Region I) requested a hydrologic variance to use modified versions of the Run 3 WAMs for the Trinity River, Neches River, and Sabine River Basins to develop supplies for the Region I 2021 RWP. This hydrologic variance request is still pending approval.

For the Trinity River Basin, Region I adopted the updated Trinity Basin WAM developed by the Region C Water Planning Group. These changes are documented in Region C's hydrologic variance request to the TWDB. Region I also includes part of the Neches-Trinity Coastal Basin. As no changes were proposed by Region I to the Neches-Trinity WAM, surface water supplies in that basin were developed using the unmodified Neches-Trinity Coastal Basin WAM Run 3. This memorandum describes the modifications made to the Neches River and Sabine River WAMs by Region I.

Neches River Basin WAM for the 2021 Region I RWP

Changes to the WAM for the 2021 RWP are based on changes in previous cycles, as well as the inclusion of updated sedimentation of major reservoirs, as specified by Exhibit C ("Second Amended General Guidelines for Fifth Cycle of Regional Water Plan Development"). The following sections describe all changes made to the TCEQ Neches WAM Run 3 (2012) to develop the modified Neches WAM, which will be used to determine existing supplies in the Neches River Basin in the Region I 2021 RWP.

Area-Capacity Relationships

Exhibit C requires RWPGs to include anticipated sedimentation of all major reservoirs (those with a capacity greater than 5,000 ac-ft) in the WAM model runs. There are 12 such permitted reservoirs in the Neches Basin; information related to sedimentation of these reservoirs is shown in Table 1.

Lake Columbia has not yet been constructed, so to be conservative, Lake Columbia's full design capacity and original area-capacity curve was used when evaluating firm yields for all other reservoirs. Conversely, to estimate the yield from Lake Columbia, it was assumed that the reservoir would be built in 2020 and begin collecting sediment at that time.

Table 1. Sedimentation Rates and Projected Storage Capacity of Major Reservoirs in the Neches River Basin

Reservoir	Most Recent Survey		Sediment-Contributing Drainage Area (mi^2)	Sedimentation Rate ($ac\text{-}ft/yr/mi^2$)	Projected 2070 Capacity (ac-ft)
	Year	Conservation Pool Capacity (ac-ft)			
Lake Athens	1998	29,475	22	4.35	22,719
Lake Columbia**	*	195,500	277	0.19	192,910
Lake Jacksonville	2006	25,732	34	2.88	19,508
Lake Kurth	1996	14,769	4	8.57	12,265
Lake Nacogdoches	1994	39,523	89	1.75	27,664
Lake Naconiche	*	9,072	27	0.19	8,750
Lake Palestine	2012	367,310	817	0.76	331,689
Pinkston Lake	*	7,380	14	0.19	7,130
Sam Rayburn Reservoir	2004	2,876,033	3,010	0.18	2,839,698
Lake B. A. Steinhagen	2011	69,259	3,251	0.06	58,731
Lake Striker	1996	22,865	182	0.85	11,561
Lake Tyler	2013	77,284	107	1.00	71,192

** No survey available. Conservation pool capacity reflects design capacity.*

*** Permitted but not yet constructed. Projected 2070 capacity based on assumption of sedimentation beginning 1/1/2020.*

Subordination of Sam Rayburn Reservoir and B. A. Steinhagen Lake

Background

Special conditions 5C and 5D of Certificate of Adjudication 06-4411 require subordination of LNVA's rights in the Rayburn-Steinhagen system to (a) water rights upstream of the proposed Weches and Ponta Dam sites and (b) intervening municipal rights above Sam Rayburn Reservoir. These conditions were last amended in Amendment H, filed August 14, 2008, and granted July 20, 2010, which limited subordination to rights with priority dates between November 1963 and April 2008.

Several changes were implemented in the WAM related to dual simulation, output, and the refilling of Rayburn and Steinhagen.

a) Water rights benefiting from subordination were updated to run in both the first and second WRAP simulation.
b) FNI added additional rights for each water right benefiting from Rayburn/Steinhagen subordination, such that the original right does not have subordination, and the added right applies the subordination and backs up the original without subordination. In doing so, the effects of subordination can be distinguished in the model output.
c) Subordination rights at Rayburn and Steinhagen to back up other rights were modeled to not refill storage (Type 2 water rights) so that Rayburn and Steinhagen would not be refilling between multiple subordinations.
d) The 1963 rights for impoundment at Rayburn and Steinhagen were reordered so that Rayburn, the upstream reservoir, would be filled from available streamflow before Steinhagen is refilled.

Reservoir System Operations

UNRMWA – Lake Palestine and Rocky Point Dam

The Upper Neches River Municipal Water Authority operates Lake Palestine in conjunction with its downstream dam on the Neches River in Anderson and Cherokee Counties. The 2012 WAM Run 3 allows rights associated with the downstream dam to draw from both reservoirs, which limits the firm yield of Lake Palestine when it is used to back up the downstream dam. This set of rights was modified so that downstream diversions would first be backed up by the subordination agreement at Steinhagen Lake, and any remaining shortages would be backed up by Lake Palestine.

LNVA – Sam Rayburn Backup of Pine Island Bayou

The modified WAM approved by TWDB for the development of supplies in the 2011 RWP included "operation of LNVA's water rights [...] as a system by including backup of LNVA's Pine Island water rights with storage from Sam Rayburn."

Minimum Elevations – Sam Rayburn and B.A. Steinhagen

WS and OR records were used to set inactive pool capacity for Sam Rayburn Reservoir. The top elevation of inactive pool is 149 ft msl, and the inactive pool capacity was updated each decade based on updated area-capacity-elevation curves. The City of Lufkin has a right to a lakeside diversion of up to 28,000 ac-ft/yr from Sam Rayburn Reservoir; no inactive pool capacity was applied for this right. This diversion is lakeside and does not generate hydropower, so it is not limited by the inlet elevation.

A dead pool capacity was also set for B. A. Steinhagen using an inactive pool elevation of 81 ft msl. Inactive pools were not applied to subordination-related backup rights for either reservoir.

Lake Tyler

For the 2021 Region I WAM, Lake Tyler was modeled as a single reservoir, and associated water rights were adjusted accordingly. This is consistent with the development of the original Neches WAM, which treated this source as one reservoir.

Environmental Flows Standard for Permit 5585

The TCEQ Run 3 WAM included an incorrect target value for the instream flow record at Lake Naconiche (5585A) due to a unit conversion error. The target was corrected to 4744 ac-ft/yr (see `IF` record at 5585A).

Sabine River Basin WAM for the 2021 Region I RWP

The following sections describe all changes made to the TCEQ Sabine WAM Run 3 (2015) to develop the modified Sabine WAM, which will be used to determine existing supplies from the Sabine River Basin in the Region I 2021 RWP.

Area-Capacity Relationships

Exhibit C requires RWPGs to include anticipated sedimentation of all major reservoirs (those with a capacity greater than 5,000 ac-ft) in the WAM model runs. There are 12 such permitted reservoirs in the Sabine Basin; information related to sedimentation of these reservoirs is shown in Table 2. For each of the 12 reservoirs, sedimentation conditions were estimated based on an average annual sedimentation rate and the number of years since the last survey.

Table 2. Sedimentation Rates and Projected Storage Capacity of Major Reservoirs in the Sabine River Basin

Reservoir	Most Recent Survey		Sediment-Contributing Drainage Area (mi^2)	Sedimentation Rate (ac-ft/yr/mi^2)	Projected 2070 Capacity (ac-ft)
	Year	Conservation Pool Capacity (ac-ft)			
Lake Tawakoni	2009	871,693	756	2.96	736,428
Lake Fork Reservoir	2009	636,504	493	3.83	522,671
Lake Gladewater	2000	4,738	35	1.33	1,480
Lake Cherokee	2015	44,475	158	0.26	42,230
Brandy Branch Reservoir	*	29,513	4	0.24	29,429
Martin Lake	2014	75,726	130	0.37	73,097
Murvaul Lake	1998	38,284	115	1.64	24,873
Toledo Bend Reservoir	*	4,477,000	5,384	0.12	4,410,291
Lake Hawkins	1962	11,890	30	0.24	11,117
Lake Holbrook	*	7,990	15	0.24	7,604
Lake Quitman	*	7,440	31	0.24	6,639
Lake Winnsboro	*	8,100	27	0.24	7,403

** No recent survey available. Conservation pool capacity reflects design capacity.*

Firm Yield of Toledo Bend Reservoir

Hydropower operations at Toledo Bend were excluded during the determination of total available supply from the lake. However, hydropower operations were included in the evaluation of supplies for all other reservoirs and run-of-river supplies. The canal water rights owned by Sabine River Authority (SRA) in the lower basin modeled as being subordinate to diversions from Toledo Bend Reservoir for the purposes of determining firm yield. The remainder of the yield of Toledo Bend was evaluated assuming all diversions were taken lakeside. Within the WAM, all diversions from the lake are shared equally between SRA-Texas and SRA-Louisiana, including the additional unpermitted yield.

MEMORANDUM

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TO: File

CC: Simone Kiel

FROM: Jon Albright

SUBJECT: Beaumont Supplies from Neches River

DATE: November 21, 2013

PROJECT: Region I PLU12102

Summary

1. This memorandum describes the method used to determine available supplies from the Neches River for the City of Beaumont for regional water planning. The method is based on a daily analysis of flows in 1956 made by Tom Gooch of Freese and Nichols as part of the negotiations between the City of Beaumont and the Lower Neches Valley Authority (LNVA) in 2011. The 2011 analysis was provided to the TCEQ in response to a priority call by the LNVA. A comparison of results using the Neches WAM is part of the analysis.

2. The calculations for the available supply to Beaumont for regional water planning are preliminary. These calculations will be refined once the City of Beaumont and LNVA demands have been finalized.

3. The City of Beaumont owns Certificate of Adjudication (CA) 06-4415, which authorizes 56,467 acre-feet per year of diversion from the Neches River. The City also has supplies of 9,000 acre-feet per year from the Gulf Coast aquifer and a contract with the Lower Neches Valley Authority (LNVA) for 6,000 acre-feet of water from the Neches River and the Steinhagen/Rayburn system.

4. Table 1 compares the available supplies to preliminary demands for the City of Beaumont for the years 2020 and 2070. Table 1a uses supplies from the Neches WAM Run 3 for 1956, the year with the minimum supply available under the City of Beaumont's water rights. Table 1b shows the same analysis using the results of the daily analysis. Note that the daily analysis shows greater shortages than the WAM analysis.

5. In order to properly calculate the need in the database, Beaumont's supply from the Neches River will need to change from year to year. For example, instead of the maximum supply of 22,234 acre-feet per year, the year 2020 Neches River supply will be 15,934 acre-feet per year and the 2070 Neches River supply will be 21,588 acre-feet per year. This is necessary because the analysis uses a shorter time step (monthly) than the database (yearly).

DRAFT Beaumont Supplies from the Neches River
November 21, 2013
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Table 1a: 2020 and 2070 Supply and Demand – Worst Year Supplies from WAM Run 3
Values in Acre-Feet

Month	CA 4415 Available Supplies from WAM	2020 Conditions				2070 Conditions			
		Beaumont Demand	CA4415 Supplies Used to Meet Demand	Supplies from Other Sources	Shortage	Beaumont Demand	CA4415 Supplies Used to Meet Demand	Supplies from Other Sources	Shortage
Jan-56	4,669	2,723	2,723	0	0	3,962	3,962	0	0
Feb-56	4,132	2,419	2,419	0	0	3,518	3,518	0	0
Mar-56	4,495	2,623	2,623	0	0	3,816	3,816	0	0
Apr-56	4,390	2,579	2,579	0	0	3,749	3,749	0	0
May-56	4,832	2,842	2,842	0	0	4,131	4,131	0	0
Jun-56	26	2,817	26	2,791	0	4,098	26	4,072	0
Jul-56	8	3,034	8	3,026	0	4,409	8	4,401	0
Aug-56	6	3,006	6	3,000	0	4,370	6	4,364	0
Sep-56	5	2,886	5	2,881	0	4,197	5	2,163	2,029
Oct-56	484	2,874	484	2,390	0	4,177	484	0	3,693
Nov-56	4,485	2,621	2,621	0	0	3,812	3,812	0	0
Dec-56	4,579	2,678	2,678	0	0	3,900	3,900	0	0
Total	*32,111*	*33,102*	*19,014*	*14,088*	*0*	*48,139*	*27,417*	*15,000*	*5,722*

Table 1b: 2020 and 2070 Supply and Demand – Worst Year Supplies from Daily Analysis
Values in Acre-Feet

Month	CA 4415 Available Supplies from Daily Analysis	2020 Conditions				2070 Conditions			
		Beaumont Demand	CA4415 Supplies Used to Meet Demand	Supplies from Other Sources	Shortage	Beaumont Demand	CA4415 Supplies Used to Meet Demand	Supplies from Other Sources	Shortage
Jan-56	3,901	2,723	2,723	0	0	3,962	3,901	61	0
Feb-56	4,164	2,419	2,419	0	0	3,518	3,518	0	0
Mar-56	3,765	2,623	2,623	0	0	3,816	3,765	51	0
Apr-56	3,701	2,579	2,579	0	0	3,749	3,701	48	0
May-56	3,955	2,842	2,842	0	0	4,131	3,955	176	0
Jun-56	775	2,817	775	2,042	0	4,098	775	3,323	0
Jul-56	0	3,034	0	3,034	0	4,409	0	4,409	0
Aug-56	0	3,006	0	3,006	0	4,370	0	4,370	0
Sep-56	0	2,886	0	2,886	0	4,197	0	2,562	1,635
Oct-56	0	2,874	0	2,874	0	4,177	0	0	4,177
Nov-56	116	2,621	116	1,158	1,347	3,812	116	0	3,696
Dec-56	1,857	2,678	1,857	0	821	3,900	1,857	0	2,043
Total	*22,234*	*33,102*	*15,934*	*15,000*	*2,168*	*48,139*	*21,588*	*15,000*	*11,551*

6. The remainder of this memorandum describes the calculations in more detail. Attachment 1 contains the actual daily calculations of available supply.

Water Rights

7. Table 2 is a summary of the Beaumont (CA 06-4415) and LNVA water rights (CA 06-4411). These two water rights are the primary run-of-the-river diversions from the lower Neches River. LNVA rights are for diversions from both the Neches River and Pine Island Bayou. A canal connects the main stem of the Neches River to the LNVA diversion point on Pine Island Bayou. The LNVA right contains a complex set of maximum diversion rates for the various priorities which vary by location which are discussed in the section on the daily analysis. The LNVA rights also include authorization for Steinhagen and Rayburn Reservoirs, which are not included in Table 2.

Table 2: Beaumont and LNVA Water Rights

Number	Owner	Priority Date	Diversion Amount	Type of Use
CA 06-4415	City of Beaumont	5-Apr-15	6,570	Municipal
		8-Jan-25	49,897	Municipal and Industrial
		Total	*56,467*	
CA 06-4411	LNVA	12-Aug-13	107,108	Municipal, Industrial, Irrigation, Mining
		8-Nov-13	219,252	
		31-Dec-24	55,516	
		Total	*326,360*	

Available Supplies Using WAM

8. Figure 2 shows the annual diversions from the Neches River under the Beaumont water right from the Neches WAM plus the 15,000 acre-feet per year available from other sources (LNVA contract and groundwater). The Beaumont 2020 and 2070 annual demands are included for reference. The Beaumont diversion of 56,567 acre-feet per year is approximately 89% reliable.

9. Figures 3a and 3b are annual summaries comparing 2020 and 2070 Beaumont demands to available supplies, using the monthly availability from the WAM. For this analysis, each month in the WAM simulation is compared to the projected Beaumont demand for that month. If there is not enough water available from the Neches River, then the 15,000 acre-feet per year

from alternative sources is used if available. Once this supply is used up there is a shortage. In 2020 the three sources are sufficient to meet all Beaumont demands. In 2070, there are shortages in 1966, 1967 and 1971. The maximum shortage of 5,722 acre-feet is in 1956.

Figure 2: Annual Available Supply from Beaumont Sources Based on Neches WAM

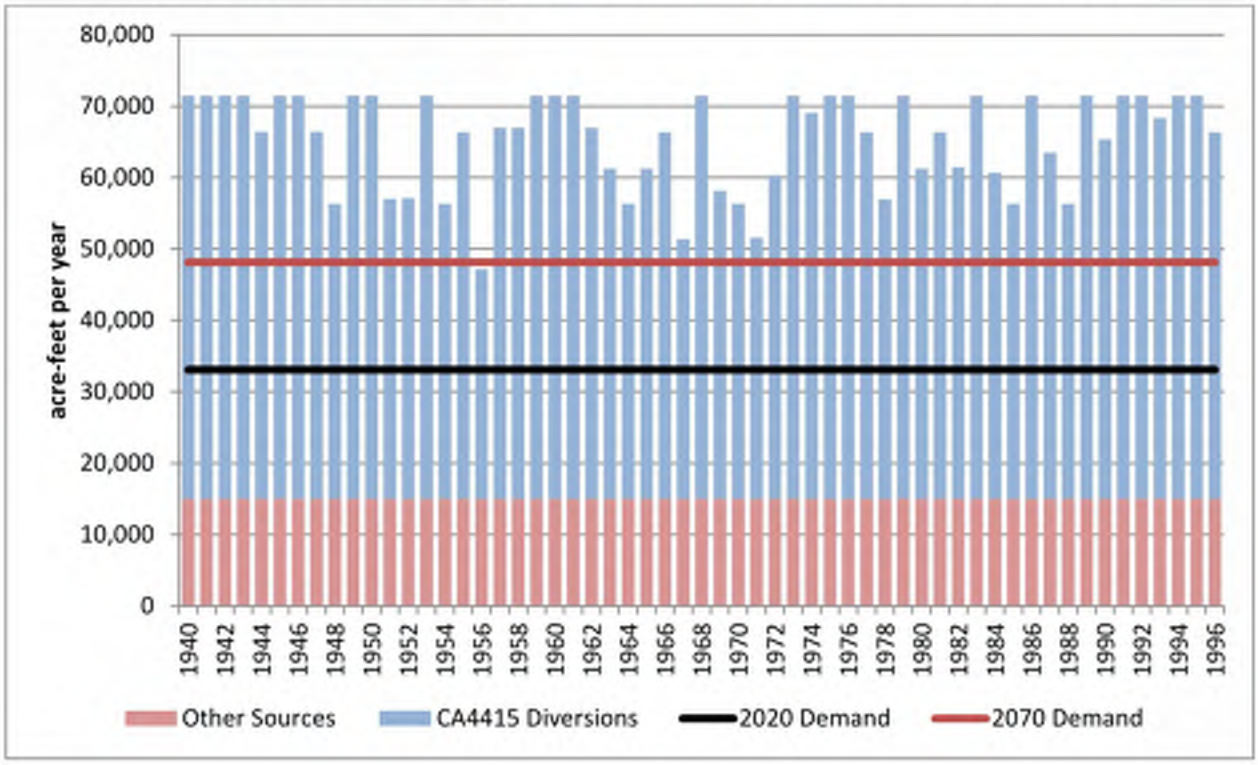


Figure 3a: Annual Source of Supply Based on Monthly Analysis using WAM – 2020 Conditions

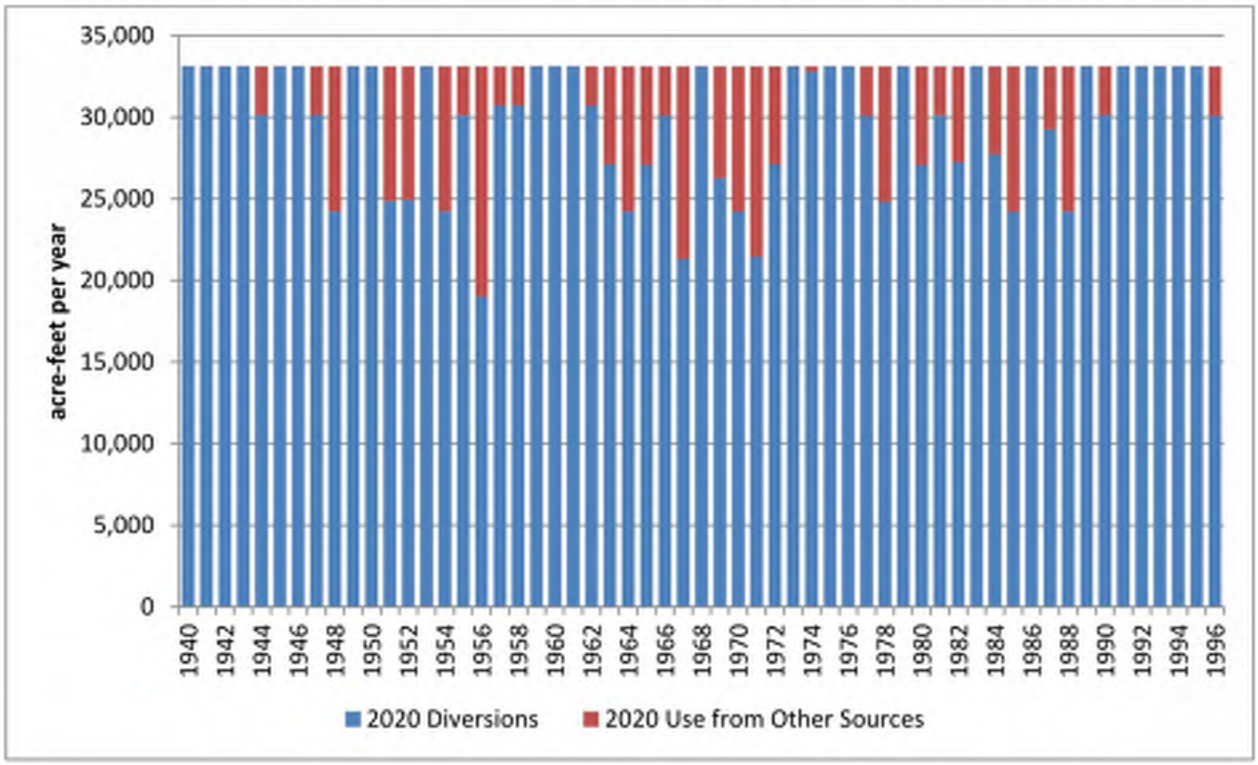
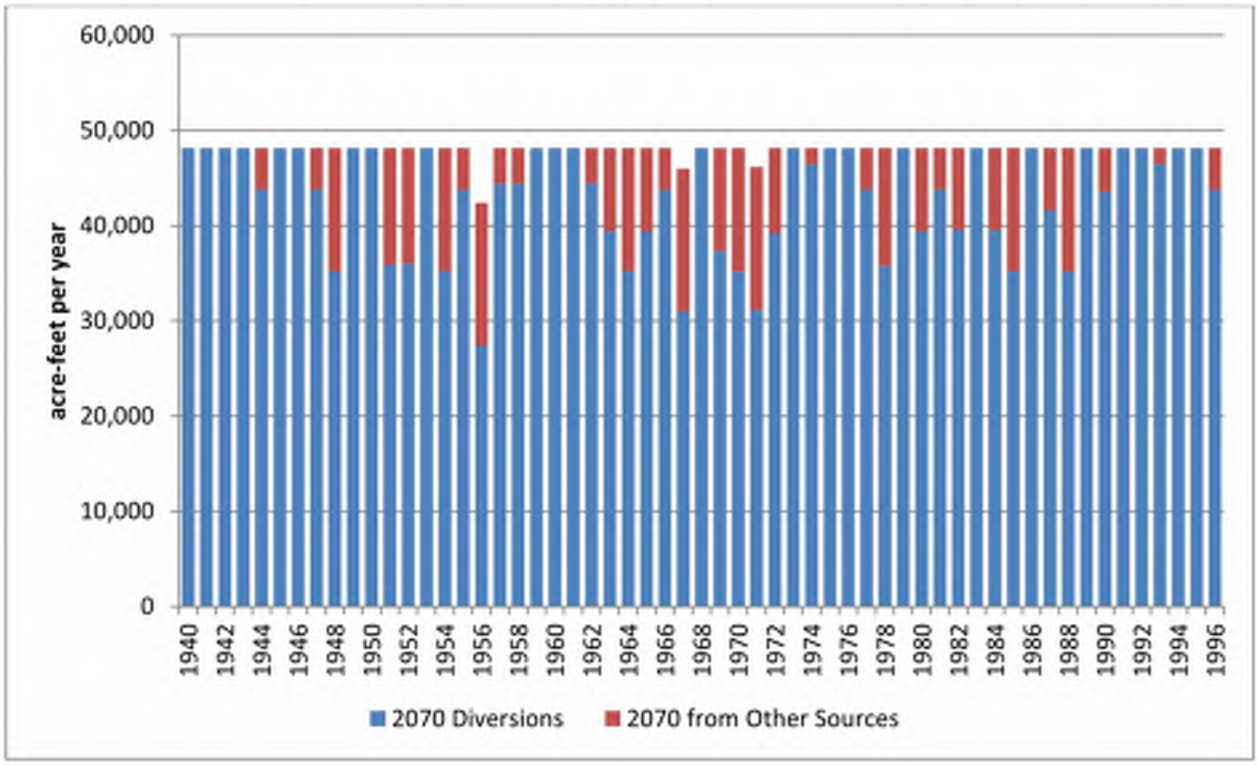


Figure 3b: Annual Source of Supply Based on Monthly Analysis using WAM – 2070 Conditions



Daily Analysis

10. The preferred method for calculating availability for Beaumont is based on an analysis performed during the negotiations between LNVA and Beaumont in 2011. These negotiations were overseen by TCEQ. Attachment 1 contains a detailed description of the calculations performed as part of the negotiations. The analysis uses daily historical flows for the years 1956, 1967, 2000, 2010 and 2011. 1956 had the lowest availability for Beaumont and was selected for the basis of water availability for Region I.

ATTACHMENT 1: DESCRIPTION OF DAILY ANALYSIS SPREADSHEET

The daily analysis spreadsheet includes the following worksheets:

Worksheet 1 (Analysis of Available Flow at the Salt Water Barrier) – This worksheet estimates the natural flows for the Neches River at the Salt Water Barrier based on inflow and outflow data from Sam Rayburn and B.A. Steinhagen Reservoirs and USGS streamflow data.

Worksheet 2 (Adjusted LNVA Analysis of Diversions Assigned to Water Rights) – This worksheet assigns diversions to various water rights using a modified version of the analysis performed by LNVA. The analysis preserves LNVA's logic and philosophy for allocating flow and diversions by water right. However, the analysis substitutes Freese and Nichols' calculations for available flow (see Worksheet 1, above); uses actual daily diversions by the City of Beaumont (Worksheet 5) instead of the hypothetical diversion in the original LNVA analysis; and divides Beaumont's diversions between 1915 and 1925 priority.

Worksheet 3 (Corps Data) – presents the raw inflow and outflow data for Sam Rayburn Reservoir and inflow data for B.A. Steinhagen Reservoir, as extracted from the Corps of Engineers' website: http://www.swf-wc.usace.army.mil/cgi-in/rcshtml.pl?page=Hydrologic. These data are provided as backup for calculations in Worksheet 1.

Worksheet 4 (USGS Data) – presents gage flow in cubic feet per second, as extracted from the U.S. Geological Survey website: http://waterdata.usgs.gov/tx/nwis/current/?type=flow. These data are provided as backup for calculations in Worksheet 1.

Worksheet 5 (Beaumont Diversions) – presents the daily diversions by the City of Beaumont from the Neches River. This data was provided by Karin Warren of the City of Beaumont to Freese and Nichols, Inc. by Beaumont. Worksheet 5 converts the raw data, provided in million gallons per day, to cubic feet per second (cfs) using the factor 1 MGD = 1.55 cfs. These data are presented as backup for calculations in Worksheet 2.

Worksheets 1 and 2 are discussed in greater detail below.

WORKSHEET 1 –ANALYSIS OF AVAILABLE FLOW AT THE SALT WATER BARRIER

This table estimates natural flows above the Salt Water Barrier. The columns in the worksheet are developed as follows:

(A) Date. This is the date to which the data apply.

(B) Inflow to Sam Rayburn Reservoir. Obtained from the U.S. Army Corps of Engineers' website. "Adjusted" inflows in cubic feet per second are used for 1 January 2010 through 30 September

2010. Adjusted inflows are not available for dates later than 30 September 2010; calculated inflows from the same data set are used for the period 1 October 2010 through 14 November 2011.

(C) Flow at the Rockland USGS Gage. Daily flow in cfs from the U.S. Geological Survey website.

(D) Estimated Inflow to BA Steinhagen Reservoir (Not Including Releases from Sam Rayburn). This is the estimated inflow to B.A. Steinhagen Reservoir downstream from Sam Rayburn Reservoir and is based on the flow at the Rockland USGS gage multiplied by the drainage area ratio. The drainage area of B.A. Steinhagen Reservoir downstream from Sam Rayburn Reservoir is 4,124 square miles, and the drainage area of the Rockland gage is 3,636 square miles, resulting in a ratio of 1.1342.

(E) Total Natural Inflow above Dams. Calculated in the spreadsheet as the sum of Column B and Column D. This value, expressed in cfs, represents inflow from the portion of the Neches River watershed above Sam Rayburn Reservoir and B. A. Steinhagen Reservoirs.

(F) Natural Inflow above Dams with Negatives set to Zero. As noted previously, natural inflow may be zero during dry periods but cannot be negative. Negative numbers in the spreadsheet represent inconsistent data. This column replicates Column G with the difference that any negative value has been reset to zero.

(G) Flow at Town Bluff Gage. Daily flow in cfs from the U.S. Geological Survey website. Data points after 7/25/2011 are provisional; all prior data are approved. Note that the datum for 10/5/2011 is missing. We have filled in 598 cfs, which is the average of flows for 10/4 and 10/6.

(H) Flow at Evadale Gage. Daily flow in cfs from the U. S. Geological Survey website. Data points after 7/25/2011 are provisional; all prior data are approved. Note that the datum for 10/5/2011 is missing. We have filled in 635 cfs, which is the average of flows for 10/4 and 10/6.

(I) Evadale less Town Bluff (Lagged 1.5 days). Calculated in the spreadsheet as Column H minus the average of the Column G value from one and two days prior. This use of previous days' values for Town Bluff flows represents travel time between the two gages. Scenarios of 1, 1.5, 2, 2.5, and 3 days travel time were tested; 1.5 days travel time produced the fewest negative values and appears to be the best fit.

(J) Corrected Flow from Town Bluff to Evadale. In certain cases, Column I contains negative numbers (highlighted in pink). While flow between the two gages may be zero under some conditions, it should not be negative. We believe these negative numbers are an artifact of varying travel times. Column J represents a manual adjustment to Column I to remove negative inflows by adjusting the inflows of adjacent dates such that no entry is less than zero and the total volume remains unchanged.

(K) Flow at Village Creek near Kountze Gage. Daily flow in cfs from the U.S. Geological Survey website. Data from 10/4/2010 on are provisional. All prior data are approved. Note that the datum for 10/5/2011 is missing. We have filled in 15 cfs, which is the average of flows for 10/4 and 10/6.

(M) Flow at Pine Island Bayou near Sour Lake Gage. Daily flow in cfs from the U.S. Geological Survey website. Data from 10/5/2010 on are provisional; all prior data are approved.

(N) Ungaged Flow. Estimates the ungaged flow between Lake B.A. Steinhagen and the Salt Water Barrier by using a drainage area ratio and flows for the gaged portion of the watershed. The watershed above the Salt Water Barrier (9,789 square miles) minus the portion of the watershed above B.A. Steinhagen Reservoir (7,574 square miles) reflects 2,215 square miles of total watershed below B.A. Steinhagen Reservoir. The gaged portion of this drainage area is the gaged portion of the Pine Island Bayou watershed (336 square miles) plus the gaged portion of the Village Creek watershed (860 square miles) plus the gaged portion of the main stem watershed between the Evadale and Town gages (7,951 square miles minus 7,574 square miles, or 377 square miles). The total gaged portion of the watershed below B.A. Steinhagen is therefore 1,573 square miles (336 + 860 + 377). The ungaged portion of the watershed is 642 square miles (2,215 total – 1,573 gaged). The ratio of 642 square miles (ungaged area) to the gaged portion (1,573 square miles) is 0.41. (The drainage area of each gage is taken from the USGS website.) The spreadsheet accordingly multiplies (Column (H) + Column (K) + Column (L)) by 0.41 to calculate Column N.

(O) Flow Between BA Steinhagen and Neches at the Salt Water Barrier. Computes the total flow between Lake B.A. Steinhagen and the Salt Water Barrier by adding gaged and ungaged flow and is equal to Column (J) + Column (K) + Column (L) + Column (M).

(P) Estimated Natural Flow on Neches at Salt Water Barrier (O + F (Lagged 1.5 Days)). Estimates the total natural flow in the Neches River at the Salt Water Barrier by adding the estimated natural flow from the portion of the watershed below B.A. Steinhagen Reservoir (Column O) to estimated natural flow above the dams (Column F) with a 1.5 day lag for the flow values from the upper portion of the watershed (average of Column F values for 1 and 2 days prior).

WORKSHEET 2 – ADJUSTED LNVA ANALYSIS OF DIVERSIONS ASSIGNED TO WATER RIGHTS

Unless otherwise indicated, the procedures used to divide available flows among water rights and priorities are the same as the procedures followed by the LNVA in its spreadsheet.

(A) Date. This is the date to which the data apply.

(B) Estimated Natural Flow in the Neches River at the Salt Water Barrier – from Worksheet 1. Calculated by FNI as described in Worksheet 1. Data from Column Q, Worksheet 1, is copied to Column B, Worksheet 2. The computations are described under Worksheet 1 above. The data are different from the data used by LNVA.

(C) LNVA Pumpage at Neches First. Actual LNVA pumping at the Neches First Lift Pump Station, as reported by LNVA on a daily basis, in cfs.

(D) Neches First Year to Date. Cumulative pumping by LNVA at Neches First Pump Station for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying diversions in cfs by 1.98347 (to convert to acre-feet) and adding each day's value to the prior

day's to determine a cumulative running total.

(E) LNVA Pumpage at Neches BI First. Actual LNVA pumping at the BI First Lift Pump Station, as reported by LNVA on a daily basis, in cfs.

(F) BI First Year to Date. Cumulative pumping by LNVA at BI First Lift Pump Station for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying diversions in cfs by 1.98347 (to convert to acre-feet) and adding each day's value to the prior day's to determine a cumulative running total.

(G) 8/12/1913 BI First Run-of-the-River Right (up to 450 cfs). Allocates LNVA's diversion at BI First (in cfs) to the most senior water right for that location, limited by the available flow (Column B), the total diversion at BI First lift (Column E), the maximum allowable diversion rate at this priority, and the maximum annual diversion at this location and priority.

(H) Year to Date Use of 1913 BI (Ac-Ft). Cumulative pumping by LNVA at BI First Lift Pump Station at the 1913 priority for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying diversions in cfs by 1.98347 (to convert to acre-feet) and adding each day's value to the prior day's to determine a cumulative running total. It is used to assure that diversions at the 1913 priority cease when the maximum annual diversion at that priority is reached.

(I) 11/8/1913 Neches First Run-of-the-River Right (up to 588 cfs). Allocates LNVA's diversion at Neches First (in cfs) to the most senior water right for that location, limited by the available flow less flow allocated to BI First 1913 (Column B – Column G), the total diversion at Neches First lift (Column C), the maximum allowable diversion rate at this priority, and the maximum annual diversion at this location and priority.

(J) Year to Date Use of 1913 Neches (Ac-Ft). Cumulative pumping by LNVA at Neches First Lift Pump Station at the 1913 priority for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying diversions in cfs by 1.98347 (to convert to acre-feet) and adding each day's value to the prior day's to determine a cumulative running total. It is used to assure that diversions at the 1913 priority cease when the maximum annual diversion at that priority is reached.

(K) Beaumont Diversion from Neches (cfs). Actual diversion by the City of Beaumont, expressed in cfs. Data for diversions in mgd were provided by the City of Beaumont by email from Karen Warren to Tom Gooch, FNI, dated 14 November 2011. The original data are included in Worksheet 5 as Column B. This column was on in LNVA's computations.

(L) 4/15/1915 City of Beaumont Right Diversion. The portion of Beaumont's diversion that can be made with available water at a 1915 priority. It is limited to the lesser of actual diversions; available flow less diversions by LNVA under their 1913 rights (The lesser of Column K and Column B – Column G – Column I); the maximum allowable diversion rate at this priority; and the maximum annual diversion at this priority. In their computations, LNVA used an assumed 50 cfs diversion by LNVA rather than actual diversions (which were always less than 50 cfs) in this column.

(M) Year to Date Use of 1915 Beaumont (Ac-Ft) (Acre-feet). Cumulative pumping by Beaumont at Neches First Lift Pump Station at the 1913 priority for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying cumulative diversions in cfs by 1.98347 (to convert to acre-feet). It is used to assure that diversions at the 1915 priority cease when the maximum annual diversion at that priority is reached.

(N) 12/31/1924 BI First Right. These are diversions by LNVA at the BI First Lift Pump Station that are allocated to LNVA's 1924 water right. They are limited by the difference between total diversions at BI First Lift (Column E) and diversions allocated to the 1913 priority (Column G), the difference between total available flow (Column B) and flows allocated to prior water rights (Columns G, I, and L), the 30 cfs diversion rate available under this right, and the total annual amount available under this right. There is a slight difference from the LNVA spreadsheet in this column. Rather than limiting diversions to (Column B – Column G – Column I – Column L), LNVA limited diversions to (Column B – Column G – Column I). This difference (correcting what appears to be a minor miscalculation by LNVA) does not significantly affect the results.

(O) 12/31/1924 Neches First Right. These are diversions by LNVA at the Neches First Lift Pump Station that are allocated LNVA's 1924 water right. They are limited by the difference between total diversions at BI First Lift (Column C) and diversions allocated to the 1913 priority (Column I), the difference between total available flow (Column B) and flows allocated to prior water rights (Columns G, I, L, and N), the 45 cfs diversion rate available under this right, and the total annual amount available under this right.

(P) Total of 1924 BI and Neches First Lift Year to Date Diversions. Cumulative pumping by LNVA at BI and Neches First Lift Pump Stations at the 1924 priority for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying 1924 priority diversions in cfs at both pump stations by 1.98347 (to convert to acre-feet) and adding each day's value to the prior day's to determine a cumulative running total. It is used to assure that diversions at the 1924 priority cease when the maximum annual diversion at that priority is reached.

(Q) 1/8/1925 City of Beaumont Right Diversion. The portion of Beaumont's diversion that can be made with available water at a 1925 priority. It is limited to the lesser of actual diversions less diversions at the 1915 priority (Column K – Column L); available flow less diversions by LNVA under their 1913 and 1924 rights and by Beaumont at its 1915 right (Column B – Column G – Column I – Column L – Column N – Column O); and the maximum allowable diversion rate less diversions at the 1915 priority.

(R) Diversions by Beaumont in Excess of Available Flow. This is equal to Column K – Column L – Column Q. These diversions could be taken from channel storage or, as LNVA points out, could come from LNVA's releases from upstream reservoirs.

(S) 11/12/1963 Actual Diversions of Water from Storage. The amount of water LNVA diverts from releases of stored water on the day in question. It is equal to LNVA's total diversions (Column C + Column E) less the diversions allocated to run-of-the-river water rights (Column G + Column I + Column N + Column O).

(T) Total Year to Date Diversions from Storage. Cumulative diversions by LNVA of water released

from reservoir storage for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying diversions of water released from storage (Column S) in cfs by 1.98347 (to convert to acre-feet) and adding each day's value to the prior day's to determine a cumulative running total. It is used to assure that diversions of water released from storage do not exceed the maximum annual amount.

(U) 11/12/1963 – Called Releases of Water from Storage. The amount of water that was released from storage in upstream reservoirs for the day. This was provided by LNVA.

(V) Total Year to Date Diversions from Storage. Cumulative water released from reservoir storage for the year. This value is expressed in acre-feet. It is computed in the spreadsheet by multiplying water released from storage (Column U) in cfs by 1.98347 (to convert to acre-feet) and adding each day's value to the prior day's to determine a cumulative running total. It is used to assure that water released from storage does not exceed the maximum annual amount.